



Matlab for engineers 4th edition solutions pdf free trial online game



BEGINNING BIRDWATCHER'S



Research7:572Total Tasks Completed

0 Pending Tasks

variable x or the variable closest to x, unless told to do otherwise. We can use this linearity property to obtain a more generally useful algebraic solution in cases where the right-hand sides are all multiplied by the same scalar. in June? Another force u(t) also acts on the mass. For example, to load and play the WAVE file chimes.wav located in C:\windows\media on some Windows systems, you type >>[y, Fs] = audioread('c:\windows\media\chimes.wav'); >> sound(y, Fs) You can also use the audioplayer and play functions instead of sound, as follows. 126 124 Compare this to >>q = fun(3,7); >>x ??? The Insert Colorbar button inserts a color map strip in the graph and is useful for threedimensional surface plots. Use this result to plot the distance of the fishing boundary as a function computes the mouse for these operations. Absolute values = $[5.8310 \ 5.0000 \ 7.2801]$. Adding Data to Axes The Plot Browser provides the mechanism by which you add data to axes. By default it displays in response to the up-arrow (1) in the Command Window. 36 Example of Problem Solving Consider the following simple example of the steps involved in problem solving. for example that humans do algebra with pencil and paper. Problems......Page 25420. Find the mean and variance of z by simulation, and compare the results with the theoretical prediction. Such an equation set is said to be overdetermined. The period of the sound wave is P = 1/f. Force f (lb) 0 100 200 300 400 500 600 700 800 Deflection x (in.) 0 0.15 0.23 0.35 0.37 0.5 0.57 0.68 0.77 Solution The following MATLAB script file generates two plots on rectilinear axes. An engineer must design a large natural gas storage tank to be expandable to maintain the pressure constant at 2.2 atm. To see how to obtain a function y = kx that passes through the origin, see Problem 8. Use MATLAB to a. Shipping costs and shipping times are reduced because the low hardware cost enables many local and small manufacturing centers to be established. function y = (x, 2-4), *cos(x); end end A test session gives the following results. of 0.5, the output is the input minus the upper limit. For example, typing syms x is equivalent to typing syms x y u v creates the four symbolic variables x, y, u, and v. An unfortunate result of the goto statement was confusing code, called spaghetti code, composed of a complex tangle of branches. Integrals that cannot be evaluated in closed form sometimes can be evaluated approximately by using a series representation for the integrand. In this case m should be greater than n. Before you give MATLAB instructions, make sure the cursor is located just after the prompt. If x0 is a vector of length 2, fzero assumes that x0 is an interval where the sign of function(x0(1)) differs from the sign of function(x0(2)). Persistent variables in that persistent variables are known only to the functions help, lookfor, and doc can be used to display syntax information for a specified function. However, a glance at the surface plot will make this easy to determine. The first function should define the function V(t) for use with the fzero function. If the numeric array values correspond to valid locations, you may use a numeric array to extract the elements. Servo Motors Our examples thus far assumed that we are controlling a device by adjusting its voltage or current input. You win the game if you get two heads, lose if you get two tails, and flip again if you get one head and one tail. For example, to create an LTI object in state-model form for the system described by Equations (9.5-6) through (9.5-8), you type >> A = [0, 1; -5/2, -3/2]; B = [0; 1/2]; >> C = [1, 0]; D = 0; >> sys3 = ss(A, B, C, D); An LTI object defined using the tf function can be used to obtain anequivalent state-model description of the system. For example, if you type q = fun(3,7); the value of q will be computed but not displayed. Click on Figure dialog box to change certain properties of the figure. Compute the PI gains required to obtain the roots s = -50 ± 50j. Test Your Understanding T9.1-2 Use the integral function to compute the integral and compare the answer with that obtained from the closed-form solution, which is A = 0.9163. Obtain a curve fit for P(T) from these data. (7.3-2) For example, to generate a vector y containing 2000 random numbers normally distributed with a mean of 5 and a standard deviation of 3, you type y = $3^{randn}(1,2000) + 5$. Investigate the accuracy of this approximation by creating three plots. This methodology is introduced in Chapter 1. Traffic and Highway Engineering. 86 >> [quotient, remainder] = deconv(f,g) quotient = 1.5 - 0.5833 remainder] = deconv(f,g) quotient = 1.5 - 0.5833 remainder = 0.0 - 0.5833 remainder] = deconv(f,g) quotient = 1.5 - 0.5833 remainder = 0.0 - 0.5833 remain same degree, so we did not have to fool MATLAB as we did when adding the polynomials. Whenever possible, we wish to obtain solutions in closed form, because it is created with a symbolic expression. Solve the following matrix equation for the matrix C. The easiest way to find and replace variables or functions in the current file is to use the automatic highlighting feature. z = xor(x,y) T4.3-2 Suppose that x = [-9, -6, 0, 2, 5] and y = [-10, -6, 2, 4, 6]. mesh surface plot. With vat photopolymerization, a liquid photopolymerization, a liquid photopolymerization of the current file is to use the automatic highlighting feature. z = xor(x,y) T4.3-2 Suppose that x = [-9, -6, 0, 2, 5] and y = [-10, -6, 2, 4, 6]. adjoining polymer chains. The command gca returns the current axes for the current figure. 7.5 Summary This chapter introduces MATLAB functions that have widespread and important uses in statistics and data analysis. Chapter 11 covers symbolic methods for manipulating algebraic expressions and for solving algebraic and transcendental equations, calculus, differential equations, and matrix algebra problems. The speed drops below 250 when the disturbance torque starts to act, because the applied voltage is 0 at that time. The resulting matrices X to act, because the applied voltage is 0 at that time. and Y contain the coordinate pairs of every point in the grid. The function returns a symbolic solution of the ode specified by the symbolic expression eqn. In this form the constant, write a script file that accepts user input for d, L, and r and computes and displays C. MAT-files are binary files that are generally readable only by the software that created them. Plot the following function for x over the interval $-3.5 \le x \le 10$. Typing B = logical(A), 163 where A is a numeric array, returns the logical array B. function c2 = cos(x, ^2); The integral function is called as follows: >>A = integral(@cossq,0,sqrt(2*pi)) The result is A = 0.6119. Figure 10.4-4 Simulink model for v = (80/9)cos($\pi t 2$ /100). We can often avoid the use of loops and branching and thus create simpler and faster programs by using a logical array as a mask that selects elements of another array. Other Menus The Desktop menu enables you to dock the Figure window within the desktop. The result is a column array that contains the polynomial roots. 20. 3.2 User-Defined Functions FUNCTION FILE LOCAL VARIABLE FUNCTION DEFINITION LINE Another type of M-file is a function file. An ordered sequence means that the instructions can be numbered, but an algorithm often must have the ability to alter the order of its instructions using what is called a control structure. How does your answer change if the ball weighs 2 lb? 1 2 3 4 5 Distance (mi) 560 440 490 530 370 Time (hr) 10.3 8.2 9.1 10.1 7.5 Figure 7.3-2 Scaled histogram of the angle θ . You can round numbers to a specified number of decimal places or significant digits. (a) Compute the motor angles required to position the hand at x = 3 ft, y = 1 ft. Common examples include airline scheduling, traffic flow studies, and production lines. Write a MATLAB program to simulate the effects of buying 50 shares of this stock whenever the price is below the \$100 mean, and selling all your shares whenever the price is above \$105. Suppose that the outer radius is constrained to be 2 in. Chemistry: The Central Science. However, Simulink has built-in blocks that represent many of the commonly found functions such as Coulomb friction. Thus sin(5) computes the sine of 5 rad, not the sine of 5 rad, not the sine of 5°. Recording and Writing Sound Files You can use MATLAB to record sound and write sound data to a WAVE file. We demonstrate two ways to use the integral function. T2.7-3 Edit your structure array to remove the SN field. How much does the profit decrease if you make one more or one less item than the optimum? The Command window in Figure 1.1- 1 shows some commands and the results of the calculations. All years evenly divisible by 400 are leap years. Check your solutions by computing A -1 A. Plot the following function for x over the interval $-2\pi \le x \le 2\pi$. INTEGRATOR BLOCK There is some variation in the notation and symbols used in simulation diagrams. Obtain a plot of h(t). The impulse can be thought of as the derivative of the step function, and is a mathematical abstraction for convenience in analyzing the response of systems subjected to an input that is applied and removed suddenly, such as the force from a hammer blow. Figure P13 145 14. Surface Plots of Implicit Functions In Section 5.2 we saw that an implicit function is a function in which we cannot isolate one variable in terms of the other. The design teams responsible for the various subsystems, such as aerodynamics, structures, hydraulics, and electrical systems, all had access to the same computer database that described the aircraft. For example, keeping two terms in the Taylor series expansion of $\cos x$ about x = 0 gives $\cos x \approx 1 - x 2/2$. $341 \blacksquare$ Solution The coefficient matrix and the augmented matrix for this problem are Making the computations in MATLAB, we find that for c = 9, rank (A) = rank([A b]) = 2. A red dot will appear at line 5 between the line number and the code. The sort(A) function sorts each column of the array A in ascending order and returns an array the same size as A. The oscillations have a period of $2\pi/\omega$, and their amplitudes decay in time at a rate determined by τ , which is called the time constant. For the model shown in Figure 10.10-5 with a unit-step command input, let m = 1 and T = 0.2. Compute the PID gains required to obtain the roots s = -10, -20 ± 20j. It is of obvious interest to see whether or not a comet's or asteroid's orbit will intersect that of a planet. (b) Because integrand function, multiplication, multiplication, division, and exponentiation. 534, 541 Symbolic linear algebra functions Item Description Pages charpoly Returns the characteristic polynomial of a matrix. Compare the response for three cases: (a) K p = 9, K I = 50 (b) K p = 9, K I = 250 44. For example, typing student(2).name displays the value 'Mary Jones'. >>initial(sys3, [5, -2]) The plot shown in Figure 9.5-2 will be displayed on the screen. [0.5, 1.8, 0.8] T2.3-4 Given the matrices 76 do the following by hand, then check your answer using MATLAB. Suppose the model is required to pass through a point not at the origin, say the point (x 0, y 0) and that point is known to be an exact solution to the equation, so that y 0 = mx 0 + b. You may use more than one gtext command for a given plot. Does it make sense? The number of hours on each machine required to produce a product is given in the following table, along with the number of hours available per week on each type of machine. from the MATLAB command line or from another M-file function. Calculate the distance at closest approach to a lighthouse located at the coordinate origin (0, 0). To use the methods of this chapter, you must have either the Symbolic Math Toolbox or the Student Edition of MATLAB. Find a functional description of these data. Plot the estimate of the derivative dy/dx from the following data. If the name is unique, it is automatically completed. Use the eig(A) function to find the roots directly without finding the characteristic root"). ylabel('Angle (rad)'), gtext('Case 1'), gtext('Case 2') The results are shown in Figure 9.4-2. Its syntax is disp(A), where A represents a MATLAB variable name. Vectors as Arrays and *Advanced Data Structures 12. Double-click on it, and set the Output when off to 0 and 100. Figure 10.7-7 A network of RC loops. Table 1.1-4 lists them. Construct a

Simulink model to plot the solution of the following equations for $0 \le t \le 2$ where f(t) = 3t. In this step you create the necessary modules and test them separately. We have not coverage to ordinary differential equations whose initial conditions are specified. Table 2.4-1 Aircraft speeds and times per leg Leg Speed (mi/hr) Time (hr) 1 2 3 4 200 250 400 300 2 5 3 4 Solution We can define a row vector t containing the times for each leg. For example, if then max(A) returns the vector [6, 2]; min(A) returns the vector [-10, -5]; size(A) returns [3, 2]; numel(A) returns 6, and length(A) returns 3. Thus, when multiplying or dividing these functions, or when raising them to a power, you must use elementby-element operations if the arguments are arrays. Write a user-defined function file with W and A as inputs. Another function file with W and A as inputs. installed on your system. Use the property editor command. You can see the code and even modify it, although this is not recommended. else statements may be omitted if not required. For example, the integral of 12x 3 + 9x 2 + 8x + 5 is obtained from q = polyint([12,9,8,5], 10). The scalars m and n give the dimensions of the matrix coeffs; m is the number of polynomial, and n is the number of coefficients for each polynomial (MATLAB will fit a lower-order polynomial if possible, so there can be fewer than four coefficients). 127 help Displays Help text in the Command window. The left-division method sometimes gives an answer for overdetermined systems, but it does not indicate whether the answer is the exact solution. These pairs are then used to evaluate the function. However, the examples given here will help you get started in exploring the other features of Simulink. The damping constant c is often difficult to determine with accuracy. 4 Chapter 3 covers file usage, functions built into MATLAB, and user-defined functions. The default appearance of the Desktop in MATLAB version R2017b is shown in Figure 1.1-1. Then you can use these results to check the output of the program. The (x, y) coordinates of a certain object as a function of time t are given by for $0 \le t \le 4$. However, another useful histogram uses data scaled so that the total area under the histogram's rectangles is 1. Then put the temperature measurements in a matrix z such that going 335 Figure 7.4-2 Temperature measurements at four locations. Marks the same color as error messages appear on the left side of the Command History to indicate commands that generate errors. 450 10.4 Piecewise-Linear Models Unlike linear models, closed-form solutions are not available for most nonlinear differential equations, and we must therefore solve such as English, to describe algorithms often results in a description that is too verbose and is subject to misinterpretation. You can resize the block to make the labels readable. The Editor helps you avoid syntax errors by using delimiter matched and mismatched delimiters, such as parentheses, brackets, and braces. The exponential function e x is computed from exp(x). The height of the step is M, and is called the magnitude. 2. [2, 0.5556, 1.25] b. 164 Special variables and constants Item Description Pages ans Most recent answer. These functions do not require the elements in x to be sorted in ascending or descending or descending or descending involving double(subs(R,a,pi/4)) R = 0.7071 0.0701 0.7071 0.0701 0.7071 0.0701 0.7071 0.0701 Characteristic Polynomial and Roots Sets of first order differential equations can be expressed in vector containing the forcing function. Obtain the solution using the MATLAB left-division method and the pseudoinverse method. EXAMPLE 8.2-4 Ethanol Production Engineers in the food and chemical industries use fermentation in many processes. If x originally had the value 3, its new value would be 5. For example, suppose we have the 2 × 2 arrays A and B: Then C = cat(3, A, B) produces a three-dimensional array composed of two layers; the first layer is the matrix A, and the second layer is the matrix B. The following example shows how the MATLAB M-function mean can be superceded by our own definition of the mean, one which gives the rootmean-square value. The essential guide to MATLAB as a problem solving tool This text presents MATLAB both as a mathematical tool and a programming language, giving a concise and easy to master introduction to its potential and power. Statements cannot have arguments; for example, clc and quit are statements. For example, sind(x) accepts the value of x in degrees. Interpret both answers. If the computed height were negative, we would know that we did something wrong. For example, if the quantities are months, choose a spacing of 12 because 1/10 of a year is not a convenient division. Solution For the given parameter values, To examine the speed ω as output, we choose C = [0, 1] and D = [0, 0]. Let r = rank(A). answers here. Engineers can use computers to determine the forces, voltages, currents, and so on that might occur in a proposed design. If the length of x is n, then x is plotted versus the rows of A. Evaluate the following expressions in MATLAB, for the values x = 5 + 8i, y = -6 + 7i. This method makes it easier to identify the function. 119 coth(x) Hyperbolic cotangent; cosh x/sinh x. Set the Stop time to 0.1 (which is simply an estimate of how long is needed to see the complete response), run the simulation, and examine the plot of $\omega(t)$ in the Scope. The set is underdetermined because there are fewer than three independent equations; the third equation can be obtained from the first two. int(E,v) Returns the integral of the expression E with respect to the variable v. The measured displacement versus time is given by t(s) 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 x(cm) 1.9 2.1 1.7 1.2 0.9 0.6 0.4 0.3 0.2 0.1 0.1 Estimate the initial displacement and velocity. Create a structure array that contains the following information fields concerning the road bridges in a town: bridge location, maximum load (tons), year built, year due for maintenance. Rousseau. Be careful when using the logical operators with inequalities. Consider the following representation of some functions named A, B, . The two side springs provide additional resistance if the weight W is too heavy for the center spring. No part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written consent of McGraw-Hill Education, including, but not limited to, in any network or other electronic storage or transmission, or broadcast for distance learning. Perform a reality check and precision check on the answer. The function should create a vector of guessed values for W, whose minimum and maximum values are W1 and W2, with spacing d. Set the Initial condition of the integrator to h10. else statement group 2 end Figure 4.4-2 shows the flowchart of this structure. For example: A{1,1} A{2,1} A{2,2} = = = 'Walden Pond'; 'June 13, 2016'; [60,72,65]; [55,57,56;54,56,55;52,55,53]; Type A at the command line. When the plot appears in the Figure window, use the mouse to position the legend box. In addition, find the maximum percent error in the predictions. The vector x0 is a guess that must be supplied by the user. 42. (Do not forget to check if a file already exists by that name!) The volume is given by Test case: h = 30, r = 5, V = 785.3982. For what range of Q is production profitable? System toolbox provides several solvers for linear models. He was the Director of the Robotics Research Center at the University of Rhode Island from 1985 to 1993, and is the coholder of a patent for a robot hand. In general, you can use the default values of these parameters, except where we have explicitly indicated that they should be changed. If so, Equation (10.10-18) will not be useful. Because this time is less than the time needed for large turns, θ will be large, and Equation (10.10-18) will not be useful. the applied voltage to reach 10 V, the motor should be able to follow the desired trapezoidal profile reasonably well. For example, to create a simple function called sq to calculate the square of a number, type sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$;
136 To improve readability, you may enclose the expression in parentheses, as sq = $@(x) x^2$; 136 To impr developed in part (a) and predict how long it will take to fill one cup when the pot contains 36 cups. Each pseudocode instruction may be numbered, but should be unambiguous and computable. The following two conditions must occur: 1. subplot(2,2,2) semilogy(time,temp,time,temp,to'), xlabel('Time (sec)'),... ylabel('Relative Temperature (deg F)') The data form a straight line on the semilog plot only (the top right plot). Use the initial function to plot the position x 1 of the mass, if the initial position is 5 and the initial velocity is 3. For example, to create a 1 × 100 vector y having 100 random values in the open interval (0, 1), type y = rand(1,100). Thus the cubic is the best fit of the four models considered. This command divides the Figure window into an array of rectangular panes with m rows and n columns. It returns a value of 1 (which means "true") if 'field' is the name of a field in the structure array S. Consider the following example. function r = CD(t); % Displays CD rate r as a function of the term t. >>x = [5, -3, 0, 0, 8]; y = [2, 4, 0, 5, 7]; >>values = 2 4 7 >>how many = 3 169 Thus there are three nonzero values in the array y that correspond to nonzero values in the array x. MATLAB uses high precision for its computations, but by default it usually displays its results using four decimal places except when the result is an integer. % Uses functions xcoord, ycoord, and vertvel. It provides a new way to optimize load-bearing designs resulting in structures that are lighter yet stronger, whose interiors are cellular and look almost bone-like. The other state variable x 1 is related to x 2 by = 2 x 1. Exponential and Logarithmic Functions 118 Table 3.1-1 summarizes some of the common mathematical functions. Use the Edit menu to copy, cut, and paste blocks. (This assumes that the road network is dense.) The weekly cost is given by ci = d i V i = 1,...,6. The power dissipated in the resistor is given by v 2 /R. So now that logical is a MATLAB data type, if A is a logical array, for example, A = logical(eye(4)), then typing A(3,4) = 1 does not change A to a double array. Specify true to relax the level of mathematical rigor in the simplification process. 424 from Kirchhoff's voltage law and Newton's law applied to a rotating inertia. The remaining items on the first pane are used as follows. Numeric ceil(x) fix(x) floor(x) round(x) sign(x) Round to the nearest integer toward ∞ . 312, 319 mode Calculates the mode. For example, the problem has the solution The session is >> syms x(t) y(t) >> Dx = diff(y,t); >> eqn1 = Dx = =3*x+4*y; >> eqn1 = Dx = =3*x+4*y; >> eqn2 = Dy ==-4*x+3*y; >> cond1 = x(0) ==0; >> cond2 = Dy = -4*x+3*y; >> eqn2 = Dy = -4*x+3* y(0) = 1; >>S = solve(eqn1, cond1, eqn2, cond2) ans = S.x = sin(4*t)*exp(3*t) S.y = cos(4*t)*exp(3*t) It is not necessary to specify only initial conditions. ODE Solvers in the Control System Toolbox Many of the functions from the Control System Toolbox Many of the functions from the Control System toolbox are available in the Student Edition of MATLAB. rng(n) Initializes the random number generator using the non-negative integer n. The function must accept a vector x and a scalar y, and it must return a vector result, so the appropriate array operations must be used. Examine the data near the origin. Then use the State-Space block instead of the Transfer Fcn block. We can use this Figure 9.4-1 A pendulum. Suppose the rocket is carrying instruments to study the upper atmosphere, and we need to determine the amount of time spent above 50,000 ft as a function of the burn time b (and thus as a function of the fuel mass qb). The coefficients are p(1) = -0.3286 and p(2) = 3.9762, which is r 0. z = ex b. The Mux block combines two or more signals into a vector signal. Check the dimensions and units. This point is called a takeoff point because it takes the value available represented by the arrow (here, the variable y) and makes that value available represented by the arrow (here, the variable y) and makes that value available represented by the arrow (here, the variable y) and makes that value available represented by the arrow (here, the variable y) and makes that value available represented by the arrow (here, the variable y) and makes that value available represented by the arrow (here, the variable y) and makes that value available (here, the variable y) and makes that value available (here, the variable y) and makes that value available (here, the variable y) and makes that value available (here, the variable y) and makes that value available (here, the variable y) and makes that value available (here, the variable y) and makes the value (here, the variable y) and makes that value available (here, the variable y) and makes the value (here, the variable y) and make (here, the variable y) and make (here, the variable y) and the value (here, the variable y) and there (here, there (her to another block. For example, to save the function associated with the handle h, type save anon.mat h. The time span and number of solution points are chosen automatically. The best way to learn more is to type Live Editor in the documentation.) The basic syntax is impulse(sys), where sys is the LTI object. z = x & y c. However, there are two dangers in using high-degree polynomials. For example, you can obtain the following integrals with the session shown below. If you later decide to change the value of A or B, you must redefine the anonymous function using the new value. In this definition the product is the sum of the individual element products; that is, $s^{t'} = [200(2) + 250(5) + 400(3) + 300(4)] = 4050$ These two examples illustrate the difference between array multiplication s.*t and matrix multiplication s.*t and matrix multiplication s.*t and matrix multiplication s.*t are the difference between array multiplication s.*t and matrix multiplication s.*t are the difference between array multiplication s.*t are the difference betwe 10 years the balance is \$14,105.99.) With an initial investment of A and interest rate r, the balance B after n years is given by: 20. You can play two different sounds simultaneously in stereo by concatenating them in a column vector, as sound ([sound vector 1', sound vector 2'], Fs). Because they are similar, decide how best to plot and label them to avoid confusion. To specify nonzero initial conditions for a state-space model, use the syntax lsim(sys,u,t,x0). Directories and Path 39 Files are stored in folders, also called directories. The conditions for the existence and uniqueness of solutions are then introduced. certain fishing vessel is initially located in a horizontal plane at x = 0 and y = 10 mi. Choose axes that will result in straight-line graphs for both V and A. Plot the unit-step response (for zero initial conditions). Find the building's natural frequencies in cycles per second for the case where m = 1000 kg and $k = 5 \times 10.6$ N/m. The function atand(x) returns degrees. The initial-condition vector xo is needed only if the initial conditions are nonzero. T2.5-2 Use MATLAB to confirm that 93 T2.5-3 Use MATLAB t Do not give a script file the same name as a MATLAB command or function. It consists of a rectangle of length L and width W and a right triangle that is symmetric about the central horizontal axis of the rectangle. m). Create a function file that computes the maximum compression x due to the falling weight. t = 0:1/Fs:duration; sound vector = amplitude*sin(2*pi*freq*t); sound(sound vector,sf) Try this function with the following values: freq = 1000, Fs = 10000, amplitude = 1, and duration = 10. 12 quit Stops MATLAB. The break statement stops the execution of the loop. To use content indexing, enclose in braces the cell subscripts on the left side, using the standard array notation LAPLACIAN 370 It can be computed with the del2 function. Minimize the number of zeros in the tick labels. For example, the command disp ('The predicted speed is:') causes the message to appear on the screen. The following function is linear in the parameters a 1 and a 2. Under these conditions, conservation of energy says that the heat flow into a subsquare equals the heat flow out. Its basic form is histogram(y), where y is a vector containing the data. $S_3 = (x^3+2*x^2+5*x+10)/(x^2+5) >>$ simplify(S3) % See if some terms cancel. Differentiation The diff function is used to obtain the symbolic derivative. Robot-assisted surgery is already common in some applications that require precise, steady motions, such as prostate surgery, in which the robot filters out tremors often present in the human surgeon's hand. You could use the global variables, or you could use the global variables, or you could use the global variables, or you could use the global variables. devices requires geometric analysis, control system design, and image processing. When the modeling is finished, we need to solve the mathematical model to obtain the required answer. This reaction produces ethanol in addition to water and carbon dioxide. Create the following M-file with the primary function fn demo1(range) and the subfunction testfun(x) to compute the zeros of the function cos x over the range specified in the input variable range. 23 grid Displays grid lines. (Answer: x 0 = 1.9044, v 0 = 4.2090.) 297 Constraining the Curve to Pass Through a Specified Point Consider the cantilever beam shown in Figure 6.1–7. include each student's name, student number (SN), email address, and test scores. To check the value of y we set a breakpoint at line 5 by typing dbstop test3 5 in the Command window. 29.* A company wants to locate a distribution center that will serve six of its major customers in a 30 × 30 mi area. (Answer: d = 10.7457 ft, θ = 60°.) 3.3 Additional Function Types 134 In addition to function handles, anonymous
functions, subfunctions, and private functions some other types of user-created functions in MATLAB. So, for example, a variable that has a value assigned to it by the 141 primary function can be read or overwritten by a function nested at any level within the main function. Getting started with Simulink is best done through examples, which we now present. Typing erf(x) returns the area to the left of the value t = x under the curve of the function. The last two items, Basic Fitting and Data Statistics, will be discussed in Sections 6.3 and 7.1, respectively. Use the curve fit to estimate the values of y at x = 2.5 and at x = 11. If the saved file contains the variables A B, and C for example, then loading the file places these variables back into the workspace and overwrites any existing variables having the same name. Before naming a function, you can use the exist function to see if another function has the same name. Let x 3 (k) and x 4 (k) be the number of juniors and seniors, respectively, in year k. Thus the acceleration is zero. Tables 7.3-1 and 7.3-2 summarize these functions. The range of the dependent variable can also be specified. (9.6-1) (9.6-2) where L, R, and I are the motor's inductance, resistance, and inertia; K T and K e are the torque constant; and v(t) is the applied voltage. Plot the amount of money in the account for a 10-year period. We take the axle midpoint to be our reference point and establish the coordinate system (x 1, y 1) there. Figure 4.5-2 gives the resulting plot. Note that in this context e does not represent the number e, which is the base of the natural logarithm. [x,k] = max(A) but returns the number e, which is the base of the natural logarithm. [x,k] = max(A) but returns the number e, which is the base of the natural logarithm. [x,k] = max(A) but returns the number e, which is the base of the natural logarithm. minimum values. This chapter requires the use of the Symbolic Math toolbox. 386 Section 8.4 18.* Use MATLAB to solve the following are the equations of motion of the two-mass suspension model shown in Figure 10.3-1. The figure handles are h1 and h2 To plan a continuation of the trajectory, the following coordinate transformation must be used. For example, suppose you want to write a program that plays a game, say, Tic-Tac-Toe. Use MATLAB to determine the 25th element. [Kreyzig, 2009] Kreyzig, 2009] Kreyzi were covered in Chapter 9. It is Plot y(t) for $\mu = 1$ and $0 \le t \le 20$, using the initial conditions y(0) = 5, (0) = 0. % Program Falling Object. Their use will increase in the future as our technology develops to make them more reliable and more versatile. Because Simulink uses numerical and not analytical methods, it computes derivatives only approximately, using the Derivative block. See the text and MATLAB help for more discovery is the process of finding, or "discovery is the process of finding, or "discovering," a function that can describe a particular set of data. Use zero initial conditions. Such diagrams are widely used to represent time-dependent and probabilistic processes. Because of the space required for such charts, we do not use them in this text. Order of Precedence SCALAR A scalar is a single number. 51. Note that this syntax is different from that used to create other function handles, fhandle = @functionname. Use the subsystem block to construct a Simulink model of the entire system of three masses. Although the rules of precedence are unambiguous here, we can always put parentheses around quantities if we are unsure how MATLAB will interpret our commands. The inputs to the second function should be x and r. The following equation describes the motion of a certain mass connected to a spring, with no friction where f(t) is an applied force. xlabel ('time (s)'), ylabel ('theta (rad)') % Nested function. 261 fplot3(fx,fy,fz) Creates a 3-D line plot. First define the function file for the perimeter length. Double-click on it, and select round for the perimeter a. The result is ans = 1 1, which indicates that it is a 1 × 1 structure array. 430 b. If the outlet is a pipe that discharges to atmospheric pressure p a and provides a resistance to flow that is proportional to the pressure difference across its ends, then the outlet flow rate is where R is called the fluid resistance. The Current Folder window is much like a file manager window; you can use it to access files. >>p = audioplayer(y, Fs); >>play(p) The sound function lets you play the sound only at a given sampling rate, but the audioplayer function enables you to do more than that, such as pause the playback and resume it, and set properties of the object. This can be seen by noting that the term e -Ts can be expanded in an infinite series as The fact that there are an infinite number of characteristic roots means that the analysis of dead-time processes is difficult, and often simulation is the only practical way to study such processes is difficult. estimate of the velocity, and it integrates the velocity estimate to produce an estimate of displacement. Select Export from the estimate of displacement. the function to be animated may be evaluated in the set function with an expression or with a function. For example, choosing the three roots to be s = -1, -1, -1 to obtain a system response time of 4, requires that P = 3, I = 1, D = 3. Consider the data given by x = [0, 1, 2, 3, 4, 5] and y = [0, -10, 60, 40, 41, 47]. The MATLAB differentiation functions discussed here are summarized in Table 9.2-1. Is the mean motion what you would expect? To do this, move the cursor to an input port or an output port; the cursor to an input port or an output port; the same size as x. Click on the new axes, and a box will surround them. For example, to solve the set using both methods, the session is >>A >>b >>x x = 3 1 >>x x = 3 1 = sym([2, -3; 5, 4]); = sym([3; 19]); = inv(A)*b % The matrix inverse method. 374 [t, y] = ode45(@RC_circuit, [0 0.5], 2); y_true = 2*exp(-10*t); plot(t,y,'o',t,y_true), xlabel('Time(s)'),... The help function is the most basic way to determine the syntax and behavior of a particular function. If we specify the interval $1 \le x \le 4$, MATLAB (R2017b) gives the answer x = 2.8236, which corresponds to the "valley" shown in the plot, but which is not the minimum point on the interval $1 \le x \le 4$. The following table gives the data for five springs: Spring 1 Force (N) Spring constant k (N/m) 2 3 4 5 11 7 8 10 9 1000 600 900 1300 700 Use MATLAB to find (a) the compression x in each spring and (b) the potential energy stored in each spring. The remainder of the MATLAB script uses the derived flow rate relation f = 0.0499V 0.433 to plot the extrapolated fill-time curve 1/f versus t. The number of points being plotted also affects the animation speed. The mean and variance of y are μ y = 15 and . If for some reason you want them displayed, remove the semicolons, but this is not usually the case. Select and place the Integrator block from the Continuous library, double-click on it to obtain the Block Parameters window, and set the Initial condition to 0 [because y(0) = 0]. For example, typing doc sqrt displays the documentation page for the function sqrt. ones(size(A)) Creates an array of 1s the same size as the arrays, which are available in MATLAB 7: So far we have used only numeric arrays, which are arrays containing only numeric arrays, which are arrays containing only numeric arrays, which are arrays containing only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So far we have used only numeric arrays are available in MATLAB 7: So f Thus the result of multiplying a 1 × n vector by an n × 1 vector is a 1 × 1 array, that is, a scalar. The initial conditions are zero. Find the voltage drop v2 as well. For example, the set has the solution The session is >> syms x(t) y(t) >> eqn1 = diff(x,t) = =3*x+4*y; >> eqn2 = diff(y,t) = =-4*x+3*y; >> [x, y] = dsolve(eqn1,eqn2) x = dsolve(eqn1 $C1^{exp}(3^{t})^{*}cos(4^{t}) + C2^{exp}(3^{t})^{*}sin(4^{t}) + C2^{exp}(3^{t})^{*}sin(4^{t}) + C2^{exp}(3^{t})^{*}cos(4^{t})$ example, the polynomial s 2 + 10s + 41 has the roots s = -5 ± 4j. An advantage of debug mode is that it lets us see the values of local variables. Write a script file to compute the three roots of the cubic
equation x 3 + ax 2 + bx + c = 0 Use the input function to let the user enter values for a, b, and c. 402 439 403 CHAPTER 10 Simulink OUTLINE 10.1 Simulation Diagrams 10.2 Introduction to Simulink 10.3 Linear State-Variable Models 10.5 Transfer-Function Models 10.5 Transfer-Function Models 10.7 Subsystems and Hardware-in-the-Loop Testing ink is built on top of MATLAB, so you must have MATLAB to use Simulink. Do this by clicking on the arrow line and then pressing the Delete key. Compute the PID gains required to obtain the roots s = -10, -20 ± 20j. Press Esc to clear the entire line; press Ctrl and k simultaneously COMMAND WINDOW You use the Command window to communicate with the MATLAB program, by typing instructions of various types called commands, functions, and Figure 1.1-1 The default MATLAB Figure (*.fig) file. Plot the results, and compare with the results from the backward and central difference methods. Thus 25 percent of 20year-old men are estimated to be 68 in. The following list gives the measured breaking force in newtons for a sample of 60 pieces of certain type of cord. Its equation is We want to find all points where the ellipses intersect. 131 fzero Finds the zero of a function. factor(E) Factors the expression E. Chapter 3 gives extensive coverage of the built-in functions. Note that the largest L AC can be is 6.7 ft (which corresponds to $\theta = 90^{\circ}$). 234 yyaxis Enables plotting on left and right axes. x = rand(1,1000); 305 y = x.^2; histogram(x), hold on histogram(x), hold on histogram for x will be that of a uniform distribution, whereas that for y will resemble a decaying exponential with a peak near 0. Suppose that the selling price and the sales quantity Q are interrelated as follows: $Q = 6 \times 10.6 - 1.1 \times 10.6 P$. The function name should be the same as the file name in which it is saved (with the .m extension). 58, 60, 161 511 length Computes number of elements. Test Your Understanding T5.1-1 Plot the equation for $0 \le x \le 35$ and $0 \le y \le 3.5$. T5.1-2 Use the fplot command to investigate the function tan(cos x) - sin(tan x) for $0 \le x \le 2\pi$. tools for working with polynomials. Find the coefficients and the J values. Explain the result. cups = [6,9,12,15]; meas times = [9,8,7,6]; meas times = [9,8,7,6]; meas times = [9,8,7,6]; meas times = [9,8,7,6]; meas times = [0,8,7,6]; meas times vectors, the result of u.*v is a column vector. Other data markers are available. The 51 following table shows the results of these calculations using the indices of the nonzero elements of the vector x. MATLAB provides algorithms for solving boundary value problems (BVPs) such as See the Help for the function by4c. Type rand(m,n) to obtain an m × n matrix of random numbers. If the application requires a real number for a solution, then we should choose log(6) as the answer. (b) First we find the solutions for the motor angles in terms of the variable y. Here we will give examples of finding matrix products, the matrix inverse, eigenvalues, and the characteristic polynomial of a matrix. The MATLAB subplot command creates such figures. The function is y = e x + 1 for x < -1, $y = 2 + cos(\pi x)$ for $-1 \le x < 5$, and y = 10(x - 5) + 1 for $x \ge 5$. As a result, software upgrades might produce changes in performance and in the syntax as capabilities are improved and bugs removed. That is, if the symbolic variable is x, then S = symsum(E,a,b) returns Here are some examples. For example, the following function circle computes the area A and circumference C of a circle, given its radius as an input argument. Problem 20 356 388 Engineering in the 21st Century... Rebuilding the Infrastructure D uring the Great Depression, many public works projects that improved the nation's infrastructure were undertaken to stimulate the economy and provide employment. This strip is the breakpoint alley. For each burn time value: Compute m 0, v b, h b, h p. Section 1.5 36. Although use of the end statement to terminate a function is sometimes optional, it is required for some cases (see Section 3.3), so it is wise to include it always. Construct a Simulink model to plot the following function for x over the interval $-2 \le x \le 16$ Use enough points to get a smooth curve. We cannot determine when this event will occur without doing a simulation. Use sensible tick-mark spacing. These features, plus MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form the basis for constructing MATLAB functions and the logical operators to be introduced in Section 4.3, form t lowercase letter o, type plot(x, y, 'o'). 82 the script file is x1 = 0:0.01:2; f1 = 10*ones(size(x2)); x2 = 2.01:0.01:4.99; f2 = zeros(size(x2)); x3 = 5:0.01:7; f3 = -3*ones(size(x2)); x x3, f3).) Matrix Division and Linear Algebraic Equations Matrix division uses both the right and left division operators, / and \, for various applications, a principal one being the solution of sets of linear algebraic equations. The Constant block is in the Sources library. Diver 2 dives 15 ft, swims east 20 ft and then north 59 ft. * These functions accept x3, f3).) in radians. 8, 63 .\ Array left-division operator. In other problems we generally do not have a good guess for tfinal, so we must try several increasing values of the following model. As a simple example, let us plot the function y = 5 cos(2x) for 0 ≤ x ≤ 7. In this example, m = 1, c = 2, k = 5, and the applied force is u(t) = 10. 118 Hyperbolic functions Item Description Pages acosh(x) Inverse hyperbolic cosine; cosh -1×109 Unit product costs ($$ \times 103$) Product Materials Labor Transportation 1 7 3 2 2 3 1 3 3 9 4 5 4 2 5 4 5 6 2 1 105 Quarterly production volume Product Quarter 1 Quarter 2 Quarter 3 Quarter 3 Quarter 4 1 16 14 10 12 2 12 15 11 13 3 8 9 7 11 4 14 13 15 17 5 13 16 12 18 39.* Aluminum alloys are made by adding other elements to aluminum to improve its properties, such as hardness or tensile strength. Evaluate the overshoot and undershoot. Let a = 10 m. Compare the pressure estimates given by the ideal gas law and the var der Waals equation for 1 mol of Cl 2 in 22.41 L at 273.2 K. 73 c. If the tank's radius is r, you can use integration to show that the volume of water in the tank as a function of its height h. The half-life of carbon 14. which is used for dating previously living things, is 5500 years. Note that the dimension of the matrix B tells Simulink that there are two inputs. Therefore, to add f(x) and g(x), we append one zero to g to "fool" MATLAB into thinking g(x) is a third-degree polynomial. Figure 9.2-1 shows three data points that represent a function y(x). function A = specmat(n) A = ones(n); for r = 1:n for c = 1:n if (r > 1) & (c > 1) 174 s = A(r,c-1); if s < 20 A(r,c-1); end end end 182 Typing specmat(5) produces the following function, assuming that the scalar variable x has a value. Typing save(myfile) causes MATLAB to save the workspace variables, that is, the variable names, their sizes, and their values, in a binary file called myfile.mat, which MATLAB can read. The material in Section 3.4 is useful for readers who must work with large data sets or spreadsheets. A certain object has a mass of 100 kg and is acted on by a force f (t) = $500[2 - e - t \sin(5\pi t)]$ N. A certain ellipse centered at the origin has the equation Another ellipse, also centered at the origin, is rotated relative to the first ellipse, also centered at the origin, is rotated relative to the first ellipse. plot(yr,th2r,2, -51.3178,'a',... For example, the previous function simplifies to y = sin x / cos x = tan x. Use element-by-element division to divide the first row of A by the first three elements of the third column of B. where we use them to create and represent complex numbers, such as x = 5 + 8i. The options argument is created with the odeset function. Plot the required motor angles versus x. Note that this procedure can be used to solve sets of equations. There are three ways to insert an equation into a live script. function show date today = date end Note that no brackets, parentheses, or equal sign are required. where α is in degrees. Use the values R = 0.8 Ω , L = 0.003 H, K T = 0.05 N
 \cdot m/A, K e = 0.05 V \cdot s/rad, c = 0, and I = 8 \times 10 -5 kg \cdot m2. EXAMPLE 6.1-2 Temperature Dynamics The temperature of coffee cooling in a porcelain mug at room temperature (68°F) was measured at various times. MEAN MODE MEDIAN The way the data are spread around the mean can be described by a histogram plot. In an ASCII file each byte represents one character according to the ASCII code. 0.02 c. New York: McGraw-Hill, 2008. The if structure may be written on a single line; for example, if $x \ge 0$, y = sqrt(x), end However, this form is less readable than the previous form. 260 surfl Same as surf but with lighting. Type help specmat to see the list of special matrix commands; also check Table 2.4-5. Y/N [Y]: ', 's'); if (isempty(response)|(response = 'Y')|(response = 'Y')|(respon Many more string functions are available in MATLAB. For each set, x = 0, 1, 2, 3, 4, 5. The next step is to develop haptic feedback, or a sense of touch, which enables the surgeon to indirectly feel the tissues being manipulated. An LTI object can be created from different descriptions of the system, it can be analyzed with several functions, and it can be accessed to provide alternate descriptions of the system. Assume that the bottom edge of the sheeting is located along the x axis at y = 0. For example, the polynomial s 2 + 60s + 500 has the roots s = -10, -50. Typing randi(imax,size(A)) returns an array the same size as A. Source: MATLAB Coefficients and norm of residuals. In this case, the search terminates when the search interval is expanded until an Inf, NaN, or a complex value is found (fzero cannot find complex zeros). However, these operations assume the initial conditions associated with each transfer function are zero. Plotting Polynomials The polyval(a, x) function evaluates a polynomial at specified values of its independent variable x, which can be a matrix or a vector. Select an object and right-click to display its context menu, then select Properties. The law of cosines for the bottom triangle. Note also that the rank of A cannot exceed the number of columns in A. For example, a set of cubic splines for the temperature data given earlier follows (y represents the temperature values, and x represents the hourly values). Impact speed v i versus time to impact: v i = gt i . LIBRARY BROWSER To select a block from the Library Browser, double-click on the appropriate library, and a list of blocks within that library then appears. As a character string identifying the appropriate function M-file, which is function $y = fun1(x) = x^2+4$; end The function may be called as follows, to compute the zero over the range $0 \le x \le 3$: >>x = fzero('fun1',[0, 3]) 2. For example, >>x=2; y=6+x, x=y+7 = 8 x = 15 Note that the first value of x was not displayed. To the far right of the Editor there are two icons for selecting where to put the outputs (in this case the plot). For a particular bronchodilator, k has been estimated to be in the range 0.047 ≤ k ≤ 0.107 per hour. The Control Systems and the Signal Processing toolboxes, and the DSP and Fixed Point block sets, are also useful for such applications. % p m b Fit a straight line to the transformed data. With one exception noted later, you must use square brackets to define the variable x to contain this collection. 90 1950 2013 Clark St. 85 1933 2012 100 1960 2013 Clark St. 85 1933 2012 Clark St. 85 1933 2013 Clark St. 85 1933 2012 Clark St. 85 1933 2013 Cla Statistics, Probability, and Interpolation OUTLINE 7.1 Statistics and Histograms 7.2 The Normal Distribution 7.3 Random Number Generation 7.4 Interpolation 7.5 Summary Problems This chapter begins with an introduction to basic statistics in Section 7.1. You will see how to obtain and interpret histograms, which are specialized plots for displaying statistical results. Select a two-dimensional axis from the New Subplots subpanel. The Variable Editor and the Variables tab appear as shown in Figure 2.1-1. Write two user-defined functions. To print the block diagram of the model, select Print on the File menu. Equation (8.3-4) shows that $x \ge 0$ if $z \ge -10$. 44. 32 stairs(x,y) Produces a stairs plot of y versus x. If multiple candidates exist, you must evaluate the function at each point to determine the global maximum and global maximum. The first layer is page 1; the second layer is page 2, and so on. Figure 10.10-7 Simulink diagram of a simplified PID algorithm. It returns a row vector containing the greatest elements in each column if A is a matrix containing all real elements. Later developments have led to a wider variety of techniques now described by the term additive manufacturing (AM). Thus we could achieve the same accuracy by using fewer panels if narrower panels are used near x = 0 and x = π. MATLAB contains sophisticated algorithms for finding roots of high-degree polynomials. Write a MATLAB program to solve this problem. Table 4.6-3 184 Enter data. dsolve(eqn1,eqn2, Returns a symbolic ...) expressions eqn1 and eqn2. The output of the block must be a scalar, as is the case here, and vou cannot perform matrix operations in this block, but these are not needed here. >> fprintf('The radii are: %4.2f \t %4.2f extrapolated to 36 cups. $\omega = 5$ rad/s c. The value then changes to 9. Table 2.5-1 summarizes these functions, as well as the poly, polyval, and roots functions. Thus valid solutions are those given by Equations (8.3-4) and (8.3-5), where $0 \le z \le 2.737$ tons. The breaking force values recorded were 92, 94, 93, 96, 93, 94, 95, 96, 91, 93, 95, 95, 95, 95, 92, 93 94, 91, 94, 92, and 93. The variable T represents temperature in degrees Celsius; the variable t represents time in minutes. However, they often do not provide enough of an overview of the program. The following guidelines will help you create plots that effectively convey the desired information. ones(m,n) Creates an m × n array of 1s. For the model shown in Figure 10.10-3 with a unit-step command input, let m = 1. The following program illustrates the process. From theory we know that ln P is proportional to 1/T. The session to do this is as follows: >>x = [0,1]; >>y = [0,2]; >>z = [49,54;53,57] z = 49 54 53 57 >> interp2(x,y,z,0.6,1.5) ans = 54.5500 Thus the estimated temperature is 54.55°F. You can clear a variable from the Workspace Browser by right-clicking on it in the Browser, then selecting Delete in the pop-up menu. Newman; SN: 0003456; e-mail: ; tests: 55, 45, 58. The following example shows how this is done using the ones function. We can always reduce an underdetermined set to such a form by multiplying the set's equations by suitable factors and adding the resulting equations to eliminate an unknown variable. The text website also has downloadable files containing PowerPoint slides keyed to the text and suggestions for projects. It required many innovative techniques in its assembly. Use MATLAB to find the length x that maximizes the sum of the areas enclosed by the square and the circle. The fplot command automatically chooses enough plotting points to display all the variations in the function. The plot3(x,y,z) function generates a three-dimensional plot of a set of data points where x,y,z are vectors or matrices, by plotting lines in three-dimensional space through the points whose coordinates are the elements of x, y, z. Only the order of the arguments is important, not the names of the arguments: >>a = 7; b = 3; >>z = fun(3,7). axis([0 0.8 0 800]) The plot appears as the first plot of Figure 6.1-8. To plot the specific ellipse given by a = 2 and b = 4, the full ellipse will be displayed if the limits for x are [-2 2] and the limits for y are [-4 4]. Depending on which row and column we choose to eliminate, there are nine possible 2 × 2 determinants we can obtain. 405 odeset Creates integrator options structure for ODE solvers. t = 0:10; a = [0,2,4,7,11,17,24,32,41,48,51]; v10 = trapz(t,a) The answer for the velocity after 10 s is v10, and it is 211.5 m/s. An example is a flow 469 Figure 10.8-1 Simulink model of a hydraulic system with dead time. clear Removes all variables from memory. Investigate whether an applied voltage having a trapezoidal profile will accomplish this. Create a Simulink model to solve the problem. 358 We want to determine the amount of ethanol f produced. 114 564 Numeric functions Item Description Pages ceil Rounds to the nearest integer toward ∞ . Sometimes it is useful or necessary to obtain the coordinates of a point on a plotted curve. The material in Section 3.3 is useful or necessary to obtain the coordinates of a point on a plotted curve. anonymous function will not save you any work because typing sq([5,7]) requires nine keystrokes, one more than is required to type [5,7]. ^2. The program follows. They can use this information to make sure the hardware can withstand the predicted forces or supply the required voltages or currents. Create a Simulink model to plot the solution of the following equation for $0 \le t \le 3$. If you construct a function handle for a nested function, you can call the nested function from any MATLAB expression $y = \exp(x) \cdot \log(x)$, we need to use the operator .* if x is an array because both $\exp(x)$ and $\log(x)$ will be arrays. 359 7-12* (144./(180*Y));0]; x = A\b; E = x(4); The session is as follows: >>ethanol(1.1, 0.5) ans = 0.0654 >>ethanol(1.05, 0.5) ans = -0.0717 The negative value for E in the second case indicates that ethanol is being consumed rather than produced. 85 Interpolation functions Item Description Pages interp1 Linear and cubic spline interpolation of a function of one variable. These include Using arrays and polynomials Creating plots Creating script files Table 1.7-1 is a guide to the tables of this chapter. Product Television Stereo unit Speaker unit Inventory Chassis 1 1 0 450 Picture tube 1 0 0 250 Speaker cone 2 2 1 800 Power supply 1 1 0 450 Electronics
2 2 1 600 80 50 40 Requirements Unit profit (\$) Section 4.6 32. This is perhaps the easiest way because the if-else structure mimics the equations. Table 1.3-1 lists some of the commonly used functions. Thus the following analysis applies exactly to such a system. If we replace the line disp(table) with the following three lines E=''; fprintf('No.Plates Capacitance (F) X e12 %s',E) fprintf('%2.0f \t \t \t %4.2f',table') we obtain the following display: 2 3 4 5 4.42 8.85 13.27 17.70 The empty matrix E is used because the syntax of the fprintf statement requires that a variable be specified. MATLAB provides a number of other functions to support interpolation for three-dimensional data. 428 Use the MATLAB linear solvers to solve linear differential equations to obtain the free response and the step response and the step response for arbitrary forcing functions. Thus the time to reach 120°F is 1112 sec. >>A = sym([3, 5; 2, 7]); >>Syms a b c d >>B = [a,b; c, d]; >>C = [3, 5; 2, 7]; >>D = sym(C); The matrix A represents the most direct method. Typing >>x = m:g:n creates a vector x of values with a spacing g. Table 4.3-4 lists several useful logical functions. Compute the mean and standard deviation of the pallet weight. Inverse tangent; arctan . The distance could also have been computed from norm(r). 304 Random Walks A random walk is a random process that describes a path produced by successive random steps. You need to find a relationship between the speed of impact and the height at which the package is dropped. To undock, or separate the window from the Desktop, click on the button containing a curved arrow. A = [1, -1; 1, 1], b = [3; 5] b. Does ? In Figure 10.7-8, the basic element for the subsystem block is a mass connected to two elastic elements. The maximum percent error of the model's predictions, as compared to the given data, is 3.2193 percent. 505 460 Order of Precedence MATLAB does not always arrange expressions in a form that we normally would use. The overdetermined case occurs when the equation set has more independent equations than unknowns (Section 8.4). (Note that 1 k $\Omega = 1000 \Omega$.) Solution Because there are as many unknowns as equations, there will be a unique solution if $|A| \neq 0$; in addition, the leftdivision method will generate an error message if |A| = 0. You may always use nested parentheses to indicate your intentions. Annotate the plot with the numerical fit results and the norm of residuals. size A = size(A); % Does the rank of A equal the number of unknowns? As described in the previous section, a warning is returned to the Command window if a fit 277 produces results that might be inaccurate. Otherwise, if the integrand is given as a function, use the integral function, to be introduced shortly. Before we solve these equations, let us develop the rest of the model. The current amount A of a principal P invested in a savings account paying an annual interest is compounded. However, because the first comment line before any executable statement is the line searched by the lookfor command, discussed later in this chapter, consider putting keywords that describe the script file in this first line (called the H1 line). d1 = diff(y)./diff(x); subplot(2,1,1) plot(x(2:n),d1,'o') % Central difference estimate of dy/dx. This gives (9.3-5) where (9.3-6) with a similar definition for f k +1. MATLAB has three commands for generating plots having log scales. If all the physically meaningful answers are identical, then we can be reasonably sure that we have found the minimum. 237 223 Figure 5.2-9 A sample report published from MATLAB. 167 logical the MATLAB search path. Van der Pol's equation is Stiff for large values of the parameter µ. 351 The procedure for doing this is developed from the concept of a matrix inverse. Sort each row and store the result in an array C. The temperature T (x, y) as a function of the xy coordinates shown is given by where The given data for this equation is the parameter pluster of the parameter pluster of the parameter by the parameter pluster of the pl problem are T1 = 70°F, T2 = 200°F, and W = L = 2 ft. is used because the heights were measured to the nearest 1/2 in. (Answer: where z = (cdate - 1890)/62.048. Table 1.1-2 summarizes these rules. PEDAGOGICAL AIDS The following pedagogical aids have been included: Each chapter begins with an overview. The program should display an error message if . 430 Figure 10.9-1 Single-mass model of a vehicle suspension. The number of kilograms in 12 slugs. These have the extensions .m, .jpg, m, and .mdl, respectively. We can also write the components in a specific order, separate them with a space, and identify the group with brackets, as follows: [5 7 2]. The law is where R is the gas constant. Develop a subsystem block for one mass. Typical values supported by most sound cards are 8000, 11,025, 22,050, 44,100, 48,000, and 96,000 Hz. For example, to record your voice for 5 seconds at 11,025 Hz on channel 1, replace the second line in the previous program with the following two lines. 191 Test Your Understanding T4.9-1 Suppose that 70 percent of the freshmen, instead of 75 percent, return for the sophomore year. Display the information on screen in a table in which the 146 first column is Year and the second is Balance (\$). Before After x(1) 1.92 1.92 x(2) 0.05 - 2.43 x(3) - 2.43 0.85 x(4) - 0.02 0 x(5) 0.09 0 x(6) 0.85 0 x(7) - 0.06 0uses a for loop with conditional statements. Also, multiplying the second column in U by the first column in P gives the total labor cost for the first quarter, and so on. We must enter complex numbers in 116 MATLAB using the rectangular form, and its answers will be given in that form. It is usually plotted on logarithmic axes. The vector dot product u. Table 11.2-1 summarizes the solve function. (See Figure P24.) It is desired to hang plastic sheeting from the cable to protect passersby while the bridge is being repainted. Develop two ways of doing this. This outcome is illustrated by the following example. This vector is [a 1 , a 2 , a 3 ,..., a n-1 , a n , a n+1]. The result will be a line with a right angle. These functions are summarized in Table 7.3-1. The definition of the product x.*y, where x and y each have n elements, is x.*y = [x(1)y(1), x(2)y(2)..., x(n)y(n)] Table 2.3-1 Element-by-element operations Symbol Operation A - b [8,3] - 5 = [3,-2] + Array addition A + B [6,5] + [4,8] = [10,13] - Array subtraction A - B [6,5] - [4,8] = [2,4,5/8] . Array multiplication A./B [2,5]./[4,8] = [2/4,5/8] . Array right division A./B [2,5]./[4,8] = [2/4,5/8] . Array right division A./B [2,5]./[4,8] = [2/4,5/8] . Array subtraction A - B [3,5].^2 = [3^2,5^2] 2.^[3,5] = [2^3,2^5] [3,5].^2 = [3^2,5^4] 64 if x and y are row vectors. [1.2, 2; 0.7143, 0.3333] b. Live scripts, which were introduced in MATLAB R2016a, are stored in a file with the extension .mlx. Many applications required using global variables. Its angular momentum vector L is found from $L = m(r \times v)$, where m is the mass. Section 4.4 17. The symbol eps is the smallest number which, when added to 1 by the computer, creates a number greater than 1. Evaluate the sum of the resulting vector. 33. This can often be done with a while loop as explained in the next section. Previous editions © 2011, 2005, and 2001. 16, 26 format short e Five digits plus exponent. Plot multiple fits simultaneously for a given data set. Across the top of the Desktop are a row of icons called the Toolstrip. The equation is technically not an implicit function because we can isolate the variable y as follows: However, the ± sign forces us to consider both possibilities when evaluating y. 58 logspace Creates logarithmically spaced vector. A true energy analysis involves more than just engine operating efficiency and emissions, but must be based on a total life-cycle assessment including production and post-use considerations such as recyclability. However, the resulting expressions for θ 1 and θ 2 are complicated. fplot3(fx,fy,fz) Creates a 3-D line plot. Chapter 11 covers symbolic processing with the MATLAB Symbolic Processing With the Processing With the MATLAB Symbolic expression E. These three coordinates specify a vector p. A certain product is assembled by placing three components end to end. To see this, in MATLAB type log(-9) to obtain 2.1972 + 3.1416i. function 5. 161 509 ~= Relational operator: not equal to. The order in which MATLAB checks for functions is very in mportant. (a) A^{*}B = I--78:39.641: (b) $B^*A = [-5, -3, 48, 22]$. As $t \to \infty$ the exponential predicts that $p(t) \to \infty$ but the logistic model predicts that 150 $p(t) \to K$. However, we can use the form [breaks, coeffs, m, n] = unmkpp(spline(x,y)) 311 to obtain the coefficients of the cubic polynomials. where f(t) is an applied force. FUNCTION ARGUMENT The power of MATLAB is due to its ability to handle vectorized functions, which means that the function argument can be a vector. Table 11.3-1 summarizes the integration functions. The electrical and mechanical parameters. Suppose you work for a company that produces packaging, 526, 532 Laplace transform functions Item Description Pages ilaplace Returns the inverse Laplace transform. As another example, suppose we measure the temperature of an object once every hour. Invert L to find the solution as a function of t. disp('There is an infinite number of solutions.') disp('There is an infinite number of solutions.') disp('There is an infinite number of solutions.') disp('There is an infinite number of solution as a function of t. disp('There is an infinite number of solutions.') disp Compute the augmented matrix. You can use the ginput function to read values from the plot. 392 Compute the gradient and Laplacian of a given function is so named because it is equivalent to connecting the data points with a linear function. Linear interpolation is (11.5-8) Applying the inverse transform
to Equation (11.5-8) gives (11.5-9) From the transform given earlier, it can be seen that which is the free response. Appendix A contains a guide to the commands and functions introduced in the text. The identity matrix is a square matrix whose diagonal elements are all equal to 1, with the remaining elements equal to 0. 502, 505 sym2poly Converts an expression to a polynomial coefficient vector. ydot = -10*y; The initial time is t = 0, so set t0 to be 0. When the input is less than or equal to the lower limit. These enable you to modify the color, font, and other attributes of the text. This means that the factored form of the polynomial must be (s + 10)(s + 50), which expands to s 2 + 60s + 500. Note x is a matrix with two columns. Define the symbolic variables, including the derivatives that appear in the equation. Variable and function highlighting indicates only references to a particular function or variable, not other occurrences, such as in comments. A model used for many single-reactant processes is 309 where C is the chemical concentration and k is the rate constant. If you use the arrow keys to move the cursor over one delimiter, MATLAB briefly underlines both delimiters in a pair. Because we do not know the time required, a while loop is convenient to use. function xdot = pendulum(t,x) g = 9.81; L = 1; xdot = [x(2); -(g/L)*sin(x(1))]; This file is called as follows. 458 Figure 10.5-2 The Simulink model of dead-zone response. This 461 Figure 10.6-2 Simulink model of nonlinear pendulum dynamics. The fining to a zero slope. What does it do? 9. In this example, the dead zone is symmetric about 0, but it need not be in general. This system is designed to help the reader locate these items. (This dot and strip are shown in Figure 4.8-1.) Now type test3(10) in the command window. Evaluate the maximum value in the vector resulting from element-by-element multiplication of the second column of B with the first column of A. In practice, the best use of the fminbnd function is to determine precisely the location of a minimum point whose approximate location was found by other means, such as by plotting the function. The value 130 returned by fzero is near a point whose approximate location of its minimum b. % Data for the problem. This is the output. Section 11.6 46. Then use the initial function as follows. It is equivalent to $V = pi^*(r^2)^*h$; a(1) = 1000; d(1) = 200; % E is the 4 x 10 enrollment matrix. Test your function for the value A = 80 m 2. It must accept a vector argument x, scalar y, and scalar z, and it must return a vector result. These correspond to y(a), , , and so on. Plot this function over the range 0 ≤ x ≤ 7. Scaled Frequency Histogram You can plot the data as a histogram You can plot the data as a histogram using either the absolute or relative frequencies. In certain kinds of structural vibrations, a periodic force acting on the structure will cause the vibration amplitude to repeatedly increase and decrease with time. For A enter [0, 1, 0, 0; -a1, -a2, a1, a2; 0, 0, 0, 1; a3, a4, -a6, -a4] For B enter [0; 0; 0; a5]. (b) |x/y| = 0.84, $\angle x/y = -1.67$ rad. 581 recordblocking Holds control until recording completes. Because we are not concerned with the time of flight in this problem, we can eliminate t and obtain an equation for y in terms of x. are 0.1, 0.08, 0.16, 0.22, 0.0, 0, 1; a3, a4, -a6, -a4] For B enter [0; 0; 0; a5]. (b) |x/y| = 0.84, $\angle x/y = -1.67$ rad. 581 recordblocking Holds control until recordblocking Holds control unt and 0.24. Some double integrals are specified over a nonrectangular region. randperm(n,k) Generates a row vector containing k unique integers selected randomly from 1 to n inclusive. Now we must obtain the backward or inverse solution. Be sure to check the order of precedence and the number and placement of parentheses when typing such expressions. 90 ... Ellipsis; line-continuation operator. As long as we agree that the vector components will be written in the order x, y, z, we can use this notation. This motion resembles that of Brownian motion. Yabel('Relative Temperature (deg F)') % % Show derived curve and estimated point on linear scales. The simulation diagram is shown in Figure 10.4-3. or less in height, and 87 percent are estimated to be between 66.3 and 72.3 in. Because the 262 exponent is 0.433, not 0.5, our model does not agree exactly with Torricelli's principle, but it is close. For example, in the following session k and w appear the same, but k is a logical array and w is a numeric array, and thus an error message is issued. They are not useful for speed control. You can obtain symbols and lines of different colors by using the color symbols and h 2 versus time. An infinite number of solutions exist, and we can solve for only two of the unknowns in terms of the third unknown. That is, PI CONTROLLER 429 where K P and K I are called the proportional and integral gains. The mean µ locates the peak of the curve and is the most likely value to occur. To use these commands and to maximize the power of MATLAB, you might need to adopt a new approach to problem solving. In the following examples we will assume that the parameter values are known well enough to compute approximate values for the gains. The spline fit can be plotted by plotting the vectors x int and y int. x 0 1 2 3 4 5 6 7 8 9 10 y 0 2 5 7 9 12 15 18 22 20 17 20. When a constant voltage was applied to a certain motor initially at rest, its rotational speed s(t) versus time was measured. We can use the principle of conservation of mass to obtain a differential equation for the height h. You may use the double function in the presence of dead time means the system does not have a characteristic equation of finite order. For example, when using the drop function in a program, we can assign a value to the variable dist before the function call, and its value will be unchanged after the call because its name was not used in the place of dist). Note that we must now test the motor separately from the load mass to obtain its value of T. The springs exert a force that is proportional to their compression, and the proportionality constant k. The number of terms in the series that is duplicated determines the order of the Runge-Kutta method. Its syntax is plot3(x,y,z). After entering the code, click at the top of the 220 Figure 5.1-4 Screen shot of the Live Editor with code and graphical output. To use content indexing to access some of or all the contents, not the cell index expression in braces to indicate that you are assigning the contents, not the cells themselves, to a new variable. In both cases . If not, MATLAB then checks to see if problem1 is one of its own commands, and executes it if it is. 16, 26 563 Array functions Item Description Pages cat Concatenates arrays. Addition, subtraction, and division of complex numbers are easily done. The Plot Browser: Use this to select and control the visibility of the axes or graphics objects plotted in the figure, and to add data for plotting. Integration of Discrete Points The simplest way to find the area under a curve is to split the area into rectangles (Figure 9.1-1a). Before you can use this function, you must generate a grid of points in the xy plane and then evaluate the function f(x, y) at these points. print Prints the plot in the Figure 9.1-1a). example. Let S represent the solubility of O 2 as millimoles of O 2 per liter of water. Subscript indices must either be real positive. DATA FILE The third type of file we will be using is a data file, specifically an ASCII data file, that is, one created according to the ASCII format. The loop variable x is initially assigned the value 5, and it has this value until the statement $x = 2^*x - 1$ is encountered the first time. This example shows that the interaction of two of more normally distributed variables does not produce a result that is normally distributed variables does not produce a result that is normally distributed. 68 = mt + b. Thus the previous equation gives which can easily be solved for as follows. function xdot = msd(t,x) % Function file for mass with spring and damping. Unless otherwise specified, the default extension is .xls. see logical operators boundary condition, 525 boundary-value problems (BVPs), 428 branches, 156 breakpoint alley, 200 breakpoints, 127, 199-200 Brownian motion, 329 bugs, 160 built-in functions, 18-19 C Calculation section, 29 calculus, 513-525 case sensitivity, 12 catenary curve, 119 Cauchy form, 410 cell arrays, 88-90 cell divider, 198 cell indexing, 88 cell mode, 198-199 central difference estimate, 399 certificate of deposit (CD), 177-178 character array, 51 characteristic polynomial, 477 548 code, 18 code cell, 198 coefficient of determination, 288 color use, 121 column arrays, 20, 21, 84 column vector, 52, 53, 410 command files, 27 Command files approximation to replace the nonlinear equation with a linear one that can be solved analytically. 579 th = 70*(pi/180); g = 32.2; s0=100; tmax = xcoord(tmax, 500); x = xcoord(tmax, 50, th, g); plot(x,y), hold, h1 = plot(x,y, 'o');... axis([0 xmax 0 + 100)); y = x and y = x1.1*ymax]), xlabel('x'), ylabel('x'), ylabel('y') % kmax = length(w); for k =1:kmax set(h1, 'XData', x(k), 'YData', y(k)) drawnow pause(0.001) end hold B.2 Sound MATLAB provides a number of functions for creating, recording, and playing sound on the computer. Note that the sqrt function returns the positive root only. Simulink is widely used in industry to model complex systems and processes that are difficult to model with a simple set of differential equations. Tables summarizing the MATLAB commands introduced in this chapter appear throughout the chapter, and Table 4.10-1 will help you locate the information you need. and c = -34.6592 lb. Once an 61 Figure 2.1-1 The Variable Editor. The reduced row-echelon form (RREF) method. 116 113 117 CHAPTER 3 Functions 3.2 User-Defined Functions 3.2 User-Defined Functions
3.3 Additional Functions, including trigonometric, logarithmic, and hyperbolic functions, as well as functions for processing arrays. 10.7 Subsystems One potential disadvantage of a graphical interface such as Simulink is that, to simulate a complex system, the diagram can become rather large and therefore somewhat cumbersome. Suppose the vehicle starts from rest at time t = 0, and its measured acceleration is given in the following table. Some integrals cannot be evaluated analytically, and we need to compute them numerically with an approximate method (Section 9.1). In this chapter we cover a subset of the capabilities of the square root of 9 and assign its value to the variable r, you type r = sqrt(9). For example, if x = [3, 5, 8], then typing x.^3 produces the array [3 3, 5 3, 8 3] = [27, 125, 512]. Confirm the identity tan(2x) = 2 tan x/(1 - tan2 x) by plotting both the left and the right sides versus x over the range $0 \le x \le 2\pi$. Although a uniformly distributed random variable has definite upper and lower bounds, a normally distributed random variable does not. Double-click on the To Workspace block. 236 Overlay Plots You can use the following variants of the MATLAB basic plot(x,y) and plot(y) to create overlay plots: plot(A) plots the columns of A versus their indices and generates n curves, where A is a matrix with m rows 222 and n columns. It searches through the first line of Help text, known as the H1 line, for each MATLAB function, and returns all the H1 lines containing a specified keyword. Accordingly, if we raise the price, the product becomes less competitive and sales drop. Investigate the effect of the parameter b on y(t). Thus, a vector is a one-dimensional array. Linear System Analyzer The Control System toolbox contains the Linear System Analyzer, which assists in the analysis of LTI systems. If file name is an ASCII file, then load file name is an ASCII file, then load file name creates a matrix containing the data to be plotted. The returned coordinates have the same scale as the coordinates on the plot. Environment: The Layout icon enables you to configure the layout of the Desktop, as discussed in Section 1.1. You can set preferences for how MATLAB displays information, and manage add-on programs. The default appearance of the R2017b Desktop is shown in Figure 1.1-1 format long e 16 digits (15 decimals) plus exponent; 6.379243784781294e-04. Chapter 2: Numeric, Cell, and Structure Arrays......Page 6113. finite(A) Returns an array of the same dimension as A with 1s where the elements of are finite and 0s elsewhere. These are described in the help files, which are comprehensive. For example, if then z = x./y gives Also, if then C = A./B gives The array left division operator (.) is defined to perform element-by-element division using left division. Substituting this expression for the peak height: . If not, the last value is less than n. function, 14 comment, 27 Comments section, 29 Compare icon, 18 complex conjugate transpose, 55 complex number functions, 115-116 computer nodel, 200 computer nodel, 200 computer nodel, 202 computer solution, 38 computer solutional fluid dynamics (CFD), 272 conditional operations, 15-16 computer solution, 38 computer nodel, 200 computer nodel, 2 170-178 conformable matrix, 78 content indexing, 88 continuous variable, 319 contour lines, 258 contour plots, 258-260 control systems position control, 480 speed control, 477-479 trajectory control, 481-484 controlled variable, 474 cost analysis, 79 critical point, 515 cubic spline interpolation, 335-339 cubic splines, 287, 336 Curiosity, 2 current directory, 26 Current Folder window, 5, 6, 25 D data file, 24 data markers, 23, 236-237 Data Statistics tool, 316 549 data symbol, 225 dead time, 467-468 dead zone, 456-457 debugger, 197 debugging, 32, 160-161, 197-200 default variable, 499, 502 definite integrals, 390 delay-differential equations (DDEs), 428 deleting and clearing, 14-15 delimiter matching, 121 Desktop, 5, 17, 25 Details window, 5, 6 differential equations, 525-532 application to, 535-537 Cauchy form, 410 characteristic roots, 415-416 delay, 428 higher order, 410-413 ordinary, 402-403 partial, 402, 428 piecewise-linear, 450 solvers, 405-406 state variable form, 410 differentiation, 513-515 numerical, 398-402 partial, 402, 428 symbolic, 496 Dirac delta function, 420, 539 direct method, 540-541 directories, 25-26 current, 26 division array, 67 matrix, 82 polynomial, 85-86 dominant time constant, 477 double integrals, 396 double precision, 502 double precision (arrays), 51 drone, 224 E Edit menu, 250-251 EDITOR menu, 27 EDITOR tab, 16, 27, 197 Editor window, 120 eigenvalue, 416 elastic constant, 297 element-by-element division, 67 element-by-element attack and the second element attack a embedded control systems, 438 empty array, 56-57 energy-efficient vehicles, 310 environment, 18 error bar plots, 246 error function, 321 error signal, 474 errors locating, 32 runtime, 32 syntax, 13, 32 estimate, 332 Euclidean norm, 361 Euler method, 403-404 exponential functions, 114-115, 243, 244, 274, 276 extrapolation, 332 F feedback loop,

224 field, 91 field name, 91 figure handle, 575 Figure Palette, 250, 252, 253 Figure toolbar, 252, 253 Figure window, 250-252 figures exporting, 231-232 saving, 231-232 savin 114, 117 call, 126, 134 complex number, 115-116 elementary mathematical, 113-119 exponential, 114-115 file, 27, 120, 142-144 handle, 128 hyperbolic, 119 integration of, 130-132 nested, 134, 135, 140-141 numeric, 116-117 overloaded, 135 primary, 135, 138, 141-142 private, 134, 135, 138 of random variables, 326 subfunctions, 134, 135, 138-139 trigonometric, 118-119 user-defined, 120-134 vectorized, 114 vs. At the top of the first pane is the Select data window associated with the Basic Fitting interface. The Desktop manages the Command window and a Help Browser as well as other tools. The syntax of the gtext command is gtext('string'), where string is a text string that specifies the label of your choice. 3nx 2 a. limit(E,v,a) Returns the limit of the expression E as the variable v goes to a. 289 Degree n J S r2 1 72 1562 0.9542 2 57 1562 0.9637 3 42 1562 0.9732 1562 0.9970 4 4.7 Because the fourthdegree polynomial has the largest r 2 value, it represents the data better than the representation from first- through third-degree polynomials, according to the r 2 criterion. The inverse of a matrix A is denoted by A -1 and has the property that where I is the identity matrix. 584 input Displays prompts and waits for input. MEMS have a large surface area to volume ratio, so surface effects such as electrostatics, surface tension, and wetting have more influence than volume effects such as inertia or heat capacity. 12, Comma; separates statements, and elements in a row of an array. variable is one that contains the numbers 0, 4, 3, and 6, in that order. 9x 3 + Polynomial Multiplication and Division To multiply a polynomial by a scalar, simply multiply the coefficient array by that scalar. First construct the Simulink model shown in Figure 10.7-3. The symbols i and j denote the imaginary unit, . 131 Whenever we use a minimization technique, we should check that the solution is a true minimum. Put a title on the plot, and properly label the axes. % Program movie1.m % Animates the function t*exp(-t/b). Source: MATLAB 299 The third pane is used for interpolating or extrapolating a fit. Chapter 5 covers two- and threedimensional plots in greater detail. Structure charts. When an organism dies, it stops accumulating carbon 14. (Hint: Use the fact that n, R, and P are constant in this problem. The number of times 91, 92, 93, 94, 95, or 96 N was measured is 13, 15, 22, 19, 17, and 14, respectively. e 2 b. Its syntax is isstruct(S). limit(E) Returns the limit of the expression E as the default independent variable goes to 0. 50. (a) Determine the energy E(t) dissipated as a function of time. 463 424 Figure 10.7-2 A hydraulic system with a flow source and two pumps. (a) Determine T(t). If we type test3(10) we get the message No solution, which is a major addition to MATLAB, is covered in Section 5.1. Chapter 6 covers function discovery, which uses data plots to discover a mathematical description of the data and is a useful tool for model building. Let p = 1 = 5x + 2 and p = 10x + 2 = 10x + 2 and p = 10x + 2 = 10x + 2. Set its initial condition to $\pi/4$ by typing pi/4 in the Block Parameters window. From the histogram we can calculate that approximately 65 percent of the values of θ lie between 19.8 and 20.2. This range corresponds to a standard deviation of 0.2°, not 0.273° as calculated from the simulation data. 59 50 Engineering in the 21st Century... Innovative Construction W e tend to remember the great civilizations of the past in part by their public works, such as the Egyptian pyramids and the medieval cathedrals of Europe, which were technically challenging to create. EXAMPLE 3.2-1 Optimization of an Irrigation Channel Figure 3.2-5 shows the cross section of an irrigation channel. MATLAB implements trapezoidal integration with the trap function. The session is >>A = [6, 12, 4; 7, -2, 3; 2, 8, -9]; >>B = [70; 5; 64]; >>Solution = A\B Solution = 3.5 - 2 The solution is x = 3, y = 5, and z = -2. See Figure 5.1-4 for an example. function A(x, y) % The primary function B(x, y); D(y); function D(x) % Nested in A E(x); 140 function E % Nested in D. This window has eight menus, which are discussed in detail in Section 5.3. The File menu is used for saving and printing the figure. When you type x = 3, you tell MATLAB to assign the value 3 to the circuit as shown, then eventually the output voltage v o will be sinusoidal also, with the same frequency but with a different amplitude and shifted in time relative to the input voltage. You should see what is shown in Figure 10.5-4. Copy the Mux block in the same way. So we will model the unit-step input with the function $y(t) = 1 - e - t/\tau$. LeMay, Jr.; and B. The answer (y) is a column array containing the values -2, -5, -5. Compute the mean and the variance of the clearance c = d1 - d 2. 107 111 Figure P45 Section 2.5 46. The motor's current is i and its rotational velocity is ω . That is, if x and y are normally distributed with means μ x and μ y and variances and , and if u = x + y and v = x - y, then (7.2-4) (7.2-6) These properties are applied in some of the homework problems. Use MATLAB to compute a. This phenomenon, called beating, also occurs in musical sounds. In both models, the voltage reaches a steady-state constant value as t $\rightarrow \infty$, and T is the time required for the steady-state value. each bin versus the bin centers as a bar chart. Working with faculty at the University of Rhode Island in developing and teaching a freshman course based on MATLAB has greatly influenced this text. That is, we type g = [0 g] to obtain [0, 6, -1, 2] for g. Handles are discussed in Section 2.2. The function movie(h,M,n,fps,loc) specifies the location to play the movie, relative to the lower left corner of object h and in pixels, regardless of the value of the object's Units property, where loc = [x y unused unused] is a four-element position vector, of which only the x and y coordinates are used, but all four elements are required. To access all of page 2, type A(:, :, 2). Interpret the results in terms of the time constant. Table 7.1-1 Histogram functions Command Description bar(x,y) Creates a bar chart of y versus x using the default color scheme. If a = 0, the series is sometimes called the Maclaurin series. 7.* Compute the length and absolute value of the following vectors: a. The effect of the clc command is different; it clears the Command window of everything in the window display, but the values of the variables remain. There it was shown that an infinite number of solutions exist. 7. Email from many users contained useful suggestions. Now that you have finished this chapter, you should be able to use MATLAB to create symbolic expressions and manipulate them algebraically, obtain symbolic solutions to algebraic and transcendental equations, perform symbolic differentiation and integration, evaluate limits and series symbolically, obtain symbolic linear algebra operations, including obtaining expressions for determinants, matrix inverses, and eigenvalues. Use linear interpolation with MATLAB to estimate the temperature at those times. With a function file: Define the integrand with a user-defined function file. Test Your Understanding T1.4-1 The surface area A of a sphere depends on its radius r as follows: A = 4 mr 2 . >> findsym(6*b+y,1) % Find the one variable closest to x. If a mass-spring system has Coulomb friction on the surface rather than viscous friction, its equation of motion is 487 where μ is the coefficient of friction. 192 Each while statement must be matched by an accompanying end. Tables 11.1-1 and 11.1-2 summarize the functions for creating, evaluating, and manipulating symbolic expressions. Typing eye(size(A)) creates an identity matrix having the same dimension as the matrix A. Systematic solution methods have been developed for sets of linear equations. Handles may be assigned to other types of objects. Note that x' is a column vector with size 3 × 1 and thus does not have the same size as y, whose size is 1 × 3. function z = fun(x,y) $u = 3^*x$; $z = u + 6^*y$. 2; end 123 Note the use of the array exponentiation operator (.^). Your model should now look like that shown in Figure 10.2-2. The pseudoinverse solution gives T 1 = 93.3333, T 2 = 133.3333, and T 3 = 173.3333. Structured programs are easier to understand and modify, especially if meaningful names are chosen for the modules and if the documentation clearly identifies the module's task. The advantages of structured programming are as follows: 1. Using this method, we find that the solid curve in Figure 9.5-3 crosses the steady-state value of 0.2 for the second time at t = 3.74. The area of a parallelogram can be computed from |A × B|, where A and B define two sides of the parallelogram (see Figure P44). Numbered Examples......Page 138. The model for the RC circuit shown in Figure P46 is For RC = 0.2 s, plot the voltage response v o (t) for the case where the applied voltage is a single square pulse of height 10 V and duration 0.4 s, starting at t = 0. 5.2 Additional Commands and Plot Types MATLAB can create figures that contain an array of plots, called subplots. The given dimensions indicate that the package is not thin and thus will not "flutter" as it falls. x = 0:pi/50:pi; n = length(x); % Data-generation function with +/-0.025 random error. Use MATLAB to plot the functions $u = 2 \log 10 (60x + 1)$ and $v = 3 \cos(6x)$ over the interval $0 \le x \le 2$. Construct a Simulink model to plot the solution of the following equation for $0 \le t \le 10$ where u s (t) is a unit-step function (in the Block Parameters window of the Step block, set the Step block, set the Step block of the cubic polynomial as 3 + bx + cx + d that passes through the three points
given in part a. In addition, a variable assigned in a nested function can be read or overwritten by any of the functions containing fraction decays exponentially according to the following formula: 303 a. For example, consider whose coefficient array is f = [9, -5, 3, 7] and whose coefficient array is g = [6, -1, 2]. 62. The following equation describes the motion of a mass connected to a spring, with viscous friction on the surface. Verify the associative law 104 d. % Relative frequency histogram using the bar function. This method uses the MATLAB command rref to obtain and ref to obtain a spring. general solution for some of the unknowns in terms of the other unknowns. Type help integral for details. The MATLAB length command gives the number of element used in simulation diagrams is the summer that, despite its name, is used to subtract as well as to sum variables. For example, the range of x values in the plot in Figure 5.2-5b is from 10 - 2 = 0.01 to 10 2 = 100, and the range of y values is from 10 - 2 = 0.01 to 10 2 = 100, and the range of y values is from 10 - 2 = 0.01 to 10 2 = 100. take advantage of the fact that the right-division method uses the least-squares method to obtain a solution to a set of equations that contains all zeros and is not the same as the empty matrix [], which has no elements. This will compute the wheel displacements required to place the vehicle at a desired location specified by coordinates (x C, y C). 399, 402 518 569 ODE solvers Item Description Pages ode45 Nonstiff, medium-order solver. following categories. It can be accessed by typing name(8). The function movie(h,...) plays the movie in object h, where h is a handle to a figure or an axis. x 2.5 3 3.5 4 4.5 5 5.5 6 7 8 9 y 1500 1220 1050 915 810 745 690 620 520 480 410 c. An untitled model window will open. Data are missing for the entries marked with a question mark (?). (b) How long will it take for the object's temperature T to reach 168°F (c) Plot the object's temperature T(t) as a function of time. The selling price is 5.5 cents per gallon. For information about these two methods, see the Help under the topic "Insert Equations into Live Scripts." Lastly, you can use the commands from the Symbolic Math Toolbox (see Chapter 11, Section 11.3 and Figure 11.3-2 for an example). The values of θ 1 (0), θ 2 (0), θ 1 (t f), and θ 2 (t f) can be found from trigonometry, if the starting and ending (x, y) coordinates of the hand are specified. Use MATLAB to compute the array y that results from the function $y = 7 \sin(4x)$. How far in each direction must diver 1 swim to reach diver 2? 2.3 Element-by-Element Operations To increase the magnitude of a vector, multiply it by a scalar. Suppose also that v(0) = 0 and f = 75,000 N for $t \ge 0$. T5.2-8 The spiral of Archimedes is described by the polar coordinates (θ , r), where $r = a\theta$. T5.2-7 Plot the function y = 8x 3 for $-1 \le x \le 1$ with a tick spacing of 0.25 on the x axis and 2 on the y axis Using this method, we find that the solid curve in Figure 9.5-3 has the following characteristics: Steady-state value: 0.2 2 percent settling time: 5.22 10 to 90 percent rise time: 1.01 Peak response: 0.237 388 Peak time: 2.26 You can also read values off any part of the curve by placing the curve at the desired point. If the length of x is m then each column of A is plotted versus the vector x. Structure arrays are used in this text only in this section. The absolute frequency is the number of times a particular outcome occurs. The index has four parts: MATLAB commands, Simulink blocks, and topics. Choose an appropriate range for the y axis. Its syntax is similar to that the number of times a particular outcome occurs. of fprintf. >>syms x >>E1 = x^2+5 ; >>E4 = 1/(x+6); >>E1 = x^2+5 ; >>E1 = x^2+5; >>E1 = x^2+5 ; >>E1 = x^2+5; >>E1 = x^2+5 ; >>E1 = x^2+5; >>E1 for the mean and variance of y = f(x), but for our purposes, the simplest way is to use random number simulation. 178 The following program computes the array B by computing the square roots of all the elements of A whose value is no less than 0 and adding 50 to each element that is negative. Chapter 7 reviews basic statistics and probability and shows how to use MATLAB to generate histograms, perform calculations with the normal distribution, and create random number simulations. 143 Input/output commands Item Description Pages disp Displays contents of an array or string. and the resulting mathematical description is called a mathematical model, or just a model. 574 gca Returns the current axes properties. A nonlinear ordinary differential equation can be recognized by the fact that the dependent variable or its derivatives appear raised to a power or in a transcendental function. Figure 1.6-2b shows the geometry of the motion. It can contain ordinary alphanumeric characters, along with escape characters, conversion specifiers, and other characters, organized as shown in the following examples. If possible, calculate the traffic flows f 1, f 2, f 3, and f 4. Figure 10.3-3 was created in this way. The functions real(x) and imaginary parts of x. 143 Creating and Importing ASCII Files As we will see in the next example, we can create a data file by opening a new script in the MATLAB Editor, typing in the data (make sure the data has the same number of entries on each line), and saving it as a .dat file (Note: be sure not to save it as the default M-file type). S2 = (x^2+5)*(y^3-2) >>expand(S2) % Expand the product. However, if the profits for each product were \$3000, \$600, and \$100, the total profit would be P = 18,000 + 500z. Its syntax is mesh(x,y,z). Binary files require special treatment and we will not discuss them further. The last value is n if m - n is an integer multiple of q. The model shown in Figure 10.10-5 shows this effect. The following MATLAB script file generates the top two plots. Plot the results. For example, consider the network of one-way streets shown in Figure 8.3-2. heads = 0; for k = 1:100 if rand < 0.5 heads = heads + 1; else tails = tails + 1; else tails = tails + 1; else tails = tails + 1; else tails = 0; for k = 1:100 if rand < 0.5 heads = heads + 1; else tails = tails + 1; else tails = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = heads + 1; else tails = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 if rand < 0.5 heads = 0; for k = 1:100 some cases we can still do a least-squares fit if the function is a linear expression in terms of its parameters. 326 You can generate a sequence of normally distributed numbers having a mean of 0 and a standard deviation of 1. %% Plot the cubic plot(x,polyval(p,x)), xlabel('x'), ylabel('y') 2. Test Your Understanding T11.3-6 Use MATLAB to find the first three nonzero terms in the Taylor series for $\cos x$. *Simulink and MuPAD are registered trademarks of The MathWorks, Inc. This function is as follows. $y = 2 - \log(x)$; if $y \ge 0$ $z = \log(x)$; end end 166 The else Statement When more than one action can occur as a result of a decision, we can use the else and elseif statements along with the if statement. How long will it take for the object's temperature? T1.3-4 Use MATLAB to plot the function over the interval $0 \le t \le 5$. Press Home to move to the beginning of a line; press End to move to the end of a line. Fortunately, MATLAB allows you to write your own programs to avoid this difficulty. Suppose that x = 3 and y = 4. Select and place the State-Space block from the functions and z $= 4 \sin(3x)$ for $0 \le x \le 5$ on the same plot, the session is >x = 0:0.01:5; 37 >>y = 2*sqrt(x); >>z = 4*sin(3*x); >>plot(x,y,x,z), xlabel('x'), gtext('z') 23 After the plot appears on the screen, the program waits for you to position the cursor and click the mouse button, once for each gtext function used. For C enter [1, 0, 0, 0; 0, 0, 1, 0], and for D enter [0; 0]. (a) Use MATLAB to solve for b. To show the mean of the dependent variable (y) on the plot, click the box in the row labeled mean under the column labeled Y, as shown in the figure. The profit per item for each product appears in the last line of the table. Note that the y returned by the load command is a row vector. Compare the step responses of the two cases. (b) Find the coefficients by using the leftdivision method to solve the three equations (one for each data point) for the two unknowns c 1 and c 2. Examples of such situations occur when the forcing function is higher than 2. Should the mechanism work the same way it does when L
1 > L 2 ? How high is each endpoint? To plot the response of the two systems and the output of the Dead Zone block versus time, type >>plot(tout,y(:,1),tout,y(:,2)) 10.6 Nonlinear State-Variable Models Nonlinear No be simulated in Simulink. Matrices of Numbers and Arrays of Strings 7. The solubility of oxygen in water is a function of the water temperature. For example, MATLAB might provide an answer in the form: -c+b whereas we would normally write b-c. ',w) Real part is -4. See [Palm, 2014] for coverage of these methods. Using a spacing of 0.2 for both x and y, generate a surface mesh plot and a contour plot of the temperature distribution. The degree of g(x) is 1 less that of f(x). 542 11.6 Symbolic Linear Algebra You can perform operations with symbolic matrices. The second danger with using high-degree polynomials is that they can produce large errors if their coefficients are not represented with a large number of significant figures. 411 When we are solving nonlinear equations, sometimes it is possible to check the numerical results by using an 378 approximation that reduces the equations, sometimes it is possible to check the numerical results by using an 378 approximation that reduces the equation to a linear one. treated in Example 4.5-4. Use a for loop to determine the sum of the first 10 terms in the series 5k 3, k = 1, 2, 3, ..., 10. Third Multiplication and division with equal precedence, evaluated from left to right. It deals with the following general categories of operations: Files: Enables you to create, open, find, and compare files. (Answer: y(t) = cos bt) 5322 Solving Nonlinear Equations MATLAB can solve many nonlinear first-order differential equations. You can use the dirac function when the input function with the dsolve function when the input function is an impulse, but the resulting expressions are more (a,b,n) Creates a row vector of n logarithmically spaced values between a and b. Every time you use rng(seed) to initialize the generator using the same seed, you always get the same result. Find the matrix product w = x*y. Look for answers to frequently asked questions (FAQ) and technical notes. A common example of a runtime error is division by zero You may view or edit the subsystem by double-clicking on it. Solution Because T(0) is finite but nonzero, the power function cannot describe these data, so we do not bother to plot the data on log-log axes. Refer to Problem 3 but make the first column of A contain the values 3x and the second column contain the values 5x - 20. The matrix C looks like the A and D, but is numeric of class double. In the interactive mode, in which all commands are entered directly in the Command window. If h p < h desired , rocket cannot reach desired height. x 1 2 3 4 5 6 7 8 9 y 10 14 16 18 19 20 21 22 23 18. An example is the information infrastructure, which includes physical facilities to transmit, store, process, and display voice, data, and images. If you construct a function, but also stores the values of all variables shared between the nested function and those functions that contain it. Test Your Understanding T6.2-4 Obtain a linear model y = a 0 + a 1 x 1 + a 2 x 2 for the following data to describe the relationship. For example, the result is obtained as follows. More examples and homework problems have been added. The process is controlled by a computer using solid modeling software. Thus the curve is not a normal distribution. Given the data (v, x), the function v = 1/(mx + b) can be converted to a first-degree polynomial by transforming the v data values with the transformation y = 1/v. The function bar(x,y) creates a bar chart of y versus x. 417 tfdata Extracts equation coefficients from an LTI object. Find the array product w = A.*B. 290 % Thread breaking strength data for 20 tests. These facts are demonstrated below: >>x = -3 + 4i; y = 6 - 8i; >>mag x = abs(x) mag x = 5.0000 >>mag product = abs(x*y) 50.0000 >>mag produc angle(x^y) angle_product = 1.2870 Similarly, for division, if z = x/y, then and $\angle z = \angle x - \angle y$. The first two dimensions are the row and column, as with a matrix. A boat moves at 20 km/hr along a straight path described by y = 11x/15 + 43/3, starting at x = -10, y = 7. Elementary Principles of Chemical Processes. 17.1123.) T1.1-3 What answer is produced by the following MATLAB expressions? 523 % animated_line_1.m h = animatedline;axis([0,10,0,2]), xlabel('t'), ylabel('t'), yla % symbol. Create four anonymous functions to represent the function 6e 3 cos x, which is composed of the functions 2 h(z) = 6e z, g(y) = 3 cos y, and f(x) = x 2 . 27.* The equation of motion of a rocket-propelled sled is, from Newton's law, where m is the sled mass, f is the rocket thrust, and c is an air resistance coefficient. For example, if , define the following function file: function $y = f_2(x) = 1 - x + exp(-x)$; end To find the value of x that gives a minimum of y for $0 \le x \le 5$, type $x = f_0(0, 1)$. Another common error is to forget to use the array multiplication operator. Simulink are registered trademarks of The MathWorks, Inc. When used without arguments, syms lists the symbolic objects in the workspace. The left division operator is useful for solving sets of linear algebraic equations, as we will see. 19 Table 1.3-1 Some commonly used mathematical functions Function MATLAB syntax* ex exp(x) sqrt(x) ln x log(x) log10 x log10(x) cos x cos(x) sin x sin(x) tan x tan(x) cos -1 x acos(x) sin -1 x asin(x) atan(x) 34 tan -1 x *The MATLAB trigonometric functions listed here use radian measure. The fix function rounds to the nearest integer toward zero. (x, y) = (5, -8) d. Learn MATLAB and Simulink Tutorials and courses to advance your skills, whether you're a beginner or expert user Teach with MATLAB and Simulink Ready-to-use courseware, code examples, and projects Get full access to Essential MATLAB for Engineers and Scientists Fourth Edition and 60K+ other titles, with free 10-day trial of O'Reilly. How much would the cost increase if we located the center 1 mi in any direction from the optimal location? If checked, the fit equation is displayed on the plot. (Answer: 1 - x 2 /2 + x 4 /24) T11.3-7 Use MATLAB to evaluate (Answer: 0) T11.3-9 Use MATLAB to evaluate (Answer: 0) T11.3-9 Use MATLAB to evaluate (Answer: 0) T11.3-7 Use MATLAB to evaluate (Answer: 0) T11.3-9 Use MAT (ode) can be written in the following form: where t is the independent variable and y is a function of t. But this effort sometimes causes the controlled variable to overshoot the desired value and to oscillate. 49 40. The following MATLAB session shows how to perform the matrix multiplication shown in (2.4-4). Estimate the percentage of fabric all the elements in the second through fifth columns of A. 342 8.5 A General Solution Program In this chapter you saw that the set of linear algebraic equations Ax = b with m equations and n unknowns has solutions if and only if (1) rank[A] = rank[A b]. An example is the square root function sqrt. The bars show the estimated or calculated errors for each data point. The following equation describes the motion of a certain mass connected to a spring, with viscous friction on the surface where f(t) is an applied force. The syms command, however, cannot be used to create symbolic constants; you must use sym for this purpose. For small mechanical devices, friction forces often dominate over inertial forces, and friction is very difficult to calculate. The MATLAB rref function 335 provides a procedure for reducing an equation set to this form, which is called the reduced row-echelon form. EXAMPLE 8.3-4 Production Planning The following table shows how many hours reactors A and B need to produce 1 ton each of the chemical products 336 1, 2, and 3. Thus s = [200, 250, 400, 300] and t = [2, 5, 3, 4]. For example, each name field can contain a different number of characters, and the arrays containing the test scores can be different number of characters, and the arrays containing the test scores can be different sizes, as would be the case if a certain student did not take the second test. Create a Simulink model for this system for the case where I = 4, mgL = 10, mg c = 0.8, and M(t) is a square wave with an amplitude of 3 and a frequency of 0.5 Hz. Assume that the initial conditions are $\theta(0) = \pi/4$ rad and . For example, asin(1) returns the answer 1.5708 rad, which is $\pi/2$, while asind(0.5) returns 30 degrees. State the problem concisely. Set the Stop time to 10, run the simulation as before, and bring up the Scope display. When used to compare arrays, the relational operators compare the array if they are regularly spaced. For example, the following equations are nonlinear. To save a figure that can be opened in subsequent MATLAB sessions, save it in a figure file with the .fig file name extension. This area, which is a function of x, is known as the 321 error function and is written as erf(x). From conservation of mass, q 1 = q 2 + q 3. Launches a dialog box that allows you to save the evaluated results to workspace variables. Double-click on the first Mux block and change the number of its inputs to 3. Specify the information to be generated by the program. Show that R -1 (a)R(a) = I, where I is the identity matrix, and R(a) is the rotation matrix given by Equation (11.6-1). These problems are denoted by an asterisk next to their number (for example, 15 *). The index has four sections: a listing of MATLAB symbols, an alphabetical list of MATLAB commands and functions, a list of Simulink block names, and an alphabetical list of topics. It is known that the following Leibniz series converges to the value $\pi/4$ as $n \rightarrow \infty$. Earlier versions of MATLAB required that the function name, here RC circuit, be enclosed within single quotes, but this might not be allowed in future versions. The yeast produced per gram of glucose consumed) is related to a as follows: where
144 is the molecular weight of glucose. of 0.2730°. MATLAB displays the prompt (>>) to indicate that it is ready to receive instructions. If we need not display C, the entire analysis would consist of only four command lines. 506, 512 Symbolic calculus functions Item Description Pages diff Returns the derivative of an expression. We can extend this technique to functions of more than two variables by using multidimensional arrays. The result is shown in Figure 10.7-4. ans = sin(x)*cos(y)+cos(x)*sin(y) ans = 6 The function factor(n) returns the prime factors of the number n, whereas if the argument is a symbolic expression E, the function factor(E) factors the expression E. Table 3.1-2 Trigonometric functions Trigonometric sec(x) cot(x) coc(x) 7 9] g = 3 7 9 Note that MATLAB displays row vectors horizontally and column vectors vertically. T7.3-3 Suppose x consists of 1000 uniformly distributed numbers between 0 and 1. Thus these functions. 322 Test Your Understanding T7.2-1 Suppose that 10 more height measurements are obtained so that the following numbers must be added to Table 7.2-1. Examining the plot, you might Figure 9.2-1 Illustration of methods for estimating the derivative. 576 get Returns a setting in the structure s. >> second = diff(f,2,th); % Second derivative. 576 get Returns a setting setti complete list of an object's properties. Assume that C d = 0.5 and that the initial water height is h(0) = 5 m. 81 To find the total miles traveled, we use the matrix product, denoted by s*t'. In MATLAB the gradient function f(x, y) can be computed with the gradient function. Euler predictor (9.3-7) Trapezoidal corrector (9.3-8) MODIFIED EULER METHOD This algorithm is sometimes called the modified Euler method. Given the matrix a. The answer is x = -0.5831. Use addpoints, getpoints, and clear points, retrieve the points, and clear the points, retrieve the points from the animated line, respectively. You use this function the same way you use the mesh function; that is, first use the meshgrid function to generate the grid and then generate the function values. Then, to find the average speed on each route using MATLAB, we use array division. They are sometimes more convenient to use and more powerful than the ODE solvers discussed thus far, because general solutions can be found for linear, time-invariant equations. Homogeneous Case. For example, suppose you had previously created the 2 × 2 array A = [2, 5; 6, 9], and then you create the 5 × 1 arrays x = (1:5)' and y = (2:6)'. The system has the dead-zone nonlinearity shown in Figure 10.5-1. That is, if you later assign x and y numeric values, typing r will not cause MATLAB to evaluate the equation. Perform polynomial algebra. Use MATLAB to compute the magnitude M for the case where F = [12, -5, 4] N, r = [-3, 5, 2] m, and n = [6, 5, -7]. Using x = y = 1, write a MATLAB program to determine how many terms are required in the series to produce a temperature calculation that is accurate to within 1 percent. To 3 7 9 The third way to create a column vector is to type a left bracket ([) and the first element, press Enter, type the second element, press Enter, and so on until you type the last element followed by a right bracket (]) and Enter. The function plot(x,y) generates a plot with the x values on the horizontal axis (the abscissa) and the y values on the vertical axis (the ordinate). The guess d = 1, $\theta = 1.5$ produces the physically meaningless result d = 3.6058, $\theta = -3.1416$. But if you did not yet press Enter, instead of retyping the entire line, press the left-arrow key (\leftarrow) several times to move the cursor and add the missing t, then press Enter. Time t (h) C (mol of (CH3) 3 CBr/L) 0 0.1039 3.15 0.0896 6.20 0.0776 10.0 0.0639 18.3 0.0353 30.8 0.0207 43.8 0.0101 284 20. Use dir to get a list of all files. It also adds new examples and applications, and uses the most recent release of Matlab. The lookfor function allows you to search for function. The terms s = x + y and r = sqrt(x^2 + y^2) are examples of symbolic expressions. A fenced enclosure consists of a rectangle of length L and width 2R, and a semicircle of radius R, as shown in Figure P29. Changes the current directory to dirname. Given the following function 249 Plot the function with a grid over the range [0.1, 100] using four types of symbolic expressions. axes: linear-linear, linear-log, loglinear, and log-log. Fixed costs include salaries of those not directly involved with production, factory maintenance costs, insurance costs clear You can use the syms function to create symbolic functions. 2.0458. Sort each column and store the result in an array B. The answer given by MATLAB is A = 2.0000, which is correct to four decimal places. Test your functions for the case where x = 50 percent and r = 10 7 L/day. To locate such an error, try the following: 1. The left-division method works for square and nonsquare A matrices. To plot the data with plus signs, use the following session: >>x = 15:2:23; >>y = [20, 50, 60, 90, 70]; >>plot(x,y,'+',x,y),xlabel('x'),ylabel(line course described by y = 2x - 10, where distances are measured in kilometers. Compute the correlation coefficient and interpolate to estimate the population in 1965. If A is $n \times n$, its rank is n if det(A) $\neq 0$. Nanotechnology is in its infancy, although some working devices have been created. Specify the data to be used by the program. Do not state the answer with greater precision than is justified by any of the following: (a) The precision of the given information. Resouces: The Help icon accesses the help system, which is discussed in Section 1.5. The remaining icons let you request help from the MATLAB community, and engage in self-learning with the MATLAB Academy Here we present a plan of attack, or methodology, for solving engineering 35 problems in general. Undefined function or variable 'y'. The principles of statics can be used to show that the tension force T in the cable is given by where D is the distance of the cable attachment point to the beam pivot. These provide additional Simulink blocks, which can be displayed by clicking on the plus sign to the left of the item. Then we cannot use the function p = polyfit(x,y,1) because in general p(2) will not be zero. One way to estimate the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine that the plate consists of four subsquares and to compute the temperature distribution is to imagine the temperature distribution is to imagine the temperature distribution is to imagine the temperature distribution distributio mathematical procedure, called runtime errors. Advanced Engineering Mathematics. To create a transfer function description of the system
sys3, previously created from the state model, you type tfsys3 = tf(sys3). >>x = Year-2000; y = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0362 >>J = sum((polyval(p,x)-y).^2); >>S = Veh_Flow; >>p = polyfit(x,y,3) p = 0.0087 - 0.1851 1.5991 2.0 sum((y-mean(y)).^2); >>r2 = 1 - J/S r2 = 0.9972 Thus the polynomial fit is good because the coefficient of determination is 0.9972. 143 xlswrite Writes an array to an Excel file. 391 polyint Integration of a polynomial. 26 xlsread Imports an Excel file. 391 polyint Integration of a polynomial. needs an accompanying end statement.) Suppose we want to create a special square matrix that has 1s in the first row and first column, and whose remaining elements are the sum of two elements, the element above and the element to the left, if the sum is less than 20. The flow rate is switched on when the height is less than 4.5 m and is switched off when the height reaches 5.5 m. Such a task is often more difficult to do with a for loop. WARNING: Basic Javascript and HTML5 skills are required for this, these can be easily picked up at www.w3schools.comOpen up the website will give you a basic HTML5 asteroids game, no gimmicks or tricks, completely free.On the right side of the screen you should see a download zip button. If you now type r at the prompt and press Enter, you will see >> r r = 0.8000 thus verifying that the variable in further calculations. Loop over years 2 to 10. Its syntax is [X,Y] = meshgrid(x,y). The Symbolic Figure 11.5-1 A step function of magnitude M. The following example shows how this can be done. Thus because the sum command sums the columns of a matrix, the quarterly costs are obtained by typing >>Quarterly_Costs = sum(C). The resulting vector, containing the quarterly costs in thousands of dollars, is [400 351 509 355]. The function atan(x)—the arctangent or inverse tangent—and returns an angle between $-\pi/2$ and $\pi/2$. 1.3 Built-In Functions, Arrays, and Plots This section discusses functions, Arrays, and Plots This section discusses functions, Arrays, and Plots This section discusses functions that are built in to MATLAB. The function find(x) computes an array containing the indices of the nonzero elements of the array x. You need to make sure that problem1.m is in a folder that is in the search path, otherwise MATLAB will not find the file and will generate an error message. You can also use a rectangular region that encloses the nonrectangular region and force the integrand to be zero outside of the nonrectangular region that encloses the nonrectangular region. method is called spline interpolation and is so named for the splines used by illustrators to draw a smooth curve through a set of points. 300 Normally Distributed Random Numbers, the values near the mean are more likely to occur. x (ft) 0 0.25 0.75 1.25 1.5 1.75 1.875 2 2.125 2.25 y (ft) 1.2 1.1875 2 2.125 2 2.1575 2 $1.1\ 1\ 0.92\ 0.8\ 0.7\ 0.55\ 0.35\ 0\ 27.\ 151\ 55\ 42\ 98\ 49\ 39\ 95\ 63\ 51\ 92\ 58\ 45\ 90\ 29.\ student.email = '[email\ protected]';$ student.tests = [67,75,84]; If you then type >>student.ame = 'John Smith'; student.tests = [67,75,84]; If you then type >>student.email = '[email\ protected]'; student.email = '[email\ protected]'; student.tests = [67,75,84]; If you then type >>student.email = '[email\ protected]'; student.email = '[email\ protected]'; student.tests = [67,75,84]; If you then type >>student.email = '[email\ protected]'; student.email = '[email\ protected]'; student.email\ protected]'; student.email\ protected]; student.email\ protected]; student.email\ protected]; student.email\ prote tests: [67 75 84] To determine the size of the array, type size (student). We can find this vector using vector subtraction: v = w - r. The impulse Function The impulse Function The impulse function plots the unit-impulse function in the remote control (RC) world, usually to control the steering of RC vehicles or the flaps on a RC plane. The polynomial's coefficients of descending powers are stored in the array a. These are enclosed in square brackets. (a) If the ball is initially dropped from a height h and is allowed to continue to bounce, find the expression for the total distance traveled by the ball, after the ball hits the floor for the nth time. The temperature is a function of two variables, the coordinates x and y. The function, x0) tries to find a zero of function, x0, if x0 is a scalar. Before each pass through the loop, x is checked to see whether its value is less than 25. This estimate of the derivative is called the central difference estimate. Modify the program from part b to compute the temperatures in the plate; use a spacing of 0.2 for both x and y. Find the first-, second-, third-, and fourth-degree polynomials that fit the data, and plot each polynomials that fit the data. We (1.6-2) can do so using the law of sines, as follows: Solve this for B: (1.6-3) Figure 1.6-2 A piston, connecting rod, and crank for an internal combustion engine. You can also assign or change values of field elements. The initial function The initial function computes and plots the free response of a state model. The following tables show the costs associated with a certain product and the production volume for the four quarters of the business year. Test Your Understanding T1.1-1 Experiment with your Desktop. We will give examples of the class function later. Figure 11.2-2 A robot arm having two joints and two links. v = xy e. format short e Five digits (four decimals) plus exponent; 6.3792e+03. The website address is . To test user-defined functions, try commenting out the function line and running the function line a file as a script. In this function t is time, and ω is the oscillation frequency in radians per unit time. Use only elseif clauses in your program. The text's many tables and its referencing system in an appendix have been designed with this purpose in mind. How many values of x are needed to obtain the same plot using the plot command? For example, we can specify the value of the dependent variable at t = t 2, where t 2 > t 1. Plot the tension forces T AB and T AC on the same graph versus L AC for L ACmin \leq 6.7. 37.* In the structure in Figure P37a, six wires support three beams. The equation for the voltage v(t) across a capacitor as a function of time is where i(t) is the applied current and Q 0 is the initial charge. (9.5-1) This can be put into Cauchy form by letting x 1 = y and x 2 =. The design specifications require that the pitch 344 diameter be 8 ± 0.01 mm. For example, suppose you want to create a three-dimensional array whose first two pages are To do so, first create page 1 as a 3 × 3 matrix and then add page 2, as follows: >>A = [4, 6, 1; 5, 8, 0; 3, 9, 2]; >>A (:, :, 2) = [6, 2, 9; 0, 3, 1; 4, 7, 5]; 62 Another way to produce such an array is with the cat command. >>% This is a comment. This can be a significant dead time in systems using inexpensive and slower microprocessors. In this case, g is 9.81 and v0 is -4. The power function y = 15x 0.37 produces a straight line on a log-log plot. The largest r 2 can be is 1. A verbal description of the program, often in pseudocode. In the Simulink ideal form, the gain P is factored out and the algorithm is written as PID CONTROLLER BLOCK (10.10-4) The PID controller block lets you choose which form to use. found from experiments to be Suppose that the supply resistance is $R1 = 30 \Omega$ and the supply voltage is v1 = 15 V. Otherwise, there are an infinite number of solutions, which can be found from the augmented matrix. constant. For example, A = [1,2,3;4,5,6]; for v = A disp(v) end 184 is equivalent to A = [1,2,3;4,5,6]; n = 3; for k = 1:n v = A(:,k) 176 end The common expression are scalars, not vectors. 540, 546 heaviside function (unit step). For example, if you
plot an array with multiple rows and columns, the browser lists each axis and the objects (lines, surfaces, etc.) used to create the graph. Label each step in the solution process. Table 3.2-1 Minimization and root-finding functions Function functions function function, x_1, x_2) Returns a value of x in the interval $x_1 \le x \le x_2$ that corresponds to a minimum of the single-variable function described by the handle @function. Saving and Retrieving Your Workspace icon on the Toolstrip or use the save command. The normal distribution that forms the basis of many 342 statistical methods is covered in Section 7.2. Section 7.3 covers random number generators and their use in simulation programs. We assume here that the spacing between the measurements is regular; that is, x 3 - x 2 = x 2 - x 1 = Δx. If this is not possible, suggest how to obtain the necessary information. Piecewise-linear models are actually nonlinear, although they may appear to be linear. Year 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2.1 3.4 4.5 5.3 6.2 6.6 6.8 7 7.4 7.8 Vehicle flow (millions) Solution If we attempt to fit a cubic to these data, as in the following session, we get a warning message. Refer to the online help for more information. Suppose we want to estimate the temperature at the point whose coordinates are (0.6, 1.5). Apply your criterion, and plot y(t) for $\tau = 0.1$, $\omega = 8\pi$, and $\phi = 2$. The following M-file produces the scaled histogram shown in Figure 7.2-1. Then the preceding equation becomes Obtain a surface plot and a contour plot of this function to help visualize the effect of τ for $0 \le t \le 15$ sec. Function Handles A function handle is a way to reference a given function. They do not necessarily occur every time the program is executed; their occurrence often depends on the particular input data. Note: You must use one of these methods to convert your script into a live script. Title......Page 43. 266 Figure 6.2-1 Regression using polynomials of first through fourth degree. %E Scientific format with uppercase E. The session consists of one command: A = integral(@sin, 0, pi). The Plot Edit Toolbar from the View menu. To add the arrays r = [3, 5, 2] and v = [2, -3, 1] to create w in MATLAB, you type w = r + v. The first value is m. diameters, respectively. In addition, compute the value of the peak torque. Compute the expressions for dp 2 /dx, d(p 1 p 2)/dx, and d(p 2 /p 1)/dx for p 1 = 5x 2 - 6x + 7. Surgery simulators use 3D graphics and motion sensors to simulate procedures to train surgeons without the need of a patient, cadaver, or animal. In such cases the solve function restricts the solution search to solutions near zero. Fourth Logical AND. As a string expression: >>fun1 = 'x.^2-4'; >>x = fzero(fun1,[0, 3]) ar as >>x = fzero(fun1,[0, 3]) ar know the range of x, except that $x \ge 0$. It appears when you click the right arrow button a second time. However, many problems involve the significance of each. plot(x,y) Generates a plot of the array x on rectilinear axes. Lusignan, Marc D. The second is , . xor(A,B) Returns an array the same dimension as A and B; the new array has 1s where either A or B is nonzero, but not both, and 0s where θ is the angular coordinate and r is the radial coordinate of a point, then the command polarplot(theta,r) will produce the polar plot (formerly called polar). To do this, create the Simulink model shown in Figure 10.7-6. Chapter 9 introduces numerical methods for calculus and ordinary differential equations. Use MATLAB to determine what number is in row 5, column 3 of the result. EXAMPLE 8.3-3 Three Equations in Three Unknowns, Continued The following underdetermined equation set was analyzed in Example 8.3-1. Use the uppercase letter D to represent the first derivative; use D2 to represent the second derivative; use D2 to represent the second derivative; use D2 to represent the second derivative; use D2 to represent the first derivative; use D2 to represent the second derivative; use D2 to represent the investigate the effects of a disturbance acting on the mass or on the output of the actuator (caused, for example, if we eliminate the second row and third column, we obtain SUBDETERMINANTS Subdeterminants are used to define the rank of a matrix. Estimate the roots of the equation. A ball hit with this speed will clear the wall only if it is hit at an angle of approximately 48°. For example, you might prefer to use the variable x in a number of different calculations. total = $10*k^2 - 4*k + 2 + total 4$. A plot of d versus A is the required output. Run the simulation and check the speed response. The linear function: y(x) = mx + b. Common sense tells us that there must be zero beam deflection if there is no applied force, so the equation describing the data must pass through the origin. The half-wave rectifier using this model is shown in Figure P28b. Sometimes the term variance is used to describe the spread of the curve. For example, in the following session, MATLAB will treat the expression w as a non-negative number. pinv(A) Computes the pseudoinverse of the matrix A. This standard and 322 compact form is useful for expressing solutions and for developing software applications with an arbitrary number of variables. Fortunately, MATLAB provides the function fimplicit(f) to plot the implicit function fimplicit(f) to plot the implic R 4 = 0.038 K/W. The following session generates the contour plot of the function whose surface plot is shown in Figure 5.4-2, namely, z = xe - [(x - y 2) 2 + y 2], for $-2 \le x \le 2$ and $-2 \le y \le 2$, with a spacing of 0.1. This plot appears in Figure 5.4-3. The comment symbol may be put anywhere in the line. Common sense tells us that the coffee will cool and its temperature will eventually equal the room temperature. It occurs, for example, when a fluid flows through a conduit. How far away does the orbiting object get from the sun? 419 linearSystemAnalyzer Invokes an interactive user interface for analyzing LTI systems. intersection. Since both ellipses are centered at the origin, if they intersect they will intersect at four points, so you will need to use the ginput function for four points. surfc(x,y,z) Same as surf but draws a contour plot under the surface. Save the fit and evaluated results to the MATLAB workspace. The Property Editor enables you to change the most account plot under the surface. commonly used object properties. If we want to plot both the real and imaginary parts on the same plot, we could use the hold command as shown in the following program: t = 0:pi/50:2*pi; x = exp(-0.3t).*(cos(2t)+j*sin(2*t)); plot(t,real(x)); hold on; plot(t,real(x)); hold off; Table 5.2-2 summarizes the plot enhancement commands introduced in this section. The array v is 1 × 6 and the array theta is 1 × 4. The first circle has a radius of 2 and is centered at x = 3, y = 5. Because their range is small, we can simply subtract 2000 from each value. Kirchhoff's voltage law applied at each node in the circuit gives a. E(:,1) = x; % Loop over years 2 to 10. To find the zero near x = 3, type x = fzero(@f1,3). The parabola function 139 constructs and returns a function 139 constructs and retu appears, click the right arrow button once. 548 7. The cellplot function produces a graphical display of the cell array's contents in the form of a grid. These are popular types used by many applications. - Solution Suppose that the current freshman enrollment is 500 students and the college decides to admit 1000 freshmen per year from now on. 260 zlabel Adds text label to z axis. A fence around a field is shaped as shown in Figure P11. Compare the specific volume estimates given by the ideal gas law and the van der Waals equation for 1 mol of Cl 2 at 300 K and a pressure of 0.95 atm. 154 Example 1. That is, the fitted function will be monotonic on intervals where the data are monotonic and will 340 Figure 7.4-4 Top graph: Interpolation with a cubic polynomial. The Function Browser, click on the left of the prompt. x = sym(x) Creates the symbolic variable with name x. The MATLAB error messages usually enable you to find syntax errors. You cannot use content indexing to retrieve the contents of more than one cell at a time. Third Relational operators; evaluated from left to right. If not, MATLAB then searches the folders in its search path, in order, for problem1.m and then executes it if found. Table 5.2-1 shows the symbols for some of the available data markers. OVERLAY PLOT Subplots 221 You can use the subplot command to obtain several smaller "subplots" in the same figure. Example 4 has two outputs and one input. Use MATLAB to compute how high the ball will go, how far it will go, and how long it will take to hit the ground. Steps for Obtaining a Computer Solution If you use a program such as MATLAB to solve a problem, follow the steps shown in Table 1.6-2. If you click on OK, the changes take effect but the window closes. For example, suppose the object is thrown upward at t = 0 with a velocity of 4 m/s. With element-by-element multiplication, it is important to remember that the dot (.) and the asterisk (*) form one symbol (.*). Then you type >> syms A s >>ilaplace(A/(s²+1.4*s+1)) The response obtained is Direct Method Instead of performing by hand the algebra required to find the response transform, we could use MATLAB to do the algebra for us., for example, y = a 0 + a 1 x 1 + a 2 x 2. Thus A is singular if ad - bc = 0.457 S1 = x²+3+y³ >>S2 = E1*E2 % Multiply the expressions. For example, subplot(3,2,5) creates an array of six panes, three panes deep and two panes across, and directs the next plot to appear in the fifth pane (in the bottom left corner). In general a linear model y = mx + b sometimes must have a zero value for b. Obtain the three-dimensional plot of the helix for the following three cases and compare their appearance with one another. For example, if the variable y has not
been assigned a value, then the following will generate an error message in MATLAB. Solution We use two loops; an inner loop for the random walk itself, and an outer loop for the random walk itself. help to discover a functional description of the plot function. Its syntax is identical to that of the spline function. Its syntax is identical to the spline function. Its syntax is + y. Some of the power of MATLAB comes for its ability to use simple code to perform operations on arrays containing many values. 373 MATLAB ODE Solvers In addition to the many variations of the predictor-corrector and Runge-Kutta algorithms that have been developed, there are more-advanced algorithms that use a variable step size. If you are preparing multiple plots of a similar type or if the axes' labels cannot convey enough information, use a title. Note that the display describes what the function does, warns about any unexpected results if nonstandard argument values are used, and directs the user to other related functions. For example, the following user-defined function show date computes and stores the date in the variable today, and displays the value of today. Thus we type the following: >>Category Costs = sum(C') The resulting vector, containing the category costs in thousands of dollars, is [760 539 316]. Use W = 100 N and the preceding values for k 1, k 2, and d. For example, the command Calendar = input('Enter the day of the week: ','s') prompts you to enter the day of the equation, tf, stands for transfer function, which is an equivalent way of describing the coefficients on the left- and right-hand sides of the equation.) The LTI object sys2 in transfer function, which is an equivalent way of describing the coefficients on the left- and right-hand sides of the equation.) The LTI object sys2 in transfer function, which is an equivalent way of describing the coefficients on the left- and right-hand sides of the equation.) The LTI object sys2 in transfer function, which is an equivalent way of describing the coefficients on the left- and right-hand sides of the equation.) The LTI object sys2 in transfer function form for the equation (9.5-9) is created by typing >>sys2 = tf([3, 9, 2], [6, -4, -4, -4]) is created by typing the coefficients on the left- and right-hand sides of the equation.) The LTI object sys2 in transfer function form for the equation (9.5-9) is created by typing >>sys2 = tf([3, 9, 2], [6, -4, -4]) is created by typing the equation (9.5-9) is created by 7, 5]); To create an LTI object from a state model, you use the ss(A, B, C, D) function, where ss stands for state space. The arbitrary constants in the solution are denoted by C1, C2, and so on. Since we did not put a semicolon after the plot function, MATLAB displays some of the properties of the graph. load Year built Due for maintenance Smith St. 80 1928 2011 Hope Ave. When the function polyfit(x,y,n) is executed, it will issue a warning message if the polynomial degree n is greater than or equal to the number of data points, or if the vector x needs centering and/or scaling. This is easily done. 19, 52 {} Braces; enclose cell elements. The residuals for the exponential are the largest of all, and indicate a poor Figure 6.2-3 Residual plots for the exponential are the largest of all, and indicate a poor Figure 6.2-3 Residual plots for the exponential are the largest of all, and indicate a poor Figure 6.2-3 Residual plots for the exponential are the largest of all, and indicate a poor Figure 6.2-3 Residual plots for the exponential are the largest of all, and indicate a poor Figure 6.2-3 Residual plots for the exponential are the largest of all (t - T). appears in Table 6.1-1. pwd Displays the current directory. Use the model to plot the projectile's trajectory v versus x for $0 \le t \le 10$ s. However, because the number of unknowns will be undetermined. % Set the data values. The sled's equation of motion is To obtain $\theta(t)$, note that and 414 Thus the equation of motion becomes or The solution is formally given by Unfortunately, no closed-form solution is available for the integral, which is called Fresnel's cosine integral, which is called Fresnel's cosine integral. 462 A Hydraulic System The working fluid in a hydraulic System is an incompressible fluid such as water or a silicon-based oil. The concept can be extended to functions of three or more variables. Private functions Private functions reside in subdirectories with the special name private, and in the future they will be visible only to functions or scripts in the directory. 366 Using the rref command rref([A b]), where A = [5, 3, 3; 3, 4] and b = [40; 30], we obtain the following augmented matrix: This matrix gives the reduced system which can be easily solved as follows: (8.3-4) (8.3-5) where z is arbitrary. T1.3-5 Use MATLAB to plot the functions and z = 5e 0.3x - 2x over the interval $0 \le x \le 1.5$. Properly label the plot and each curve. The pressures at the left- and right-hand sides. Suppose you mistakenly typed the line >x = 1 + 2(6 + 5). For example, an array with 3 rows and 2 columns is said to be a 3 × 2 array. Test Your Understanding T11.6-1 Consider three successive coordinate rotations using the same angle a. Appendix D is a list of references. Create a MATLAB program to simulate this process for 100 steps. (b) Use MATLAB to find the numeric value of the product if x = 2. The functions min(A) and [x, k] = min(A) are the same as max(A) and [x, k] = max(A) except that they return minimum values. This feature distinguishes them from cell arrays, which are accessed using the standard array indexing operations. For example, later we will create a handle for the axes. Use your function file to generate a plot of x versus h for $0 \le h \le 2 m$. (Answers: magnitude = Correctly Specifying Function Arguments When writing mathematics in text, we use parentheses (), brackets [], and braces { } to improve the readability of expressions, and we have much latitude over their use. The decision to declare a variable global is not always clear-cut. Use nested if statements in your program (do not use elseif). A grid is automatically overlaid on a 245 polar plot. Now logical is a first-class data type and a MATLAB class, and so logical is now equivalent to other first-class types such as character and cell arrays. Connect the markers for the second set with dashed lines. Let T be temperature in °C. 46. Cables are used to suspend bridge decks and other structures. Specifically, let u = x - x 0 and w = y - y 0. (Answer: 5 cos(2x)/y) Integration The int(E) function is used to integrate a symbolic expression E. We want to analyze the mass-spring system discussed in Problem 20 for the case in which the weight W is dropped onto the platform attached to the center spring. Then enter [0; 0] for the initial conditions. The MathWorks, Inc., has always been very supportive of educational publishing. The session is >>d = [560, 440, 490, 530, 370] >>t = [10.3, 8.2, 10.3,
10.3, 9.1, 10.1, 7.5] >> speed = d/t speed = 54.3689??53.6585??53.8462??52.4752??49.3333 69 The results are in miles per hour. Solution A MATLAB session to check the ranks is >> A = [2, -4, 5; -4, -2, 3; 2, 6, -8]; >> b = [-4; 4; 0]; >> rank((A) ans = 2 >> rank((A, b)) ans = 2 >> rank((A, b Suppose that x = 2 and y = 5. The gas constant is R, the absolute temperature is T, and the gas specific volume is . MATLAB allows us to separate the components with commas for improved readability if we desire so that the equivalent way of writing the preceding vector is [5, 7, 2]. This multiplication gives the cost matrix C. Basic principle: conservation of mechanical energy b. State any assumptions you make. 200 Optimization and root-finding functions Item Description Pages fminbud Finds the minimum of a function of one variable. see also files bins, 88, 312 block diagrams, 440-441, 474 Block Parameters window, 444 blocks, 439 Boolean operators. Plot the data using rectilinear scales. 4. Figure P26 268 27. Thus, when you are connecting inputs to the State-Space block, care must be taken to connect them in the proper order. Use the following values: m 1 = 250 kg, m 2 = 40 kg, k 1 = 1.5×10.4 N/m, k 2 = 1.5×10.4 ellipses in the figure. For more information, including a list of the available characters, search the online Help for the "Text Properties" page. The programs in this text often omit some of these elements to save space. Use MATLAB to plot the piston motion versus crank angle for two cases: L 1 = 0.6 ft and L 1 = 1.4 ft. 1.4 Working with Files Thus far we have shown how to use MATLAB in an interactive session. 455 0 to 3 N. You can use the class function to determine whether or not a quantity is symbolic, numeric, or a character string. Lists the MATLAB-specific files found in the current working directory. Thus, using the Jacobian, we obtain 397 Then the region R is specified as a rectangular region in terms of u and v. Simulink, however, provides for the creation of subsystem blocks, which play a role analogous to that of subprograms in a programming language. If we were to attempt to plot x versus t, only the real part would be plotted, and MATLAB would issue a warning. While the total is less than 20,000 compute the total. (This variety is what keeps engineering from becoming boring!) When you are solving a problem, it is important to plan your actions have their arguments enclosed in parentheses. 312, 315 Statistical functions Item Description Pages cumsum Computes the cumulative sum across a row. Thus D is unnecessary. The curvatures of adjacent polynomials must be equal at their common data point. & AND A & B returns an array of the same dimension as A and B; the new array has 1s where both A and B have nonzero elements and 0s where either A or B is 0. 572 Sound functions Item Description Pages audioplayer Creates a handle for a WAVE file. The answer is x = 2.8887. Measurements show that the diameter d 1 of the cylindrical hole in the bearing is normally distributed with a mean of 3 cm and a variance of 0.0064. You can also copy a figure to the clipboard and then paste it into another application: 1. The alternate syntax [p, s, mu] = polyfit(x,y,n) finds the coefficients p of a polynomial of degree n in terms of the variable mu is a two-element vector [μ x, σ x], where μ x is the mean of x and σ x is the standard deviation is discussed in Chapter 7). Space tick marks as close as is useful, but no closer. First create the function file: function y = f3(x) = polyval([0.025, -0.0625,animate 1.m % Animates the function t*exp(-:t/b). The code tells MATLAB to start a new line after displaying the number. The equation and plot x(t) for zero initial conditions over the interval $0 \le t \le 4$. Try bin widths of 10, 30, and 50 N. The gas constant is R, the absolute temperature is T, the gas volume is V, and the number of gas molecules is indicated by n. 93 Basic xy plotting commands Item Description Pages axis Sets axis limits and other axis properties. In cases where you are plotting data, as opposed to functions, you should use a data marker to plot each data point (unless there are very many data points). Fortunately, MATLAB provides the function fimplicit (x, y, z) = 0 over the default interval [-55] for x, y, and z. The what dirname command does the same for the directory dirname. For example, using the same data, the following session produces the coefficients of the polynomials given earlier: >x = [7,9,11,12]; >>y = [49,57,71,75]; >> [breaks, coeffs, m, n] = unmkpp(spline(x,y)) breaks = 7 9 11 12 coeffs = -0.3500 0.7500 6.900 57.0000 - 0.3500 0.7500 57.0000 - 0.3500 0.7500 57.0000 - 0.3500 0.7500 57.0000 - 0.3500 0.7500 57.0000 - 0.3500 0.7500 57.0000 - 0.3500 0.7500 57.0000 - 0.3500 0.7500 - 0.3500 0.7500 - 0.3500 0.7500 int(E) Returns the integral of the expression E with respect to the default independent variable. The procedure is as follows: 1. The temperature on three sides is held constant at T 1, and at T 2 on the fourth side (see Figure P40). 298 (Answers: (b) mean = 69.4 in.; standard deviation = 2.14 in.; (c) 43 percent; (d) 63 percent.) Sums and Differences of Random Variables It can be proved that the mean of the sum (or difference) of two independent normally distributed random variables are functions are functions are functions are functions are functions. Thus we cannot determine all the traffic flows based on the given measurements. Because private functions are invisible outside the parent directory rsmith, they can use the same names as functions in other directories. where f(t) = 75u s (t). Section 4.5 22. 55 You can append a row vector to another row vector to create either a third row vector or a matrix (if both vectors have the same number of columns). For this problem we can use the MATLAB built-in constant pi. Exporting Figures Exporting a figure is not the same as simply saving it. 144 save Saves workspace variables in a
file. Pseudocode may also use some simple MATLAB 7 you can place the definitions of one or more functions within another function. b Backspace. The three curves correspond to the following masses of air in the container: m = 1 kg, m = 3 kg, and m = 7 kg. (b) Demonstrate the use of a nested function to compute the more general integral (9.1-4) for n = 3. >>syms y >>eqn1 = y^2+3*y+2==0; >>solve(eqn1) ans = -2 -1 >>syms x >>eqn2 = 0; >>solve(eqn1) ans = -2 -1 >>solve(eqn1) ans = -2 -1 >>syms x >>eqn2 = 0; >>solve(eqn1) ans = -2 -1 >>sol x^2+9*y^4==0; >> solve(eqn2) % x is presumed to be the unknown variable. 581 audiowrite Creates a WAVE file. Note that the definition of multiplication requires that the number of columns in the matrix be equal to the number of rows in the vector. Chapter 8 treats linear algebraic equations in more depth by developing methods for the overdetermined and underdetermined cases. You can also include formatted text, images, hyperlinks, and equations to produce an interactive shareable narrative. You can also include formatted text, images and equations to produce an interactive shareable narrative. be made with the van der Waals equation where the term b is a correction for the volume of the molecules and the term is a correction for molecules and the term b is a correction for molecules and the term is a correction for molecules and z int at the points specified by the vectors x int and y int, using data stored in x, y, and z. z = (x c)[((a < b)&(a < d)) 16. [num den] = numden(E) Returns two symbolic expression the numerator expression num and denominator expression that represent the numerator expression num and denominator expression that represent the numerator expression num and denominator expression that represent the numerator expression num and denominator expression for the rational representation of the expression for the expression for the numerator expression num and denominator expression num and denominator expression num and denominator expression num and denominator expression for the expression for the expression for the expression for the expression num and denominator expression for the e useful in all engineering fields. 32 Debugging Script Files DEBUGGING Debugging a program is the process of finding and removing the "bugs," or errors, in a program. To compute the forces in structures, sometimes we must solve equations similar to the following. In the following analysis, assume that we produce only what we can sell; thus the production quantity equals the sales. Its parts inventory includes chassis, picture tubes, speaker cones, power supplies, and electronics. functions % of g, the initial velocity v0, and the time t. if x > 10 y = log(x) elseif x > = 0 y = sqrt(x) else y $= \exp(x) - 1$ end Decision structures may be nested; that is, one structure can contain another structure, which in turn can contain another, and so on. Substituting q = (T i - T j)/R, we find that R can be canceled out of every equation, and they can be rearranged as follows: These equations tell us that the temperature of each subsquare is the

average of the temperatures in the adjacent subsquares! 352 Solve these equations for the case where T a = 150° C and T b = 20° C. Find the array product z = B.*A. The equation describing the water height h in a spherical tank with a drain at the bottom is Suppose that the tank's radius is r = 3 m and the circular drain hole of area A has a radius of 2 cm. A traffic engineer wants to know if the traffic flows f 1, f 2, ..., f 7 (in vehicles per hour) can be computed given the measured flows shown in the figure. You must choose an appropriately small number as the lower limit on the plot. To continue the previous example, if we want the output to be the position x = x 1, then y = x 1, and we would select C = [1, 0] and D = 0. The first column contains the output of the Gain block. One model of an artificial leg now uses sensors to measure in real time the walking speed, the knee joint angle, and the loading due to the foot and ankle. S = struct('fl', 'vl', 'f2', ...) Creates a structure array with the fields 'fl', 'f2', ... having the values 'vl', 'v2', ...) The fields can be different sizes. x = [0,0.15,0.23,0.35,0.37,0.5,0.57,0.68,0.77]; f=0:100:800; k=x'\f' The result is k = 1017 lb/in. The following program creates the plot shown in Figure 5.2-8: % errorbar example x = linspace(0.1, pi, 20); approx = 1 - x.^2/2; error = approx - cos(x); errorbar(x, cos(x), error), legend('cos(x)'),... title('Approximation = linspace(0.1, pi, 20); approx = 1 - x.^2/2; error = approx - cos(x); errorbar(x, cos(x), error), legend('cos(x)'),... title('Approximation = linspace(0.1, pi, 20); approx = 1 - x.^2/2; error = approx - cos(x); errorbar(x, cos(x), error), legend('cos(x)'),... title('Approximation = linspace(0.1, pi, 20); approx = 1 - x.^2/2; error = approx - cos(x); errorbar(x, cos(x), error), legend('cos(x)'),... title('Approximation = linspace(0.1, pi, 20); approx = 1 - x.^2/2; error = approx - cos(x); errorbar(x, cos(x), error), legend('cos(x)'),... title('Approximation = linspace(0.1, pi, 20); approx = 1 - x.^2/2; error = approx - cos(x); errorbar(x, cos(x), errorbar(x 1 - x^2/2') There are more than 20 two-dimensional plot functions available in MATLAB. This selects the format of the exported file and adds the standard file name extension given to files of that type. These correspond to 30, 25, and 20 psi, respectively (1 psi = 1 lb/in 2, and atmospheric pressure is 14.7 psi). What is the sum for this number of terms? Suppose our estimate of b is off by ±1 percent. see also control systems Spirit, 2 spline interpolation, 335-336 spring constant, 297 square brackets, 121 square brackets, 121 square matrix, 83 standard deviation, 319 Standard Tessellation Language (STL), 348 state transition diagram, 202 state vector, 203 statements, 6 state-variable form, 410 state-variable models linear, 447 nonlinear, 459 statistics, 312-316 steady-state error, 476 steady-state error, 476 steady-state value, 421 step function, 533-534 step response, 421 step function, 533-534 step function, 533-5 subfunctions, 134, 135, 138-139 subplots, 234-235 subtraction arrays, 63 polynomial, 84-85 summer, 441 sums, 523 surface mesh plots, 256-258 surface mesh plots, 256-258 surface plots of implicit functions, 260. How effective is the controller in counteracting the disturbance? Otherwise the single percent sign will be interpreted as a placeholder for data. The differentia equation model for the motor torque m(t) required for a certain speed control system is where the desired speed is v d (t), and K is a constant called the "control gain." (a) Use the Laplace transform method to find the unit-step response (that is, v d (t) is a unit-step function). The deflection x of the beam is the distance its end moves in response to a force f applied at the end. Write in the values the variables have each time the while statement is executed. 325 Polynomial from its roots. In practice, you should make sure that the person giving you this assignment is making the same assumption. (a) z = [0, 1, 0, 1, 1]; (b) z = [0, 0, 0, 1, 1]; (c) z = [0, 0, 0, 1, 0]; (d) z = [1, 1, 1, 0, 1]. You can insert equations as typeset mathematics. We can find these frequencies by solving for the roots of a polynomial (characteristic polynomial) (characteristic polynom) (characteristic polynom) (characteristic polynom) (char that they need not be evaluated (with the accompanying round-off error) until a numeric answer is required. (Answer: No solutions.) Existence and Uniqueness of Solutions. Then click on the click on th Simulink Library Browser window icon under the View menu. The resulting plot appears in Figure 1.6-3. A good way to remember the difference between the right and left division operators is to note that the slash slants toward the denominator. The symbol Inf stands for ∞ , which in practice means a number so large that MATLAB cannot represent it. For example, type lookfor imaginary to get a list of the functions that deal with imaginary numbers. The magnitudes of the product of their magnitudes of the product z of two complex numbers x and y is equal to the product z of two complex numbers x and y is equal to the function y = 10(1 - e - x/4) over the interval $0 \le x \le x$ max, using a while loop to determine the value of x max such that y(x max) = 9.8. Properly label the plot. They can be called only from an M-file function inputs Function Description Pages fcontour((f) Creates a contour plot. As a simple example of the use of the trapz function, let us compute the integral 360 (9.1-2) whose exact answer is A = 2. Even if you suppress the display with the semicolon, MATLAB still retains the variable's value. Write a MATLAB assignment statement for each of the following functions, assuming that w, x, y, and z are 107 row vectors of equal length and that c and d are scalars. Use the fimplicit3 function to create a surface plot of the function 252 253 272 Engineering in the 21st Century... Virtual Prototyping V irtual prototyping V irtual prototyping is a method of product development by which a design is validated before committing to making a physical prototype. function [A, C] = circle(r) A = pi*r.^2; C = 2*pi*r; end The function is called as follows if r = 4. Figure 10.7-8 A vibrating system. If you attempt to solve this with MATLAB you will get a message indicating that a solution could not be found. However, if x is a matrix, a row vector is returned containing the mean (or mode or median) value of each column of x. You can check the results with the mean, min, and max functions. >>S3 = E3/E1 % Divide two expressions. 500, 505 factor Factors an expression. We now demonstrate the most direct way of using MATLAB to solve an equation with the Laplace transform. Chapter 4 discusses programming with MATLAB to solve an equation with the Laplace transform. doing this, consider whether to use a state-variable representation of the model. k = 1; b = -2; x = -1; y = -2; while k > f = @(x) (cos(tan(x))); >> fplot(f,[1 2]) produces the plot shown in Figure 5.1-3a. e. 3.* Use MATLAB to find the angles corresponding to the following coordinates. S = solve(E) Saves the solution in the structure S. Now it is a 1 × 2 array consisting of two structures, arranged in one row 98 and two columns. The vector tspan contains the starting and ending values of the independent variable t, and optionally any intermediate values of two structures arranged in one row 98 and two columns. terminates E end % This terminates D end % This terminates A You call a nested function in several ways. ASCII files use only seven bits of the byte, which corresponds to 3x 4 + 3x 3 + 4x 2 + 5x + 10. EMPTY ARRAY Suppose we type A = [6, 9, 4; 1, 5, 7] to define the following matrix: Typing A(1, 5) = 3 changes the matrix to Because A did not have five columns, its size is automatically expanded to accept the new element in column 5. To save the path settings, click on Save in the tool. A probability function that describes many processes is the normal or Gaussian function, which is shown in Figure 7.2-2. There will be as many curves as there are rows of A. This type of matrix can be useful for applications in which we do not know the required dimension ahead of time. Select Copy Options from the Edit menu of the Figure window. >>[X,Y] = meshgrid(-2:0.1:2); >>Z = X.*exp(-((X-Y.^2).^2+Y.^2)); >>Contour(X,Y,Z), xlabel('x'), ylabel('x'), ylabel('y') You can add labels to the contour lines. Then in early 2004, two improved rovers, Spirit and Opportunity, landed on opposite sides of the planet. Help Functions. It must accept a vector result y. (To obtain both the speed and the current as outputs, we would choose C = [1, 0; 0, 1] and D = [0; 0].) The program computes the time constants using the eig function and then creates time, the array of time values to be used by lsim. The integral exists for most of the commonly encountered functions if suitable restrictions are placed on s. Using estimates of rainfall, evaporation, and water consumption, the town engineer developed the following model of the water volume in the reservoir as a function of time where V is the town's consumption rate in liters, t is time in days, and r is the town's consumption rate in liters per day. Inverse cosecant; arccsc. The expression $r = (V/(pi*h))^{(1/2)}$ is an example of the use of nested parentheses where the inner pair makes clear our intention to multiply pi by h before dividing their product into V. It returns an answer in radians, not degrees. However, note that any algorithm can be tried as a predictor or a corrector. A particular bridge cable is described by the catenary $y(x) = 10 \cosh((x - 20)/10)$ for , where x and y are the horizontal and vertical coordinates measured in feet. >>fz = @(t)t >>fplot3(fx,fy,fz,[0,10*pi]), xlabel('x'),... ylabel('y'), zlabel('z'), grid on Test Your Understanding T5.4-1 Use plot3 and fplot3 to plot the 3-D line plot described by x = sin(t), y =
sin(t) cos(t), z = ln(t) for t between 0 and 30. 3.1 If $x \ge 0$ theta = atan(y/x) 3.2 Else theta = atan(y/x) 4. This polynomial has a different interpretation in each of the three cases: The linear function: y = mx + b. Therefore, we must estimate the slope by using nearby data points. In such a case, we must solve Equation (10.10-17) numerically. >>[A1, B1] C1, D1] = ssdata(sys1); The results are When using ssdata to convert a transfer function form to a state model, note that the output y will be a scalar that is identical to the solution variable of the reduced form; in this case the solution variable of Equation (9.5-1) is the variable y. Find the sum of A and B. 441 Figure 10.1-2 (a) The summer element The system is stable if all the roots are negative or have negative real parts. R.; R. Display the value of the total. Initialize the student toward MATLAB and the engineering applications. y = [2, -4, 7] c. The function that gives the smallest J value gives the best fit. We choose to use an increment of 0.01 to generate a large number of x values in order to produce a smooth curve. Often in the design of an engineering system, however, we must eventually deal with nonlinearities in the system and with more complicated inputs such as trapezoidal functions and this must often be done with simulation. Determine what mole fraction of benzene remains when L = 70. 278 The third pane of the Basic Fitting interface contains three items. We can find b from b = 10 p 2. Are there any saddle points? Then we can think of the problem as a network of electric resistors, as shown in part (b) of the figure. (See Figure 11.3-1.) Solution The equations of motion for a projectile launched with a speed v 0 at an angle θ relative to the horizontal are: where x = 0, y = 0 is the location of the ball when it is hit. To create a function file, open the Editor as described in Chapter 1, by selecting New under the HOME tab on the Toolstrip, but instead of selecting Script, select Function. Select the format from the list of formats in the Save As type menu. 87 T2.5-4 Use MATLAB to confirm that when x = 2. So typing atan2d(-1,-1) returns -135 degrees. Any valid variable name may be assigned to a handle. The notation can be changed to clarify the method. Find the reduced form of the following state model. Suppose the variable Speed has the value 63.2. To display its value using three digits with one digit to the right of the decimal point, along with a message, the session is >> fprintf('The speed is: %3.1f', Speed) The speed is: 63.2 Here the "field width" is 3, because there are three digits in 63.2. You may want to specify a wide enough field to provide blank spaces or to accommodate an 584 unexpectedly large numerical value. >>cossg = $(a(x)\cos(x, n)$; >>n = 2; >>A = integral(cossg,0,sqrt(2*pi)) ??? In the Workspace window enter the parameter values and compute the a i constants as shown in the following session. Plot y(t) for $0 \le t \le 10$. For example, >>r = 2.25:20:42.25; >>circum = 2*pi*r; >>y = [r;circum]; >>fprintf('%5.2f %11.5g',y) 2.25 14.137 22.25 139.8 42.25 265.46 Note that the fprintf function displays the transpose of the matrix y. You will then see a new edit window and the Plot 252 Edit toolbar in this section. G. Errors due to an incorrect mathematical procedure. Kraige (Wiley, 2002). Use the MATLAB ODE solvers to solve single first-order ordinary differential equations whose initial conditions are specified. The circuit shown in Figure P4 has five resistances and one applied voltage. The chosen applications require only a basic knowledge of physics and thus can be appreciated by readers from any engineering or scientific discipline. 161 = Relational operator: greater than or equal to. The function shown in Figure 10.4-1. Consequently, if a variable is normally distributed, there is a 68 percent chance that a randomly selected sample will lie within one standard deviation of the mean. A subsystem block is actually a Simulink program represented by a single block. Assume that the system starts from rest with $\omega(0) = 0$ and i(0) = 0 and i(0) = 0. statement must come after the elseif statement to take care of all conditions that might be unaccounted for. The vector matrix equation is 543 Thus, R(a) R(a) should be the same as R(2a). This plot shows the effect of the dead zone on the sine wave. One survey showed that more than 25 percent of the nation's bridges are substandard. Use MATLAB to determine the capacitance value for d = 0.005, L = 2, and r = 0.001. Create an array A whose first row contains the values 3x = 0.001. Create an array A whose first row contains the values 3x = 0.001. Create an array A whose first row contains the values 3x = 0.001. Create an array A whose first row contains the values 3x = 0.001. Create an array A whose first row contains the values 3x = 0.001. Create an array A whose first row contains the values 3x = 0.001. Create an array A whose first row contains the values 3x = 0.001. Create an array A whose first row contains the values 3x = 0.001. Create 3x = 0.0random processes in your simulation programs. meshz(x,y,z) Same as mesh but draws a series of vertical reference lines under the surface. Here are some examples of the use of polyder. The MathWorks provides Simulink support packages for computer hardware such as LEGO © MINDSTORMS ©, and Raspberry Pi ©, which are popular with researchers and hobbyists for controlling drones and robots. Complex conjugate. The text command text(x,y, 'string') adds a text string to the plot at the location specified by the coordinates x,y. The following list gives the measured gas mileage in miles per gallon for 22 cars of the same model. : Represents an entire row or column of an array. 279 Section 6.1 1.2) 2 - y 2], for $-2 \le x \le 2$ and $-2 \le y \le 2$, with a spacing of 0.1. This >>[X,Y] = meshgrid(-2:0.1:2); >>Z = X.*exp(-((X-Y.^2).^2 - Y.^2)); >>mesh(X,Y,Z), xlabel('x'), ylabel('x'), yla make the surface difficult to visualize, and (2) the matrices X and Y can become too large. Use MATLAB to find the coefficients of the cubic polynomial y = ax 3 + bx 2 + cx + d that passes through 355 the three points given in part a. (M. The session is >> syms y(t) c >> eqn = diff(y,t); >> cond = [y(0)==1, Dy(0)==0]; > dsolve(eqn,cond) ans = $1/2^{*}exp(-c^{*}t) + 1/2^{*}exp(-c^{*}t)$ Arbitrary boundary conditions, such as y(0) = c, can be used. The following prompt program is a script file that allows the user to answer Yes by typing either Y or y or by pressing the Enter key. There are two ways to obtain the solution with the factor 10. For example, the problem has the solution The session is >> syms y(t) >> Dy = dif(y,t); >> eqn = Dy+10*y==10+4*sin(4*t); >> cond = y(0)==0; >> y = dsolve(eqn, cond); >> fplot(y),axis([0 5 0 2]),xlabel('t') You can type this code either in the Command window or in the Live Editor to produce the plot shown in Figure 11.4-1. The Plot Tools Once a figure has been created, you candisplay any of or all three Plot Tools (Figure Palette, Plot Browser, and Property Editor) by selecting them from the View menu. ARRAY OPERATIONS MATRIX OP movie in array M once, where M must be an array of movie frames (usually acquired with getframe). EXAMPLE 11.2-2 Positioning a Robot Arm Figure 11.2-2 shows a robot arm having two joints and two links. z = [5 + 3i, -3 + 4i, 2 - 7i] 97 8. >> f = @(x) 5*sin(x); >>h = @(x) 0; (f(x)); >>h(2) and f(x) = 4.9468 To preserve an anonymous function from one MATLAB session to the next, save the function handle to a MAT-file. T3.1-2 Find the magnitude, angle, real part = 1.4705). Solution (a) The integrand cos x 2 obviously does not contain any singularities that might cause problems for the integration function. For example, to plot the z curve using a dashed line, replace the plot(x,y,x,z) function in the above session with plot(x,y,x,z, '--'). Create the vector x having 50 logarithmically spaced values starting at 10 and ending at 1000. To use the same interval for both x and y, specify xy interval as a two-element vector of the form [min max]. (b) Use MATLAB to compute and plot y(t) when y(0) = 0 and . Whenever, very small step sizes require longer run times and can result in a large accumulated error due to roundoff effects. 148 152 Engineering in the 21st Century... Nanotechnology Many of the engineering challenges and opportunities in the 21st century will involve the development of extremely small devices and even the manipulation of individual atoms. The circuit. 553 (b) Compare your answer with that obtained with the MATLAB erf(t) function, defined as 29.* Use MATLAB to compute the following limits. solve(E) 513 11.3 Calculus In Chapter 9 we discussed techniques for performing numerical integration and integration of symbolic expressions to obtain closed form results for the derivatives and integrals. 18.* a. Figure P11 147 12. Professor Palm's research and industrial experience are in control systems, robotics, vibrations, and system modeling. Section 2.3 12. The function fun between the limits a and b. Solution Modify the Simulinker and industrial experience are in control systems. model constructed in Example 10.2-1 as follows. For example, is given by >> syms x >> diff(x^3,2) ans = 6*x The function diff(E,v,n) returns the nth derivative of the expression E with respect to the variable v. 524 This handle refers to the plotted line. equal to the empty array. A certain object's acceleration is given by $a(t) = 7t \sin 5t m/s 2$. Suppose that RC = 0.2 s and that the capacitor voltage is initially 2 V. For example, the number c 1 = 1 - 2i is entered as follows: c1 = 1 - 2i. However, the plot is smooth and shows that d behaves as expected. Plot the tension forces T AB and T AC on the same graph versus L AC for L ACmin \leq LAC \leq 6.7. Section 8.3 13.* Solve the following equations: 14. Chapter 4 4. The first format gives the solution as a structure. >>n = 3; >>syms x
>>A = x.^{((0:n)'*(0:n))} A = [1, 1, 1, 1] [1, x, x^2, x^3] [1, x^2, x^4, x^6] [1, x^3, x^6, x^9] Note that it was not necessary to use sym or syms to declare A to be a symbolic variable beforehand. Complete the fields on the Copying Options page and click OK. Computer-Aided Problem Solving for Scientists and Engineers. time = [0,620,2266,3482]; temp = [145,130,103,90]; % Subtract the room temperature. Meriam and L. There is only one solution. You are told that a new packaging material can protect a package when dropped, provided that the package hits the ground at less than 25 ft/sec. The best way to locate a block, given its name, is to type its name in the search pane at the top of the Simulink Library Browser. Find the best-fit line that passes through the point x 0 = 10, y 0 = 11. Inverse secant; arcsec . 361 rank Computes rank of a matrix. (x, y = (5, 8) b. The function handle method (method 2) is the fastest method, followed by method 1. >>A = [0, -1, 4; 9, -14, 25; -34, 49, 64]; >>C = (A >= 0); The result is We can use this technique to compute the square root of only those elements that are negative. Assuming that the variables a, b, c, d, and f are scalars, write MATLAB statements to compute and display the following expressions. Notice that the mass m cancels out of the equation. This illustrates an important property of nonlinear differential equations. ??? Compare with the answer from part (a). ... Ellipsis; continues a line. Hyperbolic expressions. secant; 1/cosh x. W = 300 and T = [428.5714, 471.4286, 266.6667, 233.3333, 200, 100] 49. You can assign data to the cells by using either cell indexing or content indexing. The zeros command creates a matrix of all zeros. Open its Block Parameters window and enter the following values for the matrices A, B, C, and D. Tables Array functions Table 2.1-1 Element-by-element operations Table 2.3-1 Special matrices Table 2.4-5 Polynomial functions, and exponentiation, division, and exponentiation, division, and exponentiation, subtraction, multiplication, division, and exponentiation functions and exponentiation. Consider the motion of the piston discussed in Example 1.6-1. The norm is the square root of the sum of the squares of the residuals. 4.* The half-life of a radioactive substance is the time it takes to decay by one-half. 25.* Use MATLAB to find the roots of 13x 3 + 182x 2 - 184x + 2503 = 0. This requires that P = 3, I = 40, D = 0. The following MATLAB script solves the problem. >> fprintf('The first circumference is %6.3f.', circum(1)) The first circumference is 14.137 An apostrophe in displayed text requires two single quotes. [u,v,w] = find(A) Computes the array w, containing the values of the nonzero elements. Then [t, x] = ode45(@example_1, [0 6], [3 9]); Each row in the vector x corresponds to a time returned in the column vector t. Another correct answer is the angle that lies in the opposite quadrant. Fourth Addition and subtraction with equal precedence, evaluated from left to right. Some are M-files depending on the MATLAB version. function xdot = pendulum(t,x) xdot = [x(2); -(g/L)*sin(x(1))]; end end Table 9.4-1 summarizes the syntax of the ODE solvers using ode45 as an example. For example, >>x = 3; y = 7; q = fun(x,y); >>u ??? 118 Trigonometric Functions Other commonly used functions are cos(x), tan(x), sec(x), and csc(x), tan(x); sec(x), and csc(x), tan(x), sec(x), tan(x), sec(x), tan(x); sec(x), tan(x), tx, respectively. Then use the load function to load the file into MATLAB, and use the mean function to compute the mean value of each input-output pair of the system, assuming that the initial conditions are zero. The Insert Menu The Insert menu enables you to insert labels, legends, titles, text, and drawing objects, rather than using the relevant commands from the Command window. 317 The input of flips is the state s, and the result (0 for two tails, 1 for a head and a tail, and 2 for two heads). This is to be expected because of the effects of the tank's curvature. Cubic Spline Interpolation High-order polynomials can exhibit undesired behavior between the data points, and this can make them unsuitable for interpolation. What is the result of the following operations? 7 8 21 20 18 9 10 11 12 ? Continue the previous script as follows: X = [ones(size(t)); exp(-t)]; a = X y' The answer is a 1 = 1.7496, a 2 = -1.7682. and a 3 = 0.8885. Solution If we set mg = 1, the equations have the form AT = b where 327 The script file to solve this system is % File cable.m s34 = sqrt(32); A1 = [1/s35, -3/s34, 1/s42]; A2 = [3/s35, 0, -4/s42]; A2 = [3/s35, 0, -4/s42]; A3 = [5/s35, 5/s34, 5/s42]; A3 = [3/s35, 0, -4/s42]; A3 = [5/s35, 5/s34, 5/s42]; A3 = [5/s35, 5/s44]; A4 = [5/s35, 5/s44]; A4 = [5/s35, 5/s44]; A4 = [5/s executed by typing cable, we find that rank(A) = rank ([A b]) = 3 and obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.2915, and T 3 = 0.4166. To specify a vector of times of the form t = 0:dt:tF, at which to obtain the values T 1 = 0.5071, T 2 = 0.5071, the coefficients in terms of a, b, and r. Test Your Understanding T8.3-1 Find two solutions to the following set: (Answer: Minimum-norm solution: x 1 = 4.33, x 2 = -1.67, x 3 = 1.34. 436 This gives D = 0, P = 40, and I = 400 with the parallel form. Using a different guess, d = 1, $\theta = 0.1$, produces the same answer. The acceleration is linear with time: = 0.5t m/s 2, and $\theta(0) = 3 \text{ rad}$. We will discuss other plotting functions, and the Plot Editor, in Chapter 5. |y| b. However, for small angles, sin $\theta \approx \theta$ and cos $\theta \approx 1 - \theta 2/2$. | New York, NY : McGraw-Hill Education, [2018] | Includes bibliographical references and index. the solution of the following equation for $0 \le t \le 6$. A company has the choice of producing up to four different products with its machinery, which consists of lathes, grinders, and milling machines. 6. For example, suppose that x = [6,3,9] and y = [14,2,9]. Run the program with your input data and perform a "reality check" on the output. There can be applications where we want to not execute the case producing an error but continue executing the loop for the remaining passes. Choosing Gain Values for several reasons. You can use the tab completion feature to reduce the amount of typing. However, experience has shown that often a simple test consisting of applying a step voltage to the motor-and-mass and plotting its speed will yield a useful value for the time constant T (the time for the time constant T (the time for the motor speed to reach steady state is 4T). 0]; b = [6-6* (144./(180*Y)); 3-6*(144./(180*Y));. My father was always there for support before he passed away. To compute the component of the force F along the direction given by the vector r, you type dot(F, r). 119 asech(x) Inverse hyperbolic secant; sech -1 x. Palm III University of Rhode Island 4 ii MATLAI FOR ENGINEERING APPLICATIONS, FOURTH EDITION Published by McGraw-Hill Education, 2 Penn Plaza, New York, NY 10121. 189 nested for loops. 124 dir Lists all files in current directory. 14 The tab completion feature also corrects for misspelling. For example, if you now type student, MATLAB displays >> student = 1x2 struct array with fields: name SN email tests You can also obtain information about the fields by using the fieldnames function (see Table 2.7-1). Haptic feedback will be important for telesurgery, in which a surgeon remotely guides a surgical robot. The units of distance are AU, where 1 AU is the mean distance of the earth from the sun. When you press Enter, you see the result ans = 3. Select Export Setup from the File menu. Rewrite the following statements to use only one if statement. Sometimes we want to initialize a matrix to have all zero elements. 9.6 Summary This chapter covered numerical methods for computing integrals and derivatives, and for solving ordinary differential equations. After placing the block as shown in Figure 10.4-5, double-click on it and type pi/3 in its Upper Limit window. You must, however, always terminate a nested function with an end statement. The larger the error, the larger will be the actuator signal. Complex abs(x) angle(x) real(x) Absolute value; x. 573 surf Creates shaded three-dimensional mesh surface plot. % Program movie2.m % Rotates a 3D surface. k = p + 1; t = p*dt; time(k) = t; if t = h desired))*dt; else % Rocket did not reach the desired height. Typing
cat(n, A, B, C,...) creates a new array by concatenating the arrays A, B, C, and so on along the dimension n. 449 Figure 10.3-2 Simulink model containing the State-Space block and Step block. This step causes the original matrix to collapse to a smaller one. >>syms >>E1 = >>E2 = >>S1 = x y x^2 + 5 % Define two expressions. For example, to generate a vector y containing 1000 uniformly distributed random numbers in the interval (2, 10), you type y = 8*rand(1,1000) + 2. So to correct the error in the previous session, you may type instead w = logical([1,0,0,0,1]) before typing v = x(w). To integrate more than one function, place their values in a matrix y; trapz(x, y) will compute the integral of each column of y. The following function demonstrates the elseif structure and the use of a string variable. Word processors can store information in ASCII files. It is customary, but not required, to capitalize the names of global variables and to use long 129 names, to make them easily recognizable. You can use the Export Setup window to customize a figure before saving it. Key Terms 441 Block diagrams, 440 Dead time, 467 Dead zone, 456 Derivative block, 470 Fcn block, 470 Fcn block, 440 Integrator block, 440 Library Browser, 441 Look-Up Table block, 472 PI controller, 469 PID Controller block, 475 Piecewise-linear models, 450 Rate Limiter block, 469 Relay block, 468 Signal Builder block, 468 Signal Builder block, 468 Signal Builder block, 469 Relay block, 460 Signal Builder block, 460 Relay block, 460 Rela Problems Section 10.1 1. function pendula g = 9.81; L = 0.75; % First case. File location frequently causes problems for beginners. Finally, I want to thank my wife, Mary Louise, and my children, Aileene, Bill, and Andy, for their understanding and support of this project. k = k + 1 3.2 Update the total. The line-continuation operator, called an ellipsis consists of three periods. >> 8/10 ans = 0.8000 MATLAB indents the numerical result. On a second subplot, plot the difference between the amount obtained from continuous compounding and the other three cases. Pound for pound, spider silk is stronger than steel, and structural engineers hope to use cables of synthetic spider silk fibers to build earthquake-resistant suspension bridges. So, if we use a time step of 0.1 s, our sampling frequency is 10 Hz. If the sine wave has a period of 1 s, then we are "sampling" the function (9.3-1) with the trapezoidal rule. We have shown the most important ones for engineering applications. Conditional operations. Use a numerical method to find the free response for the case where the applied voltage is y(0) = 2 V. We could solve the second equation for t i and substitute the result into the first equation to obtain the relation between h and v i. The delay often results from the case where the applied voltage is y(0) = 2 V. We could solve the second equation for t i and substitute the result into the first equation to obtain the relation between h and v i. physical separation of the components and typically occurs as a delay between a change in the actuator signal and its effect on the system being controlled, or as a delay in the measurement of the output. Use MATLAB to find the point on the line y = 2 - x/3 that is closest to the point x = -3, y = 1. Strings and Conditional Statements A string is a variable that contains characters. For example, models (9.5-6) and (9.5-7) can represent the motion of a mass, with x 1 the position and x 2 the velocity of the mass. Another consequence of this restriction is that you cannot write in MATLAB expressions like the following: >>x+2=20 The corresponding equation x + 2 = 20 is acceptable in algebra and has the solution x = 18, but MATLAB cannot solve such an equation without additional commands are available in the Symbolic Math toolbox, which is described in Chapter 11). The equations of motion become Figure 10.3-1 Two-mass suspension model. icon, hold the mouse button down, drag the block to the new model window, and release the button. Note that the first plot in Figure 6.1-6 shows that the data points do not lie exactly on the fitted straight line. A weight W is supported by two cables anchored a distance D apart (see Figure P36). The following table gives data on the amount of force used to push a block through the given distance over five segments of a certain path. For example, to evaluate the expression the following code gives the correct answer. 6.3 The Basic Fitting Interface MATLAB supports curve fitting through the Basic Fitting Interface. Do the same to connect the input of the Gain block to the arrow connecting the Integrator and the Scope blocks. For example, to solve the equation $\sin 2x - \cos x = 0$, the session is >> solve($\sin(2^*x)$ -cos(x) = = 0) and $x = 5\pi/6$ are also solutions. Suppose \$10,000 is initially invested at 3.5 percent (r = 0.035). % % x y Program Example 1.m This program computes the cosine of the square root and displays the result. The temperature is held constant at T 1 on three sides and at T 2 on the 220 Figure P39 fourth side (see Figure P39). 29 : Colon; generates an array having regularly spaced elements. For RC = 0.1 s obtain the log-log plot of |A o /A i | versus ω and use it to find the range of frequencies for which the output amplitude A o is less than 70 percent of the input amplitude A i . Use the MATLAB Help facilities to determine what happens if you use the sqrt function with a negative argument. Use a plot over the range $0 \le x \le 5$ to confirm that sin(ix) = isinh x. If so, we include the derivative term. Where appropriate, answers immediately follow the exercise so you can measure your mastery of the material. 7.* Data analysis of the breaking strength of a certain fabric shows that it is normally distributed with a mean of 300 lb and a variance of 9. Program Design and Algorithm Development 4. Use MATLAB to determine how high h should be to maximize the brightness at point P, which is 30 ft from the base of the pole. [18, 45, 80] c. Sine; sin x. This grid consists of concentric circles and radial lines every 30°. The MATLAB function random will generate a single number that is normally distributed with a mean equal to 0 and a standard deviation equal to 1. Remember that the output xdot must be a column 379 vector. This feature is called syntax highlighting. For example, the solution of the problem is >> syms y(t) a b c >> eqn = diff(y,t)+a*y==b; >> cond = y(0)==c; >> dsolve(eqn, cond) ans = (b-exp(-a*t)*(b-a*c))/a) 529 481 Plotting the Solution The fplot function can be used to plot the solution, just as with any other symbolic expression, provided no undetermined constants such as C1 are present. In such cases we can use our physical insight to guard against grossly incorrect results. You can have other file types in the folder. and right-facing parentheses. | MATLAB. Compute the total cost. Using Equation 10.10-5 as a guide, the following MATLAB code implements a rudimentary PID algorithm where tk = kT and T is the sampling period. If h p \geq h desired, Compute t p, t hit. >>syms d g h th >>f = (1/(((cos(th))^2)*(d*tan(th)-h))); >>dfdth = diff(f,th); >>thmin = h desired for the sampling period. If h p \geq h de solve(dfdth,th); >>thmin = double(subs(thmin, {d,h}, {310,33})) thmin = $-0.7324\ 2.4092\ -2.3032\ 0.8384\ Obviously$, the solution must lie between 0 and $\pi/2$ radians, or about 48°. Thus 551 If the current is measured in amperes, the power is in watts and the energy is in joules (1 watt = 1 joule/second). CELL INDEXING CONTENT INDEXING 89 95 EXAMPLE 2.6-1 An Environment Database Suppose you want to create a 2 × 2 cell array A, whose cells contain the location, the date, the air temperature (measured at 8 a.m., 12 noon, and 5 p.m.), and the water temperatures measured at the same time in three different points in a poncession. When the step(sys) function puts a plot on the screen, you may use the plot to calculate these parameters by right-clicking anywhere within the plot area. The integrand. Smith, but R. The Help menu accesses the general MATLAB Help System as well as Help
features specific to plotting. 576 audiorecorder Records sounds. 309 The syntax of the interp1 and interp2 functions is summarized in Table 7.4-1. The largest element in the entire array is 10. For example, >> s=20*r s = 16 8 A common mistake is to forget the multiplication symbol * and type the expression as you would in algebra, as s = 20r. For such processes the probability is a function of a discrete-valued variable, that is, a variable having a limited number of values. This is one type of file, called an M-file, that we will discuss later. However, z cannot be completely arbitrary if the solution is to be meaningful. For example typing atand(1) returns 45 degrees but the tangent of -135 degrees is also 1. 9.3 First-Order Differential equations. where q mo is the outlet mass flow rate, R is the resistance, Δp is the pressure difference across the resistance, and Note that we may express the SSR(u) function in MATLAB as follows: sgn(u)*sqrt(abs(u)). You cut a length x to make a square, and use the remaining length L - x to make a square, and use the remaining length x to make a square as follows: sgn(u)*sqrt(abs(u)). flow rate q through a material to the temperature difference ΔT across the material: q = $\Delta T/R$. 264 6.2 Regression In Section 6.1 we used the MATLAB functions that are linear or could be converted to linear form by a logarithmic or other transformation. The measurement error is uniformly distributed between -0.025 and 0.025. Table C.1 summarizes the basic syntax of fprintf. The function y = f(x) must accept a vector result y. If you want to store a text input as a string variable, use the other form of the input command. When called with left-hand arguments, as [y,t,x] = initial(sys, x0,. Each called view) to set in the for loop causes the next set of points to be plotted. The basic syntax is initial(sys,x0), where sys is the LTI object in state-model form and x0 is the initialcondition vector. Because this problem involves a mass in motion, we can apply Newton's laws. If we use an elseif, we need fewer statements. Suppose the object's temperature is initially T(0) = 70°F and the bath temperature is 170°F. In this example, the values of g and L were encoded in the function pendulum(t, x). Multiplication and division of polynomials are easily done with MATLAB. Double-click on it, and type 10*sin(u) in the expression window. arrow pointing at the input port. By using a for loop. Just before the still is empty (L = 0), the liquid is pure toluene. Modules (functions) written for one application can be used for other applications (this is called reusable code). Solve the following equations: 15. Use the fit to estimate S when T = 25°C. We can determine the value of k by using the polyfit command as shown in the following script file, which is a continuation of the preceding script. Its syntax is eig(A), where A is the matrices C and D tell Simulink that there is one output. (Answer: There are an infinite number of solutions. Create a structure array that contains the conversion factors for converting units of mass, force, and 114 distance between the metric SI system and the British Engineering System. For example, typing x = sym(x') creates the symbolic variable with name x, and typing y = sym(x') creates the symbolic variable with name x. the free-body diagram, where T 1, T 2, and T 3 are the tension forces in the supports. When you have finished this chapter, you should be able to Use MATLAB to numerically evaluate integrals. A common criterion for obtaining the straight line that best fits the data is the least-squares criterion. Figure 4.1-1 shows the structure chart of such a program. Any other response is treated as a No answer. Electrical resistors are said to be connected "in series" if the same current passes through each and "in parallel" if the same current we see that the higher the sampling frequency, the better is our representation of the function. This depends on the application that produced the original equation. The solution for the coefficients is given by a = X. For example, >> syms b s >> ilaplace(1/(s+b)) ans = exp(-b*t) 535 >> ilaplace(b/(s^2+b^2)) ans = t^3/6 >> ilaplace(b/(s^2+ sin(b*t) The transforms of derivatives are useful for solving differential equations. MATLAB can also solve delay-differential equations (DDEs) such as See the help for the functions dde23, ddesd, and deval. cos 80° d. Open the Editor, type in the M-file that forms the basis of the report, and save it. For example, to evaluate the polynomial f(x) = 9x 3 -5x 2 + 3x + 7 at the points x = 0, 2, 4, ..., 10, type >> f = polyval([9, -5, 3, 7], [0:2:10]); The resulting vector f contains six values that correspond to f(0), f(2), f(4), ..., f(10). +NumberOfPears FruitPurchased = 47 Tab Completion MATLAB suggests corrections for syntax errors, which are incorrect expressions in the MATLAB language. Formulas exist for the roots of third- and fourthdegree polynomials but they are complicated. The power function y = bx m gives a straight line when plotted on log-log axes. 200 echo Traces program execution. To compute the probability of a height lying between 67 and 69 in. This function finds the coefficients of a polynomial of specified degree n that best fits the data, in the so-called least-squares sense. 12. This gives the Simulink diagram shown in Figure 10.10-6. The differential equation model for a certain position is x d (t), and K p , K I , and K D are constants called the "control gains." Use the Laplace 557 transform method to find the unit-step response (that is, x d (t) is a unit-step function). Refer to Problem 15. Convert higher-order ordinary differential equations. The required derivatives are calculated from the differential equations. The required derivatives are calculated from the differential equations. (see Table 2.1-1). xlabel('Time'), ylabel('Response') The result is shown in Figure 9.5-6. If it were very large, we might be suspicious. They are called short-circuit operand. To open a figure file, select Open from the File menu or click their second operand only when the result is not fully determined by the first operand. To open a figure file, select Open from the File menu or click their second operand only when the result is not fully determined by the first operand. Open button (the opened folder icon) on the toolbar. If so, then PI control is used, and this often eliminates any steady-state error. Test scores. Figure 7.4-1 A plot of temperature data versus time. From physics we know that the following relations result from Newton's laws and the basic kinematics of an object falling a short distance under the influence of gravity, with no air drag or initial velocity: a. Use the data in the table to write two equations in terms of x, y, and z. Use the MATLAB Help facilities to find information about the following topics and symbols: plot, label, cos, cosine, :, and *. The solubility of salt in water is a function of the water temperature. Suppose that the histogram indicates that the price is normally distributed with a mean \$100 and a standard deviation of \$5. An ASCII file may have one or more lines of text, called the header, at the beginning. In addition, y is not normally distributed. 16, 26 format + Positive, negative, or zero. Table 3.1-2 lists the MATLAB trigonometric functions that operate in radian mode From Equations (8.3-4) and (8.3-5), we obtain x = 6.36 and y = 0 tons. The generalization of arrays with more than one row or column is straightforward. When the optional parameter 'v' is used, the coefficients are returned as vectors rather than as cell arrays. (b) A spherical balloon expands as air is pumped into it. The choicees that are returned as vectors rather than as cell arrays. between a space or comma is a matter of personal preference, although the chance of an error is less if you use a comma. Spline interpolation obtains an exact fit that is also smooth. Consider the liquid-level system shown in Figure 10.7–1. The output variable y will have as many columns as there are inputs to the block. Because polynomial integrals
can be obtained from a symbolic formula, the polyint function is not a numerical integration. Does it reach 200 m? 5 Conventions In this text we use typewriter font to represent MATLAB commands, any text that you type in the computer, and any MATLAB responses that appear on the screen, for example, y = 6*x. (Answer: The polynomials are 9.5714x + 7.5714; -3.6964x 2 + 28.0536x - 4.7500; 0.3241x 3 - 6.1270x 2 + 32.4934x - 5.7222; and <math>2.5208x 4 - 24.8843x 3 + 71.2986x 2 - 39.5304x - 1.4008. We choose the time increment 0.0001 to be a very small fraction of the total time, 0.6 s. The 434 integral term "never gives" up"; it keeps changing the actuator output as long as the error is nonzero. 246 fimplicit 515 Plots an implicit function. The time constant is 0.2 and the response will oscillate with a radian frequency of 4. Note that the original values of the variables r and V are replaced with the new values. Test your script for the values W = 6 m and A = 80 m 2. Consider, as a very simple example, the following sample file polyplot.m. %% Example of Report Publishing: % Plotting the cubic $y = x^3 - 6x^2 + 10x + 4$. 247 semilogx Creates semilog plot (logarithmic abscissa). Do not change the default value of any other parameters in this window. The matrix D can be used to preserve matrix C in symbolic form. The ceil function (which stands for "ceiling") rounds to the nearest integer toward ∞ . v = g*t; % % Output section: plot(t,v),xlabel('Time (seconds)'), ylabel('Speed (meters/second)') After creating this file, you save it with the name Falling Speed.m. To run it, you type Falling Speed (without the .m) in the Command window at the prompt. Vectors with three elements can represent position, velocity, and acceleration. A common model for this process is where C(0) is the initial concentration, t is time (in hours), and k is called the elimination rate constant, which varies among individuals. specified at some initial time, which is usually taken to be t = 0. Tangent; tan x. A local maximum or local minimum (one that does not occur at one of the boundaries x = a or x = b) can occur only at a critical point, which is a point where either df/dx = 0 or df/dx does not exist. However, one advantage of MATLAB is that it requires relatively simple programs to accomplish many types of tasks. initial (sys,x0) Computes and plots the free response of the LTI object sys given in state-model form, for the initial conditions specified in the vector x0. Index.....Page 538 Citation preview 2 3 i MATLAB ® for Engineering Applications William J. 328 Write a MATLAB script file that uses given values of the applied voltages v 1 and v 2 and given values of the five resistances to solve for the currents i 1, i 2, and i 3. EXAMPLE 6.2-3 Modeling Bacteria Growth The following table gives data on the growth of a certain bacteria population with time. 391 integral2 Numerical integral2 Numerical integral2. Let r = rank[A]. The round function rounds to the nearest integer. The capacitance of two parallel conductors of length L and radius r, separated by a distance d in air, is given by where ε is the permittivity of air ($\varepsilon = 8.854 \times 10 - 12$ F/m). Its initial velocity is v(0) = 3 m/s up the incline. Greater discussion of engineering problem solving can be found in [Eide, 2008]. >> second = double(subs(second, 2008)) = 3 m/s up the incline. {th,d,h},... Student number. Any character immediately following the differentiation operator is taken to be the dependent variable. This feature allows you to name subfunctions without being concerned about whether another function exists with the same name, so you need not choose long function names to avoid conflict. The SI unit for q is the variable. watt (W), which is 1 joule/second (J/s). For example, typing r = [0; 4; 3; 6] creates a column array with four rows and one column. It consists of a rectangle of length L and width W, and a right triangle that is symmetrical about the central horizontal axis of the rectangle. So, for example, sort(A, 2, 'descend') would sort the elements in each row of A ir descending order. If it is inconvenient to edit the data file, the MATLAB environment provides many ways to bring data created by other applications into the MATLAB workspace, a process called importing data, and to package workspace 141 variables so that they can be exported to other applications. This syntax enables you to customize your plots with colors, spacing, labels, and shading. For example, embedded controllers can greatly increase the performance of orthopedic devices. Section 7.4 24.* a. (To do this for a larger file, you may use the cell mode of the Editor; use a simpler set of data, if necessary. MAT-files contain a machine signature that allows them to be transferred between machines. If the system is stable, its time constants are the negative reciprocals of the real parts of any complex roots. functions provide a quick way of making a function from any MATLAB expression without the need to create, name, and save a file. To obtain greater accuracy, we can use polynomials of degree higher than 2. Once it is published in HTML, you may click on a section heading in the Contents to go to that section. Determine the quality of the curve fit for each by computing J, S, and r 2. Select and place this block as shown. Find the results of the 197 following operations by hand and use MATLAB to check your results. Label it Disturbance Step as shown in Figure 10.4-9. = sqrt(13:3:25); = cos(x) 41 To create this new M-file when in the Command window, select New Script from the HOME tab. These are 353 called subdeterminants. For water, C d = 0.6 is a common value. [-] specifies left-justified. The test requires that we first form the augmented matrix [A b]. Contour plots and surface plots can be used together to clarify the function. Note how the steady-state response and the time to reach that state are automatically determined. Type realmax and realmin in MATLAB to determine how many more traffic sensors need to be installed, and obtain the expressions for the other traffic flows in terms of the measured quantities. PRIMARY FUNCTION ANONYMOUS FUNCTIONS SUBFUNCTIONS NESTED FUNCTIONS PRIVATE FUNCTIONS The primary function is the first function in an M-file and typically contains the main program. 500, 505 expand Expands an expression by carrying out powers. The histogram should resemble a bell-shaped curve. Only the real part of complex numbers will be displayed with the fprintf command. x = s0*cos(th)*t; function y = ycoord(t,s0,th,g); % Computes projectile vertical coordinate. Subfunctions are normally "visible" only to the primary function s outside the file. (a) Find the characteristic polynomial and the characteristic roots. The four-sided figure shown in Figure P34 consists of two triangles having a common side a. To display the Property Inspector, click on the More Property Inspector, click on th the left in Figure 5.2-2. The polyval function is very useful for plotting polynomials. Solution (a) Torricelli's principle in hydraulics states that f = rV 1/2, where f is the flow rate through the outlet valve in cups per second, V is the volume of liquid in the pot in cups. press Enter and retype the line correctly. Subfunctions are normally visible only to the primary function and other subfunctions in the same file. (9.3-13) Use MATLAB to solve this equation to determine how long it will take for the tank to empty if the initial height is 9 ft. For the weight to remain stationary, the total horizontal force and total vertical force must each be zero. 77 Element-by-Element Exponentiation MATLAB enables us not only to raise scalars and arrays to powers. For this set, the vector x and the matrices A and B are The equation |SI - A| = 0 is the characteristic roots of the model. Uses the starting value x0 to find a zero of the single-variable function. The photo above shows the 1149-ft-high Las Vegas Stratosphere Tower, the tallest observation tower in the United States. The number of C, O, N, and H atoms on the left must balance those on the right side of the equation. The data are as follows: Temperature (°F) Time Location 1 Location 2 Location 3 7 A.M. 49 52 54 9A.M. 57 60 61 11A.M. 71 73 75 12 noon 75 79 81 We define x as before, but now we define y to be a matrix whose three columns contain the second, third, and fourth columns of the preceding table. Use random number generation to verify this statement for the case where z = x + y, where x and y are independent and normally distributed random variables. Table 9.5-2 Basic syntax of the LTI ODE solvers Command Description impulse (sys) Computes and plots the time to the time to the trajectory is symmetric, the time to the ti reach y max. To plot only x 2, type plot(t,x(:,2)). Type vpa(E,d) to compute the expression E using d digits. 162 The arithmetic operators +, -, *, /, and \ have precedence over the relational operators. How many of the unknowns will be undetermined? 40 Table 1.4-1 System, directory, and file commands Command Description addpath dirname cd dirname dir Adds the directory dirname to the search path. The graph updates as you uncheck each box and rescales the axes as required. EXAMPLE 2.4-1 Miles Traveled Table 2.4-1 gives the speed of an aircraft on each leg. {thmin(4),310,33})) second = $0.0321 > v2 = (g*d^2/2)*f$; 518 >> v2min = subs(v2,{d,h,g},{310,33,32.2}); >>vmin = double(subs(vmin(1), {th,d,h,g},... Thus when one team made a design change, the database was updated, allowing the other teams to see whether the change affected their subsystem. 254 273 255 CHAPTER 6 Model Building and Regression OUTLINE 6.1 Function Discovery 6.2 Regression 6.3 The Basic Fitting Interface 6.4 Summary Problems An important application of the plotting techniques covered in Chapter 5 is function or "mathematical function point specified by its (x,y) coordinates, we need to compute the rotational
displacement required for each wheel. Structured Programming is a technique for designing programs in which a hierarchy of modules is used, each having a single exit point, and in which control is passed downward through the structure without unconditional branches to higher levels of the structure. For example, suppose that $y = \ln x$ if $x \ge 5$ and that if $0 \le x < 5$. (Hold down the left button on the mouse to move the box.) Another way to distinguish curves is to place a label next to each. You enclose the text within single quotes. This feature allows us to write generally useful functions using variables of our choice, without being concerned that the calling program uses the same variable names for other calculations. The plotting interface then displays the Property Editor—Lineseries. Function Browser This provides guick access to the documentation for MATLAB functions. With the outlet valve open, the faucet's flow rate was adjusted until the water level remained constant at 15 cups, and the time for one cup to flow out of the pot was measured. Develop a procedure for computing the length of side c 2 if you are given the lengths of sides b 1, b 2, and c 1 and the angles A 1 and A 2 in degrees. Use (7.2-2) with b = 68, that is, To determine how many men are within 3 in. b) Suppose the disturbance is a step function with a magnitude of 100 and a step time of 0.1. Run the simulation and plot the speed. m = 3, c = 39, and k = 12029. This section covers the basic features of these functions. Thus C = A + B implies that $c_{ij} = a_{ij} + b_{ij}$ if the arrays are matrices. rng(s) Restores the settings of the random number generator back to the values captured previously by s = rng. Assume that we produce only what we sell. the numerical solution gives an accurate answer. Evaluate the sum of the second row of B. Polynomial Derivatives MATLAB provides the polyder function to compute the derivative of a polynomial. End of the time loop. Errors and Pitfalls 10. We know from physics and mathematics (see Chapter 8) that the displacement x as a function of time is given by The displacement is measured every 0.2 s. However, for more detailed applications, we eventually will want to save our work and perhaps our code to be reused. addresses, etc.) is ASCII. The differential equation model for a certain speed control system for a vehicle is where the actual speed is v d (t), and K p and K I are constants called the "control gains." Use the Laplace transform method to find the unit-step function). These usually require greater effort than the Test Your Understanding exercises. The command exist('mean') will return a 2. If instead of choosing Characteristics you choose Properties and select the Options tab, you can change the defaults for the settling time and rise time, which are 2 percent and 10 to 90 percent. The volume of a sphere is given by V = 4πr 3/3, where r is the radius. Use MATLAB to find the values and the indices of the elements in x that are greater than the corresponding elements in y. See the plot of both x 1 and x 2 versus t. 535 5. == Equal to. 504, 529 number and denominator of an expression. The numbers shown are the measured traffic flows in vehicles per hour. 258 The fmesh(f,xy interval) function generates a surface plot of a function f(x,y). Its compactness is a big advantage. z = (x = y) e. For example, are given by >>syms x >>limit(1/x,x,0,'right') ans = 477 inf Table 11.3-1 summarizes the series and limit functions. >>y = subfun demo([4, -4]) y = 1.1716 - 6.8284 If we had used the MATLAB M-function mean, we would have obtained a different answer, that is, >>a = [4, -4]; >>b = a - mean(a) b = 4 - 4 Thus the use of subfunctions enables you to reduce the number of files that define your functions. Use a plot of x versus L to solve the problem. Source: MATLAB Simulink model files have the extensions .slx, and .mdl for older files. 114 conj(x) 512 Complex conjugate of x. The default value is 10, which can be deleted and replaced with 13. Add each column and store the result in an array D. Section 10.9 34. You can specify line color, line style, and marker for each system, for example, lsim(sys1,'r',sys2, 'y--',sys3,'gx',u,t). You will see A = 'Walden Pond' [1x3 double] 'June 13, 2016' [3x3 double] You can use the celldisp function to display the full contents. Structured programming, if used properly, results in programs that are easy to write, understand, and modify. The controller algorithms are adaptive in that they can be tuned to an individual's characteristics and their settings changed to accommodate different physical activities. Because this will eventually produce increasing positive values for the location x, we say this is a random walk with drift. Note that there is a definite pattern in the residuals of the linear fit. Second Arithmetic operators and logical NOT (~); evaluated from left to right. xlabel('Thread Strength (N)'),... title('Relative Frequency Histogram for 100 Tests') The result appears in Figure 7.1-3. Each of the following examples illustrates how pseudocode can document each of the control structures used in algorithms: sequential, conditional, and iterative operations. Solve the following problems using matrix inversion. The smaller τ is, the faster the oscillations die out. Consider the simplest example. Two similar mechanical systems are shown in Figure P39. x = -15.685 and $x = 0.8425 \pm 3.4008i$. If any of the elements are complex, max(A) returns the elements that have the largest magnitudes. The nature of threedimensional plots itself is quite involved, because the viewer's point of view can affect how much information and understanding can be obtained from the graph. >>syms x >>x = solve(x+3=0) x = -5 To solve the equation $e^2 x + 3e x = 54$, the session is >>syms x >>x = solve(x+3=0) x = -5 To solve the equation $e^2 x + 3e x = 54$, the session is >>syms x >>x = solve(x+3=0) x = -5 To solve the equation $e^2 x + 3e x = 54$, the session is >>syms x >>x = solve(x+3=0) x = -5 To solve the equation $e^2 x + 3e x = 54$, the session is >>syms x >>x = solve(x+3=0) x = -5 To solve the equation $e^2 x + 3e x = 54$, the session is >>syms x >>x = solve(x+3=0) x = -5 To solve the equation $e^2 x + 3e x = 54$. answer is $\ln(9) + \pi i$, which is equivalent to $\ln(-9)$. The magnitude and angle of . The input variables need not be assigned values outside the function to plot the distance, speed, or both. For example, the heights of the scaled histogram rectangles corresponding to heights of 67 through 69 in. Thus (8.3-1) The MATLAB function norm(v) computes the Euclidean norm. The Basic Fitting interface, which is available on the Tools menu of the Figure window, can also be used for cubic spline interpolation. (b) Log-log plot of the function. The halflife of a medication is the time required after an initial dosage for the concentration to be reduced by onehalf. s/rad, and $I = 6 \times 10^{-5} \text{ kg}$. If A and B are $3 \times n$ matrices, cross(A, B) returns a $3 \times n$ matrices, cross(A, B) returns a $3 \times n$ matrices. keep this in mind when using rapidly changing or discontinuous inputs. Use the fzero function to 147 solve this equation for t, and calculate the population at that time. This feature enables engineers to solve problems of 154 great complexity or requiring numerous calculate the populations. 574 set Used with a handle to set an object's properties. The response for g = 5 is found by typing >> syms s >> ilaplace((1+5*s)/(s*(s^2+1.4*s+1))) 490 The response obtained is (11.5-19). You can use the matrix inverse method, if the inverse exists, or the left-division method (see Chapter 8 for a discussion of these methods). 39. To remove a directory from the search path, use the rmpath command. Rounded to one decimal place, the answer is 8.2 million vehicles. Its properties are displayed in the Property Editor—Lineseries box, which opens on the bottom of the figure. For example, the result 472 can be obtained with the session >> syms n x >> int(x^n,n) ans = x^n/log(x) The form int(E,a,b) returns the integral of the expression E with respect to the default independent variable evaluated over the interval [a, b], where a and b are numeric expressions. Functions so defined are said to be nested within the main function. For x = 0, 1, and 2, use MATLAB to compute the following expressions. The mass inflow rate is a step function. The matrix multiplication gives We can perform similar multiplication for products 2 and 3, using the data in the table. Section 1.6 39. How much initial speed must the bar have to reach this height? If C is the product AB, then C has dimension $m \times q$ and its elements are given by (2.4-5) for all i = 1, 2, ..., m and j = 1, 2, ..., q. These include the stem, stairs, and bar plots. Determine also the minimum distance. Figure P46 401 438 Engineering in the 21st Century... Embedded Control Systems A n embedded control system is a microprocessor and sensor suite designed to be an integral part of a product. Write a MATLAB script file that uses given values of the applied voltage v and the values of the five resistances and solves for the six currents. Note that randperm calls rand and therefore changes the state of the generator. T2.5-5 Plot the polynomial over the range $-7 \le x \le 1$. This conversion process involves sampling the sound signal into discrete values and quantizing the numbers so that they can be represented in binary form. Type load census to load 291 this file. Generates an m \times n matrix containing random integer values between a and b. 200 dbstep Executes one or more lines. It is a function of the radian frequency ω of the input voltage. As a character string identifying the appropriate function M-file 2. The result is a value that is uniformly distributed in the interval (2, 10). Compare the results with the analytical solution, which is
y(t) = 2e - 10t. Write a program to determine how long it takes for the rocket to reach 40,000 ft if the burn time is 50 sec. H = 23 >> class(H) ans = double Sometimes MATLAB will display all zeros as the result of evaluating an expression, whereas in fact the value can be nonzero but so small that you need to evaluate the expression with more accuracy to see that it is nonzero. 68 Test Your Understanding T2.3-3 Given the vectors do the following by hand, then check your answer using MATLAB. 395 function A = integral(@cossq n,0,sqrt(2*pi)); % Nested function integrand = cossq n(x) integrand = cosscos(x, n); end end The session for n = 2 and n = 3 is as follows. From the derivative, If the time increment Δt is chosen small enough, the derivative can be replaced by the approximate expression (9.3-1) remains constant over the time interval (t, t + Δt), and replace Equation (9.3-1) by the following approximation: or (9.3-3) STEP SIZE The smaller Δt is, the more accurate are our two assumptions leading to Equation (9.3-3). The chapter then covers MATLAB commands for producing different types of plots and for controlling their appearance. With P control only, there is often a steady-state error. Test Your Understanding T4.5-4 Write a for loop that is equivalent to the command sum(A), where A is a matrix. (Answers: a. inv(A) Computes the inverse of the matrix A. Managing the work session. 16 -1/2 c. We sometimes must choose between a program that is concise, but perhaps more difficult to understand, and one that uses more statements than is necessary. It is defined as COEFFICIENT OF DETERMINATION 268 (6.2-3) For a perfect fit, J = 0 and thus r 2 = 1. >>x = -2:2 x = -2:1 0 1 2 >>k = (abs(x)>1) k = 1 0 0 0 1 >>z = x(k) z = -2:2 >>w = [1,0,0,0,1]; >>v = x(w) ??? However, it cannot handle arrays of values. = polyfit(time,log10(temp),1); = $p(1) = 10^p(2)$ The computed values are m = $-1.5557 \times 10 - 4$ and b = 77.4469. For example, if then max(A) returns the vector [3 + 4i, 0]. The optional parameter 385 'v' tells MATLAB to return the coefficients as vectors; 419 otherwise, they are returned as cell arrays. Similarly, the total labor and total transportation costs are the sums across the second and third rows of C. The answer is T 3 = 173.3333, the same as the minimum-norm solution given by the pseudoinverse method. Then place the Gain block and set its gain to 1/400. Problems.....Page 45130. 59 If A has one or more complex elements, the max, min, and sort functions act on the absolute values of the elements and return the element that has the largest magnitude. lsim(sys,u,t) Computes and plots the response of the LTI object sys to the input specified by the vector u, at the times specified by the vector u. The relay switches the output between two specified values, named On and Off in the figure. The values for f are obtained from the reciprocals of the given data for t. The break command, which terminates the loop but does not stop the entire program, can be used for this purpose. There is still much room for improved efficiency, and research and development engineers in this area will remain busy for some time. play(my voice); The extended syntax audiorecorder(Fs, nBits, nChannels) sets the sample rate Fs (in Hz), the sample rate Fs (in Hz), the sample size Bits, and the number of channels. So we can place some confidence in the numerical procedure. To insert an arrow, for example, click on the Arrow item; the mouse cursor changes to a crosshair style. The default MATLAB display format is the short format, which uses four decimal digits. 119 atanh(x) Inverse hyperbolic tangent; tanh -1 x. We cannot use this block for the damper function shown in Figure 10.9-3 FCN BLOCK 473 because we must write a user-defined function to describe it. 574 movie Plays recorded movie frames. 10.* A rocket's mass decreases as it burns fuel. Search for "markers" in MATLAB Help. However, in MATLAB Help. Ho numerical method to find the solution. The equation for the voltage y across the capacitor of an RC circuit is 396 where v(t) is the applied voltage. To set the properties 254 of an individual line, double-click on the line. The total mass in the tank is m = ρAh , and from conservation of mass we have (10.7-1) since ρ and A are constants. all(A) Returns a row vector having the same number of columns as the matrix A and containing 1s and 0s, depending on whether the corresponding column of A has all nonzero elements. For example, >>poly2sym([2,6,4]) ans = $2*x^2+6*x+4$ >>poly2sym([2,6,4]) ans = $5*y^2-3*y+7$ The function sym2poly(E) converts the expression E to a polynomial coefficient vector. The order of the arguments is important for such functions. Note that the value 10 then appears in the triangle. 394 EXAMPLE 9.1-2 Evaluated in closed form. 176 nargout Number of function output arguments. To avoid getting the same random number when MATLAB restarts, use the command rng('shuffle') before calling rand. 404 Equation (9.3-3) can be written in a more convenient form as (9.3-4) where t k +1 = t k + Δt. The 582 recordblocking function consists of the real values of T 1, T 2, and T 3 that minimize 334 To understand what MATLAB is doing, note that we can solve Equations (8.3-2) and (8.3-3) to obtain T 1 and T 2 = 480 - 2T 3. (Such a cell should not be confused with the cell array data type covered in Section 2.6.) Enter any blank lines you wish to

appear in the report. Because there are two or more state variables in a state model, we need to be able to specify which state variable, or combination of variables, constitutes the output of the simulation. For example, (2.3-1) Array subtraction is performed in a similar way. Select Property Editor from the View menu. Fill in the lines of the following constitutes the output of the simulation. table with the values that would be displayed immediately after the while statement if you ran the script file. What is the total spent in May? Consider the following equation. Assume that no vehicles stop within the network. Suppose that f(t) = 0 for t < 0 and f(t) = 10 for $t \ge 0$. Thus arctan(1) = 225° is also correct. Year Temperature (°C) 2000 2001 2002 2003 2004 21 18 19 20 17 22. Double-click on it, and set the Display option to signals. Mechanical Engineers' Handbook. The graphics functions and files. w = |u||w|. How does the use of functions and files. w = |u||w|. the piston stroke depend on L 1 and L 2 ? Develop a subsystem block for one RC loop. Applying these principles to each beam using the free-body diagrams shown in Figure P37b, we obtain the following equations. 499 549 Suppose that the link lengths are L 1 = 3 ft and L 2 = 2 ft. The sheet lamination process bonds sheets of material to form an object. "Very close" if the guess is within 1 of the correct number. Test your function for the values W = 6 m and A = 80 m 2. One of the major engineering challenges of the 21st century will be to develop renewable energy sources. The joint angles are θ 1 and θ 2. 2.8 Summary You should now be able to perform basic operations and use arrays in MATLAB. The mathematical foundation of the least-squares method is presented in Section 6.2. Because we are assuming that our data will form a straight line, that is, a first-degree polynomial, which we will 276 Table 6.1-1 The polyfit function Command Description p = Fits a polynomial of degree n to data described by the vectors x and y, where x is the polyfit(x,y,n) independent variable. For example, the equation has the solution can be found with the following session. The enclosure is to be built to have an area A of 2000 ft 2. Is the response time what you would expect given the specified roots? Compute the corresponding height h. Sections 4.2, 4.3, and 4.4 deal with these decision-making functions. Create a user-defined function that accepts R as the only argument and computes A for a given value of V. However, the polar representation facilitates multiplication and division of complex numbers by hand. To do this, first click on the object, such as a plotted line, Figure 5.3-1 The Figure 5.3-1 The Figure toolbar displayed. = Ax + Bu, y = sys2 = tf(sys1) Creates the transfer function model sys2 from the state model sys1. Type C(3, 4) = {'30 mph'} to put the string in cell (3, 4). (-5 - 7i)y d. 32 format long 16 digits; 17.27484029463547. The characteristic polynomial has the form where The MATLAB script file is k = 5e+6;m = 1000; alpha = $k/(4*m*pi^2); p1 = [-1,0,2*alpha]; p2 = [-1,0,2*alpha^2]; p5 = conv(p1,p4); p6 = p5 + [0,0,0,0,p3]; r = roots(p6)$ The resulting positive roots and thus the frequencies, rounded to the nearest integer, are 20, 14, and 5 models of the nearest integer Hz. 2.6 Cell Arrays The cell array is an array in which each element is a bin, or cell, which can contain an array. 368 The denominator is given by den. T4.5-2 Use a for loop to determine the sum of the first 20 terms in the series $3k_2$, k = 1, 2, 3, . Time (min) $0 \ 1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ 9 \ 10$ Flow Rate (ft 3 /min) $0 \ 80 \ 130 \ 150 \ 160 \ 165 \ 170 \ 160 \ 140 \ 120$ Section 10.3 9. Symbolic Expressions You can use symbolic variables in expressions and as arguments of functions. The extended syntax is fcontour(f,xy interval). 447 5. Thus a useful function is meshc, which shows the contour lines beneath the surface plot. Set the Initial condition of the integrator to h20. 114 log10(x) Common (base 10) logarithm $\log x = \log 10 \times 114$ sqrt(x) Square root; 114 Complex functions Item Description Pages abs(x) Absolute value. 9th ed. >>x = 5 + y In addition to assigning values that are not known ahead of time, or for changing the value of a variable by using a prescribed procedure. Next, place the Signal Builder block, then double-click on it. For objects in orbit around the sun, the sun is at one of the focal points. Create a user-defined function that computes V and A from the arguments a and b. This was not true in earlier versions of MATLAB, so if you are using code created in an earlier version, you should 161 make the necessary changes before using it in MATLAB 6 or higher. To write these equations in matrix form, let x 1 = b, x 2 = d, x 3 = e, and x 4 = f. 122 † These functions return a value in radians. The distance traveled by each wheel is its radius multiplied by its rotational displacement. whereas in the mathematical literature the name Dirac delta function is used. Its coefficient of determination is r 2 = 0.9999. Discuss how the shape of the plot depends on the value of L 1. Write MATLAB expressions to do the following. The following example shows how this is done. 5. fill time = 1/(b*36^m) The predicted fill time for 1 cup is 4.2 sec. 331 PSEUDOINVERSE METHOD MINIMUM-NORM SOLUTION An equation set can be underdetermined even though it has as many equations as unknowns. If the applied voltage y(t) for s. Thus we estimate that T = 3. d = polyder(p1,p2) Returns a vector d containing the coefficients of the polynomial that is the derivative of the product of the product of the product of the polynomials represented by p1 and p2. In addition, the text can serve as a reference for later use. Infrastructure engineers must take advantage of new materials, inspection technology, construction technology, constructing technology, construction technology, construction technology, = ymin:yspacing:ymax, then this function will generate the coordinates of a rectangular grid with one corner at (xmin, ymin) and the opposite corner at (xmax, ymax). Where there are an infinite number of solutions, we must decide whether the solutions given by the leftdivision and the pseudoinverse methods are useful for applications. 22 Reference and Learning Aids The book has been designed as a reference as well as a learning tool. Built-in functions. (b) The simplifying assumptions. The best straight line in the least-squares sense is y = 0.9x + 11/6. randperm(n) Generates a random unique permutation of the integers from 1 to n. Type cellplot(A) to see this display for the cell array 90 A. Use the function file created for that problem to generate a surface mesh plot and a contour plot of x versus h and W for $0 \le W \le 500$ N and for $0 \le h \le 2$ m. Then type in the file, and run it to check your answers. 4.3 Logical Operators and Functions MATLAB has five logical operators, which are sometimes called Boolean operators (see Table 4.3-1)., x(n)-x(n-1)]. Example 11.2-2 in Chapter 11 shows how a trajectory for a robot hand can be planned to generate position commands for the arm motors. For v on the interval [10, 25] with a spacing of 1 degree. If the logical expression is true. the statements are executed. If you type get(h) you will see a very long list of properties. If you know the correct spelling of a MATLAB function, for example, disp, you can type help disp to obtain a description of the function. When internal numerical accuracy used by MATLAB 323 is insufficient to obtain a solution, it prints the message warning that the matrix is close to singular and that the results might be inaccurate. The indefinite integral exists, but the definite integral does not exist if the limits of integration include the singularity at x = 1. Estimated population in 1965 is 189 million.) 6.4 Summary In this chapter you learned an important application of plotting—function discovery—which is the technique for using data plots to obtain a mathematical function that describes the data. The bottom graph in Figure 7.4-5 compares the results of a cubic spline fit (using pchip), which is clearly a better choice here. \t Tab. 218 231 Table 5.1-2 Basic xy plotting
commands Command Description axis([xmin xmax Sets the minimum and maximum limits of the x and y axes. Solution of higher-order equations is covered in Section 9.4. When used to solve the equation , the basic syntax is (using ode45 as the example) [t,y] = ode45(@ydot, tspan, y0) where @ydot is the handle of the function file whose output must be t and y, and whose output must be t and y, and whose output must be t and y. be a column vector representing dy/dt, that is, f(t, y). Select and place the Step block from the Sources library. To the right of this toolbar is the Search Documentation box. Use MATLAB to determine all the local minima and local maxima, and all the inflection points where dy/dx = 0, of the following function. ans = $-y^2 x^3 i y^2 x^3 i y$ more than one variable in the expression, MATLAB assumes that the variable closest to x in the alphabet is the variables in a symbolic expression. (Answer: x = 5, y = 3) 546 11.7 Summary This chapter covers a subset of the capabilities of the Symbolic Math toolbox, specifically symbolic algebra, symbolic methods for solving algebraic and transcendental equations, symbolic calculus, including integration, differentiation, limits, and series, Laplace transforms, and selected topics in linear algebra, including symbolic methods for obtaining determinants, matrix inverses, and eigenvalues. Fit a first-degree polynomial, a second-degree polynomial, and a third-degree polynomial to these data. The number n must be a scalar integer. The expression for y(t) may be differentiated to obtain the expression for the vertical velocity: The maximum distance x max may be computed from x(t max), the maximum height y max may be computed from y(t max/2), and the maximum vertical velocity occurs at t = 0. The view function specifies the 3D graph viewpoint. Wires 1 and 2 can support no more than 1200 N each, wires 3 and 4 can support no more than 218 Figure P37 400 N each, and wires 5 and 6 can support no more than 200 N each. 286 EXAMPLE 6.2-1 Effect of Polynomial Degree Consider the data set where x = 1, 2, 3, . ans = NaN NaN NaN Because the ranks of A and [A b] are equal, a solution exists. In particular, it has the linearity 486 property, which states that if a and b are not functions of t, then (11.5-2) The inverse Laplace transform L -1 [Y(s)] is that time function y(t) whose transform is Y(s); that is, y(t)= \mathcal{L} -1 [Y(s)]. Using the rand function this way is equivalent to typing rand 100 times. In practice, the high-order derivatives can be difficult to calculate, and the series (9.3-9) is truncated at some term. Note that we must use the elementby-element operations for any operations involving function inputs that are arrays. Use $0 \le t \le 10\pi$ and a = 1. The command [A, B] = xlsread('filename') imports all numeric data into the array B. The state transition diagram shows how the new values of the state variables depend on both the previous values and the inputs a(k) and d(k). Section 2.5 treats polynomial applications. The manufacturer must now decide if this time is sufficient for the user to avoid overfilling. The doc Function function function function for the specified function function function function for the user to avoid overfilling. array, use the rmfield function. Find B raised to the third power element by element. For example, to change the element in row 1, column 3 of a matrix D to 6, you can type D(1, 3) = 6. It is obtained by continuing the session as follows: >>b = [-65; 16; 5]; >>x = A\b 326 x = 2.0000 - 4.0000 7.0000 This answer gives the vector x, which corresponds to the solution x 1 = 2, x 2 = -4, x 3 = 7. For example, use a scale in millions of dollars when appropriate, instead of a scale in dollars with six zeros after every number. 362 The basic syntax is summarized in Table 9.1-1. 502 2 (a) Obtain the Taylor series for e -x about x = 0, and integrate the first six nonzero terms in the series to find I. th = 45* (pi/180); g = 32.2; s0 = 105; % tmax = 2*s0*sin(th)/g; xmax = xcoord(tmax,s0,th,g); wax = vertvel(0,s0,th,g); wax = vertplot(xcoord(w,s0,th),vertvel(w,s0,th,g)),hold, h2 = plot(xcoord(w,s0,th,g)),sold, h2 = plot(xcoord(w,s0,th,g)),s');... axis([0 xmax -1.1*vmax]),xlabel('x'),... ylabel('x'),... ylabel('x'),experiment with different values of the guess is not within 3 of the correct number. After completing this section, which has simple examples, you may study the demo files, which are more advanced. Engines incorporate embedded controllers to improve efficiency. >> $f = @(x,y,z) x^2 + y^2 - z^2$; >> interval = [-5 5 -5 5 0 5]; >> fimplicit3(f, interval) Tables 5.4-1 and 5.4-2 summarize the functions introduced in this section. Use the half-life of carbon 14 to find the value of the parameter b, and plot the functions. Here are some examples. Similarly, we can use the other plot enhancement functions discussed in Sections 5.1 and 5.2 to add a title and text and to specify line type and color. 433 PID Control A common control algorithm. Enter and connect the remaining elements as shown, and run the simulation. The following table shows how many hours in process reactors A and B are required to produce 1 ton each of chemical products 1, 2, and 3. In nested loops, continue passes control to the next iteration of the for or while loop enclosing it. New York: McGraw-Hill, 2014. A subsystem block, once created, 423 can be used in other Simulink programs. A description of the achievement, its related engineering disciplines, and a discussion of how MATLAB can be applied in those disciplines accompanies each photo. 500, 505 poly2sym Converts a polynomial coefficient vector to a symbolic polynomial. The fixture weighs 400 lb, and its mass center is 4 ft from the right end. Some Simple Functions operate on variables within their own workspace (called local variables), which is separate from the workspace you access at the MATLAB command prompt. The electric potential field V at a point, due to two charged particles, is given by where q 1 and q 2 are the charges from the point (in meters), and $\in 0$ is the permittivity of free space, whose value is Suppose the charges are $q 1 = 2 \times 10 - 10$ C and q 2 = 4× 10 -10 C. if h p > h desired h = 0; k = 0; while h < h desired % Compute h until h = h desired. Click OK. 234 blue boundary to the left. You can use the form clear var1 var2 to clear the variables from memory, or you can use the clear function, x, y) Returns the Laplace (function, x, y) Returns the Lapla transform of function, which is a function of x, in terms of the Laplace variable y. The exponential function can never pass through the origin (unless of course b = 0, which is a trivial case). 420 386 Figure 9.5-2 Free response of the model given by Equations (9.5-5) through (9.5-8) for x 1 (0) = 5 and x 2 (0) = -2. The value of the base b corresponding to these values is b = 8.7738. If the function is not continuous, fzero might return values that are discontinuous points instead of zeros. T (°C) S (g NaCl/100 g H 2 O) 10 35 20 35.6 30 36.25 40 36.9 50 37.5 60 38.1 70 38.8 80 39.4 90 40 16. If checked, the evaluated results are displayed on the data plot. This gives 28 The session is shown below. If you get a warning message, center and scale the data by checking Center and scale x data in the Interface, and fit a cubic. Make sure the cursor is at the prompt in the Command window. Chapter 5: Advanced Plotting......Page 21319. Note how the height changes more rapidly when the tank is nearly full or nearly empty. For example, to create a new function g(t) = f(t + 2) - f(t), the session is >> syms f(t) >> g = subs(f,t,t+2) - f(t) 503 LAPLACE TRANSFORM Once a specific function is defined for f(t), the function g(t) = f(t+2) - f(t) for some MATLAB functions the argument is not restricted to being a vector; it can be a general array. $y = (x - 3)^{2}$ However, if you type by mistake $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you type $y = (x - 3)^{2}$ However, if you or extrapolate a fit. 426 Functions for creating and evaluating symbolic
expressions. It $x \ge 0 = sqrt(x)$ 169 end end 176 If x = -2, for example, no action will be taken. Extending this pattern, we can see that we must multiply the transpose of U by P. Key Terms Axis limits, 228 Contour plot, 258 Data symbol, 225 Overlay plot, 234 Polar plots, 234 Subplots, 234 following session. The appropriate function to solve such equations is the solve function. limit (E,v,a, Returns the limit of the expression E as the variable v goes to a from the direction specified by 'd') d, which may be right or left. To evaluate , you type sin(sqrt(x)+1). If data are not given for x = 0, proceed to step 3. This is the initial condition $\theta(0) = 0$ π/4. When they are vectors, each error bar is a distance of e(i) above and below the point defined by (x(i),y(i)). To load just some of your variables, say, var1 and var2, type load(myfile, var1, var2). Thus 75 percent of the freshman class returns as sophomores. 19, 114 log(x) Natural logarithm; ln x. For example, consider the following set: This set can be expressed in vector-matrix form as which can be represented in the following compact form (8.1-1), where we have defined the following matrices and vectors: In general, the set of m equations in n unknowns can be expressed in the following identities. Runge-Kutta Methods The Taylor series representation forms the basis of several methods of solving differential equations, including the Runge-Kutta methods. MATLAB is powerful enough to solve the robot arm equations, including the Runge-Kutta methods. can show that the solution for a first-order reaction (n = 1) is and the solution for a second-order reaction (n = 2) is The following data (from Brown, 1994) describes the gas-phase decomposition of nitrogen dioxide at 300°C. In the above examples, there were only a few numbers in the arrays x and y, and thus we could have obtained the answers by visual inspection. 108 34. The addition shown in Equation (2.3-1) is performed in MATLAB as follows: >>A = [6, -2; 10, 3]; >>B = [9, 8; -12, 14] >>A+B ans = 15 6 -2 17 Array addition and subtraction are associative and commutative. burn time. for p = 0:t hit/dt % Use a loop to compute the height vector. Both systems are examples of the more general differential equation (11.5-16) As noted earlier, you can use the heaviside function with the dsolve function to find the step response of equations containing derivatives of the input, but the resulting expressions are more complicated than those obtained with the Laplace transform method. Use the averaging principle developed in Problem 9 to find the temperature distribution of the plate shown in Figure P10, using the 3×3 grid and the given values T a = 150°C and T b = 20°C. SINGULAR MATRIX An ill-conditioned set of equations is a set that is close to being singular. We can use parentheses to change the order of precedence; for example, z = (5 > 2) + 7 evaluates to z = 8. These machines often use cubic splines to specify the path to be cut or the contour of the part to be shaped. Write a program that accepts a numerical value x from 0 to 100 as input and computes and displays the corresponding letters. grade given by the following table. Chapter 7 covers probability, statistics, and interpolations. Plot the contour plot and the gradient (shown by arrows) for the function Section 9.3 24. Section 9.4 32. When you Figure 10.2-2 Simulink model for $\dot{y} = 10$ sin t. For instance, all elementary mathematical functions such as log10 reside in the elfun directory, and the polynomial functions reside in the polyfun directory. MATLAB provides the mean(x), mode(x), and median(x) functions to compute the mean, mode, and median the corner of a square plate by measuring the distances x and y from the corner (see Figure 7.3-1). Thus we cannot use the interp1 function to estimate the temperature at 6 A.M., for example. Figure 10.7-9 is the block diagram of an armature-controlled dc motor, which may be converted to a subsystem block. The basic form, limit(E), finds the limit as x → 0. For example, note how the period after the code %6.3f appears in the output at the end of the displayed text. Figure 10.4-7a is a graph of the logic of a relay. The responses and hints are as follows: "You won" and then stop the game. log 2 c. MATLAB ignores any extra characters. 504 double Converts an expression to numeric form. Suppose that $\phi = 0$, $\omega = 2$, and τ can have values in the range $0.5 \le \tau \le 10$ sec. Given the data (y, z), the function by transformation x = 1/z. Verify the distributive property 38. >> syms b t >> laplace(t^3) ans = 6/s^4 >> laplace(exp(-b*t)) ans = 1/(s+b) >>laplace(sin(b*t)) ans = b/(s^2+b^2) Because the transform is an integral, its has the properties of integrals. Element-by-Element Multiplication MATLAB defines element-by-element multiplication only for arrays that are the same size. If it is not, use the mouse to move the cursor. 351 Figure P9 382 The plate's edges are insulated so that no heat can escape, except at two points where the edge temperature is heated to T a and T b, respectively. 437 46. In addition, it is often necessary to use data to estimate of the derivative (Section 9.2). The linear function y = mx + b gives a straight line when plotted on rectilinear axes. To solve the equation set Ax = b using the pinv function, you type x = pinv(A)*b. Suppose y = [-2.6, -2.3, 5.7]. Instead of using the default variable and signment statement. The RLC circuit shown in Figure P23 can be used as a narrow-band filter. This is useful if the main directory is used by several individuals including R. In MATLAB you type v = 2*r. These in order are a MATLAB user-defined file, a JPEG figure file, a MATLAB user-defined file. Type help graph3d to see a number of color maps to choose for map. Fit a series of cubic 318 splines to the coordinates, and plot the splines along with the coordinate points. C and F are the same; D and E are the same.) EXAMPLE 2.3-3 Transportation Route Analysis The following table gives data for the distance traveled along five truck routes and the corresponding time required to traverse each route. which arise in applications in all fields of engineering. Table 11.4-1 The dsolve Function Command Description dsolve(eqn) Returns a symbolic solution of the ode specified by the symbolic solution of the od polyfit(x,y,2); % Cubic fit p3 = polyfit(x,y,3); % Exponential fit p4 = polyfit(x,log10(y),1); % Residuals 271 res1 res2 res3 res4 = = = polyval(p2,x) - y; polyval(function is a built-in function such as sin. 253 Figure 5.3-3 The Figure window with the Plot Tools activated. The package is dropped from rest with no vertical or horizontal velocity. The command animated line that has no data, and adds it to the current axes. The absolute frequency is 4, and its relative frequency is 4/20, or 20 percent of the time. For functions, the syntax is echo function name on. The answer is 93. Make sure you know how to start and quit a MATLAB session. Save to workspace. 339 unmkpp Computes the coefficients of cubic spline polynomials. ELECTRONIC TEXTBOOK OPTIONS McGraw-Hill offers this text as an ebook. (b) To find the power P = v 20 for the syntax is echo function name on the answer is 93. Make sure you know how to start and quit a MATLAB session. /R, use array exponentiation and array of numbers 0, 0.5, 1, 1.5,...,180. b1 = 68; P1 = (1+erf((b1-mu)/(s*sqrt(2)))/2 % How many are within 3 inches of the mean? If the sensor is "perfect" then b = c and e = r - c. Useful Features of the Editor Unless you will be using the Editor frequently, since you cannot create every type of function in the Command window. 475 Figure 11.3-2 The Live Editor displaying the operations used to obtain Equation (11.3-3). % Program animate3.m % Animation of a projectile using arrays. Display the current value of the counter. sum (A) Sums the elements in each column of the array A and returns a row vector containing the sums. Assume that the company can sell everything it produces. The max(A) function returns the algebraically greatest element in A if A is a vector having all real elements. Create simulations incorporating random processes. and $\sigma = 1.96$ in. 118 cos(x) Cosine; cos x. % Program animate2.m % Animates projectile motion. bar(x,y, 'w'') Creates a bar chart of y versus x using unshaded rectangles. Use MATLAB to plot the function T = 6 ln t - 7e 0.2t over the interval $1 \le t$ ≤ 3. If you bring that drive to use with MATLAB on another computer, say, in a public computer lab, you must make sure that MATLAB knows how to find your files. 15 eps Accuracy of floating-point precision. To create the 2 × 2 identity matrix, you type eye(2). The roots of the polynomial f(x) are the values of x such that f(x) = 0. (b) The following file uses the fact that the velocity can be expressed as where v(t 1) = 0. The loop variable must be changed somehow by the statements. Use matrices and MATLAB to solve the following. When you type a closing delimiter MATLAB briefly highlights and underlines in red the corresponding opening delimiter. What type corresponds to a saddlepoint? Understand the purpose of the problem. Find the product Ax. b. [12, 48, 42; 10, 40, 35; 6, 24, 21] b. * Table 1.6-1 Steps in engineering problem solving 1. Jenison; L. A building's natural frequencies are determined primarily by the masses of its floors and by the lateral stiffness of its supporting columns (which act as horizontal springs). (Hint: Be careful with β!) 146 Section 3.2 8. Upper-level engineering courses explain that for the RC circuit shown, this ratio depends on ω and RC as follows: where s = ωi. Enter your code in the Live Editor as you would in the Command window. shading interp % Use interpolated shading. Typing load file name loads data from the file called file_name. 452 Figure 10.4-3 Simulation diagram for $v = (80/9)\cos(\pi t 2/100)$. Measurements of a number of fittings show that the pitch
diameter of the thread is normally distributed with a mean of 8.007 mm and a standard deviation of 0.005 mm. For example, the statements $G = C\{1, :\}$ and $C\{1, :]$ and $C\{$ are both invalid. ln 2 d. Use your file to evaluate y for x = -5, x = 3, and x = 15, and check the results by hand. Source: MATLAB 421 Figure 10.5-5 Modification of the dead-zone model to export variables to the MATLAB 421 Figure 10.5-5 Modification of the dead-zone model to export variables to the MATLAB 421 Figure 10.5-5 Modification of the dead-zone model to export variables to the MATLAB workspace. Typing zeros(n) creates an n × n matrix of zeros, whereas typing zeros(m, n) creates an m × n matrix of zeros, as will typing A(m, n) = 0. In addition, we can use the other commands, such as grid, xlabel, and axis, in the same manner. T (°C) S (mmol O 2 / L H 2 O) 5 1.95 10 1.7 15 1.55 20 1.40 25 1.30 30 1.15 35 1.05 40 1.00 45 0.95 307 283 17. The equations for an armature-controlled dc motor are the following. The quotient is 2.8x - 5.12 with a remainder of 50.04x - 11.48. Investigate how well this scheme will work if the disturbance torque is a step function that increases from 417 Figure 10.4-8 An armature-controlled dc motor. Section 1.4 32. After a dose, the concentration of medication in the blood declines due to metabolic processes. Items in brackets are optional. Some common examples of the Taylor series are where a = 0 in all three examples. You can use array indices to extract a smaller array from another array. For example, to find the minimum of the polynomial over the interval [-10, 10], you type >>poly1 = @(x) 4*x.^2 - 50*x + 5; >>fminbnd(poly1, -10, 10) ans = 6.2500 If you are not going to use that polynomial again, you can omit the handle definition line and type instead >> fminbnd(@(x) 4*x.^2 - 50*x + 5, -10, 10) 137 Multiple-Input Arguments You can create anonymous functions having more than one input. The Predictor-Corrector Method The Euler method can have a serious deficiency in problems where the variables are rapidly changing, because the method assumes the variables are constant over the time interval Δt . amount = 500; k=0; while amount < 10000 k = k+1; amount = 1.0789e+004, or \$10,789, and k = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 14, or 14 years. 498, 504 digits used to do variable precision arithmetic. >>r = 8; >>h = 10, 000 k = 14, 0 15; >>V = pi*r^2*h; >>V = V + 0.2*V; >>r = (V/(pi*h))^(1/2) r = 8.7636 12 Thus the new cylinder must have a radius of 8.7636 m. 8 * Scalar and matrix multiplication operator. The third method is not discussed in this text because it is a slower method than the first two. Table 3.1-3 lists these hyperbolic functions and the MATLAB commands to obtain them. Compare each plot with the plot shown in Figure 1.6-3. The broker charges 5 cents per share traded with a minimum of \$35 per transaction. Obtain the absolute and relative frequency histograms. Compute the mean and variance of the length of the assembled product. Select and place the Scope block from the Sinks library. 16, 26 format rat Rational approximation. 164 || Short-circuit OR. However, if A is not square, the left-division method can give answers that might be misinterpreted. Interpolation is useful when one or more data points are missing. The steady-state response is indicated by the horizontal dotted line. It is important to write your programs to handle all such foreseeable circumstances. The equation for the voltage y across the capacitor of an RC circuit is 503 where v(t) is the applied voltage. The 70-ft-long mast weighs 500 lb. Test the file with the values L = 1 m, r = 0.001 m, and d = 0.004 m. Other line types can be used. 428 Consider the model of the height h of liquid in a tank, such as that shown in Figure 10.7-1, whose input is a mass flow rate q i. Find an expression for the half-life in terms of k, and obtain a plot of the half-life in terms of k, and obtain a plot of the half-life in terms of k, and obtain a plot of the half-life versus k for the indicated range. The syntax q = polyint(p, C) returns a polynomial q representing the integral sign J represents the integration process $y(t) = \int x(t) dt$, where x(t) is the cause (the input) and y(t) represents the effect (the output). Suppose that m = 1000 kg and $c = 500 \text{ N} \cdot \text{s/m}$. Because A is 3×3 and 356 rank(A) = 3, which is the number of unknowns, the solution is unique. The product of the polynomials f(x) and g(x) is Dividing f(x) by g(x) using synthetic division gives a quotient of with a remainder of -0.5833 +8.1667. If the mathematics produces multiple answers, do not discard some of them without considering what they mean. The power supply produces the fixed voltage v 1 and supplies the current i 1 required by the load, whose voltage drop is v 2. Underneath the Current Folder window is the Details window. Then our total profit P is Thus to maximize profit, we should choose z to be the smallest possible value, namely, z = 0. Create an anonymous function for 20x 2 - 200x + 3 and use it a. Underdetermined and overdetermined and overdetermined systems are also covered. Just remember to start with the input port. 295 GAUSSIAN FUNCTION NORMALLY DISTRIBUTED The normal probability function is described by the following equation: (7.2-1) It can be shown that approximately 68 percent of the area lies between the limits of $\mu - \sigma \le x \le \mu + \sigma$. EXAMPLE 6.1-1 Speed Estimation from Sonar Measurements Sonar measurements of the range of an approaching underwater vehicle are given in the following table, where the distance is measured in nautical miles (nmi). 333 Of course we have no reason to believe that the temperature follows the straight lines shown in the plot, and our estimate of 64°F will most likely be incorrect, but it might be close enough to be useful. Although it is not explicitly stated, you need to determine the maximum height from which the package can be dropped without damage. These are discussed in Chapter 5. syms y S = solve(4*cos(th1)+3 control codes and format codes. Thus we will not always need to use all the steps shown in Table 1.6-1. If you type Wednesday, this text will be stored in the string variable Calendar. EXAMPLE 9.3-1 Response of an RC Circuit Shown in Figure 9.3-1 can be found from Kirchhoff's voltage law and conservation of charge. Its syntax is p = polyfit, y,n). Its input is the state s, and its outputs are the result (1 for win, 0 for lose) and the new state s. isreal(A) Returns a 1 if A has no elements with imaginary parts and 0 otherwise. More than just computer-aided drafting, CAD and CAE include stress analysis on components and assemblies using finite element analysis (FEA). computational fluid dynamics (CFD) to calculate flow patterns and forces, multi-body dynamics, and optimization. 431 472 Figure 10.9-5 Simulation diagram of a vehicle suspension model. x = inv(A)*b Solves the matrix inverse. Operators C. (b) What is the free response in terms of x 0 and v 0 if m = 3, c = 39, and k = inv(A)*b Solves the matrix inverse. Operators C. (b)
What is the free response in terms of x 0 and v 0 if m = 3, c = 39, and k = inv(A)*b Solves the matrix inverse. 120? See the functions odeplot, odephas2, odephas2, and odeprint. Publishing Reports Containing Graphics. The basic syntax errorbar(x,y,e) plots y versus x with symmetric vertical error bars 2e(i) long. The simulation shows that this time is approximately 0.013 s. Check your answers with a calculator. 429 2. For example, the vector [4, -8, 7, -5] represents the polynomial 4x 3 - 8x 2 + 7x - 5. The ill-conditioned status depends on the accuracy with which the solution calculations are made. All generated inputs have unit amplitudes. 393 t = 0:10; a = [0,2,4,7,11,17,24,32,41,48,51]; v(1) = 0; for k = 0.013 s. Check your answers with a calculator. 429 2. For example, the vector [4, -8, 7, -5] represents the polynomial 4x 3 - 8x 2 + 7x - 5. The ill-conditioned status depends on the accuracy with which the solution calculations are made. 1:10 v(k+1) = trapz(t(k:k+1), a(k:k+1))+v(k); end disp([t',v']) The answers are given in the following table. Click the left-most icon to put the output inline; click the right. Let P be the selling price in dollars per gallon. 58 openvar Opens the Variable Editor. Figure 4.6-1 shows the flowchart of the while loop. Test Your Understanding T6.2-1 Obtain and plot the first- through fourth-degree polynomials for the following data: x = 0, 1, . across a row represents an increase in y. If you do not enter some information—for example, suppose you do not know someone's email address—MATLAB assigns an empty matrix to that field for that student. Section 1.1 provides an introduction to MATLAB as an interactive calculator. The system model from Newton's law is where m = 400 kg, f s (y - x) is the nonlinear spring function shown in Figure 10.9-2, and f d (y - x) is the nonlinear spring function shown in Figure 10.9-2. the cup is given by 2(1 - e -2t) in. Overloaded functions are functions that respond different types of input arguments. ylabel('text') Adds a text label to the vertical axis (the ordinate). 417 LTI ODE solvers Item Description Pages impulse Computes and plots the impulse response of an LTI object. 5th ed. block uses the variable u to represent the input to the block. The trapezoidal voltage function is then created with a for loop. 573 gtext Enables label placement by mouse. The meshgrid function generates the grid. Some common scaling methods are if the range of x is small, or 269 if the range of x is small, or 269 if the range of x is small. replace old with a numeric value new. linspace(a,b,n) Creates a row vector of n regularly spaced values between a and b. eye(size(A)) Creates an identity matrix the same size as the matrix A. The syntax to declare the variables A, X, and Q is global A X Q. How sensitive is your answer? Control codes can be placed within the format string. For example, x = 8; while x ~= 0 x = x - 3; end Within the loop the variable x takes on the values 5, 2, -1, -4, ..., and the condition x ~= 0 is always satisfied, so the loop never stops. 346 21. Determine what information you must find. At 10 A.M. the estimated temperatures are 64, 65.5, and 68°F. Are any of C, D, E, or F equal? The script should generate a random integer in the range 1, 2, 3, ..., 14, 15. For example, you can create a symbolic matrix A as follows. With Y(s) = 1/s, Equation (11.5-17) gives (11.5-18) The response for the case g = 0 was found earlier. It is possible to create an infinite loop, which is a loop that never ends. For example, with x = [6,3,9] and y = [14,2,9], typing z = 0 was found earlier. It is possible to create an infinite loop, which is a loop that never ends. For example, with x = [6,3,9] and y = [14,2,9], typing z = 0 was found earlier. x(x < y) finds all the elements in x that are less than the corresponding elements in y. Bursten. xii 17 SPECIAL REFERENCE FEATURES The text has the following special features, which have been designed to enhance its usefulness as a reference. The reason for using the brackets is as follows. The resulting equation will be of the form w = mu, and the coefficient m can be calculated using right division. Then the \mywork folder is a subfolder under the folder c:\matlab. Increment time from 0 to t hit. The time T is the dead time. Table 1.1-1 Order of precedence Table 1.1-2 Commands for managing the work session Table 1.1-3 Special variables and constants Table 1.1-4 Numeric display formats Table 1.1-5 Some commonly used mathematical functions Table 1.3-1 Some MATLAB plotting commands Table 1.3-2 53 System, directory, and file commands Table 1.4-1 Input/output commands Table 1.4-2 Key Terms Argument, 18 Array, 19 Array index, 20 ASCII file, 24 Command window, 5 Comment, 27 Current directory, 26 Data file, 24 Data marker, 23 Debugging, 32 Desktop, 5 Graphics window, 22 43 MAT-file, 24 Model, 35 Overlay plots, 22 Path, 25 Precedence, 8 Scalar, 8 Script file, 27 Search path, 25 Session, 7 String variable, 30 Variable, 6 Workspace, 12 Problems Answers to problems marked with an asterisk are given at the end of the text. The capacitor is initially charged to 100 V. Some functions are implemented in M-files. The remaining six chapters are independent of each other and cover more advanced applications of MATLAB, the Control Systems toolbox, Simulink, and the Symbolic Math toolbox. Function files are not converted. For example, typing B = A(:, 5:-1:1) reverses the order of the columns in A and produces Suppose that C = [-4, 12, 3, 5, 8]. Problems......Page 40228. Note how the function tests for an improper input (a term outside the range of 0.5 to 5 years). Fit polynomials of first through fourth degree to this data and compare the results. > syms x y >> eqn3 = $6^{x}+2^{y}=14$; >> eqn4 = $3^{x}+7^{y}=31$; > solve(eqn3,eqn4) ans = x: [1x1 sym] y: [1x1 sym] >> x = ans. x x = 1 >> y = ans. y 508 y = 4 >> [x, y] = solve(eqn3,eqn4) x = 1 y = 4 Solution structure with named fields (see Chapter 3, Section 3.7 for a discussion of structures and fields). 175 183 The break and continue Statements It is permissible to use an if statement to "jump" out of the loop before the loop variable reaches its terminating value. The exponential function y = be mx give a straight line when plotted on a semilog plot whose y axis is logarithmic. Clearly the fifth-order polynomial is less suitable for interpolation because of the large excursions it makes, especially over the ranges 0 < x < 1 and 4 < x < 5. A fenced enclosure consists of a rectangle of length L and width 2R, and a semicircle of radius R, as shown in Figure P13. 10.11 Summary The Simulink model window contains menu items we have not discussed. The MATLAB function name must be followed by a pair of parentheses that surround the argument. If $\varepsilon = 0$, the orbit is circular; if $0 < \varepsilon < 1$, the orbit is elliptical. All the MATLAB functions, which returns a unit impulse Interpolation and extrapolation are greatly aided by plotting the data. Use MATLAB to answer the following questions. *More Graphics 13. Use empty parentheses. 538 Figure 11.5-2 Two mechanical systems. Polynomial roots can be found with the roots(a) function, where a is the array containing the polynomial coefficients. Its syntax is trapz(x, y), where the array y contains the function values from the plot so that you can read values fr standalone on the supported hardware. Variable costs, labor costs, labor costs, labor costs, labor costs, labor costs, and energy costs. see also three-dimensional plots (xyz plots) surgery simulators, 112 symbolic constants, 497–498 symbolic differentiation, 496 symbolic expression, 495–497, 498–499 symbolic linear algebra, 542–545 Symbolic constants, 497–498 symbolic expression, 496–497, 498–499 symbolic linear algebra, 542–545 Symbolic expression, 496–497, 498–499 symbolic expression, 496–497, 498–498 symbolic expression, 496–497, 498–498 symbolic expression, 496–498 symbolic exp Math toolbox, 11, 496, 506, 534 symbolic processing, 495 symmetric matrix, 55 syntax errors, 13, 32 syntax highlighting, 121 T tab completion, 13–14 tabs, 5, 16, 17–18, 27
Taylor's theorem, 521-522 Taylor's theorem, 521 telesurgery, 112 terminating value, 179 three-dimensional plots (xyz plots) contour plots, 258–260 line plots, 255–256 surface mesh plots, 256-258 three-dimensional (3D) printing, 348 tilde, 163 time constants, 477 time history, 331 toolbar, 17 Tools menu, 251 Toolstrip, 5, 17, 120 top folder, 25 top-down design, 155-156 trajectory control, 481-484. A bin width of 1/2 in. 241 T5.2-3 Plot $y = \cosh x$ and y = 0.5e x on the same plot for $0 \le x \le 2$. Its solution can be represented symbolically as 404 BLOCK DIAGRAMS which can be thought of as two steps, using an intermediate variable x: This solution can be represented graphically by the simulation diagram shown in Figure 10.1-1a. 93 struct Creates a structure array. Double-clicking on any axis also brings up this box. You will then see the MATLAB Desktop. After this prompt, type y. diff(E,v) 469 taylor(f,x,a) Gives the fifth-order Taylor series for the function defined in the expression f, evaluated at the point x = a. The RLC circuit described in Problem 23 and shown in Figure P23 has the following differential equation model. Creation of user-defined functions is covered in Chapter 3. For example, >> syms x y >> factor(x^2-1) ans = (x-1)*(x+1) The function simplify(E) attempts to sinformation attempts to simplify(E) attempts to simpl shown in Figure 2.7-1 has two structures arranged in one row and two columns. Double-click on it, and set the Amplitude to 1, the Frequency to 1.4, the Phase to 0, and the Sample time to 0. Plot the motor's speed versus time for $0 \le t \le 0.3$ s. You can check for these errors by using a ruler and protractor to make a scale drawing of the triangle for several values of the angle A; measure the length d; and compare it to the calculated values. For other overdetermined systems, no exact solution method does not yield an answer, while in other cases the left-division method gives an answer that satisfies the equation set only in a "least-squares" sense. 60. The colon operator (:) easily generates a large vector of regularly spaced elements. To do this, we must first have a function is usually used in a for loop to assemble an array of movie frames. We will use this value as a "reality check" on our answer. t = 0:0.05:100; b = 1; p = plot(t,t.*exp(-t/b)); axis([0 100 0 10]), t = 2:20 set(p, XData', t, YData', t, YDatais a graphical interface for working with files and directories. Expand your program from part (a) to determine whether or not the projectile reaches a certain height yd, and find the statistical distribution of θ by creating random variables x and y that have means of 10 and 3.64, respectively, with a standard deviation of 0.05. A semilog plot has a log scale on only one axis. It computes the results on the screen. The straight-line distance between them is approximately 79 ft. The prompt in the Student Edition looks like EDU >>. Consider the following costs for a certain chemical product: \$3 million per year. For example, suppose that for $x \ge 0$ and that y = e x - 1 for x < 0. Then flip the block. Time (sec) Pressure (psi) 1 26.1 2 27.0 3 28.2 4 29.0 5 29.8 6 30.6 7 31.1 8 31.3 9 31.0 10 30.5 a. If this derivative is positive, the solution represents a minimum. Run the simulation for the case where $T(0) = 70^{\circ}F$, and T a (t) = 50 + 10 sin (π t/12). For example, to double the magnitude of the vector r = [3, 5, 2], multiply each component by 2 to obtain [6, 10, 4]. If $y(0) \neq 0$, try the exponential function. The last two buttons hide or show the plot tools and dock the figure if it is undocked. Deleting and Clearing Press Del to delete the character at the cursor; press Backspace to delete the character before the cursor. Output section In this section put the functions necessary to deliver the output in whatever form required. x = [4,-9,25]; if x < 0 disp('Some of the elements of x are negative.') else y = sqrt(x) end When this program is run, it gives the result y = 2.0 + 3.000i 5 The program does not test each element in x in sequence. The function of t for 31.0 $\leq t \leq t$ final , where t final is the final time entered by the user. You can, and should, use the Help system to learn how to use its features in greater detail. >> syms y(t) a >> dsolve(diff(y,t) == sin(a*t)/a Here is a second-order example. You can also print the diagram by selecting Print on the File menu. The first line in a function file must begin with a function definition line that has a list of inputs and outputs. For example, if we add zero to each element of B by typing B = B + 0, then B will be 158 converted to a numeric (double) array. Now write a function file that computes the values of x 1 and and stores them in a column vector. [30, 8; 35, 27] c. 552 Figure P24 25. rmpath dirname what Removes the directory dirname from the search path. z = B + 0, then B will be 158 converted to a numeric (double) array. sin x b. For such systems the left-division method generates an error message 360 warning us that the matrix A is singular. (Partial answer: The displacement after 10 s is 584.25 m.) Integration of Functions Another approach to numerical integration is Simpson's rule, which divides the integration range b-a into an even number of sections and uses a different quadratic polynomial to represent the integrand for each panel. The script file is given below. The result is r = -3. Run the simulation as before and observe the results in the Scope. Find the values of x and y at each minimum. Returns a row vector p of length n+1 that contains the polynomial coefficients in order of descending powers and a structure s for use with polyval to obtain error estimates for predictions. Fourth edition. In Test Your Understanding Problem T6.2-2 in Chapter 6, we used a cubic polynomial to estimate the population in 1965 to be 189 million. $[x,y] = meshgrid(-2:0.25:2); f = x.*exp(-((x-y.^2).^2+y.^2)); dx = x(1,2)-x(1,1); dy = y(2,1)-y(1,1); 402$ [df dx, df dy] = gradient(f, dx, dy); subplot(2,1,1) contour(x,y,f), xlabel('x'), ylabel('y'),... Personal experience has shown that is often is easier to use a combination of the drop-down menu under Breakpoints and the Command window. Any further plot commands issued from the Command window will direct the output to these axes. 447 Figure P30 31. For example to find the free response of the state model (9.5-5) through (9.5-8), for x 1 (0) = 5 and x 2 (0) = -2, first define it in statemodel form. For example, the probability that a circuit consisting of many components will fail is a function of the number and the age of the components, but we often cannot obtain a function to describe the failure probability Then the equation of motion is (10.10-6) where v is the velocity. t_hit = t_p + sqrt(2*h_p/g); % Compute time to hit. With directed energy deposition a high energy heating source such as a laser is used to fuse materials by melting. The first four sections of this chapter treat concepts that are essential to understanding MATLAB and therefore must be covered. To execute the function, type the name of the function handle, followed by any input arguments enclosed in parentheses. After placing the Transport Delay block, set the delay to 1.25. As another example, using tspan = [0, 5, 10] tells MATLAB to find the solution at t = 5 and at t = 10. Surface Mesh Plots The function z = f(x, y) represents a surface when plotted on xyz axes, and the mesh function provides the means to generate a surface mesh plot. From this we can estimate when the range will be zero: t = 3.9762/0.3286 = 12.1 minutes. This of course requires you to have some idea of the maximum actuator values. A MATLAB script file to predict the enrollment for the next 10 years appears in Table 4.9-2. In MATLAB we would write m = u'\w' where u and w are row vectors containing the transformed data. In general, the result is a linear combination of the variables. For example, the statements if logical expression 1 if logical expression 2 statements end end can be replaced with the more concise program 168 if logical expression 1 statement group 2 175 Figure 4.4-3 Flowchart for the general form of the if statement group 2 175 Figure 4.4-3 Flowchart for the general if structure. The command importdata can import other types of files besides text and data files, such as graphics files. For example, designers of submarine crew quarters need to know how small they can make bunk lengths without eliminating a large percentage of prospective crew members. End of the loop over years 2 to 10. z = 4 > (2 + 9) d. To find the highest average speed and the corresponding route, continue crew quarters need to know how small they can make bunk lengths without eliminating a large percentage of prospective crew members. the session as follows: >>[highest_speed, route] = max(speed) highest_speed = 54.3689 route = 1 The first route has the highest speed. (Pneumatic system composed of a tank of liquid of mass density ρ (Figure 10.7-1). After the grid is computed, you create the surface plot with the mesh function. Key Terms Anonymous functions, 135 Function definition line, 120 Function file, 120 asterisk at the end of the text. The kinematic equations describing the circuit shown in Figure P38 are a. To create a row vector z consisting of the values from 5 to 8 in steps of 0.1, you type z = 5:0.1:8. First consider an equation whose solution is known in closed form, so that we can make sure we are using the method correctly. A vector can have only one row. The basic syntax is diff(E), which returns the derivative of the expression E with respect to the default independent variable. If you now type length(student), you will get the result ans = 2, which indicates that the array has two elements (two structures). Recall that the definition of the data points and the scatter present in the data due to measurement error. Thus the system has a solution, and because the number of
unknowns (2) equals the rank of A, there is a unique solution. The tank shown in cross section in the figure is cylindrical with a bottom area A. Cotangent; cot x. Remember, 216 the company cannot make fractional units, so your answer must be in integers. From trigonometry we can derive the following expressions for the (x, y) coordinates of the hand. 436 b. This usage is no different than in mathematics. For example, the impulse function is similar to that of the initial function. 347 b. These features have more advanced features that will be useful in later chapters. These topics were treated in Section 3.3. In addition to function files, data files are useful for many applications. The following table gives the values of J, S, and r 2 for the first- through fourth-degree to fit the data x = 1, 2, 3, . The appropriate command depends on which axis must have a log scale. A(end, :) denotes the last row in A, and A(:, end) denotes the last row in A, and A(:, end) denotes the last row in A, and A(:, end) denotes the last row in A, and A(:, end) denotes the last row in A, and A(:, end) denotes the last column. This form aggregates the data into a number of bins between the minimum and maximum values in y, of uniform width automatically chosen to reveal the underlying distribution Suppose air is contained in a chamber at room temperature (20°C = 293 K). The following script file, named resist.m, uses the left-division method to solve the three equations for i 1, i 2, and i 3. Solution Because we do not know how many years it will take, a while loop should be used. New York: McGraw-Hill, 2007. 130 The syntax fzero(@f1,-0.5) is preferred to the older syntax fzero('f1', -0.5). The arrows represent the variables y, x, and f. Note that MATLAB automatically labels the plot, computes the steady-state response, and displays it with a dotted line. When the weight W is gently placed, it moves through a distance x before coming to rest. The results are d = L 1 - L 2 for A = 0° and d = L 1 + L 2 for $A = 180^\circ$. It also enables the robot arm's controller to prevent the surgeon from cutting outside the desired region. Indentations are used to emphasize the statement groups associated with each end statement. Now try 100 panels of equal width; replace the array x with x = linspace(0,pi,100). EXAMPLE 7.1-1 Breaking Strength of Thread To ensure proper quality control, a thread manufacturer selects samples and tests them for breaking strength. created by applying a sinusoidal input voltage to a hydraulic piston that has a dead-zone nonlinearity due to static friction. In fact, MATLAB uses this style for vector unless otherwise specified. 15 pi The number π.; Semicolon; suppresses screen printing; also denotes a new row in an array. The To Workspace block will enable you to plot x(t) and y(t)-x(t) versus t in the MATLAB Command window. Does μ z = μ x μ y? Conditional Operations Given the (x, y) coordinates (r, θ), where 1. The functions that operate in degree mode have the letter d appended to their names. Suppose the applied voltage is 20 V. The appropriate syntax is dsolve(eqn1,eqn2,...). For example, you may wish to store your files in the folder c:\mathematical line. TRANSPORT DELAY Let θ 1 (t) denote the incoming fluid temperature and θ 2 (t) the temperature of the fluid leaving the conduit. randn(m,n) Generates an m × n matrix containing normally distributed random numbers having a mean of 0 and a standard deviation of 1. Write a script file to play a simple number guessing game as follows. Its velocity is thus described by v = [0, 10, 0], and its position is described by r = [2, 10t + 3, 0]. int(E,v,a,b) Returns the integral of the expression E with respect to the variable v over the interval [a, b], where a and b are numeric quantities. Simulink @*, the topic of Chapter 10, is a graphical user interface for solving differential equation models. Many applications require us to know the temperature distribution in an object. 112 For chlorine (Cl 2), a = 6.49 and b = 0.0562. The power function is y = 2x - 0.5, and the exponential function is $y = 10 \ 1 - x$. A widely used alternative procedure is to fit the data points. Starting MATLAB DESKTOP To start MATLAB on a Windows system, double-click on the MATLAB icon. Using the scaled data, try three polynomial fits (linear, quadratic, and cubic), and an exponential fit. 331 Comparing the Results of Two or More Simulations, sometimes you will need to generate the same sequence of random numbers each time the simulation runs. Use your file to evaluate y for x = -5, x = 5, and x = 15, and x = and check the results by hand. Diver 1 swims 60 ft east, then 25 ft south, and then dives 30 ft. There will be as many curves as there are columns of A. If you need to compute probabilities based on the normal distribution, you can use the erf function. Problems......Page 28722. Of course, real sound contains more than one tone. Consider the secondorder equation (9.4-1) Solve it for the highest derivative: (9.4-2) Define two new variables x 1 and x 2 to be y and its derivative . Chapter 9: Numerical Methods for Calculus and Differential Equations.....Page 35827. 448 These equations are expressed in vector-matrix form as where 411 and x x To simplify the notation, let a 1 = k 1 /m 1, a 2 = c 1 /m 1, a 3 = k 1 /m 2, a 4 = c 1 /m 2, a 5 = k 2 /m 2, a 5 = k 2 /m 2, a 5 = k 2 /m 2, and a 6 = a 3 + a 5. However, typing A(3,4) = 5 will set A(3,4) to logical 1 and cause a warning to be issued. For the second case (a narrowband filter), R = 10 Ω . 219 3. % Basic data values. [u,v,w] = find(A) Computes the arrays u and v containing the row and column indices of the nonzero elements of the array A and computes the array w containing the values of the nonzero elements. Use the program developed in part a to find the currents for the case where R 1 = 1, R 2 = 5, R 3 = 2, R 4 = 10, R 5 = 5 k\Omega, and v = 100 V. 454 The Switch-on point parameter value must be greater than or equal to the Switch-off point value. statement group 1 if logical expression 2 statement group 2 end end Note that each if statement has an accompanying end statement. The fsurf(f,xy interval) function f(x,y). Write a program to determine the time at which the object is the closest to the origin at (0, 0). The y coordinates can be found in a similar way. The exponential function: y(x) = b(10) mx or its equivalent form y = be mx, where e is the base of the natural logarithm (ln e = 1). Therefore, we must make a few guesses for the range of x, using a session like the following. text(x,y, 'text') Places the string text in the Figure window at a point specified by coordinates x, y. If you prefer, you can substitute a To Workspace block for the Scope. See also pdeval. Complex Number Operations MATLAB handles complex number algebra automatically. function f = parabola(a, b, c), f = @p; % Nested function function y = p(x) and y = parabola(a, b, c), f = @p; % Nested function function f = parabola(a, b, c), f = @p; % Nested function f = parabola(a, b, c), f = @p; % Nested function f = parabola(a, b, c), f = @p; % Nested function f = parabola(a, b, c), f = @p; % Nested function f = parabola(a, b, c), f = @p; f = parabola(a, b, c), f = @parabola(a, b, c), f = @parabola(a, b, c), f = @parabola(6.2500 Note that the function p(x) can see the variables a, b, and c in the calling function's workspace. We do not discuss the following features of the Symbolic Math Toolbox: canonical forms of symbolic matrices; variable precision arithmetic that allows you to evaluate expressions to a specified numerical accuracy; and more advanced mathematical functions such as Fourier transforms. You can put several commands on the same line if you want to see the results of the previous command or semicolon if you want to see the torque constant and back emf constant, c is a viscous damping constant, and v(t) is the applied voltage. control valve whose rate of opening and closing is controlled by a rate limiter. 49. The find function is also useful when combined with the logical operators. 26 importdata Imports several different file types. You may nest them with for loops and if statements. Orbit B: p = 1.5, $\varepsilon = 0.5$. 10. What is the corresponding value of the height h? To use ode45, you type. The solution is m = 0.9 and b = 11/6. The second method uses the drawnow command. Obtain the plot for the case a = 1, b = 2. Answers to many end-of-chapter problems appear at the end of the text. Write a script file that first prompts a user to specify β, μ, and F 2 and then computes the force F 1. The fit results are displayed in the box below the menu. We want to develop a MATLAB program to compute and plot the distance d traveled by the piston as a
function of the angle A, for given values of lengths L 1 and L 2. The potential energy stored in a spring is kx 2 /2, where k is the spring constant and x is the compression in the spring. >>rng('default') Now, we initialize the generator using an arbitrary seed number, say 4. Then type 0 in its Lower Limit window. The 215 203 Figure P29 Customer x location (mi) y locat delivery cost c i for customer i depends on the volume V i and the distance d i from the distribution center. Write a program that computes the array B by computing the natural logarithm of all the elements of A whose value is no less than 1, and adding 20 to each element that is equal to or greater than 1. 312 7.1 Statistics and Histograms With MATLAB you can compute the mean (the average), the mode (the most frequently occurring value), and the median (the middle value) of a set of data. x y 0 2 5 6 10 11 285 According to the least-squares criterion, the line that gives the best fit is the one that minimizes J, the sum of the squares of the vertical differences between the line and the data points. (b) Suppose you want to move the hand along a straight, horizontal line at y = 1, for 2 ≤ x ≤ 4. MATLAB retains the last values for each axis before plotting the data. Test Your Understanding T1.1-2 Use MATLAB to compute the following expressions. These need to be repaired or replaced. The second column, and so on. In some technical specialties, such as signal processing and control systems, it is the standard software package for analysis and design. The planets have orbits that are nearly circular; comets have orbits that are nearly circular; comets have orbits that are nearly circular; comets have orbits that are highly elongated with e nearer to 1. You write and save MATLAB uses two types of M-files. script files and function files. The basic structure for the use of the else statement is if logical expression statement group 1 173 Figure 4.4-1 Flowchart illustrating two logical tests. The inputs and outputs may be arrays: [feet dropped, speed] = drop(32.2,10,0:1:5) This function call produces the arrays feet dropped and speed, each with six values corresponding to the six values of time in the array 0:1:5. 111 The number of newtons equivalent to 10 lb. The PID controller implements an algorithm that operates on the error signal e. Thus the fitted equation is r = -0.3286t + 3.9762. The lengths L 1 and L 2 and the angle A are given. Also plot the applied voltage versus time. landed on Mars in 2012 less than 2.4 km (1.5 mi) from its intended target after a 563,000,000 km (350,000,000 mi) journey. A 15-cup line. This is sometimes called the initial-condition response or the undriven response in the MATLAB documentation. Wind tunnel experiments for a particular airfoil have resulted in the following formulas. Refer to Table 2.3-1 for examples. Assuming that the batter must give to the ball in order to hit it over the Green Monster. Homework exercises conclude each chapter. We do not show this action with a separate symbol. Solution The program is shown below. There's also live online events, interactive content, certification prep materials, and more. Reports generated by the publish function may be exported to a 248 variety of common formats including HTML (Hyper Text Markup Language), which is used for Web-based reports, MS Word, PowerPoint, and L A T E X. Compare your plot with that shown in Figure 9.5-1. To do this: 420 1. Run the simulation by clicking on the Start Simulation icon on the toolbar. An international fishing boundary is described 245 by the line y = 2x + 6. u = x + y d. The session is >>R = [10000, 20000, 35000, 1000000, 100200000]; >>v = [120, 80, 110, 200, 350]; >>current = v./R current = 0.0120 0.0040 0.0031 0.0020 0.0018 The results are in amperes and should be rounded to three significant figures. Update the vector x, using x = Cx + b. Test Your Understanding T8.3-2 Use the rref, pinv, and the left-division methods to solve the following set. Specifically, if v i = Ai sin ωt , then v o = A o sin($\omega t + \phi$). This can happen if some of the equations are not independent. Continue the session as follows. Then double-click on the Scope block to view the response. Thus if we obtain the solution to Ax = b, the solution to Ay = bc is given by y = xc. How close does it approach Earth's orbit? MATLAB also has the sprintf function, which assigns a name to the formatted string, instead of sending it to the Command window. The advantage of using suitable variable names and comments is that they reside with the program; anyone who gets a copy of the program will see such documentation. Smart structures, which can detect impending failure from cracks and fatigue, are now close to reality, as are active structures that incorporate powered devices to counteract wind and other forces. (An alternative to this block is the MATLAB Function block to be discussed in Section 10.9.) Save the model and give it a name, such as Tank. Azimuth revolves about the z axis, with positive values indicating counterclockwise rotation of the viewpoint. Figure 6.3-1 The Basic Fitting interface. The use of function handles is now preferred, such as @RC_circuit. Given the matrices do the following by hand, then check your answer using MATLAB. Use the simulation to plot the response. Variable names must begin with a letter; the rest of the name can contain letters, digits, and underscore characters, but no spaces. In each case the symbol represents the 405 equation z = x - y. If you want to save the figure as another file type, such as JPEG, BMP, or PNG, select Save As. In the dialog box that appears you can select the desired type. The latter three elements can provide such an overview. It is a common application of plotting, and a separate section is devoted to this topic. Use the min function to determine with a resolution of 0.01 ft the values of R and L required to minimize the total cost of the fence. Right-click the file in the Current Folder browser and select Open as Live Script from the context menu. Use the fminbnd function to determine with a resolution of 0.01 ft the values of R and L required to minimize the total cost of the fence. Mathematical expressions are evaluated starting from the left, with the exponentiation operation having the highest order of precedence. followed by addition and subtraction with equal precedence. Cover.....Page 22. >> syms x >> int(x^2,2,5) ans = 39 The form int(E,v,a,b) returns the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the variable v evaluated over the integral of the expression E with respect to the
variable v evaluated over the variable v evaluated over the variable v evaluated over the variable v evaluated matrix: 64 If the matrix has many elements, you can press Enter and continue typing on the next line. Set the Stop time to 10, run the simulation, and examine the plot of θ(t) in the Scope. Figure 6.1-3 Range versus time: the sonar data and the fitted line. Start with the data for the first student. The Taylor series may 405 be used to represent the solution y(t + h) in terms of y(t) and its derivatives as follows: (9.3-9) The number of terms kept in the series determines its accuracy. Use this menu to select the data set to be fit. If a current $i(t) = 0.2[1 + \sin(0.2t)]$ A is applied to the capacitor, compute the voltage v(t) at t = 1.2 s if its initial velocity is zero. Create an anonymous function for 10e - 2xand use it to plot the function over the range $0 \le x \le 2$. The currents are i 1 = 0.9544, i 2 = 0.3195, and i 3 = 0.0664 mA, where 1 mA = 1 milliampere = 0.001 A. >> syms a L s y(t) >> Dy = diff(y,t); >> F = sin(t); >> F = sin(t); >> E = laplace(eqn,t,s); >> F = sin(t); >> F = sin(t); >> E = laplace(eqn,t,s); >> F = sin(t); >> F = s $= (a*y(0)+1/(s^2+1))/(a*s+1) 541 >> I = ilaplace(L) I = (sin(t)-a*cos(t))/(a^2+1) + (exp(-t/a)*(y(0)*a^2+1) + (exp(-t/a)*(y(0)*a^2+1)) + (exp(-t/a)*(y(0)*a^2+1)) + (exp(-t/$ generated M-File in the editor. Note how indenting improves the readability. No other straight line will give a lower value of J for these data. You can play two different sounds in sequence by concatenating them in a row vector, as sound([sound vector 2], Fs) if they have the same sampling frequency. Then MATLAB checks for a standard M-file on your search path. Figure 10.5-3 Modification of the dead-zone model to include a Mux block. For example, suppose the data for the independent variable is x = [15:2:23] and the dependent variable is x = [20, 50, 60, 90, 70]. Just make sure that they are sampled with the same frequency, have the same number of samples, suppose the data for the independent variable is x = [20, 50, 60, 90, 70].

and that their sum lies in the range -1 to +1. Estimate the range of the expected result and compare it with your answer. For A||B, if A is true, regardless of the value of B, the statement will evaluate to true. It must accept a vector argument x and scalar y, and it must return a vector result. This technology would allow delivery of medical services to remote areas. 329 The variables a, b, ..., f represent the masses of the products involved in the reaction. The closed-loop transfer function can be found with methods covered in texts dealing with 477 system dynamics and control systems. 15 NaN Undefined numerical result (not a number). Some calculators can solve equation sets that have many variables. Section 3.3 23. t = 0:10:4000; T = $68+b*10.^{(m*t)}$; subplot(2,2,3) semilogy(t,T-68,time,temp, 'o',t_120,120-68,'+'), xlabel('Time (sec)'),... 575 view Sets the angle of the view. When a structure array has more than one structure, MATLAB does not display the individual field contents when you type the structure array has more than one structure, MATLAB does not display the individual field contents when you type the structure array has more than one structure, MATLAB does not display the individual field contents when you type the structure array has more than one structure array has more than one structure, MATLAB does not display the individual field contents when you type the structure array has more than one structure array has more thas array has more than 51.3178 Thus there are two solutions. M., and R. The following equation describes the temperature T b (t). The components' lengths are L 1, 316 L 2, and L 3. 489 26. 301 Test Your Understanding T6.3-1 The U.S. census data from 1790 to 1990 is stored in the file census.dat, which is supplied with MATLAB. MATLAB includes some sound files. The syms command enables you to specify that certain variables are real. Three equal weights W are attached at the points shown. As we saw in Chapter 1, if file_name is a MAT-file, then load file_name is a MAT-file, then load file_name is a MAT-file into the MATLAB workspace. The package does not tumble (as it might when dropped from a moving truck). The Figure 5.3-1). Use MATLAB to find the following product: 49.* Use MATLAB to find the following product: 49. polynomial at specified values of its independent variables x and y are local to the function fun, so unless you assign them values outside of the function as was done in the first example, their values will be unavailable in the workspace outside the function. Now create a "bounding box" surrounding the diagram. The top graph in Figure 7.4-5 shows the results of fitting a fifth-order polynomial and a cubic spline to the data. Data on the vapor pressure P of water as a function of temperature T are given in the following table. [y,delta] = Uses the optional output structure s generated by [p,s,mu] = polyfit(x,y,n) to polyval(p,x,s,mu) generate error estimates. Estimate the percentage of fittings that will be within tolerance. Problems.....Page 32024. Note the use of the transpose operator on the vector unit cost. >>U = [6, 2, 1; 2, 5, 4; 4, 3, 2; 9, 7, 3]; >>P = [10, 12, 13, 15; 8, 7, 6, 4; 12, 10, 13, 9; 6, 4, 11, 5]; 80 Note that if we multiply the first column in U by the first column in P, we obtain the total materials cost for the first quarter. g = 9.8; v = 10:2:20; theta = 50:10:80; $h = (v'.^2)/(2*g)$; table = [0, theta; v', h] The arrays v and theta contain the given velocities and angles. The number of rows is always stated first! We sometimes represent a matrix A as [a ij] to indicate its elements a ij. For example, $7/2 = 2\sqrt{7} = 3.5$. PRECEDENCE The mathematical operations represented by the symbols + -*/ and $^{\circ}$ follow a set of rules called precedence. The data are repeated here. The Axes item lets you use the mouse to place a new set of axes within the existing plot. Its capacitance is C = 10 - 7 F. zeros(size(A)) Creates an array of 0s the same size as the array A. Note how the null array [] is used. It is $M = (r \times F) \cdot n$, where r is the position vector from the line to the point of application of the line. 114 floor Rounds to the nearest integer toward $-\infty$. 171 Typing if t >= 0.5 & t = 9 y(k) = 0.5 & t = 9 y(k) = 0.5 & t = 9 y(k) = 0.5 & t = 0 15*sqrt(4*x(k)) + 10; elseif x(k) >= 0 y(k) = 10*x(k) + 10; else y(k) = 10; end end plot(x,y), xlabel('x'), ylabel('y') Note that we must use the index k to refer to x within the loop, as x(k). The normal stages in the development of a new vehicle, such as an aircraft, formerly consisted of aerodynamic testing a scale model; building a full-size wooden mock up to check for pipe, cable, and structural interferences; and finally building and testing a prototype, the first complete vehicle. z = 6 > 3 + 8 b. Determining by hand whether all the equations, but it is easily done in MATLAB. Then transforming Equation (11.5-16) gives (11.5-17) Let us compare the unit-step response of Equation (11.5-16) for two cases using the values m = 1, c = 1.4, and k = 1, with zero initial conditions. This interpretation leads to various methods for computing the derivative of a set of data. Time (hours, P.M.) 1 2 3 4 5 6 Temperature (#x00B0;C) 10 9 18 24 ? We can also check the equation for singularities that might affect the numerical procedure. 336 pchip Interpolation using Hermite Polynomials. If the mass m is stationary, the sum of the tension components in the x, in the y, and in the z directions must each be zero. 8 - Minus; subtraction operator. Thus B becomes 66 Suppose that D = [3, 8, 5; 4, -6, 9]. These are summarized in Table 9.5-1. 104 35. So we must first develop a way to compute D L and D R. For example, this 207 information is important for controlling the material properties, such as hardness, when cooling an object formed from molten metal. Later we will discuss another integration function, the integral function, that can accept functions directly. The title function places the text at the point on the plot; the gtext function places the text at the point on the plot where the cursor is located when you click the left mouse button. LOG10(X) is the base 10 logarithm of the elements of X. This indicates that a polynomial degree higher than 3 will not be able to match the data curvature any better than the cubic. = 6:0.01:40; y = b*x.^m; subplot(2,1,1) loglog(x,y,cups,meas flow,'o'),grid,xlabel?('Volume (cups)'),... Improved robotic devices will make these probes more autonomous, and more capable of interacting with their environment, instead of just observing it. Obtaining these values can Figure 10.10-3 Simulink model of the simplest speed control system. Two methods can be used to create animations in MATLAB. The product AB has the same number of rows as A and the same number of columns as B. Use the input command to enable the user to select which function to plot. With relational operators that consist of more than one character, such as == or >=, be careful not to put a space between the characters. Something you might try on your own is to see what happens if L 1 \leq L 2 . % t r % Data = 0:2:10; = [3.8,3.5,2.7,2.1,1.2,0.7]; First-order curve fit. Compute the distance between diver 1 and the starting point. Loops 9. You can specify any variable name you want as the output; the default is simout. of the mean, use Equation (7.2-3) with a = $\mu - 3 = 66.3$ and b = $\mu + 3 = 72.3$, that is, In MATLAB these expressions are computed in a script file as follows: mu = 69.3; s = 1.96; % How many are no taller than 68 inches? Copyright.....Page 54. In a user-defined function, make the global command the first executable line. Table of contents : 1. Figure 2.7-1 shows a diagram of this data structure. This indicates that the linear function cannot match the curvature of the data. >>m1 >>k2 >>a1 >>a4 = = = 250; m2 = 40; k1 = 1.5e+4; 1.5e+5; c1 = 1917; k1/m1; a2 = c1/m1; a3 = k1/m2; c1/m2; a5 = k2/m2; a6 = a3 + a5; 6. Use g = 9.81 m/s 2. Algorithms and Control Structures An algorithm is an ordered sequence of precisely defined instructions that performs some task in a finite amount of time. Use the fimplicit function and the hold command to plot both ellipses on the same plot. for k = 2:10 % The following describes the admissions % and transfer policies. 464 Figure 10.7-3 Simulink model of the system shown in Figure 10.7-2. Thus for the vectors x and y the operations x'.* and y.* x' are not defined in MATLAB and will generate an error message. $\omega = 10$ rad/s 434 35. The function file is based on the last two equations. In Section 8.1 we introduce some matrix notation that is required for use with MATLAB and that is also useful for expressing solution methods in a compact way. der2 = polyder(p2) % Derivative of p1*p2. This process is called interpolation. For example, to generate values in the interval (2, 10), first generate a random number between 0 and 1, multiply it by 8 (the difference between the upper and lower bounds), and add the lower bound (2). (You can also use a comma followed by a space for maximum readability.) 53 To create a column vector, you can separate the elements by semicolons; alternatively, you can create a row vector and then use the transpose notation ('). which converts a row vector into a column vector, or vice versa. For several values of x, use MATLAB to confirm that ,x > 1 6. It also introduces the problem-solving methodology. If you first save it as another graphics file type (JPEG, etc.) you will no longer be able to edit it using the MATLAB to confirm that ,x > 1 6. It also introduces the problem-solving methodology. relative frequency histogram. Displays the MATLAB search path. A more accurate model of the diode's behavior is given by the offset voltage inherent in semiconductor diodes. The oval blocks are Input and Output Ports (In 1 and Out 1), which are available in the Ports and Subsystems library. The equation for a curve
called the "lemniscate" in polar coordinates (r, θ) is 498 Use MATLAB to find the equation for the curve in terms of Cartesian coordinates (x, y), where x = r cos θ and y = r sin θ . The top graph in Figure 7.4-4 shows the results of fitting a cubic polynomial and an eighth-order polynomial to the data. Plot y(t) for y(0) = (0) = 0. The following equations describe the speed v and height h of a rocket launched vertically, neglecting air resistance. 339 Table 7.4-2 Polynomial interpolation functions Command Description y est = interp1(x,y,x_est, method) Returns a column vector y est that contains the estimated values of y that correspond to the x values specified in the vector x est, using interpolation specified by method. To use the left-division method to solve for x, you type x = Ab. Once this file is run, the frames can be replayed as a movie by typing movie(M). Both arrays must be the same size. To mark each point with a plus sign +, the required syntax for the plot function is plot(x,y,'+'). x = input('text','s') Displays the text in quotes, waits for user input from the keyboard, and stores the input as a string in x. In Section 7.4 you will see how to use interpolation with data tables to estimate values that are not in the table. %e 531 Scientific format with lowercase e. In the next section we introduce matrix operations. EXAMPLE 3.4-1 Creating a Data File and Loading It into a Variable Create a file containing the following data, load the data into MATLAB, and plot it. Write a script file using conditional statements to evaluate the following function, assuming that the scalar variable x has a value. Typing fix(y) produces the answer -2, -2, 5. ~= Not equal to. The following equation has no analytical solution even though it is linear. The meshz function draws a series of vertical lines under the surface plot, while the waterfall function draws mesh lines in one direction only. n] = The vector breaks contains the x values, and other structures will use new technologies and new materials, some based on nature's designs. Appendix A is a complete summary of all the commands and functions described in the text, grouped by category, along with the number of the page on which they are introduced. The norm of residuals is a measure of the goodness of fit, where a smaller value indicates a better fit. Test your program with the values $\beta = 130^\circ$, $\mu = 0.3$, and F 2 = 100 N. 164 ~ Logical operator: NOT. A Control System The Simulink model shown in Figure 10.8-1 is for a specific type of control system called a PI controller, whose response f(t) to the error signal e(t) is the sum of a term proportional to the error signal and a term proportional to the integral of the error signal. The solution for b is . The Light item applies to three-dimensional plots. Figure 10.9-3 Nonlinear damping function. Redo part a, but plot A versus t on log-log and semilog plots. Problems.....Page 14916. The syntax yyaxis(x1,y1,x2,y2,'type1', 'type2') generates a 'type1' plot of y1 versus x1 with y axis labeling on the left, and generates a 'type2' plot of y2 versus x2 with y axis labeling on the right. The default is false. If we use the leftdivision method, MATLAB returns a message warning that the problem is singular, and it does not produce an answer. If h p < h desired End of the burn time loop. If y is the dependent variable, these conditions are specified as follows: y(a) = b, Dy(a) = c, D2y(a) = d, and so on. Each file type has its own icon. Plot the object's temperature T(t) as a function of time. 350 For example, MATLAB can obtain and plot equation solutions as we vary one or more parameters. However, multiplication of 71 two arrays is not so straightforward. Place the two integrators as shown, and make sure the initial values are set to 0. For example, is given by >> syms x y >> diff(x*sin(x*y),y,2) ans = $-x^3$ *sin(x*y), 515 Table 11.3-1 summarizes the differentiation functions. Thus the total material costs for the year are \$760,000; the labor costs are \$316,000. The logical expression here is x >= 0, and the statement is the single line y = sqrt(x). 26. The speed oscillates because when the applied voltage is zero, the speed decreases as a result of the back-emf and the viscous damping. The weight reduction can be achieved with all-aluminum unibody construction and by improved design of the engine, radiator, and brakes to make use of advanced materials such as composites and magnesium. To do this, select Save from the Figure window File menu or click the Save button (the data twice, once with a data marker and once without a marker. This character marks the beginning of a new cell, which is a group of commands. Pacific Grove, CA: PWS Publishing, 1999. 15. Solution methods for differential equations (which are discussed in Chapter 9) can show that the solution for a first-order reaction (n = 1) is The following data describe the reaction: 308 Use these data to obtain a least-squares fit to estimate the value of k. Maximum error = 0.2299.) Linear-in-Parameters Regression Sometimes we want to fit an expression that is neither a polynomial nor a function that can be converted to linear form by a logarithmic or other transformation. Fully label the plot and mark the breakeven point. The chapter gives an overview of the various types of problems MATLAB can solve. The poly(r) function computes the coefficients of the polynomial whose roots are specified by the array r. Imaginary part of a complex number x. The parallel form is the default fo produce an array result the same size as the array argument x. If A and B have the same size, C = max(A, B) creates an array the same size, having the maximum value from each corresponding location in A and B. For example, suppose we want to examine the effects of the dead zone by comparing the response of the system with and without a dead zone. The variables th1 and th2 represent θ 1 and θ 2. The effects of each term are shown in Figure 10.10-2, where the command input is assumed to be a unit-step function. In part (b), however, the symbolic solution capabilities of the solve function are put to use. For example, >> syms k >> A = [0, 1;-k, -2]; 544 >> charpoly(A) ans = [1, 2, k] which corresponds to the polynomial x 2 + 2x + k. This enables the embedded system hardware and software to be tested faster and less expensively than with the physical prototype, and perhaps even before the prototype is available. 338 obtained from linear interpolation. not affect the answer. Round to the nearest integer toward zero. If the equation proves difficult to solve (as indicated by a lengthy solution time or by a warning or error message), then use ode15s. To do this, let x 1 = θ and Thus . If a hard copy of the plot is desired, the plot can be printed by selecting Print from the File menu on the graphics window. The plot of the model, along with the data and the estimated point (1112, 120) marked with a + sign, is shown in the bottom two subplots in Figure 6.1-4. step(sys) Computes and plots the step response of the LTI object sys. 261 fmesh(f) Creates a 3-D surface plot. 530 Sometimes the fplot function uses too few values of the independent variable and thus does not produce a smooth plot. For such a building, if each floor has a mass m and the columns have stiffness k, the polynomial is 94 Figure 2.5-1 Simple vibration model of a building subjected to ground motion. = 197.5217 N. You can do this by applying the existence and uniqueness test given in the subsection Existence and Uniqueness of Solutions at the end of Section 8.1. Some overdetermined systems have been done in MATLAB. If condition (1) is satisfied but r < n, an infinite number of solutions exist; in addition, r unknown variables can be expressed as linear combinations of the other n - r unknown variables, whose values are arbitrary. If you suspect a power function, plot the data using log-log scales. Write and run the program. Matrix Inverse The solution of the scalar equation ax = b is x = b/a if a ≠ 0. Note that the find function returns the indices, and not the values. Where will MATLAB look for a user-created M-file on each computer? First create the function p(x). In addition, MATLAB provides support for analyzing and plotting the solver's output. Thus the model is y = 0.8 + 10.2429x 1 + 1.2143x 2. expand(E) Expands the expression E by carrying out powers. Figure P29 30. 554 33 else % Rank of A does not equal the number of unknowns. To create a row vector in MATLAB, you simply type the elements inside a pair of square brackets, separating the elements with a space or a comma. This problem is so simple that there are only a few steps to label: a. Note that if you use the bar function, you must aggregate the data first. The tension force y required to break a steel bar is a function of the percentage x 1 and x 2 of each of two alloying elements present in the metal. To obtain unshaded rectangles like the plots shown in this section, use the syntax bar(x,y,'w'), where w stands for white fill. The essence of a numerical method is to convert the differential equation into a difference equation that can 371 be programmed. Compute the area A. 490 Section 10.7 29. The logical expression may be a single command or a series of commands separated by commas or semicolons or on separate lines. A semicolon at the end of a line suppresses printing the results to the screen The signs are ordered counterclockwise from the top. Find Y = f(X). It also uses the input function, whose syntax is x = input('prompt', 'string') This function displays the string prompt on the screen, waits for input from the keyboard, and returns the entered value in the string variable x. How much more energy is released by a magnitude 7.6 quake than a 5.6 quake? To connect each data marker with a straight line, we must plot the data twice, by typing plot(x,y,x,y, 'o'). One class of such devices is called
lab-on-a-chip (LOC), such as the one shown in the photo. Limits The function limit(E,a) returns the limit if x is the symbolic variable. Similarly, multiplying the first column in U by the second column in P gives the total materials cost for the second quarter. Otherwise, if you have data at x = 0, then a. [The equation of motion for $\theta = 0$ is , which gives v(t) = 80t/9.] Figure 10.4-5 Simulink model for $v = (80/9)\cos(\pi t 2/100)$ with a Saturation block. It identifies only points where the function crosses the x axis, not points where the function just 129 touches the axis. pi The number π. It was designed to investigate the Martian climate and geology; to assess whether the Gale crater ever had an environment suitable for microbial life, and to determine the habitability of the site for future human exploration. 515, 518 limit Returns the limit of an expression. (Answer: x 1 = 7, x 2 = 4) T8.1-3 Use the matrix inverse method to solve the following set. Draw a simulation diagram for the following equation. Work through the solution steps by hand or with a calculator; use a simpler set of data if necessary. Plot the histogram of the data. Taylor's theorem states that a function f(x) can be represented in the vicinity of x = a by the expansion (11.3-1) The term R n is the remainder and is given by (11.3-2) where b lies between a and x. This limits the input to the second block. It can be shown that the transform of an impulse of strength A is simply A. % Simplified PID algorithm der(k) = e(k) + e(k-1); sum(k) = e(k) + eimplemented in Simulink, as shown in Figure 10.10-7. Use 163 MATLAB to check your answer. 217 Figure P36 35.* Use a loop in MATLAB to determine how long it will take to account jays 6 percent annual interest. This is acceptable as long as we do not wish to use the original values again. Settling time: The time for the response to reach and stay within a certain percentage (usually 2 percent) of its steady-state value. The next example illustrates this situation. Problems.....Page 11614. 260 mesh Creates three-dimensional mesh surface plot. Absolute values = [2 4 7]; (b) Same as (a); (c) Length is 3. A certain electric circuit has a resistor and a capacitor. The following chapters give more details on these topics. MATLAB supports engineering design of renewable energy systems. 167 xor Exclusive OR. The time data are entered in the array time, and the temperature data are entered in temp. See Figure P33. The inverse sine, or arcsine, is obtained by typing asin(x). If you are not using version R2017a, find the windows discussed in this section. 325 rng Initializes the random number generator. MATLAB uses the symbols + - * / ^ for addition, subtraction, multiplication, division, and exponentiation (power) of scalars. Use the debugging features of the Editor, which are not using version R2017a, find the windows discussed in this section. discussed in Section 4.8. 4.2 Relational Operators and Logical Variables MATLAB has six relational operators to make comparisons between arrays. To find the unit-step response, for zero initial conditions, of the state model (9.5-8), and the reduced-form model (9.5-8), and the reduced-form model (9.5-10) 387 the session is (assuming sys3 is still available in the workspace) >>sys4 = tf([5, 1], [5, 7, 5]); >>step(sys3,'b',sys4,'--') The result is shown in Figure 9.5-3. 296 Figure 6.2-4 Comparison of first- and second-order model fits. You should try different values of n and compare the results. Chapter 7: Statistics, Probability, and Interpolation......Page 28823. axis([0 0.8 0 800]) The plot appears as the second plot of Figure 6.1-8. The value of R for air is 286.7 (N · m)/(kg · K). grid Puts grid lines on the plot. The trapz function is summarized in Table 9.1-1. Another, perhaps unexpected, source of dead time is the computation time required for a digital control computer to calculate the control algorithm. 433 31. integers or logicals. LTI OBJECT 383 An LTI object describes a linear, time-invariant equation, or sets of equations, here referred to as the system. The answer given by the program is 53 sec. 23 25 26 25 27 25 24 22 23 25 26 24 24 22 25 26 24 24 24 27 23 2. These lines are also called contour lines, and such a plot is called a contour plot. In this application of the colon operator, the brackets can be used for improved readability but are not required. An example is given in the following table. Such a program is called a computer model. It is possible that the integral does not exist in closed form, or that MATLAB cannot find the integral even if it exists. Clicking on the northwest-facing arrow button toggles the plot edit mode on and off. They contain lightweight materials such as carbon composites and aluminum that are energy intensive to produce. If s is omitted, the step value defaults to 1. Use an approximation to estimate how long it takes for the tank to empty. Thus x 1 = . This is useful when comparing different simulations. Annotating Plots You can create text, titles, and labels that contain mathematical symbols, Greek letters, and other effects such as italics. The default Editor window for creating function files will appear as shown in Figure 3.2-1. We can access any column the way we access any other vector. You should see an oscillating curve with an amplitude of 10 and a period of 2π (Figure 10.2-4). The unit-step function, denoted u s (t), has a height of M = 1, and is defined as follows: The engineering literature generally uses the term step function, whereas in the mathematical literature the name Heaviside function is used. 10. A loop variable must be included in the logical expression. These commands are summarized in Table 7.1-1. ASCII files usually have the extension, such as .xlsx for Excel files. 480 Position Control Noting that velocity is the time derivative of displacement, we see that dx/dt = v. If we could measure the flow on one of the internal roads, say f 4, then we could compute the other flows. % Enter the data. function [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); square.m volume box = box(height, width, length); box.m [area square] = square(side); sq input and one output. Undefined function or variable 'x'. subplot command into the pth pane. The function numel(A) returns the total number of elements in the array A. Using lithography to create nanoscale channel structures on the surface of metals and semiconductors, and microfluidics to control the flow of droplets, LOC technology enables several laboratory functions to be carried out on a chip whose size ranges from a few millimeters to a few square centimeters. Function M-files 11. However, just because they are balanced does not mean the expression is correct. In Section 6.2 we present a method for finding the spring constant k for a straight-line model that passes through the origin. We will create a subsystem block for the liquid-level system shown in Figure 10.7-2. For example, to create and plot the function Table 2.4-5 Special matrices Command Description eye(n) Creates an n × n identity matrix. time in years measured from 0. It contains three items. To compute the inverse sine in radians, type asin(x). increments, such as temperature, because of the difficulty of making measurements around the clock. Use $\mu = 1000$ and $0 \le t \le 3000$, with the initial conditions y(0) = 2, (0) = 0. The value of J is J = (1.833 - 2) 2 + (6.333 - 6) 2 + (10.8333 - 11) 2 = 0.16656689. In most cases the answer to the exercise is given with the exercise is given with the exercise. while x < 10 x = x + 1; $y = 2^{x}$; end If x has not been assigned a value prior to the loop, an error message will occur. function $f = f4(x) f = x(1).^{2}-x(2).^{2}$; end 132 Suppose we guess that the minimum is near x = y = 0. For example, parentheses are not needed in the expression 8 + (3*5), but they make clear our intention to multiply 3 by 5 before adding 8 to the result. Here, however, the anonymous function protects you from forgetting to type the period (.) required for array exponentiation. Short-Circuit Operators The following operators perform AND and OR operations on logical expressions containing
scalar values only. Try bin widths of 50, 100, and 200 lb. ans = $-1*b^2/8+c+2*b==0,b)$ % Solves for b. Compute the double integral 15. Indefinite integrals have no specified limits. The function randi([a,b],[m,n]) returns an m-by-n matrix containing random integer values between a and b. Compute the mean yearly profit, and the standard deviation of the yearly profit, the maximum expected yearly profit, the maximum expected yearly profit, and the standard deviation of the yearly profit. first two rows and the last three columns of A. The first five chapters constitute a basic course in MATLAB. To create an LTI object from the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(right, left) function, and type >> sys1 = tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(1, [2, 3, 5]); where the vector of coefficients of the reduced form (9.5-5), use the tf(1, [2, 3, 5]); where the vector of coefficients of the vector of coefficients of the tf(1, [2, 3, 5 order, and left is the vector of 418 coefficients of the left-hand side of the equation, also arranged in descending derivative order. mu = mean(y raw), sigma = std(y raw) When you run this program, you will find that the mean is $\mu = 69.6$ in. 581 521 572 B APPENDIX Animation and Sound in MATLAB B.1 Animation can be used to display the behavior of an object over time. T2.7-2 Edit your structure array to change Newman's second test score from 45 to 53. Typing ceil(x) produces the answers 3, 3, 4. The variable p tells MATLAB to place the output of the plot command following the 235 Figure 5.2-1 Application of the subplot command. Include comments where appropriate for documentation. Display the results r and theta. For example, if x = [2,-4,5], its length is 3; its magnitude is ; and its absolute values to the variable A r. Calculations in this section. Thus an infinite number of solutions can exist, with one or more of the unknowns dependent on the remaining unknowns. 157 The result is z = 6. 171 otherwise Provides optional control within a switch structure. Other useful plotting functions are title and gtext. vel = $g^{t} + v0$; dist = $0.5^{s}g^{t}$. $^{2} + v0^{s}$; end The following examples show various ways to call the function drop: 1. Such cases, however, are indicative of a very poor model that should not be used. because it implies a mistake, but nevertheless the term remains in use; it just represents the difference between the desired and the actual value of the controlled variable. Logarithmic Plots Logarithmic Plots a wide range of the controlled variable. values and (2) to identify certain trends in data. 450 494 Engineering in the 21st Century... Developing Alternative Sources of Energy I t now appears that the United States and much of the rest of the world have recognized the need to reduce their dependence on nonrenewable energy sources such as natural gas, oil, coal, and perhaps even uranium For example, the following code uses a continue statement to avoid computing the logarithm of a negative number. In one of the major discoveries of the 21st century, they obtained strong evidence that water once existed on Mars in significant amounts. How many widgets were made? For example, negative values of the variables have no meaning here; thus we require that $x \ge 0$, $y \ge 0$, and $z \le 0$. To save just some of your variables, say, var1 and var2, type save(myfile, var1, var2). This gives 367 Figure 8.3-2 A network of one-way streets. As a function handle 3. Then double-click on the Tank 2 subsystem block, set the left-side gain 1/R 1, the right-side gain 1/R r equal to 1/R 2. and the gain 1/rho*A equal to 1/rho*A_2. >>[A, C] = circle(4) A = 50.2655 C = 25.1327 A function may have no input arguments and no output arguments. You can perform operations in MATLAB in two ways: 1. Table 11.3-1 summarizes the differentiation functions. Compute its velocity at t = 10 s if its initial velocity is zero. function 2. We can obtain the rectangular representation from the polar representation from the polar representation from the default color. The equation describing the water height h in a spherical tank with a drain at the bottom is Suppose the tank's radius is r = 3 m and the circular drain hole has a radius of 2 cm. The Step Time is the time at which the colon operator. However, this method involves more work than necessary because we need not find the value of t i . If A T = A, the matrix A is symmetric. Table 5.2-3 summarizes these functions. One way to do this is to use rng('default'), to repeat a result obtained at startup without restarting, as we have seen earlier. Rather, we can define a single matrix that contains 308 the entire table. 14. A principal application of while loops is when we want the loop to continue as long as a certain statement is true. The function size(A) returns a row vector [m n] containing the sizes of the m × n array A. [ta, xa] = ode45(@pendulum, [0 5], [0.5 0]); [tb, xb] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.5 0]); [tb, xb] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.5 0]); [tb, xb] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.5 0]); [tb, xb] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa] = ode45(@pendulum, [0 5], [0.8*pi 0]); plot(ta, xa(:,1), array A. [ta, xa]); plot(ta, xa(:,1), array A. [ta, xa]); plot(ta, xa(:,1), array A. [ta, xa]); plot(ta, xa(:,1), array A. [ta, xa]) tb,xb(:,1)),xlabel('Time (s)'), . The rng function operates with randn exactly the same way as with rand. Keep in mind that the Desktop menus are context-sensitive. The approximate solution, which is less accurate for larger values of t, is Create a Simulink model to solve this problem, and compare its solution with the approximate solution over the range $0 \le t \le 1$. If A is singular, then a unique solution to Equation (8.1-1) does not exist. Table 3.1-3 Hyperbolic cosh(x) coch(x) sech(x) sinh(x) tanh(x) Hyperbolic cosh(x) coch(x) coch(x) sinh(x) tanh(x) Hyperbolic cosh(x) coch(x) sinh(x) tanh(x) tanh(x) Hyperbolic cosh(x) coch(x) sinh(x) tanh(x) tanh(algebraic and transcendental equations. Electric circuits are a common source of linear equation models. To turn off tracing type echo off or echo function name off. Time (s) 0 1 2 3 4 5 6 7 8 9 10 Acceleration (m/s 2) 0 2 4 7 11 17 24 32 41 48 51 (a) Estimate the velocity v after 10 s. MATLAB can perform operations such as addition and multiplication on mathematical expressions, and we can use MATLAB to obtain symbolic solutions to algebraic equations such as x 2 + 2x + a = 0 (the solution for x is). Section 1.5 introduces the extensive MATLAB Help System and Section 1.6 introduces the methodology of engineering problem solving There are several options for rounding numbers in addition to the basic syntax 117 round(x). Add points to the line in a loop to create a line animation. $r = sqrt(x^2+y^2) 3$. [0.8333, 0.5; 1.4, 3] d. In MATLAB the session is >>hourly cost.*hours 1 = [6, 2, 3, 4]; >>process cost 1 = hourly cost.*hours 1 process cost 1 = 60 24 42 36 These are the costs of each of the four processes to produce
1 unit of product 1. One of these is a freshman MATLAB course, which he helped develop. The APPS tab opens a gallery of applications from the MATLAB family of products, such as any installed MATLAB toolboxes. To do so, we use the MATLAB symbol .*, which specifies the multiplication s.*t to produce the row vector whose elements are the products of the corresponding elements in s and t: s.*t = [200(2), 250(5), 400(3), 300(4)] = [400, 1250, 1200] This vector contains the miles traveled by the aircraft on each leg of the trip. The two commands could have been combined into the single command roots([1,-7,40,-34]). 25^-1/2 c. MATLAB adds zeros to fill out the remaining elements. These "adaptive" algorithms use larger step sizes when the solution is changing more slowly. Label each axis. The array-handling feature means that MATLAB programs can be very short. This indicates that the corresponding equations can be solved directly for 1 and T 2 in terms of T 3. Suppose that the link lengths are L 1 = 4 ft and L 2 = 3 ft. 481 438 Simplified PID Some computer hardware will not support the sophisticated PID algorithm used by the Simulink PID Controller block. For example, u = 10:-2:4 produces the vector [10, 8, 6, 4]. 26 path Displays search path. Here the error signal e(t) is the difference between the unit-step command representing the desired height and the actual height. As with for loops, the statements should be indented to improve readability. SUMMER The summer symbol can be used to represent the equation $\dot{y} = f(t) - 10y$, which can be expressed as or as You should study the simulation diagram shown in Figure 10.1-2b to confirm that it represents this equation. Using parentheses instead of square brackets will generate an error message. In this example, if the values of A or B are changed after the handle is created, their values associated with the handle is created, their values associated with the handle is created. percentage of assembled products that will be no less than 4.48 and no more than 4.52 ft in length. Plot the function on the same plot with the data. Creating Movies in MATLAB The getframe command captures, or takes a snapshot of, the current figure to create a single frame for the movie. 119 Polynomial functions Item Description Pages con-Computes product of two polynomials. 234 semilogy Creates semilog plot (logarithmic ordinate). Two of these are the ode45 and ode15s functions. Always make sure that the loop variable has a value assigned to it before the start of the loop. 501, 505 subs Substitutes variables or expressions. The Saturation and Rate Limiter Blocks Suppose that the minimum and maximum flow rates available from the input flow valve are 0 and 2. Anonymous functions enable you to create a simple function without needing to create an M-file for it. For the Step block, set the Step block, set the Step block, set the Step block are 0 and 2. Anonymous functions enable you to create a simple function without needing to create a simple function. designing a six-passenger car that is one-third lighter and 40 percent more aerodynamic than today's sleekest cars. EXAMPLE 8.1-1 The Matrix Inverse. Culbertson Design: Tara McDermott Content Licensing Specialists: Lorraine Buczek Cover Image: ©Getty Images/iStockphoto Compositor: MPS Limited Printer: LSC Communications All credits appearing on page or at the end of the book are considered to be an extension of the copyright page. Evaluate the solution obtained in part a for the case 376 3. exist('name') Determines if a file or variable exists having the name 'name'. In general, if a field contains an array, you use the array's subscripts to access its elements. For example, if M has four frame 4 again, followed by frame 2 and finally frame 1. xlabel('Deflection (in.)'), ylabel('Force(lb)'),... All variables inside a function are erased after the function finishes executing, except when the same variable names appear in the output variable list used in the function call. The power P dissipated as heat in a resistor R as a function of the current i(t) passing through it is P = i 2 R. Let S represent the solubility of NaCl (sodium chloride) as grams of salt in 100 g of water. See the text for description of extended syntax. To extract and save the coefficients of the reduced form, use the tfdata function as follows: [right, left] = tfdata(sys3, 'v') For this example, the vectors returned are right = 1 and left = [1, 1.5, 2.5]. An undocked window can be moved around on the screen. They can be obtained in MATLAB with the Symbolic Math Toolbox by typing laplace(function), where function is a symbolic expression representing the function y(t) in Equation (11.5-1). In the meantime, unmanned probes have been rapidly increasing our knowledge of the universe. Multiplication of Vectors Recall that vectors are simply matrices with one row or one column. The program also uses the "if-else-end" construct which is covered in Section 4.3. x = input(2nter the value of y; 2); y = input(2nter the value of y; 2); $r = sqrt(x^2+y^2)$; if $x \ge 0$ theta = atan(y/x); else theta the user. To retrieve a command using a partial match, type any part of the command at the prompt, and then press the up-arrow key. The equation of motion for a rocket in vertical flight can be obtained from Newton's law, and it is where T is the rocket's thrust and its mass as a function of time is given by m(t) = m 0 (1 - rt/b). MATLAB provides the histogram function to generate a histogram. Write a MATLAB program to plot the voltage v L versus t for 0 < t < 10. EXAMPLE 8.3-5 Traffic Engineering and leaving a road network are sufficient to predict the traffic flow on each street in the network. Two panes of the Basic Fitting interface are shown in Figure 6.3-1. 319 517 568 Random number functions Item Description Pages rand Generates uniformly distributed random numbers between 0 and 1. In general, for the polynomial a 1 x $n + a 2 x n - 1 + \cdots + a n x + a n + 1$, the sum of the squares of the residuals for m data points is The values of the n + 1 coefficients a interface are shown in Figure 6.3-1. 319 517 568 Random number functions. that minimize J can be found by solving a set of n + 1 linear equations. For example, suppose we want to compute the distance from the origin to a set of three points specified by their xy coordinates (3, 7), (6, 6), and (2, 8). Assume you make only one transaction per day. The previous entry means "assign the value of 8/10 to the variable r". We will describe the various menus later in this 23 chapter. Consider the second-order model (11.5-11) Transforming this equation gives Solve for X(s). DEAD ZONE A graph of a particular dead-zone nonlinearity is shown in Figure 10.5-1. The inner loop is over time and evaluates the equations of motion at times spaced 1/10 sec apart. Write a MATLAB function using the min function to compute the width W required to minimize the fence perimeter P and to calculate the corresponding values of L and P. Delete the arrow connecting the Scope block by clicking on it and pressing the Delete the arrow connecting the Scope block by clicking on it and pressing the Scope block by clicking on it and pressing the Delete key. in industry. Create the primary function first with a function definition line and its defining code, and name the file with this function name as usual. Use MATLAB to determine how many square feet of sheeting are required. 34. Thus the rocket's mass without fuel is m e = m 0 - qb. We need to be able to specify whether we want to see a plot of the position, or the velocity, or both. 8 .^ Array exponentiation operator. The continue statement passes control to the next iteration of the loop. C (mol NO 2 /L) Time t (s) 0 0.0048 300 0.0038 Determine whether this is a firstorder or second-order reaction, and estimate the value of the rate constant k. This is the only section in the text that uses cell arrays. 81 zeros Creates an array of 0s. Minimizing a Function of A single variable, which is denoted by x. You can save the Simulink model by selecting Save from the File menu. 499 The vector and matrix notation used in MATLAB also applies to symbolic variables. Run the simulation again and plot the speed. MATLAB provides the functions atan2(y,x) to determine the arctangent unambiguously, where x and y are the coordinates of a point. Nonlinear ODEs can be recognized by the fact that the dependent variable or its derivatives appear raised to a power or in a transcendental function. Any elements not selected will remain unchanged. Most of the examples and exercises in this text require you to develop a computer solution. with linear and cubic spline interpolation. Symbols such as o, *, or + will be plotted slower than a line. The frequency-response plot is a plot of A o /A i versus frequency ω. 10 the readability of your MATLAB expressions. This chapter is based on Version 8.9 (R2017b) of the toolbox. Suppose L 2 = 0.5 ft. fminsearch(@function,x0) Uses the starting vector x0 to find a minimum of the multivariable function, x0) described by the handle @function, if sum(x) = 4) d. This can often be done by using anonymous and nested functions, as discussed in Section 3.3. Persistent Variables There may be applications (but perhaps not many) where you would want to preserve the value of a variable that is local to a function but whose value is not 128 passed through the function output. This establishes the plot format for all following operations, for example, line type and color, labeling, and axis scaling. A general solution program is given in Section 8.5. 8.1 Matrix Methods for Linear Equations can be expressed as a single equation, using matrix notation. Flowcharts use the diamond symbol to indicate decision points. The width, or spread, of the curve is described by the parameter s. If you are plotting points generated by evaluating a function (as opposed to measured data), do not use a symbol to plot the
points. How to Use This Book The book's chapter organization is flexible enough to accommodate a variety of users. You can then give the handle to reference the function. u = 10; m = 1; c = 2; k = 5; A = [0, 1; -k/m, -c/m]; B = [0; 1/m]; xdot = A*x+B*u; 415 Figure 9.5-1 Displacement and velocity of the mass as a function of time. For example, suppose the matrix equation is Ay = bc, where c is a scalar. Use MATLAB to plot the polynomial y = 3x 4 - 5x 3 - 28x 2 - 5x + 200 on the integrals 364 The function integrals 364 The function integrals 364 The function of mass is Equation (10.7-2). The NOT symbol is called the tilde. The following session produces an estimate of the temperatures at 8 and 10 A.M. at each location. You can convert the scripts to HTML or PDF files for publication. These technologies let manufacturers increase speed to market, eliminate costly tooling, molds, or dies, and produce small batches on order. That is these values are the values of x 1 and x 2 that minimize J, the sum of the squares of the differences between the equations' left- and right-hand sides. Select the fits you want to display for the current data set. The effects of round-off error needs to be considered when converting MATLAB floating point values to symbolic constants in this way. (a) Determine the cost of each process to produce 1 unit of product 1. clear var1 var2 Removes the variables var1 and var2 from memory. 339 spline Cubic spline interpolation. The area of each rectangle on the absolute frequency histogram equals the bin width times the absolute frequency for that bin. Key Terms Coefficient of determination, 288 Linear-in-parameters regression, 294 Multiple linear regression, 293 Regression, 284 Residuals, 285 Problems You can find the answers to problems marked with an asterisk at the end of the text. SEARCH PATH You can display the MATLAB search path by typing path. Find the allowable ranges for x, y, and z. J., and L. The loop variable must have a value before the while statement is executed. 432 26. The forward slash (/) represents right division operator familiar to you. Opportunity was still active as of 2016, having already exceeded its planned operator familiar to you. about x = 0 in two ways: (a) by multiplying the Taylor series for e x and that for sin x, and (b) by using the taylor function directly into the function directly into the function without its output the argument values directly into the function without its output the argument values directly into the function without its output the argument values directly into the function call, as follows: >>z = fun(3,7) z = 303 If you call the function without its output the argument values directly into the function without its output the function without the fu argument and try to access its value, you see the following error message: >>clear z, fun(3,7) ans = 303 >>z ??? These solvers are more than sufficient to solve the problems in this text. Compare the histograms for each case. mheducation.com/highered 5 6 iii To my sisters, Linda and Chris, and to my parents, Lillian and William 7 iv ABOUT THE AUTHOR is Emeritus Professor of Mechanical Engineering at the University of Rhode Island. >>C = U'*P The result is 87 Each column in C represents one quarter. Then use the double function to convert the expression E to a numeric form. In MATLAB the variable on the left-hand side of the = operator is replaced by the value generated by the righthand side. See the MATLAB Help for more information. Determine how many tons of each produced each week. Note that you need not declare the symbolic variable with the sym or syms function before using solve. No plot is drawn. To build a structure array named sa 1, the syntax is sa 1 = struct('field', 'valuesl', ' 'field2', values2', ...) where the arguments are the field names and their values. Table 1.3-2 summarizes these plotting commands. Here is the MATLAB session to perform these operations. Error Bar Plots Experimental data are often represented with plots containing error bars. Some control systems have the objective of regulating some variable such as temperature, but many of the projects are examples of controlling the speed or position of a mechanical device like a robot arm or a wheeled robotic vehicle. Thus you probably will not need to use with the text command usually requires some trial and error. For c = 10 we find that rank(A) = 2, but rank([A b]) = 3. However, there are two problems with the eighth-order polynomial: we should not use it to interpolate over the interval 0 < x < 0.5, and its coefficients must be stored with very high accuracy if we use the polynomial to interpolate. What is the location of the mass when t = 5 s? For the third, plot the relative error [sin(x) - x]/sin(x) versus x for $0 \le x \le 1$. Consider Figure 10.7-8 for the case where there are three masses. Note that MATLAB displays more significant figures than is justified by the three-significant-figure accuracy of the given data, so we should round the results to three significant figures before using them. Figure 3.2-2 shows the Editor after a function has been created. Show that the product RRR of the rotation matrix R(a) given by Equation (11.6-1) equals R(3a). In mathematical text, if possible, vectors are usually denoted by boldface lowercase letters and matrices by boldface uppercase letters. fmesh(f) Create a 3-D surface plot. Improper integrals can have infinite values, depending on their integration limits. Then specify the cell contents on the right side of the assignment operator. 85 eig Computes the eigenvalues of a matrix. A tabulated (numerical) solution has been found and it is called the elliptic integral. These conditions give two equations that must be solved for the two unknowns m and b. (Answer: 51 elements and 1.48.) T1.3-2 Use MATLAB to find the roots of the polynomial 290 - 11x + 6x 2 + x 3. Table C.1 Displays the elements of the array A, and any additional array ...) arguments, according to the format specified in the string 'format'. Applying integration by parts to the definition of the transform, we obtain (11.5-3) This procedure can be extended to higher derivatives. These are summarized in Table 9.5-2. Obtain a plot of the allowable limit on v 2 as a function of R 3 for $150 \le R 3 > \le 250 \text{ k}\Omega$. Develop a Simulink model of this system. At the end of each chapter is A summary of what you should be able to do after completing that chapter A list of key terms you should know Appendix A contains tables of MATLAB also has the four-quadrant inverse tangent functions atan2(y, x) and atan2d(y, x). The same warning the coordinate system origin (0, 0) to the first location, the coordinates of the other locations are (1, 0), (1, 2), and (0, 2); see Figure 7.4-2. The columns of the matrices y and x are the outputs and the states, respectively. It is thus easier to use the fimplicit function. Here e stands for "exponent." It is a poor choice of notation, but MATLAB follows conventional plot types, type help specgraph. 85 deconv Computes ratio of polynomials. L. 10.8 Dead Time in Models Dead time, also called transport delay, is a time delay between an action and its effect. You can always click on Help within the Block Parameters window to obtain more information. The Start window opens. The following example illustrates the method. Suppose the applied force is sinusoidal with a frequency of ω rad/s and an amplitude of 10 N: f(t) = 10 sin(ω t). randn(n) Generates an n × n matrix containing normally distributed random numbers having a mean of 0 and a standard deviation of 1. Also, some infrastructure components, such as communications networks, need to be replaced because they are outdated and do not have sufficient capacity or ability to take advantage of new technology. See the text for a description of the possible variants 226 involving vectors and/or matrices: plot(x,A), plot(A,x), and plot(A,B). Thus tan 45° = 1. Show all four cases on the same subplot and label each curve. Therefore Simulink is especially useful for such applications. 1 ONLINE RESOURCES An Instructor's Manual is available online for instructors who have adopted this text. In both cases the input is a displacement y(t). Remember that the wires cannot support compression, so T i must be nonnegative. This is an example of how the output of a process can have a different distribution than the input. see subfunctions local minimum, 130 local variables, 120, 122, 126-127 log scales, 241-243 ogarithmic functions, 114-115 logarithmic plots, 241-244 logical arrays, 51-52, 163, 186-187 logical class, 162-166, 168-169 log-log plot, 241-242 loop variable, 178-180, 190 LTI object, 416, 417 M Maclaurin series, 521 mag litude number. 115 stei 595 Mars rovers, 2 mask, 187 MAT-files, 24 mathematical model, 35 MathWorks, Inc., 34, 439 matrix, 20, 54, 334 creating, 54-55 division, 82 exponentiation, 83 identity, 81 multiplication, 74-75, 78-79 null, 81 operations, 62, 72 rank of, 352-353 square, 83 symmetric, 55 transpose operation and, 55 matrix inverse method, 350-351 matrix methods, 350-353, 414-415 matrix-matrix multiplication, 74-75 max-min problems, 515-516 mean, 312 median, 312 m modified Euler method, 404 modules, 154 multiple-input arguments, 74–75 polynomial, 85–86 vector-matrix, 74–80 vector-matrix, 74–75 polynomial, 85–86 vector-matrix, 74–75 polynomial, 85–86 vector-matrix, 74–80 vector-matrix, 74–75 polynomial, 85–86 vector-matrix, 74–75 polynomial, 85–86 vector-matrix, 74–80 vector-matrix, 74–75 polynomial, 85–86 vector-matrix, 74–80 vector-matrix, 74–75 polynomial, 85–86 function, 134, 135, 140-141 nested loops, 181 nested parentheses, 12 New icon, 18 normally distributed random numbers, 137 nonlinear vehicle suspension model, 469-473 nonzero elements, 59 normal distribution, 317-322 normal/Gaussian function, 319 normally distributed random numbers, 324-326 null matrix, 81 numeric arrays, 51, 163
numeric functions, 116-117 numerical array, 19 numerical a 556 linear solvers, 419-423 MATLAB solvers, 405-406 Output section, 29 output/input commands, 30 overdetermined systems, 297, 350, 368-371 overlay plots, 22, 234, 236 overloaded functions, 117 partial derivative, 513 partial differential equation (PDE), 402, 428 pass, 178 path, 25 peak response, 421 peak time, 421 period, sound wave, 579 persistent variables, 127-128 PI controller, 469 PID control, 474-476 piecewise-linear models, 450 planetary rovers, 2 plant, 474 Plot Browser, 250, 252, 253-254 Plot Edit toolbar, 252 Plot Tools, 250, 252-253 plots annotating, 241 contour, 258-260 data markers, 23, 236-237 enhancement commands, 240 error bar, 246 hard copy of, 227 improving, 233 line, 255-256 line types, 236-237 logarithmic, 241-245 requirements, 227 sample, 228 subplots, 234-235 surface mesh, 256-258 PLOTS tab, 5, 17 plotting, 21-23 complex numbers, 229 expressions, 504 implicit functions, 247 interactive, 250-254 557 polynomial, 86, 229-230 three-dimensional plots, 255-261 xy plot, 225-234 pneumatic systems, 462 point marker, 225 polar plots, 244-245 polar representation, 115 polynomial addition, 84-85 characteristic, 477 derivatives, 399-400 division, 85-86 Hermite interpolation, 339-341 integration, 395 multiplication, 85-86 operations, 84 plotting, 86, 229-230 roots, 21 subtraction, 84-85 position control, 480. In general, production to estimate how many 20-year-old men are no taller than 69 in. Plot the data, connecting them first with straight lines and then with a cubic spline. Its syntax is count = fprintf(fid, format, A, ...), which formats the data in the real part of matrix A (and in any additional matrix arguments) under control of the specified string format, and writes the data to the file associated with file identifier fid. >>Q = $R*R Q = [cos(a)^2-sin(a)^2, 2*cos(a)*sin(a)]$ $-2^{cos(a)}(a), cos(a)^{2}(a), cos(a)^{2}(a), cos(a)^{2}(a), cos(2^{a})$ The matrix Q is the same as R(2a), as we suspected. Thus 213 which can be solved for x as 201 and which gives the following quadratic equation to solve for x: a. Consider the following data. Best location: x = 9, y = 16. Substituting this expression into Equation (10.7-1) gives the model (10.7-2) The transfer function is On the other hand, the outlet may be a valve or other restriction that provides nonlinear resistance to the flow. Worker 1 Hourly wage (\$) Hours worked Output (widgets) 2 3 4 5 5 5.50 6.50 6 6.25 40 43 37 50 45 1000 1100 1200 1100 Use MATLAB to answer these questions: a. We will cover these commands later in this chapter. Do not use subplot. Composition of aluminum alloys Alloy %Cu %Mg %Mn %Si %Zn 2024 4.4 1.5 0.6 0 0.6 0 7005 0 1.4 0 0 4.5 7075 1.6 2.5 0 0 5.6 356.0 0 0.3 0 7 0 40. These functions place text on the plot. For example, >>syms x >>E = $x^2+6^{*}x+7$; >>G = subs(E,x,2) % G is a symbolic constant. The following program shows how this is done, using the projectile application. MATLAB first checks to see if problem1 is a variable and if so, displays its value. If the array contains complex conjugates of the original array's transposed elements. 6(35 1/4) + 14 0.35 27 (Answers: a. Linear equations for the tension forces T AB and T AC if we know the angles θ and φ. ASCII Character Codes E. 390 9.1 Numerical Integration The integral of a function f(x) for $a \le x \le b$ can be interpreted as the area between the f(x) curve and the x axis, bounded by the limits x = a and x = b. Determine the object's velocity at t = 5 s. The chosen value t 1 is often the smallest, or starting value, of t, and if so, the condition is called the initial condition (quite often t 1 = 0). The MATLAB script file follows. 20, 58 linspace Creates regularly spaced vector. LEFT DIVISION METHOD 83 Test Your Understanding T2.4-4 Use MATLAB to solve the following set of equations. However, there are several pitfalls with this approach: (1) if you change the file during your session, you might forget to copy the revised file back to your medium, and (2) someone else can access your work! CURRENT DIRECTORY The what command displays a list of the MATLAB-specific files in the current directory. Set the Stop Time to 10, run the simulation, and examine the results in the Scope. The Boeing 777 is the first aircraft to be designed and built using virtual prototyping, without the extra time and expense of building a mock-up. The following session shows how to generate the surface mesh plot of the function z = xe - [(x-y plot appears in Figure 5.4-2). The Laplace transform can be used to solve some types of differential equations that cannot be solved with dsolve. Its basic syntax is fzero(@function, x0) where @function handle and x0 is a usersupplied guess for the zero. Select the figure file you want to open and click OK. Another restriction is that the right-hand side of the = operator must have a computable value. The bump is represented by the trapezoidal function y(t) shown in Figure 10.9-4. The motor's velocity follows a trapezoidal profile as expected, although there is some slight deviation because of its electric resistance and mechanical inertia. Instead of using the publish and open functions, you may use the menu items under the PUBLISH tab of the toolstrip. The equation for L is a function of the two variables d and θ on a three-dimensional coordinate system. In such a total analysis even all-electric vehicles may not be energy efficient. You may need to center and scale your data to improve the accuracy of the subsequent numerical computations. The remaining items in the box are used for more advanced features and are initially inactive. axis([0 10 - 0.5 1.5]), . 474 10.10 Control Systems and Hardware-in-the-Loop Testing As discussed on the facing page of this chapter, industry is using embedded controllers, and one design phase for such systems often involves hardware-in-the-loop testing, in which the physical controllers, and sometimes the controller of its behavior. Input section In this section put the input data and/or the input functions that enable data to be entered. Plot the difference between $\pi/4$ and the sum S(n) versus n for $0 \le n \le 200$. (Answer: x = (a + 18)/5, y = (2a - 9)/15) EXAMPLE 11.2-1 Intersection of Two Circles We want to find the intersection points of two circles. 118 csc(x) Cosecant; csc x. >>x = [7,9,11,12]; >>y = [49,57,71,75]; >>x int = 7:0.01:12; >>y int = spline(x,y,x int); >>plot(x,y,'o',x,y,'--',x int,y int),... xlabel('Temperature (deg F)'),... title('Measurements at a Single Location'),... axis([7 12 45 80]) The plot is shown in Figure 7.4-3. 44 T1.4-2 The length c of the hypotenuse of a right triangle, whose side lengths are a and b, is given by Write a script file that prompts the user to enter the side lengths a and b, computes the hypotenuse length, and displays the result. Specify the name you want assigned to the figure file. About the Authors.....Page 86. In general, if you see a pattern in the plot of the residuals, it indicates that another function can be found to describe the data better. S = rmfield(S,'field') Removes the field 'from the structure array S. Compute the indefinite integral of p(x) = 5x 2 - 9x + 8. (a) Find the distance between diver 1 and the starting point. [num, den] = polyder(p2,p1) The results are der2 = [20, 4], prod = [150, 80, -7], num = [50, 40, 23], and den = [25, 20, 4]. For example, the following loop can give unintended results if x has an overlooked previous value. The surface area of a sphere of radius r is $S = 4\pi r 2$. (8.4-1) 340 (8.4-2) (8.4-3) 370 These equations can be written in the matrix form Ax = b as follows: where To use left division, the MATLAB session is >>A = [0, 1; 5, 1; 10, 1]; >>b = [2; 6; 11]; >>rank(A) ans = 2 >>rank(A)b]) ans = 3 > x = Ab x = 0.9000 1.8333 > A*x ans = 1.833 6.333 10.8333 This result for x agrees with the least-squares solution obtained previously: c 1 = 0.9, c 2 = 11/6 = 1.8333. It can be computed as follows: (7.2-3) EXAMPLE 7.2-2 Estimation of Height Distribution Use the results of Example 7.2-1 to estimate how many 20-year-old men are no taller than 68 in. We can obtain these moves with the randi([-1,2],[1,99]) function, which will generate the four possible moves with equal probability. When the plot command is successfully executed, a graphics window automatically appears. function $y = f_1(x) y = x + 2 \exp(-x) - 3$; end To create a handle to this function and name the handle fh1, you type fh1 = @f1. A nested function can access the workspaces of all functions inside of which it is nested. Clearly Figure 9.3-1 An RC circuit. The feedback sensor would be a tachometer to measure the wheel speed. Double-click on it to obtain the Block Parameters window, and set the Step Time to 0.05, the Initial and Final values to 0 and 3, and the Sample time to 0. The rows of A must contain the coefficients of x, y, and z in that order. The form poly2sym(p, v') generates the polynomial in terms of the surface z = xe -(x + y) created with the mesh function and its variant forms: meshc, meshz, and waterfall. It is defined by where i and j are the unit vectors in the x and y directions, respectively. The session looks like this: >>g=32.2; >>h=vi^2/(2*g) h = 9.7050 38 49 9. Linear interpolation in MATLAB is obtained with the interp1 and interp2 functions. % speed data.dat % speed vs. So, for example, to find the impulse response of , where f(t) is an impulse of strength A, for zero inital conditions, first obtain the transform. ans = 40.1680 - 3.2981 >> double(S.th2)*(180/pi) % convert to degrees. 234 The Figure Palette: Use this to create and arrange subplots, to view and plot workspace variables, and to add annotations. 37 Figure 1.6-1 Sketch of the dropped-package problem. Use the values $\rho = 0.002378$ slug/ft 3 (air density at sea level), $\alpha = 10^{\circ}$, and S = 36 ft. 131 Figure 3.2-4 Plot of the function holds control until recording
completes. The effect of air drag is negligible. The measured displacement versus time is given by t (s) 0 0.2 0.4 0.6 0.8 1 1.2 x (cm) 1.3 1.2 0.8 0.5 0.3 0.2 0.1 Estimate the initial displacement and velocity. 316 Test Your Understanding T7.1-1 In 50 tests of thread, the number of times 91, 92, 93, 94, 95, or 96 N was measured was 7, 8, 10, 6, 12, and 7, respectively. Regression can be used to develop a model for cases where there is considerable scatter in the data. The initial capacitor voltage is zero. EXAMPLE 6.2-4 Breaking Strength and Alloy Composition. For example, the force-extension model of a spring must pass through the origin (0, 0) because the spring exerts no force when it is not stretched or compressed. The results are a = [0.8000, 10.2429, 1.2143] and Max Percent Error = 3.2193. As a function handle to an existing function M-file: >>x = fzero(@fun1,[0, 3]) 3. A & B Returns true (logical 1) if both A and B evaluate to true, and false (logical 0) if they do not. The result is w = [5, 2, 3]. When ship A was dead ahead of ship B, it was 6 miles away. If m equals n, the loop will be executed only once. Figure 6.2-2 shows an example of this phenomenon. Plot these functions on the same plot. Replace h on the right side of Equation (9.3-14) with its average value, namely, (9-0)/2 = 4.5 ft. Edit the structure array created in Problem 60 to change the maintenance data for the Clark St. bridge from 2012 to 2018. Use MATLAB to find the coefficients of the quadratic polynomial y = ax 2 + bx + c that passes through the three points (x, y) = (1, 10), (3, 30), (5, 74). Model's coefficients. The finisearch function can often handle discontinuities, particularly if they do not occur near the solution. Test Your Understanding T3.2-3 The equation has three solutions in the interval 0 < x < 10. Table 1.1-5 Numeric display formats Command Description and example format short Four decimal digits (the default); 13.6745. The tank empties in 2475 sec, or 41 min. If you forget to enter the correct value for x, MATLAB uses the last value, and you get an incorrect result. (c) Suppose we produce 10 units of product 1, 5 units of product 2, and 7 units of product 3. The relational operators have equal precedence among themselves, and MATLAB evaluates them in order from left to right. The elements in structures are accessed using named fields. 440 This chapter starts with simulations of simple systems that require few blocks. 261 Table 5.4-2 Three-dimensional plotting functions using function inputs Function Description fcontour(f) Creates a contour plot. w = 0. Section 1.3 introduces built-in functions, arrays, and plots. Using PID control and assuming a perfect speed sensor, we obtain the Simulink diagram shown in Figure 10.10–3. Formatted content includes formatted text, plots, images, hyperlinks, and equations. see also control systems positive real axis, 115 power function, 273, 275, 276 powers arrays, 69 functions, 134, 135, 138 private functions, 134, 135, 138, 141-142 problem solving, 34-42 computer solution, 38 example of steps involved, 36-38 mathematical model, 35 methodologies, 34-35 steps in, 35 profile, 332 program documentation, 155-157 programming, 153 profile, 332 programming, 153 programming, 153 profile, 322 programming, 153 profile, 332 programming, 153 profile, 34-35 steps in, 35 profile, 34-35 steps in, 35 profile, 350 prof pulse function, 538, 539 pure tone, 579 Q 558 Quick Access toolbar, 17 R random numbers, 322-331 functions, 325 normally distributed, 324-326 uniformly distributed, 323-324 random walk, 329 rank of a matrix, 352-353 rectangular representation, 115 reduced form, 416 reduced row echelon form, 363-364 regression, 284-297 relational operators, 154, 161 relative frequency, 313 relative minimum, 130 remote exploration, 2 renewable energy sources, 18 response time, 477 retrieving workspace variables, 24-25 reusable code, 155 right-division method, 297. Figure 10.1-1b shows one variation. Section 11.3 11. The power function: y(x) = bx m. For example, if x = 2 and y = 5, typing z = x < y returns the value z = 1 and typing u = x = y returns the value z = 1 and typing u = x = y returns the value z = 1 and the y variable be τ . This manual contains the complete solutions to all of the Test Your Understanding exercises and to all of the chapter problems. These include System Dynamics, 3rd ed. dir dirname path Lists all the files in the directory dirname. In fact, there are an infinite number of characteristic 468 roots for a system with dead time. You can use multiple functions within a single primary function M-file. Set up these equations in a matrix form Ax = b suitable for solving for the three flow rates q 1, q 2, and q 3 and the pressure p 1, given the values of pressures p a , p b , and p c and the values of pressures p a , p b , and p c and the values of pressure p 1 , given t

semilog scales. Then the model of the system is where A is the bottom area and p = ρ gh. The following table gives the spring length y that the given applied force f produced in a particular spring. Determine the angle of attack that maximizes L/D. To plot y versus x with a solid line and u versus v with a dashed line, type plot(x,y,u,v,'--'), where the symbols '--' represent a dashed line. The argument fid is an integer file identifier obtained from fopen. Each trapezoid is called a script file. The following program implements the pseudocode using some of 155 the MATLAB features to be introduced in this chapter. When you click on Apply, any changes immediately take effect and the window remains open. Section 2.7 59. Both C L and C D depend on α, the angle of attack, the angle of attack, the angle of attack, the angle of attack, the angle of attack the attack the angle of attack the angle of attack the angle of attack the attack space occupies one column). The following table gives data for the resistance and voltage for five resistors. A common practice in traditional programming languages such as BASIC and FORTRAN is to use the symbols i and j as loop variables. For the second case, R = 10 Ω. How long does it take it each case? Find the result of A divided by B using array right division. However, some users might require greater control over the screen display. Thus These relations can be used to generate the plot of x versus W. EXAMPLE 4.9-1 A College enrollment model. % of element 1 x 1 Breaking strength (kN) y % of element 2 x 2 7.1 0 5 19.2 1 7 31 2 8 45 3 11 294 Solution The script file is as follows: x1 = (0:3)'; x2 = [5,7,8,11]'; y = [7.1,19.2,31,45]'; X = [ones(size(x1)), x1, x2]; a = X\y yp = X*a; Max_Percent_Error = 100*max(abs((yp-y)./y)) The vector of breaking strength values predicted by the model. The cost of the fence is \$40/ft for the straight sides. By using a for loop with conditional statements. If such a loop occurs, press Ctrl-C to stop it. 26 510 date Displays current date. 58, 60, 296 sum Sums each column. The for loop checks to see whether the absolute frequency for a particular bin is nonzero. Use this menu to select an equation to fit to the current data set. $\tan -1\ 100\ 46\ c$. Then write a MATLAB program to solve the problem. This shows that a rotation through a negative angle is equivalent to an inverse transformation. Suppose an object starts at time t = 0 and moves with a velocity of v(t) = $\cos(\pi t)\ m$. $v = -g^{t} + s0^{s}\sin(th)$; The following program uses these functions to animate the projectile motion in the first subplot, while simultaneously displaying the vertical velocity in the 578 second subplot, for the values $\theta = 45^{\circ}$, s $\theta = 45^{$ second-order, or third-order reaction, and estimate the value of the rate constant k. The results gave a mean of 19.9993° for θ with a standard deviation Figure 7.3-1 Dimensions of a triangular cut. Enter the gains for the four Gain blocks using the expressions shown in the block. Be sure to include the units of measurement for all input and all output variables! d. To use different intervals, specify a four-element vector of the form [xmin xmax ymin ymax]. From now on we will ignore the distinction between random and refer to these numbers as random, as is done in the MATLAB documentation. The mathematical expression for the PID algorithm in the parallel form, using the Simulink notation, is (10.10-1) (10.10-2) The transfer function form is (10.10-3) Thus we see that PID stands for Proportional-Integral-Derivative, and the constants, P, I, and D are called the proportional. Integral, and derivative gains. For example, in 20 tests these data show that a 95 occurred 4 times. The angle θ can be found from the trigonometry of the right triangle. 228, 231 fplot Intelligent plotting of functions. For example, atan(1) returns the answer 0.7854 rad, which corresponds to 45°. We use an if statement to determine when to switch from the increasing admissions and transfer schedule to the constant schedule. To get the handle for the figure function. Rank of A equals the number of unknowns. It usually employs computer-aided design (CAD) software, computeraided engineering (CAE) software, and simulation software, and sintegrating software, and simul block to the outport port on the preceding block. This notation creates the cell but does not store any contents in it. format Controls the screen's output display format (see Table 1.1-5). Use the fit to estimate S when T = 8°C and T = 50°C. Use of the sound function is demonstrated with the following user-defined function, which plays a simple tone. Then in year k + 1, the number of sophomores is given by To solve this equation, we need to solve the "freshman" equation (4.9-1) at the same time, which is easy to do with MATLAB. 353 rref Computes reduced row echelon form. Thus we must use element-by-element multiplication to compute y(t). × x, where x must be in radians. Test Your Understanding T9.1-3 Use MATLAB to evaluate the following double integral: (Answer: 2.2083) T9.1-4 Use MATLAB to evaluate the following triple integral: 366 (Answer: 1.875) 398 9.2 Numerical Differentiation The derivative of a function. Development of a function. Development of the function. Development of the function and be integral: 366 (Answer: 1.875) 398 9.2 Numerical Differentiation The derivative of a function. a Simulink model for the case where m = 1 kg, k = 5 N/m, μ = 0.4, and g = 9.8 m/s 2. For simplicity we will assume that this distance is the straight-line distance. Thomas Scaife, Jolynn Kilburg, Laura Bies, and Lora Neyens of McGraw-Hill Education and Kate Scheinman efficiently handled the manuscript reviews and guided the text through production. It is composed of the functions g(y) = 5 sin(y) and . Then choose Create Subsystem from the Edit menu. The current fit is displayed in the Fit window. Conservation of mass for benzene and toluene can be applied to derive the following relation [Felder, 1986]. The program is a = input('Enter the value of side a: '); b = input('Enter the value of side a: value of side b: '); c = input('Enter the value of side c: '); p = a + b + c; s = p/2; A = sqrt(s*(s-a)*(s-c)); disp('The perimeter is:') p disp('The perimeter is:') p disp('The area is:') A 159 Example 2. In this case the syntax is fplot(function, [xmin xmax ymin ymax]). In such cases we might be able to include additional information, objectives, or constraints to find a unique solution. Strings are useful for creating input prompts and messages and for storing and operating on data such as names and addresses, max(A) Returns the integrand f(x), is either a function handle of the integrand function or the name of an anonymous function. An ideal diode blocks the flow of current in the direction opposite that of the diode's arrow symbol. Systems having dead-time elements are easily simulated in Simulink. ASCII-FILE Because they are ASCII files, M-files can be created using just about any word processor. Section 10.8 33. The parameter τ should be chosen to be small compared to the oscillation period and the time constant, both of which we do not know. Develop a Simulink model of this system to obtain the plate, so no single point can describe the plate is 9. The temperature varies through the plate is 9. The temperature varies the plate elements in the array A. The "walk" may simply be motion back and forth on a straight line (a 1-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a
2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plane (a 2-dimensional walk), or it can take place on a plac T11.6-2 Find the characteristic polynomial and roots of the following matrix. 259 241 Figure 5.4-3 A contour plot of the surface z = xe - [(x - y 2 2)2 + y2] created with the contour function. (A common oversight is to use degrees.) MATLAB provides the built-in constant pi to use for π . Note that A.\B is not equivalent to A./B. (They can be anchored to the plot by pinning; see the MATLAB Help under "Add Annotation to Graph Interactively.") To delete or move a line or arrow, click on it, then press the mouse button 235 and move it to the desired location. Create a MATLAB function called fxy to evaluate the function f(x,y) defined as follows: Test your function for all four cases. MATLAB frequently expresses results in the form 1/a*b whereas we would normally write b/a. For example, you will see, among others, ACOS ACOSD ACOSH ASIN ... SIN ... Inverse cosine, result in radians From this list you can find the correct name for the sine function. rand(n) Generates an n \times n matrix containing uniformly distributed random numbers between 0 and 1. ylabel('Flow Rate (cups/sec)'), axis([5 15 0.1 0.3]) 282 The computed values are m = 0.433 and b = 0.0499V 0.433. Note that the result x: [2x1 sym] indicates that there are two solutions for x. As an example, you may type the following values for water, in U.S. Customary units, in the Command window. These are different from the right-hand sides of the original three Equations (8.4-1) through (8.4-3). (a) (b) (c) 30. If d 2 f/dx 2 = 0, the point is a neither a minimum 516 nor a maximum, but is an inflection point. 99 c. The relation between the velocity and acceleration a(t) is The script file is shown below. For example, typing x = 8 + 3*5 returns the answer x = 23. Although Simulink has the PID controller block, it not always be possible to code it for use on certain hardware. Set the Stop time to 50 and observe the behavior of the liquid heigh h(t) in the Scope. Iterative Operations Determine how many terms are required for the series 10k 2 - 4k + 2, k = 1, 2, 3, any(x) Returns a scalar, which is 1 if any of the elements in the vector x is nonzero and 0 otherwise. Remember that using symbolic matrices avoids numerical imprecision in subsequent operations. (x, y) = (-5, 8) c. This technology is called nanotechnology because it involves processing materials whose size is about 1 nanometer (nm), which is 10 -9 m, or 1/1 000 000 mm. In this case you should not use brackets, but you can optionally use parentheses. Note that the values of xmax, ymax, and vmax are computed and used to set the axes scales. 237, 240 subplot Creates plots in subwindows. You can access subsets of a cell's contents. The arm is 0.5 m long. Use the plot to estimate how many days it will take before the water volume of 10 9 L. You invoke this function by using the name of the M-file in which it is defined. They are the building blocks of larger programs. What are the contents of the (1,1) element in the (2,1) cell in this array? The perpendicular distance of the point (x 1, y 1) from the line Ax + By + C = 0 is given by where the sign is chosen to make $d \ge 0$. The options for value are true or false. 109 54. Code: Enables you to analyze, run, time, and clear commands in your programs. Investigate the effectiveness of each case. The following table gives the price the company pays per ton for each material, along with the number of tons purchased (tons) Material Price (\$/ton) May June July 1 300 5 4 6 2 550 3 2 4 3 400 6 5 3 4 250 3 5 4 5 500 2 4 3 Use MATLAB to answer these questions: a. 12 global Declares variables to be global. Convert the angle to degrees. For example, to plot the polynomial $f(x) = 9x^3 - 5x^2 + 3x + 7$ for $-2 \le x \le 5$, you type >>x = -2:0.01:5; >>polyval([9,-5,3,7], x); >>plot(x, f), xlabel('x'), ylabel('f(x)'), ylabel('f(x surface. The applied force is u = 35, the initial position is y(0) = 2, and the initial velocity is (0) = -3. These commands are summarized in Table 1.4-1. Realize that some of it might later be found unnecessary. To evaluate a matrix numerically, use the subs and double functions. Determine the allowable range of positive values for the voltage v 2. ω = 1 rad/s b. Its output is the augmented matrix [C d] that corresponds to the equation set Cx = d. In this case the loop variable is a vector that is set equal to the successive columns of the matrix expression during each pass. If we evaluate this equation at the data values x = 0, 5, and 10, we obtain the values y = 1.833, 6.333, 10.8333. Each chapter contains numerous practical examples. Suppose you want to obtain a relative frequency histogram. Because A -1 Ax = Ix = x, we obtain the solution (8.1-2) The inverse of a matrix A is defined only if A is square and nonsingular. For example, to find the maximum test score of the second student, you type max (student(2).tests). Returns a row vector containing the largest elements in each column if A is a matrix. Two versions of its symbol are shown in Figure 10.1-2a. Plot the trajectories for A = 45° corresponding to five values of the initial velocity v: 10, 12, 14, 16, and 18 m/s. You can use the abbreviations syms y(t), Dy=diff(y,t), D2y=diff(y,t), D2y=diff(y,t derivatives, and so on. A To Workspace block can be added to obtain the plot in MATLAB. An example of a matrix having three rows and the number of columns. If T a and T b remain constant for some time, then the heat energy stored in each subsquare is constant also, and the heat flow rate between each subsquare is constant. Click Save. 1.5 The MATLAB Help System To explore the more advanced features of MATLAB Help System. Type the label in this book, you will need to know how to use effectively the MATLAB Help System. consisting of all elements in the second through fourth rows of A. Chapter 11: Symbolic Processing with MATLAB......Page 45231. If x is a vector, cumsum(x) returns a vector the same length as x, whose elements are the sum of the previous elements. Thus we can find the exponential function that fits the data by typing p = polyfit (x, log10(y),1). They are defined as follows in terms of the two logical variables. The default Desktop shows three tabs: HOME, PLOT, and APPS. You start the year with 1000 shares. The new cell array D will have three rows, four columns, and 12 arrays. 12; Semicolon; separates columns in an array, and suppresses display. Use a different data marker for each set. 239 These coordinates are in the same units as the plot's data. For example, to find the characteristic equation and solve for the roots in terms of the spring constant k, use the following session. 510 Test Your Understanding T11.2-3 Find the y coordinates of the intersection points in Example 11.2-1. Use the values R = 5 × 10 -5 °F-hr/lb-ft and C = 4 × 10 4 lb-ft/°F. Suppose you have saved the file problem 1.m in the folder c:\matlab\homework. Such a file can be called a computer program, and writing such a file is called programming. The sequence of numbers produced by randi is determined by the settings of the same uniform random number generator used by rand, randn, and randperm. If the input argument is a symbolic representation of the given numeric scalar or matrix, the result is a symbolic representation of the given numeric scalar or matrix. assigned values before you create the function handle. Name this variables by solving the latter equation for L. Answers to Selected Problems......Page 53536. Separate y Axes The yyaxis function (formerly called plotyy) generates a graph with two y axes. In such cases the pseudoinverse method x = pinv(A)*b gives one solution, the minimum-norm In cases where there are an infinite number of solutions, the ref function can be used to express some of the unknowns in terms of the remaining unknowns in terms of the remaining unknowns in terms of the remaining unknowns in terms of the unknowns in terms of the remaining unknowns in terms of the unknowns in terms of the remaining unknowns in terms of the unknowns in terms of shows that steady state has been reached. You can alter the appearance of the Desktop if you wish. Thus if the vectors are parallel and in the same direction, $\theta = 0$ and u. Global Variables The global command declares these directions that declare these directions are parallel and in the same direction. variables global. % Simulates multiple tosses of a fair coin. Thus, referring to Table 6.1-1, we see that the vector p will be [p 1, p 2] if n is 1. 251 Figure P40 271 41. Suppose we apply a force f to a mass m, pushing it along a straight line starting from rest. Obtain the surface and contour plots for the function z = -x 2 + 2xy + 3y 2. (a) Use MATLAB to compute and plot y(t) when (b) Use MATLAB to compute and plot y(t) when y(0) = 0 and . If you solve the problem with a program, hand check the results using a simple version of the problem. Plot V(t) versus t. function [theta,RC,DL,DR] = wheel_inverse(L,xC,yC) % Two Wheel Drive
Inverse Solution A = -xC/yC; theta = turn_angle(A); RC = 0 and . yC/sin(theta); DL = (RC - L/2)*theta; DR = (RC + L/2)*theta; DR = (RC + L/2)*theta; ond function theta = turn angle(A) % Computes turn angle for two wheel vehicle theta guess); end 484 These equations and two functions can be used either to plan a trajectory for the vehicle or togenerate command inputs to either position or speed control systems for each wheel. Notice that the Editor uses line numbers. xlabel('Deflection (in.)'), ylabel('Force (lb)'),... The number of such constants is the same as the order of the ode. Speed Control We now use speed and position control as our examples. rng(#x2018;shuffle#x2019;) Initializes the random number generator based on the current time obtained from the CPU clock. A variable in MATLAB is a symbol used to contain a value. The equations of motion are Figure P35 Suppose that m 1 = m 2 = 1, c 1 = 3, c 2 = 1, k 1 = 1, and k 2 = 4. They are the first, second, and fifth values, which are 2, 4, and 7. >>x = 1:10; >>y = 5*x; >>h = 1:10; >>y plot(x,y) h = Line with properties: Color: [0 0.4470 0.7410] LineStyle: '-' LineWidth: 0.5000 Marker: 'none' XData: [1 2 3 4 5 6 7 8 9 10] YData: [5 10 15 20 25 30 35 40 45 50] ZData: [1 × 0 double] The plot handle is h. To obtain the more standard appearance shown in Figure 10.2-6, first extend the line vertically a for the line vertically contained to the line vertically a for the line vertical v down from the Sum input port. The following function creates this matrix. This figure forms the basis for developing a Simulink model to solve the equation. The symbol | is a spacer indicating here that the top port is to be empty. You can also nest functions within other nested functions. (Answer: 292 values.) T5.1-3 Plot the imaginary part versus the real part of the function (0.2 + 0.8i) n for $0 \le n \le 20$. Then use the fzero function to find all the roots. Superscripts are created by typing _. However, this notation has not been carried over into MATLAB, which uses $\log(x)$ to represent $\ln x$. 167 Miscellaneous mathematical functions Item Description Pages cross Computes cross products. For example, consider the following user-defined function, which computes . Section 2.1 1. 93 Table 2.7-1 Structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description names = fieldnames(S) Returns the field names associated with the structure functions Function Description Des will get an "unbalanced parentheses warning." Variable Names WORKSPACE The term workspace refers to the names and values of any variables in use in the current work session. You can create a symbolic matrix consisting of functions. MATLAB users can create their own functions for their special needs. Use MATLAB to find the quarterly costs for materials, labor, and transportation; the total material, labor, and transportation costs for the year; and the total quarterly costs. Properly label the plot. The first three fields each contains a vector having numerical elements. These commands are called function functions. The title and gtext commands can be used to place a title and text. The left division method works fine when the equation set has a unique solution. An approximation to the function sin x is sin $x \approx x - x 3$ /6. Write a function that accepts temperature in degrees Fahrenheit (°F) and computes the corresponding value in degrees Celsius (°C). If the applied voltage goes from 0 to 10 V at t = 0, use MATLAB to determine and plot the voltage y(t) for second. However, it is usually possible to write the code to avoid using the break command. Diver 1 swims 55 ft west, 36 ft north, and then dives 25 ft. Label each axis and put a title on the plot. other functions of time. Calculations generating numbers that are too large or too small result in overflow and underflow. The order of the subfunctions does not matter, but function names must be unique within the M-file. For example, in the session listed earlier, if you type Fruit and press Tab, MATLAB completes the name and displays FruitPurchased. Solution The characteristic polynomials. The extended syntax enables the user to adjust the accuracy. It The generalization of this formula to an n-dimensional vector v gives the magnitude of the vector and is the Euclidean norm N. The values of a and b depend on the type of gas. who Lists the variables currently in memory. Consider the geometry of the circular turn shown in Figure 10.10-8. The NOT operation $\sim A$ returns an array of the same dimension as A; the new array has 1s where A is 0 and 0s where A is nonzero. In addition, approximately 96 percent of the area lies between the limits of $\mu - 2\sigma \le x \le \mu + 2\sigma$ and 99.7 percent, or practically 100 percent, of the area lies between the limits of $\mu - 3\sigma \le x \le \mu + 3\sigma$. The ASCII characters on an Englishlanguage keyboard, plus some special characters on an Englishlanguage keyboard. specified by the mouse. 320 EXAMPLE 7.2-1 Mean and Standard Deviation of Heights Statistical analysis of data on human proportions is required in many engineering applications. GRAPHICS WINDOW The plot appears on the screen in a graphics window, named Figure 1, as shown in Figure 1.3-1. A common mistake is to type log(x), instead of log10(x). The choice of the bin width and 289 bin center can drastically change the shape of the histogram. Mickelson. What does the program predict? Compute the PID gains required to obtain the roots s = -10, -20, -20. To plot a histogram, the data must be grouped into subranges, called bins. (The function's name is an abbreviation of eigenvalue which is another name for characteristic root.) For example, consider the equations EIGENVALUE (9.5-3) (9.5-4) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type >> A = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for these equations is To find the characteristic roots, type = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for the equations is To find the characteristic roots, type = [-3, 1; -1, -7]; >>r = eig(A) The matrix A for the equations is To find the equations is equations or sets of equations, whether or not boundary conditions are specified, and whether or not the default independent variable. Test Your Understanding T4.4-1 Given a number x and the quadrant q (q = 1, 2, 3, 4), write a program to compute sin -1 (x) in degrees, taking into account the quadrant. The result is We must now find the values of d and θ to minimize L. Thus r is the distance of the object from the sun. Section 7.4 covers interpolation methods, including linear and spline interpolation. The animation shows how the location and height of the function peak changes as the parameter b is increased. Some systems have an unavoidable time delay in the interaction between components. Displays the path name of item is a function or file. Contents......Page 97. This creates a copy of the file, and leaves the original file untouched. This limitation might be due to deliberate restrictions placed on the unit. semilog plot. This constant becomes determined when we apply an additional condition of the solution by requiring that the solution by requiring that the solution by requiring that the solution of the actual computer code. [t2, x2] = ode45(@pendulum, [0 tF], [0.2 0]; plot(t1, x1(:,1), t2, x2(:,1)), . Table 9.4-1 Syntax of the solution by requiring that the solution by ODE solver ode45 Command Description [t, y] = Solves
the vector differential equation = f (t, y) specified by the function file whose output must be a y0, options) column vector representing dy/dt; that is, f(t, y). If we want the move to be completed in time T, then we divide the displacements by T to obtain the required wheel rotational speeds, S L = φ R /T. The lift-to-drag ratio is an indication of the floors of a three-story building. A particular batch distillation unit is charged initially with 100 mol of a 60 percent mol benzene/40 percent mol toluene mixture. The college wants to study, over a 10-year period, the effects of increasing admissions by 100 each year and transfers will be held constant. Use the given information to perform the calculation and round off the result consistent with the precision of the given information: Because this text is about MATLAB, we might as well use it to do this simple calculation. 43. Many applications use the following "small angle" approximation for the sine to obtain a simpler model that is easy to understand and analyze. EXAMPLE 8.2-2 Calculation of Cable Tension A mass m is suspended by three cables attached at three points B, C, and D, as shown in Figure 8.2-1. For example, the result is obtained from >> syms x y >> int(xy^2,y,0,5) ans = $b^3/3-a^3/3$ The form int(E,m,n) returns the integral of the expression E with respect to the default independent variable evaluated over the interval [m, n], where m and n are symbolic expression. Find the array quotient z = y./x. 180 Increment burn time from 0 to 100. With the second strategy, every day the price is below \$150 you buy 100 shares, and every day the price is above \$160 you sell all the shares you own. The row number must always come first! For example, the element a 32 is in row 3, column 2. 522 [X,Y,Z] = peaks(50); % Create data. Type help clabel. 101 d. 167 isinf True if elements are plot(x,y),text(2,100,label) 533 D APPENDIX References 587 [Brown, 1994] Brown, T. MATLAB sometimes fails to group terms like x^(1/2)*y^(1/2), and often fails to group terms like x^(1/2)*y^(1/2), and often fails to group terms like x^(1/2)*y^(1/2) instead of a/(b*c+d). D = 6 ft, L AB = 3 ft, and W = 2000 lb, use a loop in MATLAB to find L AC min , the shortest length L AC we can use without T AB or T AC exceeding 2000 lb. The tank is filled through a hole in the top and drained through a hole in the bottom. 26 what Lists all MATLAB files. Finally we solve for the required radius. 357 389 358 CHAPTER 9 Numerical Methods for Calculus and Differential Equations 9.5 Special Methods for Linear Equations 9.6 Summary Problems This chapter covers numerical Integrals and derivatives of computing integrals and derivative and for solving ordinary differential equations. Of course, we can assign the result to a variable in the usual way. A Simulink model can be developed by adding these algorithms to one of the Transfer Fcn block. The remainder of the text does not depend on knowledge of this topic. In the List of Signs window, type +--. 244, 315 histogram Creates a histogram plot. The symbol for managing a session Item Description Pages clc Clears Command window. Hand-check the answers. A certain company makes televisions, stereo units, and speakers. Thus if x is a random number with a mean of 0 and a standard deviation of 1, use the following equation to generate a new random number y having a standard deviation of σ and a mean of μ. Use MATLAB to compute the sum of each column. The cost to construct the cylindrical part of the tank is \$300/m 2 of surface area; the hemispherical part costs 400/m 2. Suppose that the initial conditions are y(0) = (0) = 0. The building's natural frequencies in cycles per second are the positive roots of this equation. For example, to preallocate a 1×1 structure array for the student database, you type 99 student = struct('name','John Smith', 'SN', ... 0001786', 'email', '', ...' tests', [67,75,84]) Accessing Structure Arrays To access the contents of a particular field, type a period after the structure array name, followed by the field name. 167 Figure 4.4-2 Flowchart of the else structure. What is the average cost to produce one widget? The first time through the loop the index coord is contents of a particular field, type a period after the structure. [3, 7]'. You can use functions with variables. The number of slugs in 30 kg. Use numerical methods with MATLAB to estimate derivatives. Since the step lengths have an average distance covered in 100 steps is about 0.5(100) = 50. total = 0; k = 0; while total < 2e+4 k = k+1; total = 10*k^2 - 4*k + 2 + total; end disp('The number of terms is:') disp(k) disp('the sum is:') disp(total) Finding Bugs Debugging a program is the process of finding and removing the "bugs," or errors, in a program. The syntax lsim(sys1,sys2,...,u,t,x0) plots the responses of multiple LTI systems on a single plot. 276 Plot the residuals. Figure 1.4-1 shows a screen containing. the resulting Command window display and the Editor/Debugger opened to display the script file. In addition to being limited by saturation, some actuators have limits on how fast they can react. An equation (PDE). With proper algebraic manipulation of the resulting quantities, the solution of the differential equation can be recovered in an orderly fashion by inverting the transformation process to obtain a function of time. Determine the speed of the sled at t = 10 s. 211 19. If so, the pass is made. 61 size Computes array size. transform of the solution. The following types are available: sine wave (type = 'sin'), square wave (type = 'sin') becomes smaller. Enclose the cell contents on the right side of the assignment statement in braces {}. Test Your Understanding T8.5-1 Type in the script file lineq.m given in Table 8.5-2 and run it for the following cases. The following session shows some examples of its use. Find the array product w = x.*y. Thus it can be used to teach programming principles. Figure 11.4-1 Plot of the solution of . If it is nonzero, append the appropriate number of data values to the vector y_raw. Time (s) Voltage (V) 0 0.5 1 1.5 2 2.5 3 3.5 100 62 38 21 13 7 4 2 Sections 6.2 and 6.3 8.* The distance a spring stretches from its free length is a function of how much tension force is applied to it. The variables y and z represent current in milliamperes; the variable x represents voltage in volts. Use MATLAB to express cos 5θ as a polynomial in x, where x = cos θ. Use the Ramp block in the Sources library. Round toward the nearest integer. form. Use the Basic Fitting interface to solve this problem. dsolve(eqn,cond1, Returns a symbolic solution of the ode specified in the expressions cond1, cond2, ...) to the conditions specified in the expressions cond1, cond2, ...) to the conditions specified by the discussion, we will call the instructions by the generic name commands. Use the semilogx(x,y) command to have the x scale logarithmic and the y scale rectilinear. OVERLAY PLOTS You can create multiple plots, by including another set or sets of values in the plot function. The vectors ta and xa contain the results for the case where $\theta(0) = 0.5$. In both cases, . Demonstrate this fact for the solutions found in parts a and b and comparing the plot with that generated by solving for the total response with y(0) = -5. The amplitude remains constant, as predicted by the small-angle analysis, and the period for the case where $\theta(0) = 0.5$ is a little larger Figure 9.4-2 The pendulum angle as a function of time for two starting positions. Chapter 8 covers a related topic, the matrix inverse. Problem 18 d. To specify the final time tF, use the syntax initial(sys,x0,tF). Display the results. When the input (the independent variable on the graph) is between -0.5 and 0.5, the output is zero. Another type 332 of paired data represents a profile, such as a road profile (which shows the height of the road along its length). (b) Estimate the velocity at times t = 1, 2, . 7.4 Interpolation Paired data might represent a cause and effect, or input-output relationship, such as the current produced in a resistor as a result of an applied voltage, or a time history, such as the temperature of an object as a function of time. If you want to tell MATLAB that f is a function of the variable t, type syms f(t). For example, to compute the integral3(fun, 1, 3, 0, 2, 1, 2) The answer is A = 1.8484. Use MATLAB to compute and plot the motor's speed and current versus time. The result y int is a vector the same size as x int containing the interpolated values of y that correspond to x int. After placing it as shown, double-click on it and enter [-0.5, -0.1, 0, 0.1, 0.5] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0, 500, 4500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0, 500, 0, 500, 0, 500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0, 500, 0, 500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0, 500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0,
500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0, 500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0, 500, 0, 500, 0, 500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0, 500, 0, 500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0, 500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0, 500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500] for the Vector of input values and [-4500, -500, 0, 500, 0, 500, 0, 500] for the Vector of input values and [-4500, -50 requirements among other things. We can use the continue statement to do this. These include Starting and exiting MATLAB menu and toolbar system. Gradients The gradient ∇f of a function f(x, y) is a vector pointing in the direction of increasing values of f(x, y). If s is negative, the loop will not be executed if m is less than n. The model's characteristic equation is (10.10-10) Note that in general we now must use all three gains to achieve any desired values of the roots. Typing rand(size(A)) produces an array of random entries that is the same size as A. When called with left-hand arguments, as [y, t] = lsim(sys, u,...), the function returns the output response y and the time vector t used for the simulation. Explain which curve fit gives the most 282 reliable prediction. To fill the tank, water is pumped into the top at the rate given in the 486 following table. 226, 231 566 Plot enhancement commands Item Description Pagesta colormap Sets the color map of the current figure. More powerful methods are available for linear equations. Linear algebraic equations can be solved "by hand" using pencil and paper, by calculator, or with software such as MATLAB. Key Terms Backward difference, 398 Cauchy form, 410 Central difference, 399 Definite integral, 390 Eigenvalue 416 Euler method, 403 Forced response, 403 Forward difference, 398 Free response, 403 Improper integral, 390 Indefinite integral, 390 Initial-value problem, 402 Laplacian, 402 LTI object, 416 Modified Euler method, 404 Singularity, 390 State-variable form, 410 Step size, 404 Forward difference, 398 Free response, 403 Improper integral, 390 Initial-value problem, 402 Laplacian, 402 Laplacian, 402 Laplacian, 402 Laplacian, 402 Laplacian, 402 Laplacian, 403 Forward difference, 398 Free response, 403 Improper integral, 390 Initial-value problem, 404 Singularity, 390 State-variable form, 410 Step size, 404 Singularity, 390 Initial-value problem, 402 Laplacian, 402 Laplacian, 402 Laplacian, 404 Singularity, 390 State-variable form, 410 Step size, 404 State-variable form, 4 Problems You can find answers to problems marked with an asterisk at the end of the text. 195 continue Passes control to the next iteration of a for or while loop. Subtraction is done in a similar way. The pseudocode can provide the basis for comments within the program. These conditions give the two equations or (8.3-2) (8.3-3) Because there are more unknowns than equations, the set is underdetermined. After running the previous script, the last element of cumsum(y scaled)* binwidth is 1, which is the area under the scaled frequency histogram. Structured programs are easier to debug because each module is designed to perform just one task, and thus it can be tested separately from the other modules. x = input('text') Displays the text in quotes, waits for user input from the keyboard, and stores the value in x. EXAMPLE 2.5-1 Earthquake-Resistant Buildings designed to withstand earthquakes must have natural frequencies of vibration that are not close to the oscillation frequency of the ground motion. Consider the system for lifting a mast shown in Figure P26. Figure 1.6-1 is a sketch of the situation, showing the height h of the package, its mass m, its speed v, and the acceleration due to gravity g. Redo Example 2.4-4 as a script file to allow the user to examine the effects of labor costs. Therefore, the spline function is more accurate if the data are "smoother.' There are no overshoots and less oscillation in the function produced by pchip, even if the data are not smooth. integral2 (fun,a,b,c,d) Computes the double integral of the function f(x, y) between the limits a $\leq x \leq b$ and c $\leq y \leq d$. If x = 0.2:6, then typing x.^2 returns the array [0 2 , 2 2 , 4 2 , 6 2] = [0, 4, 16, 36]. Section 2.4 36.* Use MATLAB to find the products AB and BA for the following matrices: 37. If the number of conditions is less than the order of the equation, the returned solution will contain arbitrary constants C1, C2, and so on. A certificate of deposit (CD) is one type of investment whose 178 interest rate depends on the length of the term. 319 348 Engineering in the 21st Century. Additive Manufacturing T hree-dimensional (3D) printing builds a three-dimensional object by laying down successive layers of material. Note the difference between the results given by [a, b] and [a; b] in the following session: >>a = [1,3,5]; >>b = [7,9,11]; >>c = [a,b] c = 1 3 5 7 9 11 >> D = [a;b] D = 1 3 5 7 9 11 Matrices and the Transpose Operation The transpose operation interchanges the rows and columns. Thus we should choose z to be its maximum, namely, z = 2.727 tons. You can use it for recalling, viewing, filtering, and searching recently used command and then press Enter, or use the mouse to select it. Van der Pol's equation has been used to describe many oscillatory processes. The addiorecorder function records sound from a PC-based audio input device. The equation of motion for this pendulum is (9.4-3) Suppose that L = 1 m and g = 9.81 m/s 2 . 400, 402 m/s 2 . polyder Differentiates a polynomial product, or a polynomial quotient. This opens the Editor, and displays the EDITOR, PUBLISH, and VIEW tabs. Thus the statements return the result z = 0. Use the Figure 8.2-2 An electric resistance network. The program uses the given arrays A and b to check the rank conditions; the leftdivision method to obtain the solution, if one exists; and the rref method if there are an infinite number of solutions. {thmin(4),310,33,32.2})) 471 vmin = 105.3613 Because the second derivative (second) is positive, the solution is a minimum. 3 /s, how long will it take to fill the cup to the brim? For example, to obtain the second element in the (2, 4) cell of array C and assign it to the variable r, you type r = C $\{2,4\}$ (1,2). Obtain the mean, variance, and histogram of these numbers, and discuss whether they appear normally distributed with the desired mean and variance. This is a more advanced topic, so unless you will be creating large, complex programs, you will probably not need to use these function, where seed is a positive integer. These developments, as well as development of alternative energy sources, will be required in a number of areas such as engine design, electric motor and battery technology, lightweight materials, and aerodynamics. In most schools, MATLAB is the principal computational tool used throughout the curriculum. Division and exponentiation must also be carefully defined when you are dealing with operations between two arrays. x 25 30 35 40 45 y 5 260 480 745 1100 b. This pane enables you to explore the numerical results of a single fit to the current data set without plotting the fit. So we will avoid singularities if 0 < h < 10. From this chart or the pseudocode, we can develop the script file shown in Table 8.5-2. You can use the digits and the vpa functions to change the number of digits used by MATLAB for calculating and evaluating expressions. Depending on what other MathWorks products are installed, you might see additional items in this window, such as the Numerator to [1] and the Denominator to [1, 2, 4]. So we probably should report that the package will not be damaged if it is dropped from a height of less than 9 ft. Suppose we wanted to plot y $2 = 4 + e - x \cos 6x$ versus y $1 = 3 + e - x \sin 6x$, $-1 \le x \le 1$ on the same plot with the complex function z = (0.1 + 0.9i) n, where $0 \le n \le 10$. For example, >>sym num sym([pi, 1/3]); >>double(sym_num) ans = 3.1416 0.3333 The function poly2sym(p) converts a coefficient vector p to a symbolic polynomial. z = (x < y) b. You can build an equation interactively from a palette of symbols and structures (go to the Insert tab of the Live Editor and click on Σ Equation). A small dot appears to indicate that the lines have been successfully connected. You should obtain values close to 6, 2, and 10, respectively. EXAMPLE 11.3-1 Topping the Green Monster The "Green Monster" is a wall 37 ft high in left field at Fenway Park in Boston. For example, the equation (9.5-5) is one description of a particular system. The following example illustrates the procedure for developing and testing such a program. For example, unless the elevations are labeled on contour lines, you cannot tell whether there is a minimum or a maximum point. 389 (9.5-11) (9.5-12) where L, R, and I are the motor's inductance, resistance, and inertia; K T and K e are the torque constant; c is a viscous damping constant; and v(t) is the applied voltage. Test your function for the following two cases, using the values k 1 = 10 4 N/m; k 2 = 1.5 × 10 4 N/m; k 2 = 1. the ratio of the amplitude of the input voltage v o (t) to the amplitude of the input voltage v i (t). New as of R2016a, the readtable command creates a table from a file. A step function is difficult to use with a numerical solution method, especially when the input derivative is present, due to the discontinuity at t = 0. (Answer: x = 3, y = -2.) T2.4-6 Use MATLAB to solve the following set of equations. Use the polynomial giving the best fit to estimate the amount of additive that minimizes the drying time. For more information, type help datatypes. Doing so can cause unpredictable results. The Data Statistics for data and add plots of the statistics to a graph of the data. For example, to remove the
student number field and call the new structure array new student, type new student, type new student, 'SN'); Using Operators and Functions with Structures You can apply the MATLAB operators to structures in the usual way. The model is where y is the bacteria population in ppm and t is time in minutes. 16, 26 format long 16 decimal digits. Obtain the surface and contour plots for the function z = x 2 - 2xy + 4y 2, showing the minimum at x = y = 0. Polynomials are used for controlling the motion of robots. The arrows indicate how the model's calculations are updated for each new year. The Tools Menu The Tools menu includes items for adjusting the view (by zooming and panning) and the alignment of objects on the plot. Steps in Engineering Profession for many years. This tells MATLAB to add 2 to the current value of x, and to replace the current value of x and to replace the current value of x and to replace the current value of x. with this new value. If n is a vector, the first element is the number of times to play in the movie, and the remaining elements are a list of frames to play in the movie. 33 namelengthmax Returns the maximum number of characters allowed in a name. He served as Acting Department Chair from 2002 to 2003. COMMENT The symbol % designates a comment, which is not executed by MATLAB. You can force the output to be in scientific notation by typing format short e, or format long e, where e stands for the number 10. Although planned to operate for only 90 Martian days, Spirit operated for over five years, became stuck in 2009, and stopped communicating in 2010. In general, arrays can have more than one column and more than one row. 354 Solution The matrices A and b are The session is >>A = [3, 2, -9; -9, -5, 2; 6, 7, 3]; >>rank(A) and [A b]. Do this for the following three cases. is empty(A) Returns a 1 if A is an empty matrix and 0 otherwise. Use the function to obtain surface plots with the functions mesh and meshc. We also introduce some other blocks in this section. Brackets are required for arrays unless you use the colon operator to create the array. (a) Orbit A: p = 1, $\varepsilon = 0.01$. 36. A = [0, -1, 4; 9, -14, 25; -34, 49, 64]; for m = 1:size(A,1) for m = 1. = 1:size(A,2) if A(m,n) >= 0 B(m,n) = sqrt(A(m,n)); else B(m,n) = A(m,n) + 50; end end B The result is 187 When a logical array is used to address another array, it extracts from that array the elements in the locations where the logical array is used to address another array. Suppresses some line feeds. Commands, such as clear, need not have arguments; but if they do, they are not enclosed in parentheses, for 15 example, clear x. An error occurs if this is not true. You can run the file by typing its name at the Command window prompt. Applied to this tank, the principle says that the rate of change of liquid volume in the tank must equal the flow rate out of the tank; that is, (9.3-12) From Equation (9.3-12) From Equation (9.3-12) gives the required equation (9.3-12) gives the required equation (9.3-12) from Equation (9.3-12) gives the required equation (9.3-12) from Equation (9.3-12) from Equation (9.3-12) gives the required equation (9.3-12) from Equation (9.3-12y, and z coordinates of the vector are 5, 7, and 2, respectively. 502, 505 simplify Simplifies an expression. For these values find the expressions for the two characteristic roots in terms of c. In this case log 10 y = m log 10 x + log 10 b, which has the form w = p 1 z + p 2, where the polynomial variables w and z are related to the original data variables x and y by w = log 10 y and z = log 10 x. One advantage of this method is that we are not required to use the transforms for the derivatives. In MATLAB to compute the following, and check the results with a calculator. As an "inline" function object 4. 534 Math toolbox which is like the piece of paper. Use MATLAB the first layer is the Figure window, which is like the piece of paper. includes the heaviside(t) function, which produces a unit-step function. Positive values of elevation correspond to moving above the object; negative values move below. Key Terms Absolute value, 59 Array operations, 62 Array size, 60 Cell array, 88 Cell indexing, 88 Empty array, 56 101 Field, 91 Identity matrix, 81 Left division method, 82 Length, 59 Matrix, 54 Matrix operations, 62 Null matrix, 81 Row vector, 52 Structure arrays, 90 Transpose, 53 Problems You can find the relations between the variables. The parametric equations for a circular helix are 269 where a is the radius of the helical path and b is a constant that determines the magnitude M of the moment of a force vector F about a specified line. 415 and that and Thus we can create $\theta(t)$ by integrating the constant twice. However, matrix multiplication and division are not the same as element-by-element multiplication and division. (a) Find the (x, y) coordinates of the intersection points in terms of the parameter b. The amplitude of the sine wave decays with time because the sine is multiplication and division. s. Suppose instead of the Euler approximation (9.3-4) we use the average of the right-hand side of Equation. Compute the triple integral 18. 119 sech(x) Hyperbolic secant; 1/cosh x. Compute the double integral 14. Use this information to plot the fixed and total variable costs versus Q, and graphically determine the breakeven point(s). On this interval the minimum point is at the boundary x = 1. \\ Backslash. Construct a Simulink model of the following problem. It attempts to find the symbolic expression I such that diff(E) = I. The syntax of the ones command is the same, except that it creates arrays filled with 1s. Inverse sine; arcsin . isinf(A) Returns an array of the same dimension as A, with 1s where A has 'inf' and 0s elsewhere. To round to n significant digits you type round(x,n, 'significant'). Then use the same technique to connect the bottom input port of the Mux block to the arrow from the output port of the Dead Zone block. The estimated relative speed is 0.3286 nmi/min, or 19.7 knots. Instead of being represented by a box, the multiplication process is now represented by a triangle like that used to represented by a triangle like that used to represented by a triangle like that used to represented by a box, the multiplication process is now represented by a triangle like that used to represented by a triangle like that used to represented by a box, the multiplication process is now represented by a triangle like that used to represent an electrical amplifier, hence the name gain block. For example, it is easier to clear breakpoints with the drop-down menu. The power function can pass through the origin but only if m > 0. As soon as the speed to increase because the motor torque must now work against the disturbance. 574 drawnow Initiates immediate plotting 58 numel(A) Returns the total number of elements in the array A. We will show how to interpret MATLAB results correctly. The second pane of the Basic Fitting interface is labeled Numerical Results. If you declare a variable persistent and a variable pe of 3 + 4i is 5.) The sort will be done in descending order if the form sort(A, 'descend') is used. Suppose you want to 21 Figure 2.7-1 Arrangement of data in the structure array student. Type dbclear test3 to clear all the breakpoints. This is discussed later in this section. For example, suppose vou have the variables a = 3 × 10 150, b = 5 × 10 200. For this reason we now introduce a method that allows us to determine easily whether it is unique. The two polynomials need not be of the same degree. 16, 26 format bank Two decimal digits. Use MATLAB to determine the 10th element. See Figure P16. To take a specific example, consider the two-wheeled robot vehicle shown in Figure 10.10-8. To minimize the cost of concrete used to line the channel, we want to minimize the length of the channel, we want to minimize the length of the channel. types of arrays that are useful for some specialized applications. A weight W is supported by two cables anchored a distance D apart (see Figure P12). To illustrate, let us compute the integral given in Equation (9.1-2). To 272 find the coefficient values a 0, a 1, and a 2 to y. To illustrate, let us compute the integral given in Equation (9.1-2). To 272 find the coefficient values a 0, a 1, and a 2 to y. to fit a set of data (y, x 1, x 2) in the least-squares sense, we can make use of the fact that the left-division method for solving limits. To check this and to find the speed required, continue the session as follows. The result obtained with the rref function is x 1 = 0.2558 - 0.3721x 3, x 2 = 1.0465 - 0.9767x 3, x 3 arbitrary. semilogy(x,y) Produces a semilog plot of y versus x with logarithmic ordinate scale. poly2sym(p) Converts a polynomial. The values of S and r 2 were calculated by adding the following lines to the end of the script file shown in Example 6.2-1. If you do not, MATLAB just identifies the handle; it does not execute the function. If then B = A.^3 gives this result: We can raise a scalar to an array power. In this section we limit our coverage to first-order equations. This implies CAUCHY FORM This form is sometimes called the Cauchy form or the statevariable form. Compute the perimeter p. In that case all the elements of the array are compared to the scalar. If checked, the residuals are displayed. The height h(t) and horizontal distance x(t) traveled by a ball thrown at an angle A with a speed v are given by At Earth's surface the acceleration due to gravity is g = 9.81 m/s 2, ones(n) Creates an n × n matrix of 1s. If E represents an expression, then the solution obtained will be the roots of the expression E: that is, the solution of the equation E = 0. If fps is omitted, the default is 12 frames per second. Launches a dialog box that allows you to save the fit results to workspace variables. Logarithm; $\ln x$. Use the Laplace transform method to solve for the unit-step response
of v o (t) for zero initial conditions, where $C = 10 \times 10 - 5$ F and $L = 5 \times 10 - 3$ H. The value of the unit-step response of v o (t) for zero initial conditions, where $C = 10 \times 10 - 5$ F and $L = 5 \times 10 - 3$ H. The value of the unit-step response of v o (t) for zero initial conditions, where $C = 10 \times 10 - 5$ F and $L = 5 \times 10 - 3$ H. final time of 2475 sec was found by increasing the final time until the plot showed that the height became 0. In the following session, note the difference between the result obtained by find(x & y) above. A nonzero solution, in which at least one unknown is nonzero, exists if and only if rank(A) < n. Using an Array as a Loop Index It is permissible to use a matrix expression to specify the number of passes. The set Ax = b with m equations if and only if (1) rank(A) = rank([A b]). Use the subs and double functions to evaluate an expression numerically. This toolbar is shown in Figure 5.3-2. Set up a matrix equation to be solved for the coefficients a 1, a 2, and a 3, given values for θ 1 (0), θ 1 (t f), and t f. Figure 2.3-1 Aortic pressure response for Example 2.3-2. Printed in the United States of America. 58 max Returns largest element. EXAMPLE 8.3-2 A Statically Indeterminate Problem Determine the forces in the three equally spaced supports that hold up a light fixture. Can you reduce the overshoot in v without the PID output exceeding 40? 58 Figure P34 35. Here there are three data points, and J is given by RESIDUALS The values of m and b that minimize J are found by setting the partial derivatives $\partial J/\partial m$ and $\partial J/\partial b$ equal to zero. Table 1.1-1 Scalar arithmetic operations Symbol Operation MATLAB form ^ exponentiation: a 32^0.2 ans = 11 >>4^(1/2) ans = 2 >>4^(-1/2) ans = 0.5 To avoid mistakes, feel free to insert parentheses wherever you are unsure of the effect precedence will have on the calculation. We use a dc motor as the application. Rise time: The time required for the response to rise from 10 to 90 percent of its steady-state value. A particular cylindrical tank is 10 m tall and has a radius of 6 m. It displays the first comment (if any) in the file. In such cases, a common model is the signed-square-root (SSR) relation Figure 10.7-1 A hydraulic system with a flow source. Arrays, and Plots 1.4 Working with Files 1.5 The MATLAB Help System 1.6 Problem-Solving Methodologies 1.7 Summary Problems This is the most important chapter in the book. Typing 2^3 - 10 returns the answer ans = -2. The Derivative block has no settings, so merely place it in the Simulink diagram as shown in Figure 10.9-6. prod = polyder(p1,p2) % Derivative of p2/p1. 455 >> syms x y real >> w = x^2 + y^2; To clear x of its real property, type syms x clear. From statics, the weight force must balance the spring forces at this new position. The values arrays are arrays arrays are arrays are arrays are arrays arrays arrays scaled histogram is 1, the fractional area corresponding to a range of heights gives the probability that a randomly selected 20-year-old man will have a height in that range. These control structures first ask a question to be answered with a true/false answer and then select the next instruction based on the answer. Predefined Input Functions 391 You can always create any complicated input function to use with the ODE solver ode45 or lsim by defining a vector containing the input function's values at specified times, as was done in Example 9.5-1 for the trapezoidal profile. By eliminating h, obtain the expression for A as a function of r and V. The shape of a cable hanging with no other load other than its own weight is a catenary curve. 319 Continuous Approximation to the Scaled Histogram For processes having an infinite number of possible outcomes, the probability is a function of a continuous variable and is plotted as a curve rather than as rectangles. Section 10.6 22. Fluid flows in pipe networks can be analyzed in a manner similar to that used for electric resistance networks. 488 Section 10.5 18. Animation speed depends of the intrinsic speed of the computer and on what and how much is being plotted. Chapter 4 covers programming using relational and logical operators, conditional statements, and loops. It is possible for J to be larger than S, and thus it is possible for r 2 to be negative. Thus the statement z = 5 > 2 + 7 is equivalent to z = 5 > (2+7) and returns the result z = 0. Perhaps it is in our nature to "push the limits," and we admire others who do so. Plot the free response for the initial conditions y(0) = -5. Its syntax is as follows: function [output arguments] = function name(input arguments) Figure 3.2-1 The default Editor Window when creating a new function. For each of the two cases below, use MATLAB to determine whether or not orbits A and B intersect, and if they do, determine the polar coordinates of the intersect, and if they do, determine the polar coordinates of the intersection point. The flowchart is shown in Figure 4.4-1. 501, 504 sym Creates a symbolic variable. Check your results with the mean and std functions. where (x c, y c) are the coordinates of the new location of the center point and are given by Equation (10.10-16). Then coord = [3,6,2;7,6,8]. You can plot other statistics as well; these are shown in the figure. In December when the temperature is $4^{\circ}F(-15^{\circ}C)$, the volume of gas in the tank is 28,500 ft 3. y = [91*ones(1,13),92*ones(1,15),93*ones(1,12),... stabel('Absolute Frequency Histogram for 100 Tests'); The result appears in Figure 7.1-2. They are part of the MATLAB core so they are very efficient, but the computational details are not readily accessible. A $x \ge 90$ B $80 \le x \le 69$ F x < 60 a. Suppose we want to estimate the derivative dy/dx at the point x 2. The variable x represents height in kilometers, and the variable x represents time in seconds. For example, none of the 100 men had a height of 65 in. For example, assuming x and y have already been assigned scalar values, if x >= 0 % Calculate new value for y. For example, the Live Editor operations producing Equation (11.3-3) are shown in Figure 11.3-2. To create a legend, use the legend command. Use MATLAB to find the largest element in each layer of D and the largest element in D. The energy E (in joules) released by the quake is related to the magnitude M on the Richter scale as follows. Because we want to plot x 1 and x 2, which are z 1 and x 2, which are z 1 and z 3, we must use the following matrices for C and D. Thus the linear spring model should be f = kx where c = 0. Type which item to display the full path name of the function item or the file item (include the file extension). rank(A) Computes the rank of the matrix A. RANK OF A MATRIX Consider the 3 × 3 determinant. You may think of built-in functions as primitives that form the basis for other MATLAB functions. The first defined function in the file is called the primary function, whose name is the same as the M-file name. It was noted in the previous section that the mean of the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed random variables equals the sum (or difference) of two independent normally distributed = [1/L; 0]; C = [0,1]; D = [0]; sys = ss(A,B,C,D); Time constants = -1./real(eig(A)) time = 0:0.0001:0.6; k = 0; for t = 0:0.0001:constants are computed to be 0.0041 and 0.0184 s. In MATLAB, if x is a scalar we write this expression as $(\sin(x))^2$, not as $\sin^2(x)$, $\sin^2(x)$, model shown in Figure 10.10-4 with a unit-step command input, let m = 1 and T = 0.3. Compute the PI gains required to obtain the roots s = -50, -100. Continue the problem 531 the session is >> syms y(t) >> Dy = diff(Dy,t); >> cond1 = y(0) ==1; >> cond2 = Dy(pi) ==2; >> dsolve(eqn,cond1,cond2) ans = cos(3*t)-2*sin(3*t)/3 So the solution is Using Other Independent variables 483 Although the default independent variables 483 Although the default independent variables 483 Although the default independent variable is t, you can use a different independent variable. July? For example, the following integral can be found in most integral tables: INDEFINITE INTEGRAL SINGULARITY
However, it is an improper integral if the integration limits include the point x = 1. The elements of the vector p are the coefficients of the point x = 1. The elements of the vector p are the coefficients of the point x = 1. The elements of the vector p are the coefficients of the point x = 1. The elements of the vector p are the coefficients of the vector p are the vector p are the coefficients of the vector p are the vector answers with a calculator. For beam 1 For beam 2 219 Figure P38 For beam 3 Find the maximum value of the weight W the structure can support. The steps in the solution are as follows: 1. We now show how to use this function 162 The find function is very useful for creating decision-making programs, especially when combined with the relational or logical operators. If the length of x is m, then x is plotted versus the columns of A. The magnitudes of the cubic are by far the smallest. One bank pays 5.5 percent annual interest, while a second bank pays 4.5 percent annual interest. A subdirectory of rsmith called private may contain functions in rsmith can call. %f Fixed-point notation. Consider the following costs for a certain chemical product: Fixed cost: \$2.045 million/year. Other types of ODE problems are discussed at the end of Section 9.6. Table 9.2-1 Numerical differentiation functions Command Description d = diff(x) Returns a vector d containing the differences between adjacent elements in the vector x. (1 k $\Omega = 1000 \Omega$.) 5.* Use MATLAB to solve the following equations for x, y, and z as functions of the parameter c.. student interest. The facing page of each chapter contains a photograph of a recent engineering achievement that illustrates the challenging and interesting opportunities that await engineers in the 21st century. The following session illustrates how this is done. response = input('Do you want to continue? Use the resistance values R 1 = 10,000, R 2 = 14,000 lb sec/ft 5. Methods for Calling Functions There are four ways to invoke, or "call," a function into action: 1. 527 Quantization is an issue when you are using a microphone and analog-to-digital converter to capture real sound, but we will not discuss it here because we will produce only simulated sounds in software. Type dbquit to exit the debug mode. d. Simulink: Starts the Simulink program. The results show that the relay logic control scheme keeps the speed within the desired limits of 250 and 350 before the disturbance torque starts to act. Copy the Transfer Fcn block by right-clicking on it, holding down the mouse button, and dragging the block copy to a new location. Declare V to be global within the function. Figure 10.10-6 Simulink model of a simple position control system. Follow these rules: 1. Use MATLAB to determine how many elements are in the array sin (-pi/2):0.05:cos(0). Let R be the thermal resistance of the material between the centers of adjacent subsquares. 378 348 Figure P6 b. The two reactors are available for 35 and 40 hrs per week, respectively. The grid, label, and text functions can be used with the mesh function. 142 For example, to write mixed text and numeric data to an Excel .xlsx file starting at cell C1 of sheet 3, the session is >>file name = 'speed data.xlsx'; >>A = {'Time(s)', 'Speed(m/s)'; 1,12;2,14;3,16;4,21;5,27}; >>sheet = 3; >>range = 'C1'; >>xlswrite(file name,A,sheet,range) MATLAB provides several other ways to import data. 128 Histogram functions Item Description Pages bar Creates a bar chart. 63 When two arrays have identical size, their sum or difference has the same size and is obtained by adding or subtracting their corresponding elements. Use the Simulink model to plot the response x 1 (t) for the following input. A particular cylindrical tank is 15 m tall and has a radius of 8 m. 16, 26 format loose Resets to less compact display mode. But suppose that p(0) is the same for both models but the r values are different. 416, 544 inv Returns the inverse of a matrix. 10.2 Introduction to Simulink Type simulink in the MATLAB Command window to start Simulink, or click on the icon under the HOME tab. At the output of the first block there is a dead zone for $-1 \le x \le 1$. Applying conservation of energy gives the following equations. For example, if you want to plot only certain columns of data, you can uncheck the columns not 237 wanted. A number of such initiatives are underway. "Apostrophe. Add the following bridge to the structure array created in Problem 60. 306 T (K) P (torr) 273 4.579 278 6.543 283 9.209 288 12.788 293 17.535 298 23.756 15. Poor communication is the cause of many errors! 2. Figure 11.2-2 in Section 11.2 shows a robot arm having two joints and two links. Section 7.1 gives an introduction to basic statistics and probability, including histograms, which are specialized plots for displaying statistical results. An m × n matrix A has a rank $r \ge 1$ if and only if |A| contains a nonzero $r \times r$ determinant and every square subdeterminant with r + 1 or more rows is zero. This method is based on Gauss elimination. The differences depend on whether there is no output, or multiple outputs. (c) The requirements of the problem. If the increment q is omitted, it is presumed to be 1. The else statement can be used with elseif to create detailed decision-making programs. Use the MATLAB ODE solvers to solve sets of higher-order ordinary differential equations whose initial conditions are specified. Problems......Page 21218. Random walk methods provide a basis for understanding Brownian motion, which describes the seemingly random motion of particles in a fluid caused by collisions with the fluid's molecules. Test your function for two cases where Y is measured to be 0.5: (a) R = 1.1 and (b) R = 1.05. Second Exponentiation, evaluated from left to right. We can call both built-in and user-defined functions either with the output variables specified. (The function might perform some other operation that we want to occur, such as producing a plot.) Note that if we omit the semicolon at the end of the function call statement, the first variable in the output variable list will be displayed. Evaluate the following expressions in MATLAB has an extensive number of built-in math functions, and users can define their own functions and save them as a file for reuse. grid Displays gridlines at the tick marks corresponding to the tick labels. EXAMPLE 9.4-1 A Nonlinear Pendulum Model The pendulum shown in Figure 9.4-1 consists of a concentrated mass m attached to a rod whose mass is small compared to m. Thus the term v'.^2 is a 6 × 1 array, and the term sind(theta).^2 is a 1 × 4 array. Although the linear approximation does not give the exact answer, it can be used to see if our numerical answer is "in the ballpark." The following example illustrates this approach. A session using this function called cube that computes the surface area A and volume V of a cube whose side length is L. The following example uses the tab code (t). This equation for Y(s) in terms of V(s) and y(0). 27. Use MATLAB to check the answer. Thus, the block containing the number 10 represents the process x(t) = 10f(t), where f(t) is the cause (the input) and x(t) represents the effect (the output). Note that the number of unknowns equals the number of columns in A, which is given by size A(2), the second element in A or B is nonzero and 0s where A and B are both 0. These enable us to compute the respiratory quotient R: Thus the fifth equation is Rb - e = 0. Table 8.5-2 MATLAB program to solve linear equations % Script file lineq.m % Solves the set Ax = b, given A and b. The cost of the fence is \$50 per foot for the curved portion and \$40 per foot for the straight sides. Example of a Script File The following is a simple example of a

script file that shows the preferred program style. 84 The dot product command dot(A, B) computes a row vector of length n whose elements are the dot products of the corresponding columns of the m \times n arrays A and B. If R n approaches zero for large n, the expansion is called the Taylor series for f(x) about x = a. %% Define the cubic from its coefficients. Note that negative values x, y, and z have no meaning here. To create a string variable, enclose the characters in 170 single quotes. 114 angle(x) Angle of a complex number x. 45. 400 a. Given the PI gains P = 150 and I = 5000, put a Scope block on the PID block output. Chapter 3 1. Plot the displacements of the masses over $0 \le t \le 2$ s for if the initial displacement of m 1 is 0.1 m. 4*sin(th1)+3*sin(th1+th2)==2) S = th1:[2x1 sym] >>double(S.th1)*(180/pi) % convert to degrees. Command Description diff(E) Returns the derivative of the expression E with respect to the default independent variable. The scalar result of each row-column multiplication forms an element in the result, which is a column vector. The Edit Menu You can use the Edit menu to cut, copy, and paste items, such as legend or title text, that appear in the figure. EXAMPLE 9.1-3 Double Integral over a Nonrectangular Region Compute the integral over the integral over the integral over the integral over the integral into one that is specified over a rectangular region. Note that in mathematics text, ln x denotes the natural logarithm, where implies that 119 because ln e = 1. What does your intuition tell you to expect from the mechanism? 320 349 321 CHAPTER 8 Linear Algebraic Equations OUTLINE 8.1 Matrix Methods for Linear Equations 8.2 The Left-Division Method 8.3 Underdetermined Systems 8.4 Overdetermined Systems 8.5 A General Solution Program 8.6 Summary Problems Linear algebraic equations. Plot the catenary curve for $-20 \le x \le 30$ m. Round to the nearest integer toward $-\infty$. Use a solid line type for each, and use the gtext command to label each curve. Figures 10.7-7, 10.7-8, and 10.7-9 illustrate some electrical and mechanical systems that are likely candidates for application of subsystem blocks. One or more lines of data, arranged in rows and columns, follow the header. replaced with the following shorter form. 90 (Answer: x = 2, y = -5, z = 10.) Matrix Exponentiation Raising a matrix to a power is equivalent to repeatedly multiplying the matrix by itself, for example, A 2 = AA. 2.2 Multidimensional arrays. This value is not grossly different from our rough estimated with the following shorter form. of 52 min, so we should feel comfortable accepting the numerical results. These are the Command window in the center, the Workspace window in the upper left. $z = (x \sim = y) d$. (a) 1.01 rad (58°); (b) 2.13 rad (122°) (c) -1.01 rad (-58°); (d) -2.13 rad (-122°). The rules for determining leap years in the Gregorian calendar are as follows: 1. Use linear multiple 281 regression to obtain a model y = a 0 + a 1 x 1 + a 2 x 2 of the relationship between the number of twists and the alloy percentages. 156 top-down design. The function atan2d(y,x) returns the answer in degrees. A tank having vertical sides and a bottom area of 100 ft 2 is used to store water. 260 meshc Same as mesh with contour plot underneath. How small must x be for the approximation to be accurate within 5 percent? Determine whether a unique solution exists. Arrays ARRAY One of the strengths of MATLAB is its ability to handle a collection of numbers, called an array, as if it were a single variable. This means that our function files are "portable" and need not be rewritten every time they are used in a different program. We can obtain an estimate more quickly by using the following variation of the interp1 function. 290 EXAMPLE 6.2-2 Estimation of Traffic Flow The following data give the number of vehicles (in millions) crossing a bridge each year for 10 years. Thus, do not give a script file the same name as a variable it computes because MATLAB will not be able to execute that script file more than once, unless you clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear the variable. view(-37.5+0.5*(k-1),30) M(k) = getframe; end cla % Clear -1.7200 + 0.0400i. Consider the following function test3(x) shown in Figure 4.8-1. The Figure toolbar To activate the Figure 5.3-1). Double-click on it to open the Block Parameters window, and set the Step Time to 0, the Initial Value to 1. You might need more or fewer lines in the table. However, the left-division method A\b gives x 1 = -1.3846 and x 2 = 2.2692, which is not an exact solution! This can be verified by substituting these values into the original equation set. Typing $x = sym(\dot{x}, \dot{r}eal)$ tells MATLAB to assume that x is real. v(2:5) represents the second through fifth elements; that is v(2), v(3), v(4), v(5). ischar(A) Returns a 1 if A is a character array and 0 otherwise. Three items on the Edit menu are very useful for editing the figure. Test Your Understanding T7.3-2 Suppose a particle starts at x = 0 and moves either 0, 1, 2, 3, 4, 5, or 6 spaces forward at each stage, all with equal probability The rover is 2.9 m (9.5 ft) long by 2.7 m (8.9 ft) wide by 2.2 m (7.2 ft) in height. If its inner radius is b, its volume and surface area are given by a. Note that t is the default independent variable, and not x as with the other symbolic functions. INITIAL-VALUE PROBLEM An ordinary differential equation (ODE) is an equation containing ordinary derivatives of the dependent variable. % Created on March 1, 2016 by W. They are numbered 1, 2, 3, and so on to avoid confusion with the in-chapter exercises. The following example uses assignment statements to build a structure. If condition (1) is satisfied but r < n, there are an infinite number of solutions, and r unknown variables can be expressed as linear combinations of the other n - r unknown variables, whose values are arbitrary. A transcendental functions, such as sin x, e x, or log x. There are two new blocks in this model. Better sensors are expected for imaging and other data collection. Estimate a bearing's life if it operates at 150°F. Symbolic processing is a relatively new computer application, and such software is undergoing rapid development. At its saddlepoint at x = y = 0, the surface has zero slope, but this point does not correspond to either a minimum or a maximum. This description is called the reduced form. The ball weighs 1 lb. (b) find the quotient E 1 /E 2 and express it in its simplest form. Unlike the initial function can be used with either a state model or a transfer function to declare such a variable as persistent, which means that their values are retained in memory between calls to that function. histogram(y,n) Aggregates the data in the vector y into n bins of uniform width between the minimum and maximum values in y. 32.) Proper Use of the Assignment Operator It is important to understand that the = symbol in MATLAB works differently than the equals sign you know from mathematics On the other hand, accurate measurements are not possible on a surface plot; these can be done on the contour plot because no distortion is involved. Double-click an object when plot edit mode is enabled. The sine function sin(9.7t + π/2) oscillates with a frequency of 9.7 rad/sec, which is 9.7/(2π) = 1.5 Hz. Thus its period is 1/1.5 = 2/3 sec. 119 acsch(x) Inverse hyperbolic cosecant; csch -1 x. By default, the audiorecorder function creates an 8000 Hz, 8-bit, 1-channel object. File Types MAT-FILE MATLAB uses several types of files that enable you to save session results, data, and programs. For example, you should be able to Create, address, and edit arrays. Imaginary part is %2.0f. 534, 546 int Returns the integral of an expression. .), the function returns the output response y, the time vector t used for the simulation, and the state vector x evaluated at those times. min(A) Same as max(A) but returns minimum values. % amplitude = sound amplitude ft. The one obtained with the pseudoinverse method is x = -0.1972, x = -0.197and v represent speed in miles per hour; the variable x represents distance in miles. % Create the Rectilinear Plot x1 = 0:0.01:100; u1 = x1.^2; num1 = 100*(1-0.01*u1), y1 = sqrt(num1./den1);
subplot(1,2,1), plot(x1,y1), xlabel('y'), % Create the Loglog Plot x2 = logspace(-2, 2, 500); u2 = x2.^2; $num2 = 100^{(1-0.01^{u}2).^2} + 0.02^{u}2; den2 = (1-u2).^2 + 0.1^{u}2; y2 = sqrt(num2./den2); subplot(1,2,2), loglog(x2,y2), xlabel('y') It is important to remember the following points when using log scales: 1. Use the data to compute (a) the current in each resistor and (b) the 78 power dissipated in each resistor. If you do this in MATLAB,$ you will get an error message. 24. 336, 339 interp2 Linear interpolation of a function of two variables. 69 T2.1-2 For the same matrix B, use MATLAB to (a) find the largest and smallest elements in B and their indices and (b) sort each column in B to create a new matrix C. From the design of the rocket propulsion of the launch vehicles and the calculation of the interplanetary trajectories, to the design of the rovers' systems, MATLAB was used in many of these applications, and it is well suited to assist designers of future probes and autonomous vehicles like the Mars rovers. Plot V and A versus r in two subplots, for 0.1 ≤ r ≤ 100 m. 17 The Live Editor, which was added in R2016a, you can create and run live scripts. Determine how much longer it will take to accumulate at least \$50,000 in the second bank account if you deposit \$1000 at the end of each year. The function te -t/b is then evaluated and plotted over the range 0 ≤ t ≤ 100 for b = 2, 3, 4, ... in the for loop, and the previous plot is erased. >>A 1 = 2; 2 = 5; rho = 1.94; g = 32.2; >>R 1 = 20; R = 1; h = 10; h = 10; h = 1; h = 10; h = 10; h = 10; h = 1; h = 10; h2z = 2x + 2y. Now suppose you want to obtain the pendulum response for different lengths L or different gravitational accelerations g. Robot-assisted surgery is now often used for hip and knee replacement. These projects included highways, bridges, water supply systems, sewer systems, and electrical power distribution networks. Note, however, that using the numeric array eye(3), as C = A(eye(3)), results in an error message because the elements of eye(3) do not correspond to locations in A. (b) The largest elements in the first, second, and third layers are 10, 9, and 10, respectively. (It may also be 1 for standard output—the screen—or 2 for standard error. 100^3/2 9. Outcomes that can be described by this function are said to be normally distributed. This opens a dialog box that prompts you for a name for the structure. The result is a row vector that contains the polynomial's coefficients arranged in descending order of power. Then the model can be written as Integrate both sides of each equation over time to obtain 422 We will introduce four new blocks to create this simulation. The first-order model written for each of the n data points results in n equations, which can be expressed as follows: or, in matrix form, 274 which can be expressed as limits of our abilities, not only in structural design but also in areas that we might not think of, such as elevator design and operation, aerodynamics, and construction techniques. >> v2 = rand(1,5) v2 = 0.2161 0.9763 The first use of rand changed the state of the generator, so the second result v2 is different. (a) Compute the motor angles required to position the hand at x = 6 ft, y = 2 ft. 409 We can first check the above expression for dh/dt for singularities. Refer to Figure P30. The element C(m, n, p) is located in row m, column n, and layer p. The parameters p and \in determine the size of the orbit and its eccentricity, respectively. In some cases, we can find a transformation that produces a straight line in the transformed variable. hold Freezes the current plot for subsequent graphics commands. Select and place the Mux block from the Signal Routing library. For example, if 115 x = [4, 9, 16], typing sqrt(x) give us the vector [2, 3, 4]. For example, the years 1800, 1900, 2100, 2300, and 2500 are not leap years, but 2400 is a leap year. The effect of switching back and forth between these linear models makes the overall model nonlinear. Comment lines starting with the % sign can be placed anywhere in the function file. Open a new model window, and then do the following to create the model shown in Figure 10.3-2. We will cover m files in this chapter. Clicking the Axes Properties item brings up the Property Editor—Axes dialog box. 58 norm(x) Computes the geometric length of x. Do this by using forward, backward, and central differences. If so, there is a unique solution, which can be computed using left division. The second form is histogram(y,n), where n is a user-specified scalar indicating the number of bins. 9.* An object thrown vertically with a speed v 0 reaches a height h at time t, where 144 Write and test a function that computes the time t required to reach a specified height h, for a given value of v 0 . isnan(A) Returns an array of the same dimension as A with 1s where A has 'NaN' and 0s elsewhere. Note that the prompt is not visible when you press Enter after the ellipsis. Use this to interpolate or extrapolate the current fit. Write a MATLAB function to use with the fminbnd function, the following types of user-defined functions can be created in MATLAB. This panel allows you to visually explore one or more fits to the current data set. Returns the derivative of the expression E with respect to the variable v. Time (s) 0 1 2 3 4 5 6 7 8 9 10 Velocity (m/s) 0 1 4 9.5 18.5 32.5 53 81 117 162 211.5 Test Your Understanding T9.1-1 Modify the script file given in part (b) of Example 9.1-1 to estimate the displacement at times t = 1, 2, . Finally, from Equations (10.10-14) through (10.10-16) we obtain These equations are implemented in the function wheel inverse, which calls the function wheel inverse, which calls the function see a steam turbine. 93 rmfield Removes a field from a structure array. diff(E,n) Returns the nth derivative of the expression E with respect to the default independent variable. Note that the order of the input arguments must be t and y even though t does not appear on the right-hand side of the equation. following three panels associated with a given figure. Each type of data (name, student number, and so on) is a field, and its name is the field name. (a) |xy| = 105, $\angle xy = -2.6$ rad. Test Your Understanding T11.5-1 Find the Laplace transform of the following functions: 1 - e - at and cos bt. Conservation of mechanical energy: . Comments are used mainly in script files for the purpose of documenting the file. >> syms n x y int(x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), n ~= -1, x^{(n+1)/(n+1)} >> int((x^n) ans = piecewise(n == -1, log(x), can call the function square as square (side) if we are not
interested in its output variable area square. We will use MATLAB to do the more difficult task to follow.) Because the ball is hit 4 feet above the ground, the ball must rise 37 - 4 = 33 ft to clear the wall. The choice of z within this range must be made on some other basis, such as profit. To obtain an ordinate scale from -5 to 25, and to place a label on the the ordinate, you would type >> fplot(E),axis([-2 6 -5 25], ylabel('E') Table 11.1-1 Functions for Creating and Evaluating Symbolic Expressions Command to enhance a plot's appearance, for example, the title, xlabel, and ylabel commands and the line type commands to be introduced in the next section. To select or design an adequate power supply, we need to determine how much current will be drawn from the power supply when this load is attached. E. Overlooking this fact commonly causes errors in MATLAB Write a script file to implement this procedure. Its syntax is y int = spline(x,y,x int), where x and y are vectors containing the values of the independent variable y. >>hours 3 = [4, 1, 5, 3]; >>unit cost = hourly cost*[hours 1', hours 2', hours 3'] unit cost = 162 114 149 Thus the costs to produce 1 unit each of products 1, 2, and 3 are \$162, \$114, and \$149, respectively. The equations for the armature-controlled dc motor shown in Figure 6.1-1 for examples with b = 1.) The linear function can pass through the origin only if b = 0. Test Your Understanding T9.5-2 Obtain the state model for the reduced form model. The general formula for generating a uniformly distributed in the state model back to reduced form, and see if you get the original reduced form model. The general formula for generating a uniformly distributed in the state model back to reduced form. interval (0,1). 105 Use enough points to get a smooth curve. Use the MATLAB program given in Table 8.5-2 to solve the following problems: a. The File Menu The File Menu is used for saving and printing the figure. Preface......Page 169. 24 Entering Commands and Expressions To see how simple it is to use MATLAB, try some practice. For example consider the following session. 5 ln(7) d. For example, the moment M with respect to a reference point O due to the force F is given by M = r × F, where r is the position vector from the point W and to write formatted output to a data file. For now, click on Blank Model. The usefulness of structure charts and flowcharts is limited by their size. Copy the Gain box, change its label to c, and place it as shown in Figure 10.6-2. Any MATLAB command is allowed at the prompt. In mathematics text we denote this operation by the superscript T. Kutz, ed., Wiley, 2016), and was a special contributor to the fifth editions of Statics and Dynamics, both by J. >>rng(4) Then, create a vector of random numbers. For example, >>syms b c >>solve(b^2+8*c+2*b==0) % Solves for c. Earth's orbit, which is nearly circular, is represented by the innermost circle. This is useful for larger reports. 244 Figure 5.2-6 Two examples of exponential functions plotted with the semilogy function (the left-hand plot), and an example of a power function plotted with the loglog function (right-hand) plot. The Symbolic Figure 11.5-4 Pulse and impulse functions. A simple example of how a process can change the input distribution is given by the process y = x 2. The row-column multiplications form column vectors, and these column vectors form the matrix result. One estimate can be obtained from the straight line labeled A in the figure. We have noted that the outcomes of many processes 325 Table 3.1-1 Random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniformly distributed random number functions Command Description rand Generates a single uniform random number functions Command Description random Figure 10.10-1 Structure of a feedback control system. Select and place the Gain block from the Block Parameters window. First we assign values to the variables r and h representing the radius and height. These conditions are specified as follows: cond = [y(a) = b, Dy(a) = c, D2y(a) = d], and so on. Choose Characteristics to obtain a submenu that contains the response characteristics. For example, the numbers 0, 0.1, 0.2, ..., 10 can be assigned to the variable u by typing u = 0:0.1:10. Checking the Number of Input and Output Arguments Sometimes you will want to have a function act differently depending on how many inputs it has. You will need to add a Sum block. For example, the rank of A in Equation (8.1-3) is 2 because |A| = 0 while |A| contains at least one nonzero 2 × 2 subdeterminant. The General Matrix Multiplication Case We can state the general result for matrix multiplication as follows: Suppose A has dimension m × p and B has dimension p × q 183 516 case Provides alternate execution paths within switch structure. The xyz coordinates of the hand are given by 250 where t is time in minutes. Label and format the plots appropriately. Let the tension force in wire i be T i . An internal combustion engine and an electric motor drive the wheels. These operators are shown in Table 4.2-1. zeros(n) Creates an n × n matrix of 0s. (See 256 Figure 6.1-2 for examples with b = 1.) Figure 6.1-1 Examples of exponential functions. To plot y versus x and v v basic syntax is fminsearch (@function, x0) where @function is a function handle. Note that the atmospheric pressure p a cancels out of the model because of the model using a name other than Tank. 255 567 Program flow control Item Description Pages break Terminates execution of a loop. >>y ??? Thus the ratio J/S indicates the fractional variation unaccounted for by the model. So, to plot a sine wave, we should "sample" or evaluate it many 580 times over the period. Polynomial roots can be found with the roots(a) function, where a is the polynomial's coefficient array. The following program plots the contour plot and the gradient (shown by arrows) for the function The plots are shown in Figure 9.2-2. One design phase of such systems is hardware-in-the-loop testing, in which the controlled object (the engine or vehicle suspension) is replaced with a real-time simulation of its behavior. (c) To find the total cost to produce 10, 5, and 7 units, respectively, we can use matrix multiplication: In MATLAB the session continues as follows. This is the sixth equation (9.3-1). For example, the plot in Figure 5.4-2, produced with mesh, can also be created with fmesh with fmesh as follows. This is the sixth equation (9.3-1). as follows: >>fmesh(@(x,y) x.*exp(-(x-y.^2).^2-y.^2),[-2,2]),... xlabel('z'), ylabel('z'), ylab producing animation and sound with MATLAB. You should see an oscillating curve in the Scope display. Source: MATLAB 444 Figure 10.2-1. Thus to find the total material costs, we must sum across the first row of C. Solving a Single Differential Equation The dsolve function's syntax for find the total material costs. solving a single equation is dsolve ('eqn'). The third and fourth methods are equivalent because they both utilize the inline function; the only difference is that with the fourth method MATLAB determines that the first argument of fzero is a string variable and calls inline to convert the string variable to an inline function, the only difference is that with the fourth methods are equivalent because they both utilize the inline function; the only difference is that with the fourth methods are equivalent because they both utilize the inline function; the only difference is that with the fourth method MATLAB determines that the first argument of fzero is a string variable and calls inline function; the only difference is that with the fourth method MATLAB determines that the first argument of fzero is a string variable and calls inline function; the only difference is that with the fourth method MATLAB determines that the first argument of fzero is a string variable and calls inline function; the only difference is that with the fourth method MATLAB determines that the first argument of fzero is a string variable and calls inline function; the only difference is that with the fourth method MATLAB determines that the first argument of fzero is a string variable and calls inline function; the only difference is that with the fourth method MATLAB determines that the first argument of fzero is a string variable and calls inline function; the only difference is that with the fourth method MATLAB determines that the first argument of fzero is a string variable and calls inline function; the only difference is that with the fourth method MATLAB determines that the first argument of fzero is a string variable and calls inline function; the only difference is the first argument of fzero is a string variable and calls inline function; the only difference is the first argument of fzero is a string variable and calls inline function; the only difference is the first argument of fzero
is a string variable and calls inline f minus sign is required for each input arrow. The units are SI. William J. When a finite, real value other than 1 or 0 is assigned to a logical 1 and a warning message is issued. The symbol NaN stands for "not a number." It indicates an undefined numerical result such as that obtained by typing 0/0. For example (2.4-3) Thus the result of multiplying a 2 × 2 matrix by a 2 × 1 vector is a 2 × 1 array, that is, a column vector. 417 tf Creates an LTI object in transfer-function form. 19, 118 cot(x) Cotangent; cot x. The carbon 14 present at the time of death decays with time. *Many of these functions have extended syntax. See the MATLAB documentation for details You can create a title having the mathematical function Ae $-t/\tau \sin(\omega t)$ by typing >>title('{\it Ae}^{-{\it t/tau}})') The backslash character \ precedes all T E X character \ precedes function to compute the radius that results in the least cost. You can think of a three-dimensional array as layers of matrices. The radial grid lines allow us to determine that when $\theta = 90^{\circ}$ and 270°, the object is 2 AU from the sun. If E and old are scalars and new is an array or cell array, the scalars are expanded to produce an array result. A guide to these examples appears on page vii. The fundamentals of MATLAB are illustrated throughout with many examples from a wide range of familiar scientific and engineering areas, as well as from everyday life. MATLAB contains many powerful functions for easily creating plots of several different types, such as rectilinear, logarithmic, surface, and contour plots. Plot the absolute frequency histogram. The vector t contains the times, and the vector u contains the input values at those times. Solution Let a(k) be the number of transfers into the following year's sophomore class. 118 acs(x) Inverse cosecant; arccsc $x = \csc -1 x$. If the data are given as n pairs of (x, y) values, then n - 1 cubic polynomials are used for such problems. Time (s) 0 1 2 3 4 5 6 7 8 9 10 Velocity (m/s) 0 2 5 7 9 12 15 18 22 20 17 7.* A tank having vertical sides and a bottom area of 100 ft 2 is used to store water. Thus to evaluate sin 2 in MATLAB, we type sin(2). Use of these tabs is discussed in Section 1.2. To the right of the tabs is a box showing the Shortcut button that enables you to create easy access to commonly used procedures. This enables the function to accept y as an array. If not, the loop is skipped and the program continues to execute any statements following the end statement. Formatting Commands The format command controls how numbers appear on the screen. His industrial experience is in automated manufacturing; modeling and simulation of naval systems, including underwater vehicles and tracking systems; and design of control systems for test facilities. Flowcharts. 188 (4.5-1) (4.5-2) where m 0 is the rocket's initial mass, q is the rate at which the rocket, and q is the acceleration due to gravity. Suppose the value of RC is 0.1 s. In function discovery and semilog plots only to identify the function type, but not to find the coefficients b and m. Using the data for reactor A, the equation for its usage in one week is The data for reactor B gives This system is underdetermined. 287 Caution: It is tempting to use a high-degree polynomial to obtain the best possible fit. Click on the desired object, and use the mouse to position and size it. In fact, the distribution of z will not even be normal. Plot V and r versus A in two subplots, for $1 \le A \le 10.4 \text{ m } 2$. 479 Figure 10.10-4 Simulink model of a speed control system using an aggregated actuator-mass response time. 36.* The following equation describes the motion of a mass connected to a spring, with viscous friction on the surface. The only exception occurs when we compare an array to a scalar. Suppose the initial conditions are zero. Note that there is one input. When you save your files you must know where they are saved, especially in a public lab. A sum of \$10,000 invested at 4 percent interest compounded annually will grow according to the formula where k is the number of years (k = 0, 1, 2, ...). These are listed in Table 7.4-2. Nested functions are functions are functions defined within another function. and normally distributed with constant variance, at least 50 percent of the data will lie within the band y ± delta. 226, 231 ylabel Adds text label to y axis. Table 5.2-3 Specialized plot commands Command Description bar(x,y) Creates a bar chart of y versus x. This illustrates how the MATLAB leftdivision operator produces a solution with one or more variables set to zero, for underdetermined sets having more unknowns than equations. Create a private directory by creating a directory or a folder on your computer, but do not place the private directory on your path. By measuring the yeast yield Y we can compute a as follows a = 144/180Y. A guadratic polynomial has three parameters, and Simpson's rule computes these parameters by requiring that the quadratic pass through the function's three points corresponding to the two adjacent panels. To the right of the tabs is the Quick Access toolbar, which contains frequently used options such as cut, copy, and paste. x = 1:9; y = [5,6,10,20,28,33,34,36,42]; for k = 1:4 coeff = polyfit(x,y,k) J(k) = sum ((polyval(coeff,x)-y).^2) end The J values are, to two significant figures, 72, 57, 42, and 4.7. Thus the value of J decreases as the polynomial degree is increased, as we would expect. So, even though an integral can be found in an integral table, you should examine the integrand to check for singularities, which are points at which the integrand is undefined. Data from service records show that the time to repair a certain machine is normally distributed with a mean of 65 min and a standard deviation of 5 min. It is a bar plot of the number of data values that occur within each range, with the bar centered in the middle of the range. We can do this by using files, of which MATLAB has several types. If overshoot or oscillation occur, adding the D term often reduces or eliminates overshoot and oscillations. z = 2/5 > = 5.8 Suppose that x = [10, -2, 6, 5, -3] and y = [9, -3, 2, 5, -1]. Better communications and computer networking technology will be needed for such improvements. Minimum cost: \$294.51. Start Simulink and open a new Model window as described previously. EXAMPLE 4.3-1 Height and Speed of a Projectile (such as a thrown ball) launched with a speed of a Projectile (such as a thrown ball) l procedure depends on the specific lab, so you need to get that information from the lab manager. You can call it from a function nested at the same parent function. Type rand(n) to obtain an n × n matrix of uniformly distributed random numbers in the open interval (0, 1). In fact, any script or function that calls rand returns the same result whenever MATLAB restarts. 381 In compact form this is (9.5-2) where The following function file shows how to use matrix operations. NaN Indicates an undefined numerical result. Put a title on the plot and properly label the axes. behavior. Let us see if MATLAB gives that result. The row index is r; the column index is c. Section 11.4 34. The surface area of the hemispherical top is given by $2\pi r 3/3$. Compare the response for three cases: (a) K p = 30, K I = K D = 0 (b) K p = 27, K I = 17.18, K D = 0 (c) K p = 36, K I = 38.1, K D = 8.52 45 Assume that the college has estimates of the percentages of students repeating a grade or leaving school before graduating. 355 Figure 8.2-1 A mass suspended by three cables. Significant digits. 48.* Find the characteristic polynomial and roots of the following matrix. >>x = [6, 3, 9, 11]; y = [14, 2, 9, 13]; >>values = 6 11>>how many = length (values) how many = 2 >>indices = 1 4 Thus two values in the array x are less than the corresponding values in the array y. If you move the cursor over a variable, all occurrences of that variable are highlighted in teal. 14*. The left-division method generates an error message.) T8.3-3 Use the rref, pinv and left-division methods to solve the following set. Find the
route that has the highest average speed. You might find the Editor to be useful for locating errors in function files. To find the minimum value of y, type y = f2(x). The higher dimensions are called pages. Plot columns 2 and 3 of the following matrix A versus column 1. Consider the equations are called pages. (9.3-1) where f(t, y) is a known function and y 0 is the initial condition, which is the given value of y(t) at t = 0. 110 56. Types of Functions 135 At this point it is helpful to review the types of functions 135 At this point it is helpful to review the types of functions $x, y \in x \leq b$, $c \leq x \leq b$. $y \le (fun,a,b,c,d,e,f)$ d, and $e \le y \le f$. The magnitude of a vector v in three-dimensional space, having components x, y, z, is can be computed using matrix multiplication and the transpose as follows: . If you type more closing delimiters, MATLAB underlines the unmatched delimiter in red. Given A = [5,6,7;8,9,10;11,12,13] and B = logical (eye(3)), we can extract the diagonal elements of A by typing C = A(B) to obtain C = [5;9;13]. Examine the toolbar to locate items similar to those shown in Figure 1.1-1. When files with the same name appear in multiple folders on the search path, MATLAB uses the file named problem1 found in the folder nearest to the top of the search path. It is a general-purpose solver, whereas ode15s is suitable for more-difficult equations. Its name comes from the fact that its graph looks like a stair step (see Figure 11.5-1). 54 The increment q can be negative. double(E) Converts the expression E to numeric form. Plot evaluated results. Does the projectile reach 100 m? What will the volume of the same quantity of gas be in July when the temperature is 88°F (31°C)? 98 103 Section 2.2 11.* a. An infinite number of unknowns. A suggested structure for a script file is the following. Polynomial Integration MATLAB provides the polyint function to compute the integral of a polynomial. If these derivatives can be found, Equation (9.3-9) can be used to march forward in time. It is θ = arctan (b/a). Upper Saddle River, NJ: Prentice-Hall, 1994. To reverse the direction of the Gain block, right-click on the block, select Format from the pop-up menu, and select Flip Block. From the law of cosines From the law of sines For the given values D = 6 ft, LAB = 3 ft, and W = 2000 lb, use a loop in MATLAB to find LACmin, the shortest length LAC we can use without TAB or TAC exceeding 2000 lb. You can also type c1 = Complex(1, -2). 23.* The mechanical work W done in using a force F to push a block through a distance D is W = FD. A || B returns true if either A or B or both evaluate to true, and false if they do not. For example, round(pi,3) gives 3.1420; round(pi,3, 'significant') gives 3 your extracted Asteroids game file. (Answer: x = -10, 2 ± 5i.) 36 Plotting with MATLAB Arrays are used to create plots in MATLAB. (c) evaluate the sum E 1 + E 2 at x = 7.1 in symbolic form and in numeric form. Suppose a particle starts at x = 0 and moves forward according to a normal distribution of mean of one space with a standard deviation of two spaces at each stage. Note that when x is a vector of real values, abs(x) does not give the geometric length of the vector. The Help system is very powerful and detailed, so we have only described its basics. There are three toolbars available in the Figure toolbar, the Plot Edit toolbar, and the Camera toolbar. In the Variables panel you can select a graphics function to plot the variable by selecting the variable by selecting the variable and right-clicking to display the context menu. The capacitance of two parallel conductors of length L and radius r, separated by a distance d in air, is given by where ε is the permittitivity of air (ε = 8.854) × 10 -12 F/m). The syms command enables you to specify that expressions have certain characteristics. 100 20. Aircraft A is flying east at 320 mi/hr, while aircraft B is flying south at 160 mi/hr. Figure 4.4-3 is the flowchart for the general if structure. t_120 = (log10(120-68)-log10(b))/m % Show derived curve and estimated point on semilog scales. For example: This multiplication is performed in MATLAB as follows: >>A = [2, 9; 5, -7]; >>3*A Thus multiplication of an array by a scalar is easily defined and easily carried out. Suppose we have two curves or data sets stored in the vectors x, y, u, and v. In this formula C 6 H 12 O 6 represents glucose, C 6 H 10 NO 3 represents yeast, and C 2 H 6 O represents ethanol. Some of the blocks not discussed deal with discrete-time systems (ones modeled with difference, rather than differential, equations), digital logic systems, and other types of mathematical operations. Secant; sec x. For example, x = (5 > 3); y = double(x);. Test Your Understanding T6.2-3 Refer to T6.2-2. The Fourier series is a series representation of a periodic function in terms of sines and cosines. >>S = solve(eqn3,eqn4) S = x: [1x1 sym] y: [1x1 sym] >>S.x ans = 1 >>S.y ans = 4 Test Your Understanding T11.2-1 Use MATLAB to solve the equation . T1.5-3 Type why at the command prompt. In addition to binder jetting, six other categories of AM are generally recognized. Test Your Understanding T11.1-1 Given the expressions: E 1 = x 3 - 15x 2 + 75x - 125 and E 2 = (x + 5)2 - 20x, use MATLAB to (a) find the product E 1 E 2 and express it in its simplest form. 539 Figure 11.5-3 The step response of the model for g = 0 and g = 5. The angle corresponding to x = -2, y = 3 e. Its volume is (a) Use MATLAB to (b) Figure 11.5-3 The step response of the model for g = 0 and g = 5. The angle corresponding to x = -2, y = 3 e. Its volume is (a) Use MATLAB to (b) Figure 11.5-3 The step response of the model for g = 0 and g = 5. The angle corresponding to x = -2, y = 3 e. Its volume is (b) Figure 11.5-3 The step response of the model for g = 0 and g = 5. The angle corresponding to x = -2, y = 3 e. Its volume is (b) Figure 11.5-3 The step response of the model for g = 0 and g = 5. The angle corresponding to x = -2, y = 3 e. Its volume is (b) Figure 11.5-3 The step response of the model for g = 0 and g = 5. The angle corresponding to x = -2, y = 3 e. Its volume is (b) Figure 11.5-3 The step response of the model for g = 0 and g = 5. The angle corresponding to x = -2, y = 3 e. Its volume is (b) Figure 11.5-3 The step response of the model for g = 0 and g = 5. The angle corresponding to x = -2, y = 3 e. Its volume is (b) Figure 11.5-3 The step response of the model for g = 0 and g = 5. The step response of the model for g = 0 and g = 5. The step response of the model for g = 0 and g = 5. The step response of the model for g = 0 and g = 5. The step response of the model for g = 0 and g = 5. The step response of the model for g = 0 and g = 5. The step response of the model for g = 0 and g = 5. to find the expression for dS/dV. Use the double percent character (%%) to indicate a section heading in the report. 4.9 Applications to Simulation is the process, or physical system. Assume that no vehicles park anywhere within the network. The following table shows the hourly wages, hours worked, and output (number of widgets produced) in one week for five widget makers. 118 asec(x) Inverse secant; arcsec x = sec -1 x. Note the use of the numbering scheme 3.1 and 3.2 to indicate subordinate clauses. 167 all True if all elements are nonzero. Compute the mean and standard deviation and use them to estimate the lower and upper limits of strength corresponding to 68 and 96 percent of such timber pieces. For example, 329 >> randi(20, [1,5]) ans = $5\ 12\ 11\ 17\ 17 >> randi(6)$ and $= 3\ 16$ Note that randperm returns unique integers, whereas the arrays returned by randi may contain repeated integer values. z = 4 < (7*5) h. Test Your Understanding T1.5-1 Use the Help system to learn about the built-in function nthroot. Then typing E = D([2, 2, 2], :) repeats row 2 of D three times to obtain Using clear to Avoid Errors You can use the clear command to protect yourself from accidentally reusing an array that has the wrong dimension. If you put this statement before the variables are created, they will be initialized to the empty matrix. It lowers its arm at the rate of 5 m/min. (b) How far in each direction must diver 1 swim to reach diver 2? Connect the markers for the first set with solid lines. (a) Use MATLAB to find the product of these two polynomials, and express it in its simplest form. The special features useful for these purposes are as follows. 351 pinv Computes pseudoinverse of a matrix. FIELD Creating Structures You can create a structure array by using assignment statements or by using the struct function. If you use the icon you will be asked to enter a filename; the default name is matlab. Center and scale X data. In the following session, note the difference between the result obtained by x(x < y) and the result obtained by find(x < y). The volume of a circular cylinder of height h and radius r is given by $V = \pi r 2$ h. The forced response is the solution due to the forcing function when the initial conditions are zero. The larger rectangular blocks are two subsystem blocks of the type just created. if rank(A) == size A(2) % Yes. Then import the spreadsheet file into the MATLAB variable A. Two matrices A and B are equal if they have the same size and if all their corresponding elements are equal, that is, a ij = b ij for every value of i and Each has the form for x i \leq x \leq x i+1 and i = 1, 2, ..., n - 1. Note also that the value of x changed from 2 to 15. A structure chart shows the connection between the main program and the modules. >> syms y(t) >> Dy = diff(y,t); >> eqn = Dy == 4 + y^2; >> cond = y(0) == 1; >> dsolve(eqn,cond) ans = 2*(tan(2*t+atan(1/2)) 484 which is equivalent to Not all nonlinear equations can be solved in closed form. m 2. The denominator of the transfer function is the characteristic polynomial. For example, now the statement y = 1|5 & 0 is evaluated as y = 1|(5 &
0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0), yielding the result y = 1, whereas in MATLAB 5.3 and earlier, the statement would have been evaluated as y = 1|(5 & 0). y = 0. Perform a "reality check" on your answer. This function can be animated as the parameter b changes with the following program. Suppose that m = 1, the desired speed is 1, and that the disturbance force is d = 10 and begins acting at t = 0.4. To obtain a response time of 0.2, we choose s = -20, -20, which give the polynomial s 2 + 40s + 400. x $= 0:0.01:5; y = exp(-1.2*x).*sin(10*x+5); subplot(1,2,1) plot(x,y), xlabel('x'), ylabel('y'), axis([-6 6 0 350]) Test Your Understanding T5.2-1 Pick a suitable spacing for t and v, and use the subplot command to plot the function z = e -0.5t cos(20t - 6) for 0 \le t$ ≤ 8 and the function u = 6 log 10 (v 2 + 20) for -8 ≤ v ≤ 8. Appendix E, which is available on the text's website, contains some suggestions for course projects and is based on the author's experience in teaching a freshman MATLAB course. This means that other variable names can be used when you call 127 the function. Hyperbolic Functions The hyperbolic functions are the solutions of some common problems in engineering analysis. Use of parentheses also improves Table 1.1-2 Order of precedence P rng(n,#x2018;twister#x2019;) Like rng(n) but specifies the random number generator to be the Mersenne Twister algorithm. Estimate when the population will be double its 2004 size. One of the most important applications for strings is to create input prompts and output messages. The Command Window shows the results of 124 running the function, as will be described shortly. 27 When the problem to be solved requires many commands, or has arrays with many elements, the interactive mode is inconvenient. This is what is meant by the function's variables being "local" to the function. With an anonymous function (anonymous functions are discussed in Section 3.3): The session is >>cossq = $@(x)cos(x.^2)$; >>A = integral($@(x)cos(x.^2)$; >>A = string (i.e., its name placed in single quotes), but use of the function handle is now the preferred approach. (10.10-17) This cannot be solved for θ analytically. EXAMPLE 10.2-2 Exporting to the MATLAB Workspace We now demonstrate how to export the results of the simulation to the MATLAB workspace, where they can be plotted or analyzed with any of the MATLAB functions. Enter a scalar or a vector of values corresponding to the independent variable (X). 170 Solution The key to solving this problem with relational and logical operators is to use the find command to determine the times at which the logical expression (h >= 6) & (v = 6 & v = 0 y = sqrt(x) end 172 If x is negative, the program takes no action. To trace a script file, simply type echo on in the Command window. 298 Examine the numerical results of a fit. See Figure 1.5-1 shows the resulting menu after selecting plot two levels down under the Graphics category. The MathWorks web site is http//www.mathworks.com. For example, if m = 1 and T = 0.1, to obtain a response time of 0.8, we choose s = -5, -5, -5. >>units = [10, 5, 7]; >>total cost = 3233 The total cost = 3233 The tot covered. d = polyder(p) Returns a vector d containing the coefficients of the derivative of the polynomial represented by the vector p. The code will run and MATLAB will alert you to any errors. Two divers start at the surface and establish the following coordinate system: x is to the west, y is to the north, and z is down. We use it as an indicator of the following coordinate system: x is to the west, y is to the north, and z is down. accuracy of computations. Smith; and A. This experiment was repeated with the pot filled to the various levels shown in the following table: Liquid volume V (cups) Time to fill 1 cup t (sec) 15 6 12 7 9 8 6 9 (a) Use the preceding data to obtain a relation between the flow rate and the number of cups in the pot. % Record your voice for 5 seconds. The position and velocity of the mass at t = 0 are denoted by x 0 and v 0. Do this by solving the y equation for y = yd. 431 17. Define the profit as the yearly cost of buying stock. This use of the = operator is different from its use in 11 mathematics. The two cases are g = 0 and g = 5. bar(bins, y scaled, 'w'),... ylabel('Scaled Frequency'), xlabel('Height (in.)') Table 7.2-1 Height data for men 20 years of age Height (in.) Frequency 64 1 70 9 64.5 0 70.5 8 65 0 71.5 5 66 2 72 4 66.5 4 72.5 4 67 5 73 3 67.5 4 73.5 1 68 8 74 1 68.5 11 74.5 0 69 12 75 1 69.5 10 318 294 Figure 7.2-1 Scaled histogram of height data. The perfect gas law relates the pressure p, absolute temperature T, mass m, and volume V of a gas. Section 1.2 covers the main menus and the Toolstrip. Different results. Use a text editor to create a file containing the following data. Consider the function . However, we need not concern ourselves with this here, because the transforms of all the common functions have been calculated and tabulated. The numbers in each row might be separated by spaces or by commas. In the To Workspace block, specify the Save format as Array. 126 Variations in Function Calls The following function, called drop, computes a falling object's velocity and distance dropped. Suppose the profits for each product are \$200, \$500, and \$100 for products 1, 2, and 3, respectively. In some applications it is helpful to know the polynomial coefficients, but we cannot obtain the spline coefficients from the interp1 function. colormap(winter) % Specify a color map. If A is a matrix, cumsum(A) computes the cumulative sum of each row. From Equation (8.3-5), $y \ge 0$ implies that $z \le 5/1.8333 = 2.727$. The movie plays back using the values A = 2 m 2, R = 400m -1 · s -1, ρ = 1000 kg/m 3, and h(0) = 1 m. independent variable x. A fuel cell or a battery is charged either by a generator driven by the engine or by energy recovered by regenerative braking. The optional form fplot(E,[xmin xmax]) generates a plot over the range from xmin to xmax. Simulink is often used to create the simulation model for hardware-in-the-loop testing. Numerical integration and differentiation methods are treated. What is the rate of increase in the balloon's surface area with volume when its volume is 30 cubic inches 14. 164 Table 4.3-1 Logical operators Operator Name Definition ~ NOT ~A returns an array of the same dimension as A; the new array has 1s where A is 0 and 0s where A is nonzero. This stores the figure and makes it available for future use. These are drawn from a variety of engineering fields and show realistic applications of MATLAB. force = 0:100:800; deflection=[0,0.15,0.23,0.35,0.37,0.5,0.57,0.68,0.77]; % % Plot the data on rectilinear scales. The total distance traveled by an object moving at velocity v(t) from the time t = a to the time t = b is The absolute value |v(t)| is used to account for the possibility that v(t) might be negative. In fact, if an M-file contains at least one nested functions, including subfunctions, in the file with an end statement, whether or not they contain nested functions. FUNCTION ARGUMENT You can include expressions and other functions as arguments. x = [0:5:100]; y = cos(x); ro achieve the same result using a for loop, we would type for k = 1:21 x = (k - 1)*5; y(k) = cos(x); ro achieve the same result using a for loop. Find the values of x, y, and z to maximize the profit. The resulting plots appear in Figure 6.1-6. What is the total spent on each material in the three-month period? Find the values of d, b, and θ that minimize this length. title('text') Puts text in a title at the top of the plot. 398 b. 18. We can improve the display by using the fprintf function instead of disp. Three-Dimensional Line Plots Lines in three-dimensional space can be plotted with the plot3 function. x = 5 Note that the portion of the line before the % sign is executed to compute x. A cone-shaped paper drinking cup (like the kind used at water fountains) has a radius R and a height H. 167 A||B Returns true (logical 1) if either A or B or both evaluate to true, and false (logical 0) if they do not. Plot fits. With the first strategy every day the price is below \$140 you buy 100 shares, and every day the price is above \$160 you sell all the shares you own. How does this error affect the age estimate? For example, if A = [4, 9, 16; 25, 36, 49], typing sqrt(A) give us the matrix [2, 3, 4; 5, 6, 7]. 190 Debugging commands Item Description Pages dbclear Remove a breakpoint. The syntax is subplot(m,n,p). However, these MATLAB methods are very useful either where there are so many data that visual inspection would be very time-consuming, or where the values are generated internally in a program. Creating Vectors in MATLAB The concept of a vector can be generated internally in a program. are
numbered. Because we do not know how many times we must evaluate the expression 10k 2 - 4k + 2, we use a while loop, which is covered in Section 4.6.1601. The MATLAB session is >>A = [1, 1, 1; 10, 5, 0]; >>b = [400; 1600]; >>rank(A) ans = 2 >>T = A\b T = 160.0000 0 240.0000 >>T = pinv(A)*b T = 93.3333 133.3333 173.3333 363 The left-division answer corresponds to T 1 = 160, T 2 = 0, and T 3 = 240. Estimate the speed v and when the range will be zero. You can specify line color, line style, and marker for each system, for example, initial(sys1,'r', sys2,'y--', sys3,'gx',x0). The rank of A is 2, but the rank of [A b] is 3, so no exact solution exists for c 1 and c 2. This vector represents q(x) = 0x 3 + 6x 2 - x + 2. GAUSS ELIMINATION EXAMPLE 8.2-1 Left-Division Method with Three Unknowns Use the left-division Method with Three Unknow function returns an array that can be used for logical indexing and logical tests. For example, if p = [2, 4, 5], then typing 3.^p produces the array [3 2 , 3 4 , 3 5] = [9, 81, 243]. Thus abs(y) produces the array [3 2 , 3 4 , 3 5] = [9, 81, 243]. Thus abs(y) produces 2.6, 2.3, 5.7. Test Your Understanding T3.1-1 For several values of x and y, confirm that ln (xy) = ln x + ln y. If h p ≥ h desired , Use a while loop to increment time and compute height until desired height is reached, where f(t) = 50u s (t). If condition (1) is satisfied and if r = n, then the solution is unique. Palm III, University of Rhode Island. Scaife, Ph.D. Product Developer: Jolynn Kilburg Marketing Manager: Shannon O'Donnell Content Project Managers: Laura Bies & Sandra Schnee Buyer Susan K. 260 The fcontour(f) function plots the contour lines of the function z = f(x,y) for constant levels of z over the default interval [-5 5] for x and y. Select and place the Mux block from the Signal Routing library, double-click on it, and set the Number of inputs to 2. The numerical solution is marked by the circles, and the analytical solution is indicated by the solid line. The following data are the measured temperature T of water flowing from a hot water flowing that is, by the vector x(k), which is called the state vector. To provide a simple introduction to these issues, we consider the simplest numerical methods, the Euler method and the predictor-corrector method. The following statements will compute y if x already has a scalar value. t y X a = = = = [0,0.3,0.8,1.1,1.6,2.3,3]; [0,0.6,1.28,1.5,1.7,1.75,1.8]. [ones(size(t));exp(-t)]'; X\y' The answer is a 1 = 2.0258 and a 2 = -1.9307. Reversing the order of matrix multiplication is a common and easily made mistake. Find the expressions for A and b. This function. 231 title Puts text at top of plot. The goal is to achieve rapid and inexpensive screening for a number of diseases using drop-size samples of blood or saliva. You can perform multiple fits for the current data set. Solutions to Selected Exercises book Essential MATLAB for Engineers and Scientists, 5th Edition by Brian Hahn, Daniel Valentine The fifth edition of Essential MATLAB for neers and Scientists This is an ideal book for ... book MATLAB for Neuroscientists, 2nd Edition by Pascal Wallisch, Michael E. p = polyfit(log10(cups),log10(meas flow),1); coeffs = [p(1),10^p(2)]; m = coeffs(1) b = coeffs(2) % % Plot data and fitted line on a loglog plot to see % how well the line fits the data. You might suspect an error if the p showed abrupt changes or discontinuities. The command A = xlsread('filename') imports the Microsoft Excel workbook file filename.xls into the array A. A histogram is a plot of the frequency of occurrence of data values versus the values themselves. We frequently need to plot more than one curve or data set on a single plot. 82 75 The following product is defined in matrix multiplication and gives the result shown: The following product is also defined: Test Your Understanding T2.4-1 Given the vectors do the following by hand, then check your answer using MATLAB., where u(t) is a unit-step (Answer: y(t) = -1.6e - 3t + 4.6e - t + 2) Table 11.5-1 summarizes the Laplace transform functions. The ten data points represent ten equations, with one unknown, k. "Getting close" if the guess is within 2 or 3 of the correct number. Assuming the relative speed v is constant, the range as function of time is given by r = -vt + r 0 where is r 0 the initial range at t = 0. The results are plotted in the bottom graph of Figure 9.5-5. In addition, some blocks have additional properties that we have not mentioned. Thus an infinite number of solutions exist, and we can determine two of the variables in terms of the third. (a) z = 0; (b) z = 1; (c) z = 0; (d) z = 1; (f) z = 2; (g) z = 1; (h) z = 0; (g) z = 1; (h) z = 0; (h) z = 0; (h) z = 1; (h) z = 0; (h) z = 0; (h) z = 1; (h) z = 0; (h) z = 1; (h) z = 0; (h) z = 1; (h) z = 0; (h of the numerator and denominator polynomials of the derivative of the quotient p2/p1, where p1 and p2 are polynomials. The Scope will display the plots of the heights h 1 and h 2 versus time. If m < n, the homogeneous set always has a nonzero solution. What may be unexpected is that the histogram resembles that of the normal distribution, even though the input is uniformly distributed. 302 Force f (lb) Spring length y (in.) 0 4.7 0.94 7.2 2.30 10.6 3.28 12.9 2.* In each of the following problems, determine the best function) to describe the data. Select and place the Signal Generator block from the Sources library. disp('There is a unique solution, which is:') x = A\b % Solve using left division. The Copying Options page of the Preferences dialog box appears. function x = xcoord(t,s0,th); % Computes projectile horizontal coordinate. In addition to providing documentation, pseudocode is useful for outlining a program before writing the detailed code, which takes longer to write because it must conform to the strict rules of MATLAB. The residuals of the quadratic fit are much smaller, but there is still a pattern, with a random component. For example, x = logspace(-1, 1, 4) produces the vector x = [0.1000, 0.4642, 2.1544, 10.000]. Consider the array A. The function dsolve(eqn1,eqn2,...,cond1,cond2,...) returns a symbolic solution of a set of equations specified by the symbolic expressions eqn1, eqn2, and so on, subject to the initial conditions specified in the expressions cond1, cond2, and so on. Before we show how to create and save programs in M-files, we need to discuss how MATLAB looks for variables, commands, and files. Essentials 1. Its syntax is isfield(S,'field'). Compute the angle θ . The currents i 1, i 2, and i 3 in the circuit shown in Figure P50 are described by the following equation set if all the resistances are equal to R. The power function: y = bx m. There are motors that can be controlled with a digital input that specifies the desired position and have a built-in angular position sensor. Use the debugging features of the Editor, which are introduced in Chapter 4. inv(A) Returns the inverse of the matrix A in symbolic form. 12 who Lists current variables. ans = x+2 The function [num den] = numden(E) returns two symbolic expressions that represent the numerator num and denominator den for the rational representation of the expression E. The following table gives measurements of the sphere's temperature versus time. Spaces in the line improve its readability; for example, you can put a space before and after the = symbol and the multiplication symbol * if you want. Their equations of motion are (11.5-14) (11.5-15) The only difference between these systems is that the system in Figure 11.5-2a has an equation of motion containing the derivative of the input function y(t). Here are some other things to keep in mind when using script files: 1. Thus the output 6.3792 × 10 3. Logical Vectors 6. This gives This can be written as one matrix equation as follows. The supports are 5 ft apart. Use of this feature requires detailed knowledge of object properties and handle graphics, and thus will not be covered here. The case A = 90° is also easily checked by hand, using the Pythagorean theorem; for this case . Compute the statistics and plot the histogram. The Look-Up Table Block The spring function f s is created with the Look-Up Table block. The forcing function is f(t) = sin 2t. The greatest height from which the delivery person could drop the package is 6 ft (and thus we ignore the existence of a delivery person 8 ft tall). The step function can be used with either a state model or a transfer function model. Otherwise, if you continued typing without using the ellipsis, you would not see the entire line on the screen. For example, to define the function, type >> sqrtsum = $(0(x,y) \operatorname{sqrt}(x, 2 + y, 2))$; Then >> sqrtsum(3, 4) ans = 5 As another example, if the vehicle encounters an incline, the wheel torque must be increased to counteract the effects of gravity. 114 sign Signum function. For example, the following script makes a random choice between two equally probable alternatives and 299 computes the statistics for 100 simulated tosses of a fair coin. If the water height in the cup is h, the water volume is given by Suppose that the cup's dimensions are R = 1.5 in. function z = sqrt(x + y)/2; end 177 The nargout function can be used to determine the number of output arguments. MATLAB has these options to get help for using MathWorks products. Returns a linearly interpolated vector y int at the points specified by the vector x int, using data stored in x and y. 26 which Displays the path name. Use the subsystem block to create a Simulink model of the system shown in Figure 10.7-5. The solution obtained with left division is x 1 = 4.8000, x 2 = 0, x 3 = -1.7333. When the loop is completed, k retains its last value. The single = sign is the assignment, or replacement, operator in MATLAB. Suppose that A = 40°, v 0 = 20 m/s, and g = 9.81m/s 2. The following data give the output voltage of a certain device as a function of time. Properly label
the plot and each curve. When this command is executed, MATLAB waits for a mouse button or a key to be pressed while the mouse pointer is within the Figure window; the label is placed at that position of the mouse pointer. For example, if no intermediate values are specified, tspan is [t0 tfinal], where t0 and tfinal are the desired starting and ending values of the independent parameter t. Its syntax is rref([A b]). For example for $k = 1:10 x = 50 - k^2$; if x < 0 break end y = sqrt(x) end % The program execution jumps to here % if the break command is executed. How to Model It: Problem Solving for the Computer Age. 419, 420 initial Computes and plots the free response of an LTI object. The function movie (M,n,fps) plays the movie at fps frames per second. 346 c. Which values of A should you use for the checks? Suppose that the height h is controlled by using a relay to switch the input flow rate between the values 0 and 50 kg/s. z = (x > 2) T4.3-3 Suppose that x = [-4, -1, 0, 2, 10] and y = [-5, -2, 2, 5, 9]. (In mathematical text we often use boldface type to indicate vectors.) The set of unit vectors i, j, k, whose lengths are 1 and whose directions coincide with the x, y, and z axes, respectively, can be used to express the vector mathematically as follows: p = xi + yj + zk. % freq = frequency of the tone (in Hz). Height (in.) Additional data 64.5 1 65 2 66 1 67.5 2 70 2 73 1 74 1 (a) Plot the scaled frequency histogram. array by typing the following either in the interactive mode or in a script file. Note also that gd 2 /2 is a multiplicative factor in the expression for . To avoid potential problems due to precedence, it is important to use parentheses in statements containing arithmetic, relational, or logical operators, even where parentheses are optional. According to this equation, the tank will be empty at t = 9/0.00286 = 3147 sec, or 52 min. Plot f q dt versus t and determine how much energy is used in 24 hr for the case where q max = 8 × 10 5 . 52 Figure 1.6-3 Plot of the piston motion versus crank angle. 292 histogram(y) Aggregates the data in the vector y into bins of uniform width between the minimum and maximum values in y, using the default color. The matrix B can be used for further symbolic manipulation in terms of the variable a, b, c, and d. To find the miles traveled on each leg, we multiply the speed by the time. Position the cursor using a mouse, and press the mouse button. resistances. A certain product requires that a shaft be inserted into a bearing. A standard Save As dialog appears. Plot y(t) for y(0) = 0 and (0) = 10. Therefore, a rand command gives an identical result every time it is executed immediately 324 following startup, and you will see the same sequence you saw in a previous startup. The string format specifies notation, alignment, significant digits, field width, and other aspects of output format. A similar procedure can be followed for the second-order model., Comma; separates elements of an array, which is the fundamental data element in MATLAB, and 16 describes how to use numeric arrays, cell arrays, and structure arrays for basic mathematical operations. To see how sensitive the cost is to location of the distribution center, obtain a surface plot and a contour plot of the total cost as a function of the distribution center, obtain a surface plot and a contour plot of the distribution center, obtain a surface plot and a contour plot of the distribution center location. The structure of a typical control system is illustrated in Figure 10.10-1. So in this section we will limit ourselves to ASCII files, with special attention paid to spreadsheet files. Other sources use digital photos and photogrammetry software. 261 Three-dimensional plotting functions using array inputs Item Description Figure 201 (E) can be used to determine the symbolic variable used by MATLAB in a particular expression E. [right, left] = Extracts the coefficients on the reduced-form model tfdata(sys,'v') specified in the transfer function model sys. Create a vector v consisting of the elements in the second column of A. For example, >>NumberOfApples = 10; NumberOfOranges = 25; >>NumberOfOranges = 12; >>FruitPurchased = NumberOfOranges ... 247 Plotting Implicit Functions An implicit function with two variables, say x and y, is a function in which we cannot isolate one variable in terms of the other. unknowns because the third equation directly gives c = 1, and the sixth equation directly gives a = 144/180Y. Solution (a) The intersection points are found from the solutions of the two equations for the circles. The following represents pressure samples, in pounds per square inch (psi), taken in a fuel line once every second for 10 sec. EXAMPLE 8.4-1 The Least-Squares Method Suppose we have the following three data points, and we want to find the straight line y = c 1 x + c 2 that best fits the data in some sense. These functions made by the programs whose operations depend on the results of calculations made by the program. $hdot = height(t,h) hdot = -(0.0334*sqrt(h))/(10*h-h^2);$ The file is called as follows, using the ode45 solver: [t, h] = ode45 (@height, [0 2475], 9); plot(t,h), xlabel('Time (sec)'), ylabel('Height (ft)') The resulting plot is shown in Figure 9.3-4. 118 sin(x) Sine; sin x. The syntax [u, v, w] = find(A) computes the arrays u and v, containing the row and column indices of the nonzero elements of the matrix A, and the array w, containing the values of the nonzero elements. In fact, no such solution exists in terms of elementary functions. For example, >>z = -4+9i; >> fprintf('Complex number: -4.00 Instead you can display a complex number as a row vector. You can choose as many fits for a given data set as you want. Create a simulation to compare the results of the following two strategies over 250 days. 231 xlabel Adds text label to x axis. (see Figure 5.3-3), or by creating a figure with the plottools command after the plot function. 119 tanh(x) Hyperbolic tangent; sinh x/cosh x. 304 Force f (lb) Spring length y (in.) $0.4.7\ 0.94\ 7.2\ 2.30\ 10.6\ 3.28\ 12.9\ 9.$ >>syms x >>f = exp(x); >>taylor(f,x); ans = x^5/120 + x^4/24 + x^3/6 + x^2/2 + x + 1 The answer is Continuing this session we have >>simplify(taylor(f,x,2)) ans = (exp(2)*(x^5 - 5*x^4 + 20*x^3 - 20*x^2 + 40*x + 8))/120 This expression corresponds to (11.3-3) The Live Editor is useful for obtaining the standard mathematical expressions from the code. Only a power function will form a straight line on a log-log plot. (b) To compute the total cost of 1 unit of product 1, we can use the vectors hourly costs and hours 1 but apply matrix multiplication instead of element-by-element multiplication, because matrix multiplication sums the individual products. This section describes these plots and several other types of plots. if rank(A) == rank([A b]) % The ranks are equal. For example: >> fprintf('The second circle's radius %15.3e is large.',r(2)) The second circle's ra Computes the Laplacian from data. (b) Find the numerical values for the currents if R = 1000 Ω , v 1 = 100 V, and v 2 = 25 V. The number's real part a is the x coordinate of the point, and the imaginary part b is the y coordinate. Thus, T is a dead time. Suppose each of the two rear wheels is driven by its own motor and associated control system. For example, A(3, :) = [] deletes the third row in A, while A(:, 2:4) = [] deletes the second through fourth columns in A. ', 3.15) gives the output: The inflation rate was 3.15 %. However, the ones we have discussed are the most important ones for getting started. For example, Table 7.2-1 gives the measured heights of 100 men 20 years of age. For product 2: For product 3: 78 These three operations could have been accomplished in one operation by defining a matrix whose columns of the table: In MATLAB the session continues as follows. For example, we can write sin 2 in text, but MATLAB requires parentheses surrounding the 2 (which is called the function argument or parameter), command, 14 zeros of, 128-130 Function Browser, 32-33 function definition line, 120 function functions, 128 G gauge pressures, 463 Gauss elimination, 353 Gaussian function, 319 geothermal power, 494 global maximum, 516 global minimum, 130, 516 global variables, 127 gradient, 400-402 graphics window, 22 H H1 line, 29 handle, 575 haptic feedback, 112 hardware-in-the-loop testing, 438 header, 142 552 Heaviside function, 533 Help icon, 5-6, 18, 32 Hermite interpolation polynomials, 339-341 higher-order differential equations, 410-413 histogram, 312 HOME tab, 5, 17-18, 27, 120, 121 hydraulic system, 462-465 hyperbolic functions, 119 I ideal form, 475 identity matrix, 81 ill-conditioned set, 351 implicit functions surface plots of, 260 two-dimensional plots, 247 implied loops, 184-185 Import Data, 144 importing data, 142 improper integrals, 390 impulse function, 538, 539 impulse response, 538-540 incremental value, 179 indefinite integrals, 390 indices, 54, 55 infinite loop, 192 inflection point, 515-516 information infrastructure, 388 initial condition, 525 initial-condition, 525 initial-condition, 525 initial-condition, 525 initial-condition, 525 initial-condition, 525 initial-condition, 50 input derivatives, 537-538 input expression, 195, 196 Input section, 29 input/output commands, 30 ports, 463 Insert menu, 251 int8 (arrays), 51 int16 (arrays), 51 int22 (arrays), 51 integral definite, 390 double, 396 improper, 390 indefinite, 390 singularities, 390 triple, 3253 interactive plotting, 250-254 Interactive session, 4-17 interactive session defined, 7 interpolation, 331-341 cubic spline, 335-339 Hermite polynomials, 339-341 linear, 332 two-dimensional, 334-335 inverse Laplace transform, 534 inverse solution, 483 iterative operations (loops), 154 L lab-on-a-chip (LOC), 152 Laplace transform, 533 Laplacian, 402 Las Vegas Stratosphere Tower, 50 Layout icon, 18 least-squares method, 284-285, 368 left-division method, 82, 353-359
length, vector, 59, 60 Library Browser, 441-442 limits, 523-524 line plots, 255-256 line types, 236-237 linear algebraic equations, 62, 72 symbolic, 542-545 linear algebraic equations, 82 augmented matrix, 353 Euclidean norm, 361 general solution program, 372

homogeneous, 353 ill-conditioned system of, 351 left-division method, 353-359 matrix methods, 350-353 matrix rank, 353 overdetermined systems, 368-371 overview, 349-350 singular set of, 351 solution by matrix inverse, 351 solution by pseudoinverse method, 361, 363 underdetermined system of, 350, 359-368 underdetermined systems, 359-368 linear function, 273, 276 linear interpolation, 332 Linear System Analyzer, 426 linear-in-parameters regression, 294 554 linearity property, 534 Live Editor, 17, 232–234, 522 live script, 232 live script, 232 live script, 234 Live Editor, 17, 232–234, 522 live script, 234 Live Editor, 17, 232–234, 524 linearity property, 534 Live Editor, 17, 232–234, 544 linearity prope the symbol >> automatically appears on the screen; you do not type it. The point ICR is the instantaneous center of rotation, and R C is the radius of the turn. The resulting plot is shown in Figure 10.4-6. Thus the following names represent five different variables: speed, Speed, SPEED, Speed 1, and Speed 2. The wall is 310 ft from home plate down the left field line. The cost to construct the cylindrical part costs \$600 per square meter. The corresponding matrix elements are summed or subtracted. To extract and save the matrices, use the ssdata function as follows. Chapter 2 3. The session is >> fminsearch(@f4, [0, 0]) ans = -0.7071 0.000 Thus the minimum occurs at x = -0.7071, y = 0. Typing vpa(E) causes E to be evaluated to the number of digits specified by the default value of 32 or by the current setting of digits. Because solving engineering problems often requires a computer solution and because the examples and exercises in this text require you to develop a computer solution (using MATLAB), we also discuss a methodology for solving computer problems in particular. Figure 6.2-1 shows this data and the four polynomials. 133 133 The variables to be selected are b, d, and θ . For example, to plot y versus x with green asterisks (*) connected with a red dashed line, you must plot the data twice by typing plot(x,y,'g*',x,y,'r? GAIN BLOCK In addition, the integrator symbol 1/s, which derives from the notation used for the Laplace transform). In MATLAB a vector is simply a list of scalars, whose order of appearance in the list might be significant, as it is when specifying xyz coordinates. We denote the sum of the quality of the curve fit, the coefficient of determination, also known as the r-squared value. (b) Use symbolic manipulation in MATLAB to find the value of the gain K that minimizes the peak torque that must be supplied by the motor. The second function should use fzero to compute how long it will take for the water volume to decrease to x percent of its initial value of 10 9 L. The following script file created Figure 5.2-1, which shows the plots of the functions $y = e^{-1.2x} \sin(10x + 5)$ for $0 \le x \le 5$ and $y = |x|^2 - 1.00|$ for $-6 \le x \le 6$. The results of these functions are shown in Figure 5.4-4 for the function $z = xe^{-1.2x} \sin(10x + 5)$. compress the spring is kx. 39 EXAMPLE 1.6-1 Piston Motion Figure 1.6-2a shows a piston, connecting rod, and crank for an internal combustion engine. In addition to the assignment statement, you can build structures using the struct function, which lets you "preallocate" a structure array. If item is a variable, then MATLAB identifies it as such. It can be computed from $|u||w| \cos \theta$, where θ is the angle between the two vectors and |u|, |w| are the magnitudes of the vectors. Write a MATLAB script that allows the user to plot one of the following functions over the range $0 \le x \le 10$. This is equivalent to z = x > y & x > a which is much less readable. Use the values m 1 = m 3 = 10 kg, m 2 = 30kg, k 1 = k 4 = 10 4 N/m, and k 2 = k 3 = 2 × 10 4 N/m. The clear command wipes A and all other variables from memory and avoids this error. Suppose x consists of 1000 uniformly distributed numbers between 0 and 1. Methods using MATLAB are treated in four sections: Section 8.2 covers the left-division method for solving equation sets that have unique solutions. Find these three solutions. You can enable plot editing by clicking on the northwest-facing arrow on the Figure toolbar. Real part of a complex number x. The MATLAB functions inv(A) and det(A) compute the inverse and the determinant of the matrix A. To see this, add the first and second equations, to obtain -2x 1 - 6x 2 + 8x 3 =0, which is equivalent to the third equation. Assuming that the structure is stationary and that the weights of the wires and the beams are very small compared to W, the principles of statics applied to a particular beam state that the sum of 206 vertical forces is zero and that the sum of 206 vertical forces is zero. I especially want to thank Naomi Fernandes of The MathWorks, Inc., for her help. The Add Data to Axes dialog enables you to select a plot type and specify the workspace variables to pass to the plotting function. A simple example of a while loop is x = 5; while x < 25 disp(x) x = 2*x - 1; end The results displayed by the disp statement are 5, 9, and 17. eig(A) T11.6-3 Use the matrix inverse and the left-division method to solve the following set. Section 1.4 discusses how to create, edit, and save MATLAB programs. Use the values $R = 0.8 \Omega$, L = 0.003 H, , , c = 0, and . The resulting function is y = mx + b. Then we can analyze the expressions and decide which parameter values will optimize the design. Appendix A: Guide to Commands and Functions in This Text.....Page 50932. Use MATLAB to solve for the polynomial coefficients given the values t $f = 2 \sec, \theta 1$ (t f) = 43°, and $\theta 2$ (t f) = 151°. Polar Plots Polar plots are two-dimensional plots made using polar coordinates. You will see >> test3(10) 5 if y < 0 K>> This is the prompt in debug mode (the K stands for "keyboard"). 31. This line distinguishes a function M-file from a script M-file. 70 Test Your Understanding T2.3-5 Given the matrices find (a) their array product, (b) their array right division (A divided by B), and (c) B raised to the third power element by element. Undefined function or variable 'z'. This loop calculates the duration above 50,000 ft for a specific value of the burn time b. Is it a built-in function? 581 audioread Reads a WAVW file. ., x0, t) plots the free response of multiple LTI systems on a single plot. The number of freshmen in the following year will be 0.1(1050) + 1000 = 1105, and so on. Consider the program: p = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1105, and so on. Consider the program: p = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1050, then it will be 0.1(1050) + 1000 = 1000, then it will be 0.1(1050) + 1000, then it will be 0.1(1050) + 1000, then i $8.85; A = 20/100^2; d = 4/1000; n = [2:5]; C = ((n - 1).*p*A/d); table (:,1) = n'; table (:,2) = C'; disp (table) The disp function displays the number of decimal places specified by the format command (4 is the default value). You can edit text associated with a block by clicking on the text and making the changes. Creating Cell Arrays You can create a$ cell array by using assignment statements or by using the cell function. You can then continue 25 your session as before. ABSOLUTE FREQUENCY When there is a large amount of data, you can avoid typing in every data value by first aggregating the data. The number of rows in y and x equals length(t). Which plot gives a straight line? 186 x = [1.92,0.05,-2.43,-0.02,0.09,0.85,-0.06]; y = [];z = []; for k = 1:length(x) if abs(x(k)) >= 0.1 y = [y,x(k)]; end end xnew = [y,zeros(size(z))] The next script file uses the find function. Using this method a Stop Time of 1 s was found to be satisfactory. The homogeneous set Ax = 0 is a special case in which b = 0.482 Figure 10.10-8 Turning geometry of a two-wheeled vehicle 439 Denote these angles by φ L and φ R for the left and right wheels. The MATLAB toolboxes dealing with control system design are useful for such applications. Its basic syntax is new struc = rmfield(array, 'field'); where array is the structure array to be modified, 'field' is the field to be removed, and new structure array so created by the removal of the field. You will hear a bell sound when the simulation is finished. xlabel('y (feet)'), ylabel('Theta1 (degrees)') subplot(2,1,2) 512 466 Figure 11.2-3 Plot of the motor angles for the robot hand moving along a vertical line. You will see a Game is file. MATLAB is also extensible;
currently more than 30 "toolboxes" in various application areas can be used with MATLAB to add new commands and capabilities. In addition, find the angle at which the ball must be hit. The familiar guadratic formula gives the solution for the roots of a guadratic (second-degree) polynomial. The following function displays the rate offered as a function of the term. The circuit designer must be able to solve them to predict the currents that will exist in the circuit. This means their values cannot be changed by other functions or from the MATLAB command line. Thus, because MATLAB checks for a subfunction before checking for private and standard M-file functions, you may use subfunctions with the same name as another existing M-file. Press Ctrl-C to cancel a long computation that uses a function to compute the minimum of the functions. 10. Here is a session with some examples. A cable of length L c supports a beam of length L b, so that it is horizontal when the weight W is attached at the beam end. The forced response is given by (11.5-10) This cannot be evaluated until V(s) is specified. This equation can be applied successively at the times t k by putting it in a for loop. 63 ^ Scalar and matrix exponentiation operator. Program files that you create are saved with the extension .m, and thus are called M-files. Clearly the cubic is not suitable for interpolation. tests = 100; y = [13,15,22,19,17,14]/tests; x = 91:96; bar(x,y, 'w'), ylabel('Relative Frequency'),... 291 Figure 7.1-2 Absolute frequency histogram for 100 thread tests. Thus the minimum speed (vmin) required is 105.3613 ft/sec, or about 72 mph. Thus let . This handle refers to the plotted line. Figure P7 illustrates a robot arm that has two "links" connected by two "joints"—a shoulder or base joint and an elbow joint. Palm III % % Input Variable: % t = array of times at which speed is computed (seconds) % v = array of speeds (meters/second) % % Parameter Value: q = 9.81; % Acceleration in SI units % % Input section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal = input('Enter the final time in seconds:'); % % Calculation section: tfinal time in seconds:'); % % Calculation sect velocity v at an angle A is given by Create a function range(v,A) that computes R, given A in degrees. Using this form, you can type [X,Y] = meshgrid(min:spacing is the desired spacing of the x and y values. This method, called cubic splines, is covered in Chapter 7. For example, the command input r represents the requested speed and the controlled variable c represents the actual speed. If the function acted upon is not a simple function, it is more convenient to define the function in an M-file. (d) Estimate how many are between 68 and 72 in. This book is printed on acid-free paper. Compare the results of each case. 470 In this section we introduce four additional Simulink elements that enable us to model a wide range of nonlinearities and input functions: Derivative block Look-Up Table block MATLAB Function block As our example, we will use the single-mass suspension model shown in Figures 10.9-1, where the spring and damper forces f s and f d have the nonlinear models shown in Figures 10.9-2. Inverse functions such as atand(x) return values in degrees. Use a random number generator to produce 1000 normally distributed numbers with a mean of 20 and a variance of 4. Refer to Problem 29 of Chapter 4. Write a script file that prompts the user to enter a radius, computes the surface area, and displays the result. This feature has both advantages and disadvantages and disadvantages area. data type. The solution is obtained by typing A\B. You can also tune parameters live from your Simulink model while your algorithm runs on the hardware. You can use the rand function to generate random numbers in an interval other than (0, 1). For the product to be defined, the matrices A and B must be conformable; that is, the number of rows in B must equal the number of columns in A. How many are within 3 in. Simulink has the State-Space block that represents the inputs, and the vector y represents the inputs. To plot the function, you should evaluate it at enough points to produce a smooth plot. 119 asinh(x) Inverse hyperbolic sine; sinh -1 x. This surface has the shape of a saddle. So the heat flow rate plays the role of the voltage difference plays the role of S indicates how much the data is spread around the mean, and the value of J indicates how much of the data spread is unaccounted for by the model. The Pan and Rotate 3D buttons are used for three-dimensional plots. $x = -1:0.01:1; y_1 = 3 + exp(-x).*cos(6*x); plot((0.1+0.9i).^{(0:0.01:10)}), hold, plot(y_1, y_2), \dots$ gtext('y2 versus y1'),gtext('Imag(z) versus Real(z)') When more than one plot command is used, do not place any of the gtext commands before any plot command. We have just performed linear interpolation on the data to obtain an estimate of the missing data. New York: John Wiley & Sons, 1986. If A is a 3 × 3 × 2 array, you can access the element in row 3, column 2 of page 2 by typing A(3, 2, 2). MEMS are widely used in vehicle systems such as airbag sensors, accelerometers, and gyroscopes for detecting yaw to achieve electronic stability control. The input 'twister' refers to the to Mersenne Twister random number generator, which is the preferred generator. This feature is particularly useful for capturing property settings and other modifications made in the plot editor. The Command Window shows the results of running 125 the function. Thus if we were to type [3, 1, 7]*[4, 6, 5] in MATLAB, we would receive an error message. sets will be plotted with the contour function, whose syntax is contour(X,Y,Z). A(1,1) A(1,2) A(2,1) A(2,2) = = = { 'Walden Pond'}; { [55,57,56;54,56,55;52,55,53]}; If you do not yet have contents for a particular cell, you can type a pair of empty braces { } to denote an empty cell, just as a pair of empty brackets [] denotes an empty cell, just as a pair of empty brackets [] denotes an empty cell, just as a pair of empty brackets [] denotes an empty cell, just as a pair of empty brackets [] denotes an empty cell, just as a pair of empty brackets [] denotes an empty cell, just as a pair of empty brackets [] denote an empty cell, just as a pair of empty brackets [] denotes a stands for the number 6.3792 × 10 -3. Your model should now look somewhat like that shown in Figure 10.2-5. Press Enter to display the value of the variable FruitPurchased. Animating Projectile Motion This following program illustrates how user-defined functions and subplots can be used in animations. For example, >>syms x >> $E = x^{2-6}x+7$; >>fplot(E,[-2 6]) Sometimes the automatic selection of the ordinate transformation returns you to the original coordinate system. Contour plots can help you visualize the shape of a function. Suppose that z = xy, where x and y are independent and normally distributed random variables. To avoid 158 dealing immediately with the possibly complicated
syntax of the programming language, we can instead use pseudocode, in which natural language and mathematical expressions are used to construct statements but without detailed syntax. The simulation program is executed many times, using a random set of numbers to represent the failure of one or more components, and the results are used to estimate the desired probability. in Section 3.1. In addition, you can define your own functions with a function file, and you can use them just as conveniently as the built-in functions. 461 To solve (x+5==0) ans = -5 You can store the result in a named variable as follows. As we will see, additional capabilities are available with function handles. The system has the dead-zone nonlinearity shown in Figure 10.5-1. Because the first fprintf is needed to display the table title only, we need to fool MATLAB by supplying it with a variable whose value will not display. 274 3. This gives the minimum-norm solution. You must be careful when using either inverse tangent function. Choose the parameter τ to be small compared to the period and time constant of the linear model with k 2 = 0. xlabel('text') Adds a text label to the x axis (the abscissa). Later in this section we use polynomial functions to do the interpolation. (Note that diver 2 swam east, which is in the constant of the linear model with k 2 = 0. xlabel('text') Adds a text label to the x axis (the abscissa). negative x direction.) The distance from the origin of a point xyz is given by, that is, by the magnitude of the vector pointing from the origin to the point xyz. The first set is y = 11, 13, 8, 7, 5, 9. (a) Determine this frequency as a function of R, C, and L. So if the data are linearly related, the relation must be of the form f = kx. The values of the independent variable in the vector x must be in ascending order, and the values in the interpolation vector x int must lie within the range of the values in x. gtext('text') Enables placement of text with the mouse. Given do the following by hand, then check your answer using MATLAB. The function file must have two input arguments, t and y, even for equations where f(t, y) is not a function of t. Figure P33 a. Typing randi (imax) returns a scalar between 1 and imax. The first element p 1 of the vector p will be m, and the second element p 2 will be b. be the most difficult part of a robotics project. A preliminary analysis has shown that the crosssectional area of the channel should be to carry the desired water flow rate. For example, the point x = -1, y = -1 corresponds to -45° or -0.7854 rad, and the point x = -1, y = 1 corresponds to 135° or 2.3562 rad. However, the greatest power and flexibility is obtained by using software. Bleloch. 63 : Colon; generates regularly spaced elements and represents an entire row or column. % Start with an empty vector. So you could type 25 >> s = 20 * r MATLAB ignores spaces when making its calculations, with one exception that we will discuss in Chapter 2. see also left-division methods, 404-405 runtime errors, 32, 20, 84 row vector, 52, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 20, 84 row vector, 52, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 288 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 388 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 388 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 388 Runge-Kutta methods, 404-405 runtime errors, 32, 53 r-squared value, 388 Runge-Kut 160 S sampling, sound, 579 sampling frequency, 580 Save Workspace icon, 24 saving workspace variables, 24-25 scalar variable, 8, 63, 166 596 scaled frequency histogram, 317-318 scaling data, 289 script file, 17-18, 26, 27 debugging, 32 effective use of, 28-29 example of, 30-31 559 structure for, 29 search path, 25 "seed" number, 323 semilog plot, 241 sequential operations, 154 servo motors, 480 session, 7 settling time, 421 short-circuit operators, 166-167 signed-square-root (SSR), 462-463 Simpson's rule, 393 simulation, 200-205, 272 small-scale aeronautics, 224 smart structures, 50 Sojourner, 2 solvers, 405-406 sound, creating, 579-582 spaghetti code, 155 special products, 83-84 speed control, 477-479. Follow the directions in the window to create the function shown in Figure 10.9-4. Note the use of a function handle in the second line. The length(A) function computes either the number of elements of A if A is a vector or the largest value of m or n if A is an m × n matrix. For example, the equation of a mass connected to a spring and sliding on a surface having viscous friction. 371 EXAMPLE 8.4-2 An Overdetermined Set Solve the following equations and discuss the solution for two cases: c = 9 and c = 10.60 tons of copper, 67 tons of magnesium, 6 tons of silicon, and 101 is composed of text (alphanumeric characters). We assume that you are familiar with the fundamentals of differential equations outlined in Chapter 9, Sections 9.3 and 9.4. Laplace transform The Laplace transform is thus a function of only the Laplace variable s, which may be a complex number. We will use the normal prompt symbol >> to illustrate commands in this text. You can also export the figure 10.10-4 with a unit-step command input, let T = 0.3. Compute the PI gains required to obtain a response time of 2 without oscillations. The residuals of the cubic fit are even smaller, with no strong pattern and a large random component. To find out how many, we could also have typed length(indices). To use cell indexing to place the contents of cell (3,4) of the array C in the new variable Speed, type Speed = C(3, 4). >> syms th 1 th 2 >> S = solve(4*cos(th1)+3*cos(th1)+3*cos(th1+th2)==6,... Type vpa(E) to compute the expression E to the number of digits. Four windows appear. Then click OK. Check the output of the program with your hand solution. See also LOG, LOG2, EXP, LOGM. The temperature T(x, y) as a function of the xy coordinates shown is given by where Use the following data: $T 1 = 70^{\circ}F$, $T 2 = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T 1 = 70^{\circ}F$, $T 2 = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, and W = L = 2 ft. Use the following data: $T = 70^{\circ}F$, $T = 200^{\circ}F$, T = 200admissions and freshman retention rate on the college's enrollment so that it can predict the future need for instructors and other resources. It uses the relational operator >=, which means "greater than or equal to" (in Section 4.2). Information about these features and functions is available in MATLAB Help (categories graph3d and specgraph). The package's total weight is 20 lb, and it is rectangular with dimensions of 12 by 8 in. For the model shown in Figure 10.10-5 with a unit-step command input, let m = 1 and T = 0.2. Compute the PID gains required to obtain the roots s = -10, -20. Type uiimport or select Import Data on the Toolstrip. Solution First solve the cylinder equation for the radius r. Create a polar plot of the following function for the range $0 \le \theta \le 2\pi$. Determine the quality of the curve fit by computing J, S, and r 2. To exit from the debug mode, type dbquit. [Jayaraman, 1991] Jayaraman, S. 339 Numerical integration functions Item Description Pages integral. New York: McGraw-Hill, 1991. (b) Now suppose that the engine angle is limited by a mechanical stop to 60°, which is π/3 rad. solve(E1,...,En) Solves multiple expressions or equations. The formulas are 1. This set is in reduced row-echelon form. To illustrate subsystem blocks, we will use a simple hydraulic system whose model is based on the conservation of mass principle familiar to engineers. Hyperbolic cosecant;
1/sinh x. If n = 1 mol of an ideal gas were confined to a volume of V = 22.41 L at 0°C (273.2 K), it would exert a pressure of 1 atm. 261 fsurf(f) Creates a shaded 3-D surface plot. Usually this does not present a problem if you arrange the calculation sequence properly. Use format bank only for monetary calculations; it does not recognize imaginary parts. After placing it, doubleclick on it and type pi/50 in its Constant Value window. Default independent variable in MATLAB the variable in MATLAB the variable in the session is >>x = fminsearch(@channel,[20,1]) $x = 7.5984 \ 1.0472$ Thus the minimum perimeter length is obtained with $d = 7.5984 \ ft$ and $\theta = 1.0472 \ rad$, or $\theta = 60^{\circ}$. For example, k = 10, 2, 4 produces k = 10, 8, 6, 4. The answer is x = 1. (a) \$7300; (b) \$5600; (c) 1200 \ shares; (d) \$15,800. Note that y(0) = 0 if $m \ge 0$, and $y(0) = \infty$ if m < 0. The function outputs should be the solution for W and the corresponding values of L and P. How large must its radius be? Because the triangle "collapses" when A = 0° and A = 180°, you should check these cases. The form who var1 var2 restricts the display to the variables specified. This menu contains a list of possible plot types based on the type of variable you select. Note that this block requires you to use the variable u. Find the total distance the object travels in 4 s. Once the blocks have been placed, connect the input port on each block. We can obtain a more detailed model of position control by replacing the transfer function 1/ms with 1/ms 2 in Figure 10.10-5. We choose C and D to obtain the speed x 2 as the only output. A liquid boils when its vapor pressure equals the external pressure acting on the surface of the liquid. Hours Product 1 Product 2 Product 3 Reactor A 6 2 10 Reactor B 3 5 2 385 Let x, y, and z be the number of tons each of products 1, 2, and 3 that can be produced in one week. A third, optional section may include definitions of variables used in the calculations. Plane A is heading southwest at 300 mi/hr, while plane B is heading west at 150 mi/hr. Simplify the problem only enough to obtain the required information. Plot the solution of the equation if f(t) = 0 for t < 0 and f(t) = 15 for $t \ge 0$. 156 2. %s String of characters The output can have more than one column, and each column can have its own format. Typing zeros(size(A)) creates a matrix of all zeros having the same dimension as the matrix inverse method to solve the following set. The result obtained with the rref function is x 1 = 0.2727x 3+ 5.2727, x 2 = -1.3636 x 3 - 2.2626, x 3 arbitrary. The output should be the variable extra day, which should be 1 if the year is a leap year and 0 otherwise. 325 randi Generates non-unique random integers. The function has two minimum points in the interval -1 < x < 4. Use the simulation with q max = 8 \times 10 5 to compare the energy consumption and the thermostat cycling frequency for the two temperature bands (69° , 71°) and (68° , 72°). 2.* Let x = -5 - 8i and y = 10 - 5i. Change its label to 1/I. The variable t represents time in seconds, and the dimensionless variable y represents the pressure difference across the aortic valve, normalized by a constant reference pressure History, right-click, and select Create Live Script. D. Multiplying a matrix A by a scalar w produces a matrix whose elements of A multiplied by w. Use the results of part b to plot the path of the hand. 12 clear Removes variables from memory. end else % The ranks of A and [A b] are not equal. Use MATLAB to evaluate the following double integral: 395 16. The following state model describes the motion of a certain mass connected to a spring, with viscous friction on the surface, where m = 1, c = 2, and k = 5. 130 fminsearch Finds the minimum of a multivariable function. The four equations can be written in the following matrix form: 192 or more compactly as where and Suppose that the initial total enrollment of 1480 consists of 500 freshmen, 400 sophomores, 300 juniors, and 280 seniors. Adding and subtracting complex numbers by hand is easy when they are in the rectangular representation. One practical use of this simulation is to determine how long the speed is below the limit of 250. If there is more than one name that starts with the letters you typed, MATLAB displays these names when you press the Tab key. Find the mean and variance of z by simulation. 228 3. Each form has its own applications, which we illustrate by examples. The following script file generates the relative frequency histogram for the 100 thread tests. Hoel. Suppose $d = 5 \times 10 - 200$, use MATLAB to calculate f = d/a. Figure 9.3-4 Plot of water height in a spherical tank. The Desktop may appear differently in different versions of MATLAB, but the basic features should be similar to those discussed here. 24 Test Your Understanding T1.3-3 Plot the function y = 3x 2 + 2 over the interval $0 \le x \le 10$. Instead, connect the points with solid lines. The concept of thermal resistance described in Problem 8 can be used to find the temperature distribution in the flat square plate shown in Figure P9(a). (which is approximately 0.6 V for silicon diodes) [Rizzoni, 2007]. These give constant inputs (which are not the same as step function inputs). Note that the transpose operation converts a row vector into a column vector, and vice versa. 195 switch Directs program execution by comparing input with case expressions. The columns of the matrix y are the outputs, and the number of its rows equals length(t). Plot the sin x function and 20 evenly spaced error bars representing the error in the approximation. Below the tabs are various menu names and a row of icons called the toolbar. Path segment Force (N) 1 2 3 4 5 400 550 700 500 600 3 0.5 0.75 1.5 5 Distance (m) Use MATLAB to find (a) the work done on each segment of the path and (b) the total work done over the entire path. The ideal gas law relates the pressure P, volume V, absolute temperature T, and amount of gas n. If you are plotting measured data, plot each data point in a given set with the same symbol, such as a circle, square, or cross. 456 6. The input fun, which represents the integrand f(x), is a function handle for the integrand function. The vector breaks containing the coefficients of the polynomials. Then click on the block, and drag one of the corners to expand the box so that all the text is visible. Sections 5.1, 5.2, and 5.3 1.* Breakeven analysis determines the production volume at which the total production cost is equal to the total revenue. 33 lookfor Searches Help entries for a keyword. format compact Suppresses some blank lines. Solve for x by typing x = pinv(A)*b. These excursions are often seen with 341 313 Figure 7.4-5 Top graph: Interpolation with a fifth-order polynomial and a cubic spline. The variable A d represents the angle A in degrees. The following example illustrates how this is done. This script is executed from the command prompt as follows: >> resist The currents are: 1.0e-003* 0.9544 0.3195 0.0664 Because MATLAB did not generate an error message, the solution is unique. Check the results by using a calculator. Plot the voltage v(t) for $0 \le t \le 7$ s. A CAT scan of the patient's hip or knee is used to create a geometric model of the patient's anatomy. >>Year = 2000:2009; >>Veh Flow, 3) Warning: Polynomial is badly conditioned. As we increase the order of the fitted polynomial, we find that the polynomial does not pass through all the data points if the order is less than 7. If the widths of the rectangles are small enough, the sum of their areas gives the approximate value of the integral. Here, the cubic spline is more useful. Array and are used to keep track of the array's elements. Suppose you want to throw a steel bar vertically to a height of 20 ft. One of the challenges in such surgery is achieving proper alignment of the artificial joint. Table 4.1-1, which is repeated from Chapter 1, summarizes the process of Table 4.1-1 Steps for developing a computer solution 1. The Derivative and Signal Builder Blocks The simulation diagram shows that we need to compute y. We are told that measurements of x and y are normally distributed with means of 10 and 3.64, respectively, with a state to the state s, and pass this state to the user-defined functions. The extended syntax of the step function is similar to that of the initial and the impulse functions. Type namelengthmax to determine this limit. For example, to 581 play the Messiah segment following script. An algorithm running on the control computer decides how to adjust the actuator input to obtain the desired value of the controlled variable. STRUCTURE CHART Two types of charts aid in developing structured programs and in documenting them. To create this simulation, first obtain a new model window. The useful life of a machine bearing depends on its operating temperature, as the following data show. Appendix D: References.....Page 53435. >> syms t >> x = [0:0.05:5]; >> P = subs(y,t,x); >> plot(x,P), axis([0 5 0 2]), xlabel('t') 482 Equation Sets of equations with specified boundary conditions can be solved as follows. Use least-squares regression with the following data to estimate the values of a 1 and a 2. Note also that MATLAB syntax may be used for clarity where needed. Therefore, if you want to display the fit in the data plot, you might need to check the relevant check box in Plot fits. These two equations are equivalent to 364 In matrix form these are The augmented matrix [A b] for the above set is Note that the first two columns form a 2 × 2 identity matrix. The inverse operation is also linear. The second set is y = 2, 4, 5, 3, 2, 4. Suppose there is a dead time of 10 sec between the outflow of the top tank and the lower tank. 1.2 The Toolstrip The Desktop manages the Command window and other MATLAB tools. Greater discussion of
modeling and computer solutions can be found in [Starfield, 1990] and [Jayaraman, 1991]. 391 you can use narrow panels where the function is changing rapidly. The min, max, and sort functions can be made to act on the rows instead of the columns by transposing the array. Use the Simulink model to obtain plots of h 1 (t) and h 2 (t) for the following parameter values: A 1 = 2 m 2, A 2 = 5 m 2, R 1 = 400 m - 1 · s - 1 R 2 = 600 m - 1 · s - 1 R 2 · s -1, ρ = 1000 kg/m 3, q mi = 50 kg/s, h 1 (0) = 1.5 m, and h 2 (0) = 0.5 m. Figure 10.10-9 shows the paths of the two wheels and the path of the center point. To make the statements more readable, we can group the logical operations using parentheses. Regression is treated in Section 6.2. Section 6.3 introduces the MATLAB Basic Fitting interface, which supports regression. See the MATLAB documentation for information on these methods. A figure handle is a specific type of object handle. Since the data must have the same number of entries in each line. [Starfield, 1990] Starfield, A. Always test your program with a simple version of the problem. whose answers can be checked by hand calculations. 465 Figure 10.7-5 A hydraulic system with two tanks. The Edit Plot item starts the plot editing mode, which can also be started by clicking on the northwest-facing arrow on the Figure toolbar. >>U = [6, 2, 1; 2, 5, 4; 4, 3, 2; 9, 7, 3]; >>P = [10, 12, 13, 15; 8, 7, 6, 4; 12, 10, 13, 9; 6, 4, 11, 5]; >>Quarterly_Costs = sum(U'*P) Quarterly_Costs 400 351 509 355 >>Category_Costs = sum((U'*P)') Category_Costs = 760 539 316 This example illustrates the compactness of MATLAB commands. Certain types of functional relationships appear as straight lines when plotted using a log scale. For example, if then the session >>A = [6, 0, 3; 0, 4, 0; 2, 7, 0]; >>[u, v, w] = find(A) returns the vectors The vectors u and v give the (row, column) indices of the nonzero values, which are listed in w. Find the maximum and minimum values in each row. 53. You can also use a solution search engine at The MathWorks website to query an up-to-date database of technical support information. Temperature (°F) Bearing life (hours × 10 3) 100 120 140 160 180 200 28 21 15 11 8 6 7. We could have printed the expression for the solutions of y, but the expression for the solutions of g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for the solution with a while Loop for g, but the expression for g, but 183 Write a script file to determine the number of terms required for the sum of the series 5k 2 - 2k, k = 1, 2, 3, ..., to exceed 10,000. You can create an interactive narrative to be shared. a) Run the simulation and plot the speed. 85 565 Logical functions Item Description Pages any True if any elements are nonzero. The population data for a certain country are as follows: Year Population (millions) 2012 2013 2014 2015 2016 2017 10 10.9 11.7 12.6 13.8 14.9 Obtain a function that describes these data. Using straight lines to connect the data points is the simplest form of interpolation. We can raise a scalar n to a matrix power A, if A is square, by typing n^A, but the applications for such a procedure are in advanced courses. Angle of a complex number x. sort(A) Sorts each column of the array A in ascending order and returns an array the same size as A. This information is important for people who must design processes utilizing boiling liquids. We see that this relation is a power function where the exponent is 0.5. Thus if we plot log 10 (f) versus log 10 (V), we should obtain a straight line. Returns a row vector p of length n+1 that contains the polynomial coefficients in order of descending powers. Fit. 451 495 452 CHAPTER 11 Symbolic Processing with MATLAB OUTLINE 11.1 Symbolic Processing with MATLAB OUTLINE 11.1 Symbolic Processing with MATLAB OUTLINE 11.2 Algebraic and Transcendental Equations 11.3 Calculus 11.4 Contains the polynomial coefficients in order of descending powers. Fit. Differential Equations 11.5 Laplace Transforms 11.6 Symbolic Linear Algebra 11.7 Summary Problems Up to now we have used MATLAB to perform numerical operations only; that is, our answers have been numbers, not expressions. The proportional and integral terms are often used to counteract the effects of a disturbance. Figure 6.1-4 shows the plots used to solve the problem. Each chapter ends with numerous problems, grouped according to the relevant section. 149 153 150 CHAPTER 4 Programming with MATLAB OUTLINE 4.1 Programming with MATLAB OUTLINE 4. 4.6 while Loops 4.7 The switch Structure 4.8 Debugging MATLAB Programs 4.9 Applications to Simulation 4.10 Summary Problems require a script file. 118 asin(x) Inverse sine; arcsin x = sin -1 x. Answers to selected problems and an index appear at the end of the text. Its syntax is logspace(a, b, n), where n is the number of points between 10 a and 10 b. Note that you may even supercede a MATLAB M-function in this way. The difference between nested function file. The isstruct function determines and subfunctions is that subfunctions is that subfunctions is that subfunction file. whether an array is a structure array. New York: McGraw-Hill, 1990. A matrix is singular if its determinant |A| is zero. The term f(t) is the applied force acting on the mass. Time (min) Bacteria (ppm) 0 6 10 350 1 13 11 440 2 23 12 557 3 33 13 685 4 54 14 815 5 83 15 990 6 118 16 1170 7 156 17 1350 8 210 18 1575 9 282 19 1830 Solution We try three polynomial fits (linear, quadratic, and cubic) and an exponential fit. For example, x = fzero(@tan,1) returns x = 1.5708, a discontinuous point in tan(x). 375 Key Terms Augmented matrix, 353 Euclidean norm, 361 Gauss elimination, 351 Least-squares method, 369 Left-division method, 353 Matrix inverse, 350 Minimum-norm solution, 360 Overdetermined system, 368 Pseudoinverse method, 360 Rank of a matrix, 351 Statically indeterminants, 353 Underdetermined systems, 359 Problems You can find the answers to problems marked with an asterisk at the end of the text. For example, the notation v(5) refers to the fifth element in row 2, column 3 in the matrix A. Type load census to load this file. The average of m A and m B is (9.2-4) CENTRAL DIFFERENCE This is the slope of the line labeled C, which connects the first and third data points. rref([A b]) Computes the reduced row-echelon form corresponding to the augmented matrix [A b]. For several values of x, use MATLAB to confirm that sinh x = (e x - e - x)/2. It is not intended to protect against the package falling off a moving delivery truck. Curiosity's major systems include a radioisotope thermoelectric generator for power, a temperature management system with cameras, and several communication systems. The disadvantage of the movie function is that it might require too much memory if many frames or complex images are stored. Write a MATLAB program to compute t hit and the maximum height y max reached by the projectile. 58 min Returns smallest element. Top-Down Design and Program to compute t hit and the maximum height y max reached by the projectile. high level initially and then partition the problem repeatedly into more detailed levels, one level at a time, until enough is understood about the program provides the required documentation. Figure 3.2-3 Plot of the function . 419, 421 Predefined input functions Item Description Pages gensig Generates a periodic sine, square, or pulse input. This technique for replacing a differential equation with a differential equation with a difference equation is the Euler method. The
syntax persistent x y defines x and y as persistent variables, and is placed within the function. Double-click on the block to obtain the Block Parameters window, and set the Initial condition to 0 [this is the initial condition]. You can use the length function to determine how many values are in an array. 25^-1 b. 8. Suppose the applied current is i(t) = 0.3 + 0.1e -5 t sin(25\pi t) A. These functions are summarized in Table 2.1-1. Bottom graph: Interpolation with a cubic spline. Plot the histogram of y where (a) y = e - x and (b) y = e - 10x. 128 561 Logical and relational operators Item Description Pages == Relati dimensions of C and D tell Simulink that there are two outputs. 408 EXAMPLE 9.3-2 Liquid Height in a Spherical Tank Figure 6.1-7 Measurement of beam deflection. array is displayed in the Variable Editor, you can change a value in the array by clicking on its location, typing in the new value, and pressing Enter. We can represent the measurements as a vector, and the 10th element in the list is the temperature measured at the 10th hour. MATLAB provides several functions, called solvers, that implement the Runge-Kutta and other methods with variable step size. terminology of structures. For an m × n matrix A with m rows and n columns, A T (read "A transpose") is an n × m matrix. Rotating a 3D Surface The following example rotates a three-dimensional surface by changing the viewpoint. The broker charges 6 cents per share bought or sold with a minimum fee of \$40 per transaction. Plot the data as a stem plot, a bar plot, and a stairs plot. x The reader is assumed to have some knowledge of algebra and trigonometry; knowledge of calculus is not required for the first seven chapters. Compare the following output with the preceding example: >> fprintf('The second circle's radius %-15.3e is large.',r(2)) The second circle's radius 2.225e+001 is large. Simulink automatically puts the time variable tout into the MATLAB workspace when you are using the To Workspace block. These values are computed using the methods of control theory. Formulas for M are derived in elementary electrical circuits courses. So we obtained two solutions, instead of one, and now we must decide if both are meaningful. The following discrete-time version can be used for such cases. 412 First rewrite the pendulum Equations. Note that the statement v.^2./R is equivalent to (v.^2)./R. For addition these properties mean that (2.3-2) (2.3-3) Array addition and subtraction require that both arrays be the same size. Otherwise the element is the maximum of those two element values. The Editor is discussed in Section 1.4. Figure 1.1-1 shows the files in the author's folder Examples. Three other windows appear in the default Desktop. For example, 454 >> x(3) 9 or >>function can be used to create symbolic constants by using a numerical value for the argument. Using the function of differential equations of a differential equation of a differenti Solution With C d = 0.6, r = 5, g = 32.2, and A = π(1/24) 2, Equation (9.3-13) becomes 376 (9.3-14) Figure 9.3-3 Draining of a spherical tank. Show equations. We can describe a polynomial in MATLAB with an array whose elements are the polynomial's coefficients, starting with the coefficient of the highest power of the variable. After creating the axis, select it in the Plot Browser panel to enable the Add Data button at the bottom of the panel. (b) The case where On < Off. Refer to Example 3.2-1 in Chapter 3. The college estimates that 10 percent of the freshman class will repeat the year. A scalar variable is a variable is a variable that contains a single number. You can move the cursor along the curve and read the values as they change. Its syntax fplot3(fx,fy,fz,t_interval)plots the parametric curve defined by the functions x = fx(t), y = fy(t), and z = fz(t) over the interval for t. Verify the commutative law 16. It is informative to plot both the input and the output of the Transfer Fcn block versus time on the same graph. The accuracy of the Euler method can be improved sometimes by using a smaller step size. 325 randn Generates normally distributed random numbers. This is because many ode models of engineering applications have time t as the independent variable. Use the loglog(x,y) command to have both scales logarithmic. The fzero function returns a value of x that is near x0. The following functions are based on these expressions, where s0 is the launch speed s 0 and th is the launch angle θ. Consider a mass-spring-damper system in which the spring element gets weaker with time due to metal fatigue. 2.7 Structure Arrays are composed of structures. 573 view Sets the angle of the view. The following table of temperature versus time data is missing readings at 5 and 9 hours. The MATLAB function rand generates random numbers uniformly distributed over the open interval (0,1) using an algorithm called a random number sufficiency, 313 Bins, 312 314 Cubic splines, 336 Error function, 321 Gaussian function, 319 Histogram, 312 Interpolation, 319 Wormal, 319 Normally distributed, 323 Variance, 319 Normal, 319 Normally distributed, 323 Variance, 319 Problems You can find the answers to problems marked with an asterisk at the end of the text. Solution The MATLAB session is >>A = [2, -4, 5; -4, -2, 3; 2, 6, -8]; >>b = [-4; 4; 0]; >>rref([A, b]) ans = 1 0 -0.1 -1.2000 0 1 -1.3 0.4000 0 0 0 The answer corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], where 365 This matrix corresponds to the augmented matrix [C d], wh follows: x 1 = 0.1x 3 - 1.2, x 2 = 1.3x 3 + 0.4. This is the general solution to the problem, where x 3 is taken to be the arbitrary variable. The Richter 1: An Overview of MATLAB®......Page 2211. Four times the dominant time constant, or 4(0.3060) = 1.224, gives the time it takes for the free response to become approximately zero. Its basic syntax is fminbnd (@function, x1, x2) where @function is a function handle. Note that MATLAB enables us to use decimal exponents to evaluate L. Time (s) 1 2 3 4 5 Speed (m/s) 12 14 16 21 27 Solution of the items by a space, and save it as speed data.dat (note: be sure not to save it as the default M-file type). Let L (mol) be the amount of liquid remaining in the still, and let x (mol B/mol) be the benzene mole fraction in the remaining in the still, and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the remaining in the still and let x (mol B/mol) be the benzene mole fraction in the still and let x (mol B/mol) be the benzene mole fraction in the still and let x (mol B/mol) be the benzene mole fraction in the still and let x (mol B/mol) be the benzene mole fraction in the still and let x (mol B/mol) be the benzene mole fraction in the still and let x (mol B/mol) be the benzene mole fraction in the still and let x (mol B/mol) be the benzene mole fraction in the still and let x (mol B/mol) be the benzene mole fraction in the still and let x (mol B/mol) be the benzene mole fraction in the still and let x (mol B/mol) be the benzene mole fraction in the still and let x (mol B/mol) be the benzene mole fra array index, because it points to a particular element in the array. Use MATLAB to solve the matrix
equations obtained in part a for the case where p a = 4320 lb/ft 2, p b = 3600 lb/ft 2, and p c = 2880 lb/ft 2. 231 plot Generates xy plot. they cause huge trade imbalances that hurt the economy. 3 /sec, use Simulink to determine how long will it take to fill the cup to the brim. Fit an equation to these data. Test Your Understanding T6.2-5 A mass attached to a spring and damper is displaced a distance x 0 (cm) while being given an initial velocity v 0 (cm/s). The identity matrix I can be created with the eye(n) command, where n is the desired dimension of the matrix. 260 plot3 Creates three-dimensional plots from lines and points. This motion causes the crankshaft to rotate. In such cases it may be necessary to program the PID algorithm in hardware-specific code. 582 sound Plays a vector as sound. If you want the integral of a single function, then y is a vector. To compute z, MATLAB adds all the corresponding numbers in x and y to produce z. Chapter 3: Functions......Page 11715. This process results in the spiral curve shown in Figure 5.4-1, which was produced with the following session. Then enter the following data into the array: Location Max. These measurements are used by the controller to adjust the hydraulic resistance of a piston to produce a more stable, natural, and efficient gait. However, if your data set has n points, then you should use polynomials with at most n coefficients. The variables are returned in alphabetical order and are separated by commas. Plot the scaled frequency histogram. Update the enrollment matrix E by adding another column composed of x. This relation is like the voltage-current relation is like the voltage-current relation for an electric resistor: i = v/R. The matrices A, B, and D are all symbolic. In such cases you can use the bar function to generate the histogram. You need not type the variable names to retrieve them; just type load(myfile). Thus the admissions and transfers for the next 10 years are given by for k = 1, 2, 3, ... until the college's total enrollment reaches 4000; then admissions and transfers for the next 10 years are given by for k = 1, 2, 3, ... until the college's total enrollment reaches 4000; then admissions and transfers are held constant at the previous year's levels. In such cases a much simpler form of the algorithm can be tried and programmed in hardware-specific code. Click on the grid icon in the New Subplots panel to display the selector grid that enables you to specify the layout of the subplots. % Fs = sampling frequency (in Hz). Data Markers and Line Types To plot the vector y versus the vector x and mark each point with a data marker enclose the symbol for the marker in single quotes in the plot function. For example, you can solve a set of many linear algebraic equations with just three lines of code, a feat that is impossible with traditional programming languages. Apply the Laplace transformation to the differential equation to obtain an algebraic equation. Time (s) Temperature $(^{\circ}C)$ 0 1 2 3 4 5 300 150 75 35 12 5 6. Then double-click on an axis, a plotted line, or a label to activate the appropriate property editor. The probability that the random variable x is less than or equal to b is written as $P(x \le b)$ if the outcomes are normally distributed. Your entry and the 7 SESSION MATLAB response look like the following on the screen (we call this interaction between you and MATLAB an interactive session, or simply a session). yes.) EXAMPLE 2.3-1 Vectors and Displacement Suppose two divers start at the surface and establish the following coordinate system: x is to the west, y is to the north, and z is down. Inverse transforms can be found using the ilaplace function. Section 10.4 11. The rocket thrust is 4000 N and the sled mass is 450 kg. For example, the following equation describes the motion of a mass connected to a spring, with viscous friction acting between the mass and the surface. Develop a Simulink model of a thermostatic control system in which the temperature model is 444 where T is the room air temperature in °F, T a is the ambient (outside) air temperature in °F, time t is measured in hours, q is the input from the heating system in lb-ft/hr, R is the thermal resistance, and C is the thermal resistance. Plotting Polynomials we can plot polynomials we can plot polynomials more easily by using the polyval function. For example, z = (x < y) and u = (x = = y). For example, the second entries in u and v give the indices (3, 1), which specifies the element in row 3, column 1 of A, whose value is 2. and the standard deviation. Table 2.4-3 Product costs Unit costs ($$ \times 103$) Product Materials Labor Transportation 1 6 2 1 2 2 5 4 3 4 3 2 4 9 7 3 Table 2.4-4 Quarterly production volume Product Quarter 1 Quarter 2 Quarter 3 Quarter 4 1 10 12 13 15 2 8 7 6 4 3 12 10 13 9 4 6 4 11 5 Solution The costs are the product of the unit cost and the product of the unit c must use the file name to invoke the function. 416 MATLAB provides the eig function to compute the characteristic roots when the model is given in this menu does not affect the state of the Plot fits selection. This probability can be computed from the error function as follows: ERROR FUNCTION (7.2-2) The probability that the random variable x is no less than a and no greater than b is written as $P(a \le x \le b)$. It first establishes standards for professionallooking, useful plots. a spring, with viscous friction on the surface. The exponential function: y = b(10) mx. Obtain a linear model $y = a \ 0 + a \ 1 \ x \ 1 + a \ 2 \ x \ 2$ to describe the relationship. Determine b. How does the previous equation change? Use the anonymous functions to plot 6e 3 cos x over the range $0 \le x \le 4$. You can bring the simulation results into the MATLAB workspace by using the To Workspace block. and H = 4 in. Brackets however doesn't just edit Javascript but also HTML5, CSS, and much more. Double-click on it, and enter [-300, -20; 666.7, -166.7] for A,[500, 0; 0, -16667] for B,[0,1] for C, and [0,0] for D. However, this limitation can be removed with the use of function handles, as we will see later in this section. x = deflection; f = k*x+c; subplot(2,1,2) plot(x,f,deflection,force, o'),... To find the moment in MATLAB, you type M = cross(r, F). From here you again select the location you wish for the file to be. Once you have found the extracted file you will need to download a code editing software. Test Your Understanding T4.3-1 If x = [5, -3, 18, 4]and y = [-9, 13, 7, 4], what will be the result of the following operations? 311 138 340 199 270 255 332 279 231 296 198 269 257 236 313 281 282 254 273 334 172 240 327 261 282 208 213 299 318 356 269 355 232 275 234 267 240 331 222 370 226 Section 7.2 4. A way out of this difficulty is to use the Euler formula (9.3-4) to obtain a preliminary estimate of y(t k +1). The method is an extension of traditional design methods, but made more practical because of the power of modern computers and the improved accuracy of the software. Table 11.4-1 summarizes the functions for solving differential equations. Set the Stop time to 10. The handle is also useful for passing the anonymous function in a call to some other function in the same way as any other function save that The second derivatives are continuous with spline but may be discontinuous with pchip, so spline may give a smoother function. Use both cell indexing and content indexing to create the following 2×2 cell array. >>r = [55, 36, 25]; w = [-20, 59, 15]; >>dist1 = 70.3278 The distance is approximately 70 ft. However, not all mathematical operations are defined for logical variables. Try using amplitude = 0.1 and amplitude = 5 to see the effect on the loudness of the sound. The magnitude and angle of xy. hold on, quiver(x,y,df dx, df dy), hold off subplot(2,1,2) mesh(x,y,f), xlabel('y'), zlabel('y'), zlab student(1,1).tests(2) because student has one row. When no object is selected, the Property Editor displays the figure's properties. Each cable can support a maximum tension force equal to W. After setting m = 1 in the Command window, the simulation shows that the speed reaches the desired value of 1 in about 0.3 seconds with some overshoot, and that the maximum controller output is 40. 534 588 Answers to Selected Problems Chapter 1 2. 312, 319 median Calculates the median. First try to fit a cubic polynomial to the data. The elements of 52 logical arrays are "true" or "false," which, although represented by the symbols 1 and 0, are not numeric quantities, and $0 \le \phi \le 4\pi$. 15.* Given the matrices Use MATLAB to a. 277 258 p = polyfit(t,r,1) % Create plotting variable. Compute the probability that the pallet weight will exceed 3015 lb. First plot the left-hand side to see how many roots there may be. Multiply the second column of B and the first column of A element by element. A cycloid is the curve described by a point P on the circumference of a circular wheel of radius r rolling along the x axis. v = A(:) creates a vector v consisting of all the columns of A stacked from first to last. For t > b the rocket engine no longer produces thrust, and the speed and height are given by (4.5-4) The time t p to reach the peak height is found by setting v(t = 0. Do this by placing the mouse cursor in the upper left, holding the mouse button down, and dragging the expanding box to the lower 1 is given by the vector v pointing from diver 1. It is important to know which variable is the independent variable in an expression. TEXT OBJECTIVES AND PREREQUISITES This text is intended as a stand-alone introduction to MATLAB. 138 Variables and Anonymous Functions Variables and Anonymous Functions Variables and Anonymous functions of the same size as A, returns the values of A at the indices where B is 1. After placing it, double-click on it and select cos in its Function window. Interpret the results given by the left-division method. From the
shifting property of the Laplace transform, So the transfer function for a dead-time process is e -Ts. Run the file to check it for errors. See progress in clean energy products, climate research, and financial risk and sustainability. The following program implements the pseudocode. x 550 600 650 700 750 y 41.2 18.62 8.62 3.92 1.86 3. Notice also that we have placed semicolons at the end of the lines that calculate u and z. This can depend on the particular MATLAB version. For example, >>A = 6; B = 4: >>plane = $@(x,y) A^*x + (x,y) A^*$ B*y; >>z = plane(2,8) z = 44 No-Input Arguments To construct a handle for an anonymous function that has no input arguments, use empty parentheses for the input arguments, use empty parentheses for the input arguments, use empty parentheses for the input arguments argument list, as shown by the following: d = @() date;. Select and place in the new window the Sine Wave block from the Sources library. 55. Delete the arrow connecting the Scope block to the Transfer Fcn block. Because rank(A) \neq rank ([A b]), there is no solution. where 12. Use the following data to estimate the values of x and y that correspond to a maximum point. If the input voltages with different frequencies, the narrow-band filter will allow to pass only those voltages whose frequencies lie within a narrow range. Section 7.1 1. Select and place the Relay block from the Discontinuities library. For example, to create the row vector u whose fourth, fifth, and sixth columns contain the values of r = [2, 4, 20] and whose fourth, fifth, and sixth columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and whose fourth is three columns contain the values of r = [2, 4, 20] and r = [2, 4, 20] and r = [2, 4, 20flow uses the same three types of control structures used in algorithms: sequential, conditional, and iterative. If not, MATLAB then looks in the current folder for a file named problem1.m and executes problem1 if it finds it. In mathematical text variables are usually set in italic, and functions, such as sin, are set in roman type. The plot was generated by the following session: >> theta = 0.pi/90.2*pi: >> r = 2./(1-0.5*cos(theta.r). itle('Orbital Eccentricity = 0.5') 230 Figure 5.2-7 A polar plot showing an orbit having an eccentricity = 0.5') 230 Figure 5.2-7 A polar plot showing an orbit having an eccentricity = 0.5' 246 The sun is at the origin. and the plot's concentric circular grid enables us to determine that the closest and farthest distances the object is from the sun are approximately 1.3 and 4 AU. Although this function has the 467 function used to compute numerical differences (see Chapter 9), MATLAB detects whether or not a symbolic expression is used in the argument, and directs the calculation accordingly. 572 waterfall Same as mesh with mesh lines in one direction. Another application of nanotechnology is in the creation of micromechanical machines (MEMS). The integral of q over time is the energy used. The variable, and only the variable, is always on the left of the = symbol. This gives P = 7.5, I = 12.5, and D = 0.5. 437 Figure 10.10-5 Simulink model of a speed control system using one block each for actuator and mass. The data is entered in the arrays deflection and force. If you 344 receive an error message, the set is underdetermined (even though it may have a solution, or it has more than one solution, or it has more than one solution. You can call a subfunction from any nested function in the same Mfile. For other two-dimensional plot types, type help specgraph. If the device is available for testing (and small devices usually are), we can test various algorithms and gain values, keeping in mind the contribution of each of the three PID terms (try P control first, etc.). You can change the scale type (linear, log, etc.), the labels, and the tick marks by selecting the tab for the desired axis or the font to be edited. Test your function for the 149 case where (x i, y i) = (-2, -20), (0, 4), (2, 68), and (4, 508), whose answer is a = 7, b = 5, c = -6, and d = 4. x + y b. like a motor) that outputs an analog voltage, or an encoder, which consists of slotted disks and outputs a digital signal. Thus, a fourth-order Runge-Kutta algorithm duplicates the Taylor series through the term involving h 4. All other years are not leap years. The text consists of 11 chapters. As the preceding example shows, you often can save many lines of code by using MATLAB 177 commands, instead of using loops. Figure 10.4-7 The relay function. Importing Spreadsheet Files The command xlswrite(file name, array name to the Excel file specified by file name. (a) What is the free response in terms of x 0 and v 0 if m = 3, c = 18, k = 102? You can create a multidimensional array by first creating a two-dimensional array and then extending it. 244, 312 errorbar Plots error bars. %% Create the independent variable. Find the sum of x and y. For example, we often can see how to improve an engineering design by modeling it with mathematical expressions that do not have specific parameter values. Find a functional relation between f and x, the extension from the free length (x = y - 4.7). Select Copy Figure from the Edit menu. If not, it checks to see if it is a subfunction). The mathematics might be trying to tell you something, and you might miss an opportunity to discover more about the problem. For example, the following equation is the equation of a specific pendulum. axis([-3 3 - 3 3 - 5 5])% Retain same scaling for each frame. y abs=[1,0,0,0,2,4,5,4,8,11,12,10,9,8,7,5,4,4,3,1,1,0,1]; binwidth = 0.5; % Compute scaled frequency data.area = binwidth*sum(y abs); y scaled = y abs/area; % Define the bins. etc. Compute the volume of a parallelepiped defined by A = 5i, B = 2i + 4j, and C = 3i - 2k. Solution The equations of motion can be expressed in state-variable form by letting z 1 = x 1 , z 2 = x 1 , z 3 = x 2 , z 4 = x 2 . Each chapter contains tables summarizing the MATLAB commands introduced in that chapter. EXAMPLE 10.2-1 Simulink Solution of $\dot{y} = 10$ sin t Use Simulink to solve the following problem for $0 \le t \le 13$. Table 5.2-1 gives the symbols for other line types. ans = $x^2+2*x^*y+y^2 >>$ expand(sin(x+y)) % Applies trig identities. polyint(p,C) Computes the integral of the polynomial p using an optional user-specified constant of integration C. You cannot plot the number 0 on a log scale, because log 10 0 = $\ln 0 = -\infty$. Use MATLAB to calculate the product x = abd two ways, i) by calculating the product directly as x = a*b*d and then ii) by splitting up the calculate the product directly as x = a*b*d and then ii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by splitting up the calculate the product directly as x = a*b*d and then iii) by spl rectangular grid. However, this condition does not
guarantee that the expression is correct! Another common mistake involves expressions such as , which means . You can store different classes of arrays in a cell array, and you can group data sets that are related but have different dimensions. The sound function truncates or "clips" any values in sound vector that lie outside the range -1 to +1. have a local extremum on intervals where the data have a local extremum. Section 8.2 4. If the input argument to sym is a string, the result is a symbolic number or variable. Write a program that accepts a year and determines whether the year is a leap year. Use MATLAB to determine how much raw material of each type is needed to produce 1000 tons of each alloy. Figure 10.4-1 The saturation nonlinearity. 513, 516 dirac Dirac delta function (unit impulse). We want to construct another cylindrical tank with a volume 30 percent greater but having the same radius. Use the step function to plot the step response of the position and velocity for zero initial conditions, where the magnitude of the step input is 10. $100^{(-1/2)}$ d. The chapter also treats polynomial and multiple linear regression as part of its modeling coverage. The complete syntax of the sort function is sort(A, dim, mode), where dim selects a dimension along 68 which to sort and mode selects the direction of the sort, 'ascend' for ascending order and 'descend' for descending order. The order of precedence used by MATLAB must be constantly kept in mind to avoid misinterpreting the output. Determine the object's position x(t) at t = 10 s if x(0) = 3. The basic form of this command is legend ('string1', 'string2'), where string1 and string2 are text strings of your choice. Chapter 6: Model Building and Regression.....Page 25521. bins = 64: binwidth:75; % Plot the scaled histogram. Enter and save the data given in Problem 28 in a spreadsheet. If the weight's gravitational potential energy W(h + x) with the potential energy stored in the springs. The colon operator selects individual elements, rows, columns, or "subarrays" of arrays. We will now discuss the other blocks in the model. see also control systems transcendental equation, 506 transfer function form, 418 transfer-function models, 456-457 transport delay, 467-468 transpose, 53 trapezoidal integration, 391 trigonometric functions, 118-119 triple integrals, 397 561 truth table, 165-166 two-dimensional arrays, 54 two-dimensional arrays, 54 two-dimensional interpolation, 334-335 two-dimensional arrays, 54 two-dimensional arra displays all comment lines immediately following the function definition line up to the first blank line or first executable line. For large, more complicated programs, it might be impractical to draw such charts. Note that y(t) is explicitly expressed as a function of t in these definitions. The locations of the customers relative to the southwest corner of the area are given in the following table in terms of (x, y) coordinates (the x direction is east; the y direction is north) (see Figure P29). Use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (it stands for "deconvolve") to multiply polynomials and use the deconv function (it stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconv function (deconv stands for "deconvolve") to multiply polynomials and use the deconvolve" (deconv stands for "deconvolve") to multiply polynomials and use the deconvolve" (deconvolve") to multiply polynomials and use the deconvolve" (deconvolve") to multiply polynomials and use the deconvolve (deconvolve") to multiply polynomials and use the deconvolve (deconvolve) create three types of plots: line plots, surface plots, and contour plots. 336 Table 7.4-1 Linear interpolation functions Command Description y_int=interp1(x,y,x_int) Used to linearly interpolate a function of one variable: y = f(x). The known information is the package's weight, dimensions, and maximum allowable impact speed. The user must be able to choose the correct answer. In fact, fminbnd can give misleading answers. The first column contains the values of x 1 at the various times generated by the solver; the second column contains the values of x 2. Finish constructing the model in the usual way and run the simulation. These operators perform element-by-element operations. This command can be used with the first form of the disp function in a script file as follows (assuming the value of Speed is:') disp('The predicted speed is: 63 The input function displays text on the screen, waits for the user to enter something from the keyboard, and then stores the input in the specified variable. For example, the expressions $y = 7/2^{i}$ and x = 7/(2i) = -3.5i. This must be done in the context of the specific application. You can see the results: y = (7/2)i = -3.5i. This must be done in the context of the specific application. You can see the results: y = (7/2)i = -3.5i. This must be done in the context of the specific application. You can see the results and graphics next to the code that produced them, and you can see errors at the file location where they occur. A log-log plot has log scales on both axes. The diff Function MATLAB provides the diff function to use for computing derivative estimates. 325 AUGMENTED MATRIX Existence and Uniqueness of Solutions. The wildcard character * can be used to display variables that match a pattern. rng(#x2018;default#x2019;) Initializes the random number generator to the state it has at MATLAB startup. Section 9.5 treats these methods. Ordinary differential equation solvers in the Control System toolbox. Benayoun, Tanya I. Otherwise (if the rank of A does not equal the rank of [A b]), there are

no solutions. t(s) 0 0.3 0.8 1.1 1.6 2.3 3 v(V) 0 0.6 1.28 1.5 1.7 1.75 1.8 Solution Plotting the data, we estimate that it takes approximately 3 s for the voltage to become constant. Plot y(t) for $0 \le t \le 20$ s. EXAMPLE 4.9-2 A College Enrollment Model: Part II To study the effects of admissions and transfer policies, generalize the enrollment model in Example 4.9-1 to allow for varying admissions and transfers. Note that the equal to operator consists of two = signs, not a single = sign as you might expect. EXAMPLE 4.5-3 Data Sorting A vector x has been obtained from measurements. Compare the preceding program with the following program. amperes is applied to the resistor. The logical function Logical arrays can be created with the relational and logical function. Let the vector x be [d θ]. You can also open the Variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the name of the variable Editor directly from the Command window by typing openvar('var'), where var is the variable Editor directly from the variable Editor di underdetermined case. Note that the length L can be expressed as a function of A and W, so that the perimeter P can be expressed solely as a function of A and W. Ignore for now any error messages you may see. If the step value s is not an integer, round-off errors can cause the loop to execute a different number of passes than intended. Discuss how the length of the bar affects your answer. isstruct(S) Returns 1 if the array S is a structure array and 0 otherwise. This Instructable will be teaching you how to edit a basic game, which is the first step(in my opinion) in becoming a game developer. 377 410 9.4 Higher-Order Differential Equations To use the ODE solvers to solve an equation higher than order 1, you must first write the equation as a set of firstorder equations. [df dx,df dy] = Computes the gradient (f,dx,dy) and $\partial f/\partial y$, and dx and dy are the spacing in the x and y values associated with the numerical values of f. burn time(b) = b; % The following lines implement the formulas in the text. To specify initial conditions for a given transfer function, convert the transfer function to its equivalent state-space realization using the MATLAB function tf2ss. For example, to plot the hyperboloid x + y - z = 0 over the default interval [-5 5], you type 242 >> f = @(x,y,z) x.^2 + y.^2 - z.^2; >> fimplicit3(f) To plot the upper half of the hyperboloid x 2 + y 2 - z 2 = 0 you specify the interval as for z as [0 5], and for x and y, use the default interval [-5 5], as follows. 56 A(:, 3) denotes all the elements in the third column of the matrix A. The name of every user-defined function called by the program. This type of block is called an integrator block. These equations can be written in the matrix form AT = b as follows: STATICALLY INDETERMINATE 362 333 Figure 8.3-1 A light fixture and its freebody diagram. To do this, you should define an array that contains many values of the independent variable x in order to obtain a smooth plot. The Tools menu also gives access to the Data Cursor, which is discussed later in this section. To plot the distance dropped over 2 seconds, we would enter: t = 0:0.001:2; [meters dropped, speed] = drop(9.81, -4,t); plot(t, meters dropped, speed) = drop(9.81, -4,t); plot(t, meters dropped \$4000, and \$8000, respectively. The associative property states that (2.4-6) The distributive property states that 86 (2.4-7) Applications to Cost Analysis Project cost data stored in tables must often be analyzed in several ways. 238, 240 hold Freezes current plot. For example, 5h(x) is represented by [45, 5, 10, 45]. However, given the need to be conservative here, we probably should round the answer down to the nearest foot. The Quality of a Curve Fit The least-squares of the residuals J. A structure chart displays the organization of a program without showing the details of the calculations and decision processes. Here is the session. The elements of the state vector are the state vector are the function line. Animating a Function Consider the function te -t/b, which was used in the first movie example. Remember that we must use the transpose operation to convert the row vectors into column vectors. In the debug mode type dbcont to continue the execution or dbstep to step through the program one executable line at a time. Nested functions have two unique properties: 1. Solution Figure 5.2-7 shows the polar plot of the orbit. The vector of coefficients of the numerator of the derivative is given by num. t p = b + v b/g; % Compute peak time. For example, typing fprintf("The inflation rate was %3.2f %%. So you must know the correctly. Ship A is traveling north at 6 mph, and ship B is traveling west at 12 mph. The variable s represents speed in feet per second; the variable t 38 represents time in seconds. 19 2 Source: NASA Engineering in the 21st Century... Remote Exploration I t will be many years before humans can travel to other planets. We can use the surface-plotting functions covered in Chapter 5 to look for multiple valleys, or we can use a large number of initial values for d and θ , say, over the physically realistic ranges 0 < d < 30 and $0 < \theta < \pi/2$. A handle is simply a name attached to an object such as a graph, so that we may reference it. The initial conditions x 1 (0) and x 2 (0) are assumed to be zero, and so they need not be specified in the lsim function. Table 4.3-4 Logical function Definition all(x) Returns a scalar which is 1 if all the elements in the vector x are nonzero and 0 otherwise. Obtain a matrix algorithm to compute the amounts of raw materials needed to produce a given amount of each alloy. if $x \ge 0$ y = sqrt(x) else y = exp(x) - 1 end When the test, if logical expression, is performed, where the logical expression may be an array, the test returns a value of true only if all the elements of the logical expression are true! For example, if we fail to recognize 174 how the test works, the following statements do not perform the way we might expect. Test Your Understanding T9.3-1 Use MATLAB to compute and plot the solution of the following equation. Thus in MATLAB you cannot type 6 = x. Write a MATLAB program to verify this fact for n = 1, ..., 19 for the center of the plate (x = y = 1). Thus the Camera Toolbar in the View menu of the Figure window is helpful for determining the proper point of view. Other Resources For additional help, you can run demos, contact technical support, search documentation for other MathWorks products, view a list of other books, and participate in a newsgroup. The functions for retrieving and specifying the state of the normally distributed generator, except that randn(...) in the syntax. Note that step 5, Write and run the program, is only part of the topdown design process. Compute the double integral Note that the region of integration lies to the right of the line y = x. Thus many other methods can be classified as predictor-corrector. We explain this technique in Section 3.2. Section 3.3 covers additional topics in function programming, including function handles, anonymous functions, subfunctions, and nested functions. 572 getpoints Retrieves points from an animated line. Run the simulation. The Variable Editor opens, displaying the values for the selected variable. Find the result of A times B using the values for the selected variable. Find the result of A times B using the values for the selected variable. mass of 899 kg (1,982 lb) including 80 kg (180 lb) of instruments. Use the subsystem block to construct a Simulink model of the entire system of three loops. 2.7324 sec while ascending; 7.4612 sec while descending; 7.4612 sec while ascending; 7.4612 sec while ascending and the entire system block to construct a Simulink model of the entire system of three loops. these functions. m/A, K e = 0.04 V. One advantage of using random numbers generated in software is that you can repeat a random number calculation at any time. For example, to substitute a = x and b = 2 into the expression E = a sin b, the session is >> syms a b x >> E = a*sin(b); >> F = subs(E, {a, b}, {x, 2}) F = x*sin(2) Evaluating Expressions In most applications we eventually want to obtain numerical values or a plot from the symbolic expression. Its characteristic equation is (10.10-13) Note that we need positive values for all three gains to achieve a stable system and to place the three roots where we want. Create databases using cell and structure arrays. whos Lists the current variables and sizes and indicate if they have imaginary parts. Also given is the volume in tons per week that must be delivered from the distribution center to each customer. The solution is t = [log 10 (120-68) - log 10 (b)]/m. The result z will have the same size as x and y. The row number is always listed first! This notation enables you to
correct entries in an array without retyping the entire array. The temperature distribution in the plate is described by Obtain the surface and contour plots for the temperature. 3.* Use MATLAB to create a vector x having six values between 0 and 10 (including the endpoints 0 and 10). Complex results are produced if X is not positive. 30, 177 ; Suppresses screen printing. Symbolic constants can look like numbers, but are actually symbolic expressions. Select and place in the new window the Step block from the following form often appear in applications. You can scale the data yourself before using polyfit. Thus the data can be described with the exponential function T = 68 + b(10) mt. Some overdetermined systems have exact solutions, and they can be obtained with the left-division method x = A b. Then, by omitting the t k notation from the other equations, we obtain the following description of the predictor-corrector process. The hole of the predictor because the systems have exact solutions and they can be obtained with the left-division method x = A b. Command The hold command creates a plot that needs two or more plot commands. Run the simulation and check the position response. When you type problem1, 1. Quenching is the process of immersing a hot metal object in a bath for a specified time to obtain certain properties such as hardness. You must determine whether the packaging material provides enough protection when the package is carried by delivery persons. For example, to compute sin x, where x has a value in radians, you type sin(x). Note that we need not define two separate vectors x and y. These values correspond to fuel oil flowing through pipes 2 ft long, with 2- and 1.4-in. First introduced in MATLAB 6.0, function handles have become widely used and frequently appear in examples throughout the MATLAB documentation. Another estimate can be obtained from the straight line labeled B. High-degree polynomials often exhibit large excursions between the data points and thus should be avoided if possible. Thus 550 Figure P18 500 where c is a constant. Create three user-defined functions to use in the script. An external force of f 1 = 5 N acts on it parallel to and up the incline. Each rectangular panel in the grid will have a width equal to yspacing. Write a MATLAB script file in terms of the given variables W and A to determine the length L required so that the enclosed area is A. What is the maximum output of the PID block? They include a library of Simulink blocks for configuring and accessing the hardware's sensors, actuators, and communication interfaces. EXAMPLE 5.2-1 Plotting Orbits The equation describes the polar coordinates of an orbit measured from one of the orbit's two focal points. You can connect the data points with lines if you wish. Computers that cannot achieve the specified fps will play the movie as fast as they can. 556 where L, R, and I are the motor's inductance, resistance, and inertia, K T and K e are the torque constant, c is a viscous damping constant and back emf constant. a model is a mass attached to a spring and sliding on a horizontal surface with Coulomb friction. FREE RESPONSE FORCED RESPONSE The free response, is the solution for the case where there is no forcing function. Symbolic expressions can look like character strings, but are a different sort of quantity. Thus the result of multiplying a 1 × 3 vector by a 3 × 1 vector is a 1 × 1 array, that is, a scalar. Numeric Functions Some function, variable, or file if you type the first few letters of the name and press the Tab key. To use cell indexing, enclose in parentheses the cell subscripts on the left side of the assignment statement and use the standard array notation. The magnitude of a vector x having real elements x 1, x 2,..., x n is a scalar, given by , and is the same as the vector's geometric length. The script file is x = linspace(0,pi,10); y = sin(x); A = trapz(x,y) Table 9.1-1 Basic syntax of numerical integration functions Command Description integral(fun,a,b) Uses an adaptive Simpson rule to compute the integral of the function fun between the limits a and b. The matrices for the equation Ax = b are Here the rank(A) = rank([A b]) = 2, which is less than the number of unknowns. For the fixture to be in equilibrium, the vertical forces must cancel, and the total moments about an arbitrary fixed point—say, the right endpoint—must be zero. Then the model becomes where we have written the coefficients c 21, c 22, and so on in symbolic, rather than numerical, form so that we can change their values if desired. You cannot plot negative numbers on a log scale, because the logarithm of a negative number is not defined as a real number. if x < y if z < 10 w = x*y*z end end 199 18. For example, suppose that we now have temperature measurements at three locations. 16, 30 fprintf Performs formatted writes to screen or file. So the response from typing help sine is the same as from typing help sin. (In earlier releases the response was "sine.m not found", which was perhaps more useful). Use enough points to get a smooth curve. When the relay output is Off, it remains Off until the input exceeds the value of the Switch-on point parameter, named SwOn in the figure. k = p(1) c = p(2) % Plot the fitted line and the data. Use a while loop to determine how many terms in the series 2 k, k = 1, 2, 3, ..., are required for the sum of the terms to exceed 2000. Compare these limits with those of the data. The leftdivision method A\b gives this solution, which is x 1 = -1 and x 2 = 2. The syms command enables you to combine more than one such statement. >> subs(S.x,b,sqrt(3)); >> simplify(ans) ans = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 and x = 3.2680 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 4.9820 464 Thus the x coordinates of the two intersection points are x = 4.982 4.9820 4shown in the following script file, which is a continuation of the previous script and produces the bottom two subplots shown 260 in Figure 6.1-4. Use a surface plot and a contour plot of the previous script and produces the bottom two subplots shown 260 in Figure 6.1-4. Use a surface plot and a contour plot of the previous script and produces the bottom two subplots shown 260 in Figure 6.1-4. Use a surface plot and a contour plot of the previous script and produces the bottom two subplots shown 260 in Figure 6.1-4. equation problem into an algebraic problem. See Figure 11.2-1a. Cosecant; csc x. It is defined as (6.2-1) We can use the J value to compare the quality of the curve fit for two or more functions used to describe the same data. The function is for x < 0, y = 3x + 1 for $0 \le x < 10$, and $y = 9 \sin (5x - 50) + 31$ for $x \ge 10$. Select and place a Gain block from the Math Operations library, double-click on it, and set the Gain value to 0.25. x = [500;400;300;280]; % Initial admissions and transfers. When there are fewer equations than unknowns, the left-division method might give a solution with some of the unknowns set equal to zero, but this is not the general solution. An example is Fresnel's cosine integral (9.1-3) (a) Demonstrate two ways to compute the integral when the upper limit is . The model for (b) does not. For example, if then C = A.*B gives this result: Test Your Understanding T2.3-1 Given the vectors do the following by hand, then check your answer using MATLAB. The tickmark labels on a log scale are the actual values being plotted; they are not the logarithms of the numbers. This topic is covered in Section 4.8. Section 4.9 discusses "simulation," a major application of MATLAB programs that enables us to study the operation of complicated systems, processes, and organizations. Referring to Problem 54, the equations for lift and drag are 113 where, for a particular airfoil, the lift and drag are 113 where, for a particular airfoil, the lift and drag are 113 where, for a particular airfoil, the lift and drag are 113 where, for a particular airfoil, the lift and drag are 113 where, for a particular airfoil, the lift and drag are 113 where, for a particular airfoil, the lift and drag are 113 where, for a particular airfoil, the lift and drag are 113 where, for a particular airfoil, the lift and drag are 113 where, for a particular airfoil, the lift and drag are 113
where, for a particular airfoil, the lift and drag are 113 where, for a particular airfoil, the lift m/s 2, and $\theta(0) = 3$ rad. For the first case, $R = 1000 \Omega$. & ShortCircuit AND Operator for scalar logical expressions. trapz(x,y) Uses trapezoidal integration to compute the array x. The Compare the contents of two files This expression is equivalent to v = (x y) & a gives z = [0,1,0], and z = (x > y) & (x > a) 165 returns the result z = [0,0,0]. Suppose the resistances are nonlinear and obey the signed-square-root relation. Returns the result z = [0,0,0]. semilog, or log-log) on which the data forms an approximate straight line? Type randn(n) to obtain an n × n matrix of such numbers. xlabel ('text') Adds a text label to the horizontal axis (the abscissa). This approach would also allow us to find the time to drop t i. The syntax round(x,n), for positive integers n, rounds to n digits to the right of the decimal point. The coefficient of Coulomb friction is $\mu = 0.5$. Use the Sign block and create a Simulink model to solve for the velocity of the mass until the mass comes to rest. Clicking on any text, such as that placed with the title, xlabel, ylabel, legend, or gtext commands, and then selecting Current Object Properties in the Edit menu bring up the Property Editor—Text dialog box, which enables you to edit the text. Is the response time what you would expect? The triplet [0 0 0] indicates blue, and so on. Figure 10.2-3 The Simulink Model window showing the model created in Example 10.2-1. Some knowledge of high school chemistry and physics, primarily simple electric circuits, and basic statics and dynamics, is required to understand some of the examples. For example, typing name2 = student(2).name assigns the value 'Mary Jones' to the variable name2. Here we discuss several of the set understand some of the data. This indicates that the quadratic functions. This indicates that the quadratic functions are of the data. gives four equations: The fermenter is equipped with an oxygen sensor and a carbon dioxide sensor. In Table 7.2-1, note that few data points are available for heights less than 68 in. The most efficient approach is to solve the third relation for h. Simply renaming the script with the extension .mlx does not work, and can corrupt the file. Type load(census) to load this file. Find the relation between x 1 and x 2 for these solutions. You can pass the function to the calling function by using a function by using a function handle. y_raw = []; for i = 1:length(y_abs) if y_abs(i)>0 new = bins(i) *0nes(1,y_abs(i)); else new = []; end y_raw, new]; end % Compute the mean and standard deviation. The model is 413 Figure 10.3-2, and save the model. For this circuit, Using the same supply voltage given in part a., 20. The name of a script file must follow the MATLAB convention for naming variables. You can confirm this information by typing size(student), which returns ans = 1 2. Choose enough points to obtain a smooth curve. The elbow-up solutions are marked with an "o", and the elbow-down solutions are marked with an "x". After you enter a value and press Enter, you will see the plot on the screen. Use MATLAB to find the coefficients of the quadratic polynomial y = ax 2 + bx + c that passes through the three points (x, y) = (1, 4), (4, 73), (5, 120). 26 If you have saved your file on a removable medium and you bring it to a public computer lab, if you cannot change the search path. 15 i,j The imaginary unit 15 Inf Infinity. 42 Programming Style Comments may be put anywhere in the script file. Its slope is m and its intercept is b. h desired = 40000; m e = 100; q = 1; u = 8000; g = 32.2; dt = 0.1; b = 50; % Compute values at burnout, peak time, and height. However, if you assume that the heights are normally distributed, you can use Equation (7.2-2) to estimate how many men are shorter than 68 in. If a variable with the same name as the global variable already exists in the current workspace, MATLAB issues a warning and changes the value of that variable cost: 2.5 cents per gallon of product. Instead it tests the truth of the vector relation x < 0. Figure 10.4-9 Simulink model of a relay-controlled motor. Only script files can be opened as live scripts. For example, to solve the matrix Equation (8.1-1) for x, we must somehow "divide" by A. 62 find Finds indices of nonzero elements. Various MATLAB toolboxes are useful for such projects. You can also start the environment by first creating a plot and then clicking on the Show Plot Tools icon at the far right of the Figure toolbar 236 Figure 5.3-2 The Figure and Plot Edit toolbars displayed. To recover it in a later session, type load anon.mat h. If no corresponding delimiter exists, MATLAB underlines the unmatched delimiter in red. Suppose also that the applied voltage is v(t) = 10[2 - e -t sin(5πt)] V. >>yzero = fun demo1([3, 6]) yzero = 4.7124 So the zero of $\cos x$ over $3 \le x \le 6$ occurs at x = 4.7124. STANDARD DEVIATION VARIANCE The functions mean(x), var(x), and std(x) compute the mean, variance, and standard deviation of the elements in the vector x. The winch applies a force f = 380 lb to the cable. The syntax for creating an anonymous function from an expression is fhandle = @(arglist) expr where arglist is a comma-separated list of input arguments to be passed to the function and expr is any single, valid MATLAB expression. In Section 8.5 we develop a general-purpose program that checks the ranks and solves a general-purpose program that checks the ranks and solves a general set of linear equations. 19, 118 acot(x) Inverse cotangent; arccot $x = \cot -1 x$. The correlation coefficient is r = 2 = 1. 0.9988. Using the command axis manual freezes the scaling at the current limits, so that if hold is turned on, subsequent plots will use the same limits. 263 plot(deflection,force,'o'),... The temperature measurements are shown in the figure. 58 ndims(A) Returns the number of dimensions of A. Unlike a script file, all the variables in a function file are local variables, which means their values are available only within the function. Plot the electric potential field on a three-dimensional surface plot with V plotted on the z axis over the ranges $-0.25 \le y \le 0.25$ and $-0.25 \le y \le 0.25$. We know from physics and mathematics (see Chapter 8) that the displacement x as a function of time is given by 275 The displacement is measured every 0.2 s. Use MATLAB to compute the object's velocity v at t = 5 s. This principle gives the equations for the tension forces T AB and T AC if we know the angles θ and φ. Command History 30 The Pop-up Command second velocity v at t = 5 s. This principle gives the equations for the tension forces T AB and T AC if we know the angles θ and φ. Command History 30 The Pop-up Command second velocity v at t = 5 s. This principle gives the equations for the tension forces T AB and T AC if we know the angles θ and φ. Command History 30 The Pop-up Command History displays commands recently used in the Command Window. For example, choosing a spacing of 0.01, and using 217 plot, we obtain the plot in Figure 5.1-3b. The term "double" stands for floating point, double precision. MATLAB has the four quadrant inverse tangent function, atan2(y,x), that automatically computes the radian angle in the correct quadrant of a line from the origin (0,0) to a point whose coordinates are (x, y). The volume flow rates in the pipes are q 1, q 2, and q 3. To design and apply these devices, engineers must first model the appropriate mechanical, fluid, and electrical properties. Consider the coefficients of determination and the residuals for each fit in making your decision. In Figure 10.7-7, the basic element for the subsystem block is an RC circuit. Calling One Function within Another One anonymous function composition. If you walk along a contour line, you remain at the same elevation. [q,r] = Computes the result of dividing a numerator polynomial, whose coefficient array is num, deconv(num,den) by a denominator polynomial represented by the coefficient array den. You would type >> fimplicit(@(x,y) x.^2/4 + y.^2/16 - 1,[-2 2 - 4 4]) Test Your Understanding T5.2-6 Plot the following functions using axes that will produce a straight-line plot. 16 (-1/2) d. Using our sample file, we can obtain a report in HTML format by typing >> publish ('polyplot', 'html') >>open html/polyplot.html You should see a report like the one shown in Figure 5.2-9. It is compatible across all these platforms, which enables users to share their programs, insights, and ideas. The law is More accurate estimates can be made with the van der Waals equation
where the term nb is a correction for the volume of the molecules and the term an 2 /V 2 is a correction for molecular attractions. Continue the above MATLAB session as follows: >>v = w-r v = -75 23 -10 >> dist2 = 79.0822 Thus to reach diver 2 by swimming along the coordinate directions, diver 1 must swim 75 ft east, 23 ft north, and 10 ft up. It also shows the number of hours required of each process to produce three different products. For example, the polynomial $4x \ 3 - 8x \ 2 + 7x - 5$ would be represented by the array [4, -8, 7, -5]. 515, 523 symsum Returns the symbolic summation of an expression. The resulting values of L and D will be in pounds. Note that the value of Off need not be zero. These instructions are executed in order. 3.4 File Functions There are two kinds of computer files normally of interest to us: binary files and text files, which are commonly called ASCII files. Estimated population in 1965 is 189 million.) Using Residuals We now show how to use the residuals as a guide to choosing an appropriate function to describe the data. In the example shown, the plot will appear after the third line of code is executed. Using a final time of 5 and the initial conditions x 1 (0) = 0 and x 2 (0) = 0, we call the solver and plot the solver and plot. For example, consider the polynomial . Saving Figures When you create a plot, the alloy numbers (2024, 6061, and so on) [Kutz, 1999]. This gives the following three equations: Determine T 1, T 2, and T 3 in terms of an unspecified value of the weight mg. The function inputs should be the desired area A, guesses W1 and W2, and spacing d. Thus the element C(2, 1, 1) is 9, and the element C(2, 2, 2) is 3. If a heavy uniform cable hangs suspended from its two endpoints, it takes the shape of a catenary curve whose equation is where a is the height of the lowest point, and y is the vertical coordinate measured up from the reference line. Variables Enables you to create variables by importing data or by using the Variables Editor. 260 surfc Same as surf with contour plot underneath. 114 imag(x) Imaginary part of a complex number x. 23. 2.* a. A = [0, 0, -1, -2; 2, -1, -2, -1; . Compute the resulting turn radius R C, the turn angle θ , and the coordinates of the new location of the vehicle reference point. This syntax creates the function handle function. Initialize the total to zero. This means that the piston does not generate a force until the input voltage exceeds a certain magnitude, and thus the system model is piecewise linear. Use MATLAB to plot the polynomials y = 3x 4 - 6x 3 + 8x 2 + 4x + 90 and z = 3x 3 + 5x 2 - 8x + 70 over the interval $-3 \le x \le 3$. (b) Modify the model in Figure 10.4-4 as follows to obtain the model shown in Figure 10.4-5. [Eide, 2008] Eide, A. Here is a simple example that illustrates how to create, save, and run a script file, using the Editor built into MATLAB. Use the results from part a to predict the pressure at t = 11 sec. In both cases the input is the displacement y(t) of the base and the spring constant is nonlinear, so the differential equations are nonlinear, so the differential equations are nonlinear, so the differential equations are nonlinear. 85, 285 roots Computes the roots of a polynomial from its coefficients. x = [4, -9, 25]; if $x \ge 0$ y = sqrt(x) else disp('Some of the elements of x are negative.') end When executed, it produces the following result: Some of the elements of x are negative. A condensed flowchart is shown in Figure 8.5-1. The complex number identity e ix = cos x + i sin x is often used to convert the solutions of equations into a form that is relatively easy to visualize. 63 ./ Array right-division operator. If you are unsure of what directory to search, type help to obtain an extensive list of all the directories, with a description of the function category each represents. 8.2 The Left-Division Method MATLAB provides the left-division method for solving the equation set Ax = b. The diameter d 2 of the shaft is normally distributed with a mean of 2.96 cm and a variance of 0.0036. A 2013 study estimated that the needed improvements for all types of infrastructure would cost about \$3.3 trillion, about \$1.4 trillion more than the current funding level. 167 isreal True if all elements are real. Use the axis command to change the tick-label spacing. For example, x is the loop variable in the statement while x < 25. 28 Figure 1.4-1 The MATLAB Command window with the statement while x < 25. 28 Figure 1.4-1 The MATLAB Command window with the statement while x < 25. 28 Figure 1.4-1 The MATLAB Command window with the statement while x < 25. 28 Figure 1.4-1 The MATLAB Command window with the statement while x < 25. 28 Figure 1.4-1 The MATLAB Command window with the statement while x < 25. 28 Figure 1.4-1 The MATLAB Command window with the statement when the statement w Editor open. find(A) Computes an array containing the indices of the nonzero elements of the array A. They result Figure 9.5-4 An armature-controlled dc motor. Because of this syntax, you cannot use uppercase D as a symbolic variable when using the dsolve function. s = 0.05; % standard deviation of x and y n = 8000; % number of random simulations $x = 10 + s^{randn(1,n)}$; $y = 3.64 + s^{randn(1,n)}$; theta = (180/pi) * atan(y./x); mean theta = std(theta) xp = 19:0.1:21; histogram(theta,xp,'Normalization', 'probability'),... ylabel('Theta (degrees)'),... ylabel('Relative Frequency') The choice of 8000 simulations was a compromise between accuracy and the amoun of time required to do the calculations. If you type fruit and press Tab, MATLAB correctly displays FruitPurchased. The following functions of machines and structures. duration(b) = 0; end end % Plot the results. You can construct an anonymous function either at the MATLAB command line or from within another function or script. For example, the problem has the solution $y(t) = (1 - \cos bt)/b$. Syntax: Quick Reference B. (Note that 1 k $\Omega = 1000 \Omega$.) Suppose that each resistance is rated to produce the data to plot. Why can't you use the min and max functions to check your results? When x has complex values, they must be split into real and imaginary parts. Such a plot would help the engineers designing the engine to select appropriate values for lengths L 1 and L 2. The variable th represents the angle θ of the ball's velocity vector relative to the horizontal. Fit a straight line to the data. Table 2.8-1 is a reference guide to all the MATLAB commands introduced in this chapter. Plot the temperatures T and T a versus t on the same graph, for $0 \le t \le 24$ hr. Wave power uses the change in water surface level due to waves to drive water through a turbine or other device. The function ode45 is called as follows, and the solution plotted along with the analytical solution y_true. Use the values T = 48,000 N, m 0 = 2200 kg, r = 0.8, g = 9.81 m/s 2, and b = 40 s. For example, typing isstruct(student) returns the result ans = 1, which is equivalent to "true." Test Your Understanding T2.7-1 Create the structure array student shown in Figure 2.7-1 and additional addited additional additional additional additional add the following information about a 100 third student: name: Alfred E. This distance is computed in the following session. For example, one block type is a multiplier, another performs a sum, and still another is an integrator. For example, continue the previous session as follows: >>m = length(w) m = 101 21 Arrays and Polynomial Roots Many applications require us to solve for the roots of a polynomial. i,j The imaginary unit Inf Infinity. Typing rand again generates a different number. As Simulink evolves through new versions, some libraries are renamed and some blocks are moved to different libraries, so the library we specify here might change in later releases. EXAMPLE 8.2-3 Ar Electric Resistance Network The circuit shown in Figure 8.2-2 has five resistances and two applied voltages. Geothermal power is obtained from ground heat or steam vents. (Do not use colors if you are going to print the plot on a black-and-white printer.) Labeling Curves and Data When more than one curve or data set is plotted on a graph, we must distinguish between them. The isfield function determines whether a structure array contains a particular field. The typical structure of a while loop follows. 445 where f(t) = 50u s (t). Use commas or spaces with braces to indicate columns of cells and use semicolons to indicate rows of cells (just as with numeric arrays). You can use the model shown in Figure 10.2-2 by rearranging the blocks as shown in Figure 10.2-6. 234 stem Creates stem plot. To investigate the effect of panel width, let us first use 10 panels with equal widths of $\pi/10$. 234 polarplot Creates polar plot. It is important to understand the concept of "step size" and its effects on solution accuracy. For the first case (a broadband filter), $R = 1000 \Omega$. Fifth Logical OR. The variance is the square of the standard deviation σ . (Answer: x = 2, y = 5.) T2.4-5 Use MATLAB to solve the following set of equations. The part weight is normally distributed with a mean of 1 lb and a standard deviation of 0.2 lb. For example, we can create program modules using function files that do specific, readily identifiable tasks. The syntax is identical for the solver ode15s. Figure 5.4-2 A plot of the surface z = xe -[(x - y 240 2)2 - y2] created with the mesh function. Plot the concentration after 1 hr, C (1), versus k for the case where a = 1 and k is in the range 0.047 $\leq k \leq 0.107$ per hour. 4.6 while loop. The greater the spacing, the more difficult it is to estimate the derivative. 114 round Rounds toward the nearest integer. 161 & Logical operator: AND. 47 7. How many hours does it take to produce one widget on average? Suppose that a particle starts at x = 0 and at each stage of the process it either stays still, moves
back one space, or moves forward either one or two spaces, all with equal probability. Figure 10.2-3 shows the Model window after completing the following steps. [Garber, 1999] Garber, N. Given the vectors do the following steps. [Garber, 1999] Garber, N. Given the vector x. It has two Table 4.5-1 Pseudocode for Example 4.5-4 Enter data. Students should work these exercises as they are encountered. The flowchart representation of the verbal description of the if statement (covered in Section 4.3) is shown in Figure 4.1-2. Equipped with six 50 cm (20 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in a rocker-bogie suspension that gives a ground clearance of 60 cm (24 in) diameter wheels in) diameter wheels i in), Curiosity can navigate obstacles nearly 65 cm (26 in) high. Steady-state value: The limit of the response as $t \rightarrow \infty$. To flip the box left to right, right-click on it, select Format, and select Flip. The logspace command creates an array of logarithmically spaced elements. That is, define x 1 = y and that . Use the subsystem block developed in Section 10.7 to create a Simulink model of this system. If necessary, you can create your own functions, using the methods of Section 3.2. This section also covered functions, using the methods of all the functions in that directory, with a brief description of each, type help polyfun. % Absolute frequency data. 12 doc Displays documentation. subplot(2,1,2) plot(x,1./y,cups,meas_times,'o'), grid, xlabel('Volume(cups)'),... 1. The first step is to calculate the derivative df/dθ, and solve the equation df/dθ = 0 for θ. For more information, see Chapter 4. Connec the input and output ports and edit the labels as shown. (The abbreviation vpa stands for "variable precision arithmetic.") 504 Plotting Expressions E, which is a function of one variable. The Simulink blocks are located in "libraries." These libraries are displayed under the Simulink heading in Figure 10.2-1. This answer is the solution to the equation set in a least-squares sense. Examples include software to study the performance of a unified power flow controller to relieve congestion in a power transmission system. Use MATLAB to find all the values of x where the graph of y = 3x - 2x has a horizontal tangent line. 576 The line color is indicated by the RGB triplet (red, green, blue). The function returns an empty matrix if you press the Enter key without typing anything. The output d is a vector containing the coefficients of the derivative polynomial. 323 Rolling a pair of "fair" dice generates numbers that are truly random, but "random number. The following formulas are commonly used by engineers to predict the lift and drag of an airfoil: where L and D are the lift and drag forces, V is the airspeed, S is the wing span, ρ is the air density, and C L and C D are the lift and drag coefficients. Apply interpolation techniques. (a) sin 2 x + cos 2 x = 1 (b) sin(x + y) = sin x cos x (d) cosh 2 x - sinh 2 x = 1 2. This technique prevents a false impression of the magnitudes of any variations shown on the plot. As an "inline" function object: >>fun1 = 'x.^2-4'; >>fun inline,[0, 3]) 4. 488 You can use the heaviside function to find the step response, but the resulting expressions are more complicated than those obtained with the Laplace transform method. For example, the following integral is used for some probability calculations (see Chapter 7, Section 7.2). 10.9 Simulation of a Nonlinear Vehicle Suspension Model Linear or linearized models, especially when the inputs are relatively simple functions such as the impulse, step, ramp, and sine. The result is a column vector that contains the polynomial's roots. At present most renewable energy systems are not very efficient, and so the engineering challenge of the future is to improve their efficiency. Laplace transform methods for solving differential equations are also introduced. Use a for loop to plot the function given in Problem 16 over the interval $-2 \le x \le 6$. Accessing Arrays Using Logical Arrays When a logical array the elements in the locations where the logical array has 1s. The result is . The following three function types can often describe physical phenomena. Once the file is created, you can use the load command to load the data into a variable whose name you choose. Note the difference in the output formats in the following example. To ensure repeatability, you can specify the seed and the generator type together, using the function rng(n, 'twister') where n is an integer seed number. If you want to access all object properties, use the Property Inspector. poly(r) Computes the coefficients of the polynomial must pass through the data points at x i and x i+1. Consider the slightly different system shown in Figure 10.7-2, which has a flow source q and two pumps that supply liquid at the pressures p l and p r. This section gives a brief introduction to these functions. The menu appears as shown in Figure 7.1-4. Construct a Simulink model to plot the solution of the following equations for $0 \le t \le 3$ 443 where f 1 (t) is a step function of height 3 starting at t = 0 and f 2 (t) is a step function of height -3 starting at t = 1. TEXT ORGANIZATION In addition to updating material from the previous edition to include new features, new functions, and changes in syntax and function names, the text incorporates the many suggestions made by reviewers and other users. % Thread strength data for 100 tests. Draw a sketch and label any necessary variables. >> syms y(t) b >> cond = y(0) ==0; >> eqn = diff(y,t) == sin(b*t)/b The problem has the solution $y(t) = (e \ ct + e \ -ct)/2$. There is a motor at each joint. Consider the integral The basic syntax is A = integral2(fun, a, b, c, d) where fun is the handle to a user-defined function $y(t) = (e \ ct + e \ -ct)/2$. There is a motor at each joint. that defines the integrand f(x, y). Place it at the end of all the plot and plot formatting statements, so that the plot will be in its final form. However, if z is a nonlinear function of x and y, then the mean and variance of z cannot be found with a simple formula. The mathematics just told us something! It told us (1.6-1) that the mass does not affect the relation between the impact speed and the height dropped. Use MATLAB to evaluate the following triple integral: Section 9.2 19. Max-Min Problems The derivative can be used to find the maximum or minimum of a continuous function, say f(x), over an interval a $\leq x \leq b$. The free response is obtained from 537 Suppose the initial conditions are x(0) = 2 and x(0) = -3. To open the Variable Editor from the Workspace Browser, double-click on the variable you want to open. You should see the result displayed in the Command window. Determine which search path MATLAB uses on your computer. 164 && Short-circuit AND. The function pdepe can solve partial differential equations. of the mean? This scaled frequency histogram is the absolute frequency histogram. For continuous compounding, A = Pert. Fit a cubic polynomial to the data and use the fit to estimate the flow in the year 2010. 3.* Two polynomials in the variable x are represented by the coefficient vectors p1 = [6, 2, 7, -3] and p2 = [6, 2, 7, -3] and p2 = [6, 2, 7, -3]. [10, -5, 8]. plot(A,x) plots the vector x versus the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array
A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the sizes of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the size of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the size of the m × n array A. The same.) T2.3-2 Given the matrix A. size(A) Returns a row vector [m n] containing the size of the m × n array A. The same [m n] containing the size of the m × n array A. The same [m n] containing the size of the m × n array A. The same [m n] containing the size of the m × n array A. The same [m n] containing the size of the m × n array A. The same [m n] containing the size of the m × n array A. reasonable input values. 276, 285 polyval Evaluates polynomial. The applied voltage in volts is given by This is shown in the top graph in Figure 9.5-5. Chapter 2 covers arrays, which are the basic building blocks in MATLAB. Cell arrays and structure arrays are covered in Sections 2.6 and 2.7. Function handles are treated in Chapter 3. For example, the relationship between the coordinate system rotated counterclockwise through an angle a relative to the (x 1, y 1) coodinate system is 493 These equations can be expressed in matrix R(a) is defined as (11.6-1) The symbolic matrix R can be defined in MATLAB as follows: >> syms a >>R = [cos(a), sin(a); -sin(a), cos(a)] R = [cos(a), sin(a)] [-sin(a), cos(a)] If we rotate the coordinate system twice by the same as a single rotation with twice the angle. Use the Simulink model to obtain plots of h 1 (t) and h 2 (t) for the following parameter values: A 1 = 3 ft 2, A 2 = 5 ft 2, R 1 = 30 ft -1 -sec -1, R 2 = 40 ft -1 -sec -1, R 2 = 40 ft -1 -sec -1, P = 1.94 slug/ft 3, q mi = 0.5 slug/sec, h 1 (0) = 2 ft, and h 2 (0) = 5 ft. Plot and label the path of the vessel and the boundary. Table 11.5-1 Laplace (function) Returns the inverse (function) Returns (funct the Laplace transform of function. The upper Constant block and Integrator block are used to generate the solution when the engine angle is $\theta = 0$, as a check on our results. >> syms y(t) >> dsolve(diff(y,t)+2*y==12) ans = C1*exp(-2*t)+6 There can be symbolic constants in the equation. For example, >> syms y(t) >> dsolve(diff(y,t)+2*y==12) ans = C1*exp(-2*t)+6 There can be symbolic constants in the equation. For example, >> syms y(t) >> dsolve(diff(y,t)+2*y==12) ans = C1*exp(-2*t)+6 There can be symbolic constants in the equation. -(1-k)^(1/2)-1 (1-k)^(1/2)-1 You can use the inv(A) and det(A) functions to invert and find the determinant of a matrix symbolically. (b) Evaluate your solution for the case a = 17. You access cell arrays using the same indexing operations used with ordinary arrays. Find a quadratic polynomial that fits the data. For example, to obtain the roots of x 3 + 12x 2 + 45x + 50 = 0, you type y = roots([1, 12, 45, 50]). That is, if x has n elements, d will have n-1 elements, where d = [x(2)-x(1), x(3) - x(2), . Double-clicking on a file name with the extension .m will open that file in the MATLAB Editor. 81 ones Creates an array of 1s. You can check to see if a command, function, or file name already exists by using the exist command as discussed in Section 1.1. 29 Note that not all functions supplied with MATLAB are built-in functions. Enter the side lengths a, b, and c. The inputs for the block would be the voltage from a controller and a load torque, and the output would be the motor speed. 453 Figure 10.4-6 Speed response of the sled for $\theta = 0$ and $\theta \neq 0$ 0. function xdot = example_1(t,x) % Computes derivatives of two equations x(0) = 3, the initial condition for the vector x is [3, 9]. Larger programs are usually composed of a main program that calls on the modules to do their specialized tasks as needed. All engineering disciplines were involved with the rover projects. Before you run the model, in the Command window assign numerical values to the variables. (See Section 9.5 for a discussion of these forms.) If the mass-spring system is subjected to a sinusoidal forcing function f(t), it is easy to use the MATLAB commands.) presented thus far to solve and plot the response y(t). You should obtain values close to 5 and 3, respectively. We are told that typical values of the parameters m, c, k, and u by making msd a nested function as was done with the functions pendulum and pendula in Section 9.4. Test Your Understanding T9.5-1 Plot the position and velocity of a mass with a spring and damping, having the parameter values m = 2, c = 3, and k = 7. This test implies that if A is square and of dimension $n \times n$, then rank([A b]) = rank(A), and a unique solution exists for any b if rank(A) = n. If A = [1, 2; 3, 4] then 2.^A gives the array [2, 4; 8, 16]. If x_int is a vector containing the value or values of the independent variable at which we wish to estimate the dependent variable, then typing interp1(x,y,x_int) produces a vector the same size as x_int containing the interpolated values of y that correspond to x_int. Use Equations (1.6-2) and (1.6-3) to compute d; use enough values of A in the range $0 \le A \le 180^\circ$ to generate an adequate (smooth) plot. The syntax yyaxis(x1,y1,x2,y2) plots y1 versus x1 with y axis labeling on the right. 139 138 function y = a - mean(a); function w = mean(x) = a - mean(x), we sufficiently a syntax yyaxis(x1,y1,x2,y2) plots y1 versus x1 with y axis labeling on the right. sample session follows. 535, 541 laplace Returns the Laplace transform. When you have finished this chapter, you should be able to use MATLAB 523 Sums The symsum(E) function returns the symbolic summation of the expression E; that is The symsum(E,a,b) function returns the sum of the expression E as the default symbolic variable varies from a to b. The accuracy of individual arithmetic operations can be carried out to an arbitrary number of digits. Create a Simulink subsystem block for this element. 463 (b) Evaluate the solution for the case where . 96 b. The second column in y will be the output of the integrator block. We try different values of the final time until we see the entire response. We use the functions tic and toc to time the process. T5.2-5 Use the hold command and the plot command twice to plot $y = \sin x$ and y = x - x 3/3 on the same plot for $0 \le x \le 1$. Put Scope blocks on v and the output of the PID block, and experiment with different values of P and I. Figure 7.1-4 The Data Statistics tool. The elements in MATLAB can perform many spreadsheet, and MATLAB can perform many spreadsheet type calculations for analyzing such tables. Use the Saturation block to create a Simulink model to plot the solution of the following equation for $0 \le t \le 6$. So we subtract the room temperature from the data and plot the relative temperature, T - 68, 259 versus time. 172 elseif Conditionally executes statements. Use MATLAB to solve the following problem: 22. Controlling Input and Output MATLAB provides several useful commands for obtaining input from the user and for formatting the output (the results obtained by executing the MATLAB commands). The model file can then be reloaded at a later time. Now that you have finished this chapter, you should be able to do the following. We find that L > 100 if x > 0.6, so we choose x = 0:0.001:0.6. We use the ginput function to find the value of x corresponding to L = 70. xi The chapter then shows how to use MATLAB to solve systems of linear equations that have a unique solution. They are the first and fourth values, 6 and 11. Then set the axis limits to cover the entire data range plus an additional amount to allow convenient tick-mark spacing to be selected. Use a legend, and label the plot axes appropriately. Display the results and stop. Test your function for the following two cases, using the values k 1 = 10 4 N/m; k 2 = 1.5 × 10 4 N/m; and d = 0.1 m. Uniformly Distributed Numbers, all values within a given interval are equally likely to occur. Plot the histogram of y where y is the square root of x. Subfunctions A function M-file may contain more than one user-defined function. Finally, many differential equations cannot be solved analytically, and so we must be able to solve them by using appropriate numerical techniques. 19, 118 atan(x) Inverse tangent; arctan $x = \tan -1 x$. Table 5.4–1 Three-dimensional plotting functions using array inputs Function Description contour(x,y,z) Creates a contour plot. 497, 504 syms Creates one or more symbolic variables. For example, the following equations generate a three-dimensional curve as the parameter t is varied over some range: 238 If we let t vary from t = 0 to t = 10 π, the sine and cosine functions will vary through five cycles, while the absolute values of x and y become smaller as t increases. The angle computed by these functions is the angle between the point (x, y). An example session follows. Creating Matrices The most direct way to create a matrix is to type the matrix row by row, separating the elements in a given row with spaces or commas and separating the rows with semicolons. Product 1 2 3 4 Hours available Lathe 1 2 0.5 3 40 Grinder 0 2 4 1 30 Milling 3 1 5 2 45 Hours required 204 Unit profit (\$) 100 150 90 120 31. We will use the following notation to describe a polynomial: We can describe a polynomial in MATLAB with a row vector whose elements are the polynomial's coefficients, starting with the coefficient of the highest power of x. Figure 10.9-6 Simulink model of a vehicle suspension system. Plot the water height as a function of time until h(t) = 0. The Euler Method The Euler Method is the simplest algorithm for numerical solution of a differential equation.
Figure 10.9-6 Simulink model of a vehicle suspension system. 10.9-4 Road surface profile. Use the fit to estimate the vapor pressure at 285 and 300 K. These are: directed energy deposition, material extrusion, material extrusio typing p = polyfit (log10(x), log10(y),1). The test if x < 0 returns a false value because it generates the vector [0,1,0]. The mast is supported initially horizontal. 67 Solution Note that if t is a vector, the MATLAB functions exp(-8*t) and sin(9.7*t+pi/2) will also be vectors the same size as t. Embedded controllers in new active suspensions use actuators to improve on the performance of traditional passive systems consisting only of springs and dampers. Chapters 5 through 11 are independent chapters that can be covered in any order. A. Graphs in MATLAB can be modified using handle graphics. The heights were recorded to the nearest 1/2 in., so the height variable is discrete-valued. Fully label the plot and mark the breakeven points. The vector y0 contains the initial values. % Program sounds.m load handel S = load('chirp.mat') y1 = S.y Fs1 = S.Fs sound([y',y1'],Fs) % Note that Fs = Fs1 here. We can obtain greater accuracy by using a smaller value of the time increment dt. Sequential Operations Compute the perimeter p and the area A of a triangle whose sides are a, b, and c. 417 ssdata Extracts state-space matrices from an LTI object. We use the Saturation block in the Discontinuities library to limit the range of θ to π/3 rad. Using this property, we multiply both sides of Equation (8.1-1) from the left by A -1 to obtain A -1 Ax = A -1 b. Hatsopoulos MATLAB for Neuroscientists serves as the only complete study manual and teaching resource for MATLAB, the ... book Formal Verification: An Essential Toolkit for Modern VLSI Design presents practical approaches for design and validation, ... book Creating and New Products and Services by Rosanna Garcia It's no secret that some of the most successful companies. such as 3M. Procter & Gamble, ... In this Instructable you will NOT be learning how to make a game from scratch, however this will lead you to the eventual process of that. To access all of page 1, type A(;,;,1). Sin OPERATIONS RESEARCH 201 engineers to study the past, present, and future actions of the organization for this purpose. LCC TA345 .P356 2018 | DDC 620.00285/53-dc23 LC record available at The Internet addresses listed in the text were accurate at the time of publication. 28. We can assign a handle to a graph as shown in the following program and resulting output. Figure P33 48 34. You can use the other solvers in the same way, although the menu choices may be different. You are encouraged, however, to use them when solving problems. 449 38. FLOWCHARTS Flowcharts are useful for developing and documenting programs that contain conditional statements, because they can display the various paths (called branches) that a program can take, depending on how the conditional statements are executed. Minimizing a Function of Several Variables, use the finine variable, use the finine variable variable. Depending on your specific curve-fitting application, you can use the Basic Fitting interface, the command line functions, or both. Obtain the expression for the distance D between the aircraft as a function of time. Use the subsystem block developed in Section 10.7 to construct a Simulink model of the system shown in Figure P30. Determine the value entering the information for your specific function, then save it as you would any other M-file. k = 0; for coord = [3,6,2;7,6,8] k = k + 1; distance, farthest] = max(distance, farthest] = max(di which uses the diag function to extract the diagonal elements of an array. Use these facts to develop a criterion for choosing the spacing of t should be a small fraction of the period in order to generate enough points to plot the curve. Control system engineers call this a disturbance. % File dcmotor.m R = 0.6; L = 0.002; c = 0; K T = 0.04; I = 6e-5; 425 390 Figure 9.5-5 Voltage input and resulting velocity response of a dc motor. Create a Simulink model to solve the projectile's equations of motion where x and y are the horizontal and vertical displacements of the projectile. This estimate is then used to compute f k +1 for use in Equation (9.3-5) to obtain the required value of y(t k +1). The following equation describes a certain dilution process, where y(t) is the concentration of salt in a tank of freshwater to which salt brine is being added. You can use the function nargin, which stands for "number of input arguments." Within the function you can use conditional statements to direct the flow of the computation depending on how many input arguments there are. 397 Suppose that y(0) = 0. Compare the performance of the forward, backward, and central difference methods for estimating the derivative of $y(x) = e - x \sin(3x)$. To insert them into the model, open the Tank subsystem model, select Copy from the Edit menu, then paste it twice into the new model window. For example, this section might contain functions for displaying the output on the screen. Plot the lift and drag of this airfoil versus V for $0 \le V \le 150$ mi/hr (you must convert V to ft/sec; there is 5280 ft/mi). For chlorine (Cl 2), a = 6.49 and b = 0.0562. Assume that we are given the following values: m e = 100 slugs, g = 1 slugs/sec, u = 8000 ft/sec, and g = 32.2 ft/sec 2. Some more advanced MATLAB applications, such as those found in some of the toolboxes, do use cell arrays. Introduction to Engineering Problem Solving. Use 3.0180). If the global statement, it will be initialized to the empty matrix. Use the following data to obtain a curve fit for S as a function of T. By the time you have finished this chapter, you will have seen the block types needed to simulate a large variety of common applications. If the number of data values is relatively small, the bin width cannot be small because some of the data. Also compute the minimum cost. tan -1 2 56 b. A (degrees) d (ft) 0 1.5 60 1.15 90 0.87 120 0.65 180 0.5 5. For this particular circuit, M is given by 501 Figure P23 The frequency of the desired carrier signal. Suppose we have the following temperature measurements, taken once an hour starting at 7:00 A.M. The measurements at 8 and 10 A.M. are missing for some reason, perhaps because of equipment malfunction. So when modeling such devices in Simulink, we assume that the controlled position. If not, use MATLAB to find the relations between x, y, and z. These filters are used in tuning circuits, such as those used in AM radios, to allow reception only of the carrier signal of the desired radio station. To insert a label on the y axis, for example, click on the Y Label item on the weator b. Any assignment to those variables, in any function or in the base workspace, is available to all the other functions declaring them global. 17.* Given the matrices Use MATLAB to a. How much did each worker earn in the week? If the particular bin frequency is 0, y raw is left unchanged. Each box holds 300 parts of different types. This is so because with v = 100, the system achieves a steady-state condition in which the motor torque equals the sum of the disturbance torque and the viscous damping torque. First we define the row vectors d and t from the distance and time data. The third form is [num, den] = polyder(p2,p1). This means that these variables persist in memory between calls made by means of the function handle. We will also use arrays for generating plots. Suppose that 5 percent of the sophomores and juniors leave school and that 5 percent of the sophomores, juniors, and seniors repeat the grade. 195 while Repeats statements an indefinite number of times. See Table 5.2-1. Much of the infrastructure is 40 to 80 years old and is literally crumbling or not up to date. The polynomial's coefficient array is a. If we start the arm from rest with zero velocity and acceleration, the following polynomials are used to generate commands to be sent to the joint motor controllers 380 where $\theta = 0.1$ (0) and $\theta = 0.08206$. Suppose you have analyzed the price behavior of a certain stock by plotting the scaled frequency start the arm from rest with zero velocity and acceleration, the following polynomials are used to generate commands to be sent to the joint motor controllers 380 where $\theta = 0.08206$. Suppose you have analyzed the price behavior of a certain stock by plotting the scaled frequency start the arm from rest with zero velocity and acceleration, the following polynomials are used to generate commands to be sent to the joint motor controllers 380 where $\theta = 0.08206$. histogram of the price over a number of months. Throughout each chapter margin notes identify where new terms are introduced. The following script file produced the plot in Figure 5.2-3. Compute the duration above desired height. (that is, above the 6th value up to the 11th value), type >>prob = cumsum(y scaled) *binwidth; >>prob67 69 = prob(11)-prob(6) The result is prob67_69 = 0.4000, which agrees with our previous calculation of 40 percent. The function polyval(p,x) evaluates the polynomial p at specified values of its 230 Figure 5.1-3 (a) The plot was generated with fplot. This feature also protects you from using another function unintentionally. Motor 28C Test ID 6 b. It provides an interactive user interface that allows you to switch between different types of response plots and between the analysis of different systems. w = x/y f. This is the minimumnorm solution for real values of the variables. The following script file generates the histogram shown in Figure 7.1-1. 55 = Assignment (replacement) operator. 427 Figure 9.5-6 Square wave response of the model + 2 + 4x = 4f. A particular circle is centered at the origin and has a radius of 5. For example, >> syms pi >> b = 4*pi % This gives a symbolic result. histogram(y, 'FaceColor', 'w') Aggregates the data in the vector y into
bins of uniform width between the minimum and maximum values in y, using unshaded (white) rectangles. Find the array product z = y.*x. Solving overdetermined sets is the subject of Section 8.4. The following program illustrates this method as applied to the cantilever beam data given in Example 6.1–4. 3. For linear differential equations, the complete or total response is the subject of Section 8.4. The following program illustrates this method as applied to the cantilever beam data given in Example 6.1–4. 3. For linear differential equations, the complete or total response is the subject of Section 8.4. the linearity property, we multiply these results by mg and obtain the general solution T 1 = 0.5071 mg, T 2 = 0.2915 mg, and T 3 = 0.4166 mg. Use the values m = 100, c = 600, k 1 = 8000, and k 2 = 24,000. These differences are called the residuals. function y = p(x) global a b c y = polyval([a, b, c], x); end Then, in the Command window, type >>global a b c >>a = 4; b = -50; c = 5; >> fminbnd(@p, -10, 10) Nested functions might seem to be the same as subfunctions, but they are not. Right-clicking on the plot brings up the menu containing the Characteristic available is the peak response. You should also check one angle in the guadrant 0° < A < 90° and one in the quadrant 90° < A < 180°. 13 results of the line on the screen. Write a user-defined function that computes f, the amount of ethanol produced, with R and Y as the function's arguments. Suppose we have a sensor that measures the motor speed, and we use the sensor's signal to activate a relay to switch the applied voltage v(t) between 0 and 100 V to keep the speed between 250 and 350 rad/s. 152 2. Compare the results. If you will use the program as a general tool in the future, test it by running it for a range of reasonable data values; perform a reality check on the results. See Figure 10.2-3. (McGraw-Hill, 2014). To find A 2, type A^2. Handcheck the answers. A fence around a field is shaped as shown in Figure P33. Problems......Page 35726. Are there valleys other than the one corresponding to d = 7.5984 and $\theta = 1.0472$? 85 To add the polynomials, type h = f+g. If the parameter a is omitted the function returns the series evaluated at x = 0. (b) Find the mean and standard deviation. 572 pause Pauses the display The solution is y = A - 1 bc = xc. To place the contents of the cells in rows 1 to 3, columns 2 to 5 in the new cell array D, type D = C(1:3, 2:5). The curve is described in parametric form by the equations to plot the cycloid for r = 10 in. For example, the 2 × 2 identity matrix is NULL MATRIX IDENTITY MATRIX These matrices have the following properties: 88 MATLAB has specific commands to create several special matrices. For example, >>syms x y >> E = x^2+6*x+7 >> F = subs(E,x,y) F = 458 y^2+6*y+7 If old and new are cell arrays of the same size, each element of old is replaced by the corresponding element of new. The optional output variable mu is a two-element vector containing the mean and standard deviation of x. For example, by defining the matrix temp to be the preceding table, the session will look like this: >>temp(:,1) = [7, 9, 11, 12]'; >>temp(:,2) = [49, 57, 71, 75]'; >>temp(:,2) = [52, 60, 73, 79]'; >>temp(:,2) = [54, 61, 75, 81]'; >>temp(:, 53.0000 56.0000 57.5000 64.0000 65.5000 68.0000 Two-Dimensional Interpolation Now suppose that we have temperature measurements at four locations are at the corners of a rectangle 1 mi wide and 2 mi long. If the rocket's maximum fuel load is 100 slugs, the maximum value of b is 100/q = 100. Here we note that Figure 10.4-2 A rocket-propelled sled. The forcing function is the simulation diagram. Note that it is difficult to solve this equations with only two unknown variables, hand solution is easy and adequate. plot(x,A) plots the matrix A versus the vector x, where x is either a row vector or a column vector and A is a matrix with m rows and n columns. 148 15. Renewable energy (both solar-electric), geothermal and solar-electric), geothermal power, tidal and wave power, wind power, as well as crops that can be converted to alcohol. Virtual prototyping is changing the traditional development cycle. Then the equations can be written as In matrix form these becomes constant, instead of oscillating. This corresponds to the relay logic shown in Figure 10.4-7b, with SwOff = 250, SwOn = 350, Off = 100, and On = 0. Use the rref function to obtain the solutions. The measured force in pounds required to break them is given in the following list. This toolbar is customizable. 354 Figure P16 17. d2 = (y(3:n)-y(1:n-2)); subplot(2,1,2) plot(x(2:n-1),d2,x(2 program to use the forward difference method to estimate the derivative. You can do this by typing the first student's phone number as follows: student(1).phone = '555-1653' All the other structures in the array will now have a phone field, but these fields will contain the empty array until you give them values. Find the mean and variance of y by simulation. EXAMPLE 1.1-1 Volume of a Circular Cylinder The volume of a circular cylinder of height h and radius r is given by $V = \pi r 2$ h. The variable names used in the function definition may, but need not, be used when the function is called: a = 32.2; initial speed = 10; 128 time = 5; [feet dropped, speed] = drop(a, initial speed, time) 2. Test the program using various values for L 1 and L 2, and examine the resulting plots to see whether they are reasonable. 33 45 Figure 1.5-1 The Function Browser after plot has been selected. These devices are often called servo motors (which stands for "servomechanism"), and they usually employ P control with a gain that is not adjustable by the user. How far in a straight line must diver 1 swim to reach diver 2? So we use the Fcn block under the User-Defined Function, which pauses the program execution for n seconds. If the function is written as z = f(x, y) and we wish to estimate the value of z for x = x i and y = y i, the syntax is interp2(x,y,z,x i,y i). Note that the data used to make the plot are given in the arrays XData and YData. For example, suppose that $y = \ln x$ for x < 0. Try not to use the names of special constants as variable names. Read the values from the plot corresponding to the values of A given in the preceding table. The block implementing the dead-time transfer function e^{-Ts} is called the Transport Delay block, which is in the Continuous library. At the output of the first block there is a saturation that limits x to be $|x| \leq 1$. Click on the Tools menu, then select Data Statistics. Then typing B(2, :) = C replaces row 2 of B with C. 267 25. These are arranged by category (for example, one category is the Symbolic Math Toolbox). A structure consists of all this information for a single 97 student. subs(E,old,new) Substitutes new for old in the expression, new can be a symbolic variable, expression, or matrix, or a numeric value or matrix. Suppose v(t) is a unit-step function. The syntax for ode15s is identical. A flow source dumps liquid into the tank at the mass flow rate q mi (t). Compare this prediction with that obtained using (a) linear interpolation. Enter 13 for the Stop time in the window to the right of the Start Simulation icon (the black triangle). MATLAB thinks A should be a 2 × 2 matrix because A was previously defined to have only two rows and its values remain in memory. wav file from the file handel.mat, you type >>load handel.mat >> audiowrite('handel.wav',y,Fs); >>[y1, Fs1] = audioread('handel.wav'); >>sound(y1,Fs1) Many computers have WAVE files to play bells, beeps, chimes, etc., to signal you when certain actions occur. Command and Function: Quick Reference D. In the dialog box that appears, replace the default name provided (usually named Untitled) with the name Example 1, and click on Save. m. This is what hardware-in-the-loop testing is all about. The damper model is unsymmetric and represents a damper compartment when the vehicle strikes a bump). Suppose the profits for each product are \$200, \$300, and \$100 for products 1, 2, and 3, respectively. Here we anticipate that t will be an array, so we use the element-by-element operator (.^). % File
resist.m % Solves for the currents i 1, i 2, i 3 R = [5, 100, 200, 150, 250]*1000; v1 = 100; v2 = 50; A1 = [R(1) + R(4), C(1) + R(4),

-R(4), 0]; A2 = [-R(4), R(2) + R(4) + R(5), -R(5)]; A3 = [0, R(5), -(R(3) + R(5))]; A = [A1; A2; A3]; b=[v1; 0; v2]; current = A\b; disp('The currents are:') disp(current) The row vectors A1, A2, and A3 were defined to avoid typing the lengthy expression for A in one line. You can use the cumsum function to calculate areas under the scaled frequency area.') disp(current) The row vectors A1, A2, and A3 were defined to avoid typing the lengthy expression for A in one line. You can use the cumsum function to calculate areas under the scaled frequency area.') disp(current) The row vectors A1, A2, and A3 were defined to avoid typing the lengthy expression for A in one line. You can use the cumsum function to calculate areas under the scaled frequency area.') disp(current) The row vectors A1, A2, and A3 were defined to avoid typing the lengthy expression for A in one line. You can use the cumsum function to calculate areas under the scaled frequency area.') disp(current) The row vectors A1, A2, and A3 were defined to avoid typing the lengthy expression for A in one line. You can use the cumsum function to calculate areas under the scaled frequency area.'' histogram and therefore to calculate probabilities. z = (4 < 7) + 3 e. Peak time: The time at which the peak response occurs. The Editor will automatically provide the extension .m and save the file in the MATLAB current directory. on the same straight line. How long will it take for the object's temperature T to reach 168°F? The polyfit function provides this solution. The set function can be used with the handle to change the object of the change the object properties. The third wheel, at the front, is simply a free-swinging castor that is not driven. The histogram is shown in Figure 7.3-2. When a problem can be solved numerically, as in this case, the solve function will not perform a symbolic solution. The angles θ 1 (t f) and θ 2 (t f) are the joint angles corresponding to the desired destination of the arm at time t f. In step 4 you create the algorithms used to obtain the solution. However, with this approach, right-clicking on the plot will no longer give you information about the step response characteristics. symsum(E) Returns the symbolic summation of the expression E. These functions are summarized in Table 9.5-1. The only exception to this rule in MATLAB occurs when we add or subtract a scalar to or from an array. Two ways to open a new live script are: On the Home tab, in the New drop-down menu, select Live Script. You can subtract arrays in a similar way, but array multiplication and division requires more detailed treatment, which we will see in Chapter 2. In simulation mode, you should also put a Scope on the actuator variable m, or put a Saturation block after the actuator block. For example, peak response 422 Figure 9.5-3 Step response of the model given by Equations (9.5-6) through (9.5-8) and the model (9.5-10), for zero initial conditions. A && B returns true if both A and B evaluate to true, and false if they do not. randi(b, [m,n]) randi([a,b], [Workspace Browser, type workspace at the Command window prompt. see xy plots U uint8 (arrays), 51 uint16 (arrays), 51 uint32 (step function, 533 unity matrix, 81 unmanned aerial vehicle (UAV), 224 user-created functions, 134 user-defined functions, 120-134 V Variable editor, 60-61 variables, 6, 18 anonymous functions, 120-134 V Variable editor, 7-8 variance, 319 vector, 52, 334 absolute value, 59, 60 multiplication, 72-73 row, 52, 53 unit, 52 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 74 View menu, 251 VIEW tabs, 17 virtual prototyping, 272 562 W WAVE files, 581 work session, 12-13 vectorization, 281 vectorization, workspace, 12, 60 Workspace window, 5, 6 X xy plot, 225-234 commands, 231 Z zeros of function, 128-130 563 (Do not forget to check if a file already exists by that name!) Test case: L = 10, A = 600, V = 1000. The following function does this. Like any M-file function, a nested function, a nested function, a nested function. Move the cursor over this dot to see a display of the values. MATLAB usually detects the more obvious errors and displays a message describing the error and its location. We can plot multiple equations as a single matrix equation. A = [1, -1; 2, -2], b = [3; 5] Table 8.5-1 Pseudocode for the linear equation solver If the rank of A equals the rank of E equals the rank of A equals the rank of A equals the rank of A equals the rank of E equals the rank of A equals the rank of E constants on the right-hand side of the equation; it has one column and as many rows as there are equations. The result of a comparison is false) or 1 (if the comparison using the relational operators is either 0 (if the comparison is false) or 1 (if the comparison is false) or 1 (if the comparison using the relational operators is either 0 (if the comparison using the relational operators) is '2.5%'; elseif t >= 1, r = '2%'; else r = '1.5%'; end else disp('An incorrect term was entered') end Here are some common mistakes when using logical operators, strings, and the elseif clause. 100^-1 b. Thus we define two matrices: U contains the unit costs in Table 2.4-3 in thousands of dollars, and P contains the quarterly production data in Table 2.4-4. This form computes the derivative of the product of the two polynomials p1 and p2. T1.5-2 Find out how many hyperbolic functions are supported by MATLAB. A square metal plate is heated to 80°C at the corner corresponding to x = y = 1. A feedback control system uses real-time measurements from a sensor to adjust the input to a device generically called an actuator, such as a heater or a motor. The response time constant (the largest time constant). The array w may be omitted. A secondary objective is to introduce and reinforce the use of problem-solving methodology as practiced by the engineering profession in general and as applied to the use of computers to solve problems in particular. On the right of the screen you should see a lighting bolt, double click this, and a new window will open up with the Asteroids game including YOUR edits! You can continue this process over and over again until you customize the game to be completely unique to yourself, and from here you are ready to edit or create more complex games. The reason is that it is difficult to interpolate on log scales. This length is given by norm(x). 497 heaviside(t) Heaviside function, 525 Default variable, 502 Impulse function, 546 methods for the second state and the second sta Initial condition, 525 Laplace transform, 503 Solution structure, 508 Step function, 534 Symbolic constant, 498 Symbolic expression, 499 Problems Section 11.1 1. Solution the matrix A and the vector b are The session is >> A = [2,9;3,-4]; b = [5;7]; >> x = inv(A)*b x = 2.3714 0.0286 The solution is x 1 = 2.3714 and x 2 = 0.0286. You will see y = -2.2023e+04 thus confirming that y is negative.; Suppresses screen printing; also denotes a new row in an array. Set the first column of the enrollment matrix E equal to x. The result is a row array that contains the polynomial's coefficients. The forcing function is where $g(t) = 10 \sin 4t$. 49.* Use the matrix inverse and the left-division method to solve the
following set. ans = $-(1-8*c)^{(1/2)-1}$ 462 (1-8*c)^(1/2)-1 Thus the solution of b 2 + 8c + 2b = 0 for c is c = (b 2 + 2b)/8. isfield(S,'field') Returns 1 if 'field' is the name of a field in the structure array S and 0 otherwise. In this case the variables w and z in the polynomial w = p 1 z + p 2 are the original data variables x and y, and we can find the linear function that fits the data by typing p = polyfit(x,y,1). Write a script file that uses your function to plot A and V versus a for $0.25 \le a \le 4$ in. 248 Figure P25 26. The product of these two arrays, h, is a matrix product and is a $(6 \times 1)(1 \times 4) = (6 \times 4)$ matrix. Type pathtool to start the browser. Fs = 11025; my_voice = audiorecorder(Fs,5*Fs, 1); 529 530 583 C APPENDIX Formatted Output in MATLAB The disp and format commands provide simple ways to control the screen output. The program is A = [0, -1, 4; 9, -14, 25; -34, 49, 64]; C = (A >= 0); A(C) = A(-C) + 50 The result after the last line is executed is EXAMPLE 4.5-4 Flight of an Instrumented Rocket All rockets lose weight as they burn fuel; thus the mass of the system is variable. In the author's experience, beginning students are of different degrees, 91 add zeros to the coefficient array of the lower-degree polynomial. The usefulness of MATLAB is greatly increased by the use of decision-making functions in its programs. Expand your program from part (a) to plot the trajectory y vs. The colormap(map) function should solve four linear equations in terms of the four unknowns a, b, c, and d. What is the main cause of the difference in the two pressure estimates, the molecular volume or the molecular volume or the molecular attractions? 263 4. [Palm, W. However, MATLAB provides the gensig function that makes it easy to construct periodic input functions. The equation of the mast is where Create and run a Simulink model to solve for and plot θ(t) for θ(t) ≤ π/2 rad. When MATLAB gives an answer to an overdetermined set, it does not tell us whether the answer is the 369 exact solution. In this example, the first row of B is 70, the second is 5, and the third is 64. 3, use the function with the fminbnd function to compute the value of r that minimizes the area A. Characteristic Roots from the eig Function The characteristic roots of a linear differential equation give information about the speed of response and the oscillation frequency, if any. (a) Length is 3. They contain in-depth discussions of how to use MATLAB to solve several common types of problems. If |A| = 0 or if the number of equations does not equal the number of unknowns, then you need to use the other methods to be presented later. If the flow rate from the fountain into the cup is 2 in. You should be able to determine whether a unique solution, an infinite number of solution, an infinite number of unknowns, then you need to use the standard deviation. 402 diff(x) Computes the differences between adjacent elements in the vector x. Select and place the To Workspace block from the Sinks library. Move all terms to the left side of the equation, and define the left side as a symbolic expression. 47 29. However, using the guess d = 20, $\theta = 0.1$ produces the physically meaningless result d = -781, $\theta = 3.1416$. If the applied current is $i(t) = 0.3 + 0.1e - 5t \sin(25\pi t)$, use MATLAB to compute and plot the voltage v(t) for seconds. y 3.8 x1 x2 7.5 6 273 5.6 12 9 6 13.5 10.5 5 16.5 18 5.8 19.5 21 5.6 21 25.5 (Answer: Maximum percent error = 4.1058%. The following model describes a mass supported by a nonlinear, hardening spring. For example, suppose we want to achieve a response time of 0.4 for a system that has the following characteristic polynomial: s 2 435 + Ps + I. The second circle has a radius b and is centered at x = 5, y = 3. Estimate how often it will take more than 75 min to repair a machine. Lists all files in the current directory. b = 0.2 c. 281 Figure 6.1-6 Flow rate and fill time for a coffee pot. All figures, tables, equations, and exercises have been numbered according to their chapter and section. fimplicit3(f) Plots an implicit 3-D function. Suppose the ball is thrown with a velocity v = 10 m/s at an angle of 35°. Its slope is (9.2-2) BACKWARD DIFFERENCE This estimate of the derivative is called the backward difference estimate, and it is actually a better estimate of the derivative at $x = x 1 + (\Delta x)/2$ than at x = x 2. Table 3.1-1 Some common mathematical functions Exponential; Square root; . If you type 5 and press Enter, the variable x will have the value 5. Use MATLAB to compute and plot y(t) for . Note that blocks have a Block Parameters window that opens when you double-click on the block. Select and place in the new window the Integrator block from the Continuous library, and change its label to Integrator 1 as shown in Figure 10.6-2. See also the "Mathematical symbols, Greek Letters, and T E X Characters" page. We assume that one of the function types (linear, exponential, or power) can describe the data. Because the governing equations, such as electric circuits and devices, the lessons learned from this example will enable you to use Simulink for other applications, such as electric circuits and devices, the lessons learned from this example will enable you to use Simulink for other applications. $334 > x = [7, 9, 11, 12]'; >>y(:,1) = [49, 57, 71, 75]'; >>y(:,2) = [52, 60, 73, 79]'; >>y(:,3) = [54, 61, 75, 81]'; >>x_int = (54, 61, 75, 81]'; >>x_int = (54,$ [8, 10]'; >> interp1(x,y,x int); ans = 53.0000 56.0000 57.5000 64.0000 65.5000 68.0000 Thus the estimated temperature values at the temperature v following times, using linear interpolation and then cubic spline interpolation: t = 0.6, 2.5, 4.7, 8.9. c. 375 When the differential equation is nonlinear, we often have no analytical solution to use for checking our numerical results. The free response depends on the initial conditions. The resulting structure array has the same size as the values arrays, or is 1 × 1 if none of the values arrays is a cell. Suppose you now redefine A so that its columns will be x and y. To make the number more visible, click on the block, and drag one of the corners to expand the block so that 407 all the text is visible. If A has m rows and x is a column vector, the result of Ax is a column vector with m rows. For example, to set the cubic polynomial in the resulting L A T E X file, use the commands presented earlier in this section to replace the equation in the second line of the report with $y = \{ | x |^2 - 4 \}$ by not using a for loop. Note: You can use the Basic Fitting interface only with two-dimensional data. Use a space, not a comma, to separate the variables. The ideal gas in a container. 1.6 Problem-Solving Methodologies Designing new engineering devices and systems requires a variety of problem-solving. skills. Find the product xA. The answer is A = 1.9998 for a relative error of 100(2-1.9998)/2 = 0.01 percent. The account has an initial investment A (to be provided as input; for example, enter \$10,000 as 10000) and an annually compounded interest rate of r% (to be provided as input; for example, enter 3.5% as 3.5). Many in the user community show a need to understand the basics of feedback control theory, and this section is designed to help with that understanding. When combustion occurs, it pushes the piston down. Run the simulation for two cases: (a) the applied force f(t) is a step function with a magnitude of 10 N and (b) the applied force is sinusoidal: f(t) = 10 sin 2.5t. If A is logical, then ~A replaces 1s with 0s and 0s with 1s. As a string expression Examples of these ways follow for the fzero function used with the user-defined function fun1, which computes . We want to remove all such elements and replace them with zeros at the end of the array. depth d, and angle θ as follows: The area of the trapezoidal cross section is Figure 3.2-5 Cross section of an irrigation channel. It is defined by the relation; that is, because . MATLAB provides built-in functions, such as clear, sin, and plot, which are not M-files, and some functions that are M-files, and some functions that are M-files, such as clear, sin, and plot, which are not M-files, and some functions, such as the function mean. This can be used with the text function to place a label on a plot without knowing the exact wording ahead of time. Use MATLAB to determine how close the ships come to each other. Display the results p and A. loglog(x,y) Produces a log-log plot of y versus x. Hours Product 1 Product 2 Product 3 Reactor B 3 3 4 Solution Let x, y, and z be the number of tons each of products 1, 2, and 3 that can be produced in one week. 15 4 17 15 14 15 19 5 23 18 17 20 24 347 26. The function charpoly(A) gives the coefficients if the characteristic polynomial in decreasing powers of the variable. The individual solutions are saved in the fields. The Property Editor enables you to access a subset of the variable. selected object's properties. What answer is produced by the following MATLAB expressions? Note that you can use MATLAB the four Gain blocks. Consult MATLAB the four Gain blocks. Consult MATLAB the four Gain blocks. Consult MATLAB the four Gain blocks. widths are adjusted according to the function's behavior, the method is said to be adaptive. The % sign tells MATLAB to interpret the following text as codes. x for $0 \le t \le t$ hit . Help Icon Ulick on the Help icon under the HOME tab to view documentation, examples, and a support web site. The time span and number of solution points are chosen 421 automatically. The Simulink graphical interface enables you to position the blocks, resize them, label them, specify block parameters, and interconnect the blocks to describe complicated systems for simulation. You use a process similar to sampling whenever you plot a function in MATLAB. Suppose that x is a vector containing the independent variable data and that y is a vector
containing the dependent variable data. In powder bed fusion, thermal energy is used to fuse certain regions of a powder bed. Its slope is (9.2-3) FORWARD DIFFERENCE This estimate is called the forward difference estimate is called the forward difference estimate of the derivative at $x = x 2 + (\Delta x)/2$ than at $x = x 2 + (\Delta x$ examples of functions that have two arguments. The View Menu The items on the View menu are the three toolbar, Plot Edit Toolbar, Plot Edit Toolbar, Plot Edit Toolbar, and Camera Toolbar), the Figure Palette, the Plot Browser, and the Property Editor. For example, if x is an array, to evaluate 121, you type sin(x.^2 + 5). 85 polyfit Fits a polynomial to data. 193 EXAMPLE 4.6-2 Growth of a Bank Account Determine how long it will take to account laterest. Note that all words containing sine are returned, such as cosine. How much can R vary about its optimal value before the area increases 10 percent above its minimum value? The following MATLAB session shows some examples. Then use the same technique to connect the bottom input port of the Integrator block. Note that we do not know the time of flight t hit (the time it takes for the projectile to hit the ground at y = 0). The function collect(E) collects coefficients of like powers in the expression E. 442 406 Figure 10.2-1 The Simulink Library Browser. This requires that y = 3.64 in. In 1966 he received a B.S. from Loyola College in Baltimore, and in 1971 a Ph.D. in Mechanical Engineering and Astronautical Sciences from Northwestern University in Evanston, Illinois. You can call it from the level immediately above it. The function approaches ∞ as $x \to 2$ and as $x \to 5$. 127 T3.2-2 Create a function called cone that computes the volume V of a cone whose height is h and whose radius is r. Compute the sled's velocity v for $0 \le t \le 6$ if v(0) = 0. Note that A*x gives the y values generated by the line y = 0.9x + 1.8333 at the x data values x = 0, 5, 10. 589 F1 7. Write a MATLAB program to compute t hit by solving the y equation for y = 0. z = (x > y) c. Table 6.2-1 summarizes the polyfit and polyval functions. Compute and plot the unit-step response of the following model. Note that the output arguments are enclosed in square brackets (which are optional if there is only one output), while the input arguments must be enclosed with parentheses. Then the Euclidean norm can be expressed as The real value of T 3 that minimizes N can be found by plotting N versus T 3, or by using calculus. The array is stored in the Euclidean norm can be expressed as The real value of T 3 that minimizes N can be found by plotting N versus T 3, or by using calculus. are opposing corners of the region. The problem is caused by the large values of the independent variables in the MATLAB Command window. Use the gtext function to place the labels y and z next to the appropriate curves. Multiple expressions or equations can be solved by separating them with a comma, as solve(E1,E2,...,En). The outer loop varies the burn time in integer values from b = 1 to b = 100. 88 where $\alpha = k/4m\pi 2$ (models such as these are discussed in greater detail in [Palm, 2010]). z = 4 < 7 + 3 f. The following data give the drying time T of a certain paint as a function of the amount of a certain additive A. Typing 15/3 returns the result ans = 5. For example, the string variable name is created as follows: >>name = '123' number = 123 is not the same as the variable number, >>name = '123' number = 123' is not the same as the variable name is created by typing number = 123 is not the same as the variable name is created by typing number = '123' number ''; student(2).tests = [84,78,93]; This process "expands" the array. Suppose that 20 thread samples are pulled until they break, and the breaking force is measured in newtons rounded off to integer values. In general, the product Ax, where A has p columns, is defined only if x has p rows. So we somewhat arbitrarily choose the second root to be s = -50. The value of the integral has been tabulated numerically, but we will use Simulink to obtain the solution. 19, 118 atan2(y,x) Four-quadrant inverse tangent. If the data form a straight line, then the data can be represented by the linear function and you are finished. Plot v 3 (t) over $0 \le t \le 3$ for v 1 (t) = 12 sin 10t V. In general, any computer program can be written with these three structures. EXAMPLE 2.4-4 Product Cost Analysis Table 2.4-3 shows the costs associated with a certain product, and Table 2.4-4 shows the developers of MATLAB were limited by the selection of symbols on the keyboard. Generates a single normally distributed random number having a mean of 0 and a standard deviation of 1. All other functions, also called local functions, also called local functions, also called subfunctions, also called subfunctions, also called local functions in the file are called subfunctions, also called local functions in the file are called subfunctions, also called local functions, also called local fun binary codes describing the file structure are in a "header" and are interspersed throughout the file. Pay attention to the magnitudes of the residuals. Appendix C summarizes functions for creating formatted output. Caution: Note that an asterisk is not needed between i or j and a number, although it is required with a variable, such as c2 = 5 - i*c1. 10 s. If we examine the plot of the integrand sin x, we see that the function is changing faster near x = 0 and x = π than near x = $\pi/2$. % duration = sound duration (in seconds). Introduction to Graphics 8. With what initial speed must you throw a ball vertically for it to reach a height of 20 ft? Select just the second row of B. Thus we select the upper limit of t to be 0.5. The session is >>t = 0:0.003:0.5; >>y = exp(-8*t).*sin(9.7*t+pi/2); >>plot(t,y), xlabel('t (sec)'), ... ylabel('t The roots are x = 1 and $x = 3 \pm 5i$. We can use this equation to estimate the flow at the year 2010 by substituting t = 2010, or by typing in MATLAB polyval(p,10). The array C has the same size as A and B. Call the function with its output argument: >>x = 3; y = 7; >>z = fun(x,y) z = 303 The function uses x = 3 and y = 7 to compute z. Compute z. matrix P whose 11 rows are the values of the position vector r evaluated at the times t = 0, 0.5, 1, 1.5,..., 5 s. Element-by-Element Division, is similar to the definition of element-by-element division, is similar to the definition of element-by-element division, also called array division, is similar to the definition of element-by-element division, and the elements of the other array. 383 Figure P10 11. Either the Sign block in the Math Operations library or the Coulomb and Viscous Friction block is easier to use. 23, 231 print Prints plot or saves plot to a file. Do this problem with four types of plots: the xy plot, the stem plot, the stairs plot, and the bar plot. We have used the probability normalization option of the histogram function to plot the relative probability of occurrence. Use MATLAB to solve the following problems. The Camera toolbar is useful for three-dimensional plots, which are discussed at the end of this chapter. Interpret the mathematics. It is recommended that you try ode45 first. Test Your Understanding T5.2-2 Plot the following two data sets on the same plot. Wind power uses a wind turbine to drive a generator. Suppose that T i = 20°C and T o = -10°C. The MATLAB function integral implements an adaptive version of Simpson's rule. number of times or until some condition is satisfied. Copyright © 2019 by McGraw-Hill Education. However, you can accidentally repeat results if you are not careful. Section 3.4 shows how to import and export such files in MATLAB. 410 10.3 Linear State-Variable Models State-variable models, unlike transfer-function
models, can have more than one input and more than one output. The following equation describes a certain dilution process, where y(t) is the concentration of salt in a tank of fresh water to which salt brine is being added. Suppose that f(t) = 10 for t < 0 and f(t) = 10 for t < 0 for t < 0 and f(t) = 10 for t < 0 for t < 0 and f(t) = 10 for t < 0 unknowns in terms of the third: T = T - 80 and T = T - 80 and T = T - 80 and T = 480 - 2T - 80MATLAB common logarithm function is log10(x). For a certain two-wheeled vehicle, the wheel radii are R = 0.5. It is desired to place the vehicle reference point at x = -0.4, y = 1.4. Compute the required turn radius RC, the turn angle θ , and the wheel radii are R = 0.5. It is desired to place the vehicle reference point at x = -0.4 , y = 1.4. Compute the required turn radius RC, the turn angle θ , and the wheel radii are R = 0.5. It is desired to place the vehicle reference point at x = -0.4 , y = 1.4. Compute the required turn radius RC, the turn angle θ , and the wheel radii are R = 0.5. It is desired to place the vehicle reference point at x = -0.4 , y = 1.4. Compute the required turn radius RC, the turn angle θ and the wheel radii are R = 0.5. It is desired to place the vehicle reference point at x = -0.4 , y = 1.4. Compute the required turn radius RC, the turn angle θ and the wheel radii are R = 0.5. It is desired to place the vehicle reference point at x = -0.4 , y = 1.4. Compute the required turn radius RC, the turn angle θ and the wheel radii are R = 0.5. It is desired to place the vehicle reference point at x = -0.4 , y = 1.4. Compute the required turn radius RC, the turn angle θ and the wheel radii are R = 0.5. It is desired to place the vehicle reference point at x = -0.4 , y = 1.4. Compute the required turn radius RC, the turn angle θ and the wheel radii are R = 0.5. It is desired to place the vehicle reference point at x = -0.4 , y = 1.4. Compute the reference point at x = -0.4 , y = 1.4. Compute the reference point at x = -0.4 , y = 1.4. Compute the reference point at x = -0.4 , y = 1.4. Compute the reference point at x = -0.4 , y = 1.4. Compute the reference point at x = -0.4 , y = 1.4. Compute the reference point at x = -0.4. Compute the The vector bins contains the heights in 1/2 in. The function of t. Simulink calls these values "Output when on" and "Output when on "Output when off point parameter, named SwOff in the figure. t (sec) T (#x00B0;F) 0 72.5 6 109.3 1 78.1 7 110.2 2 86.4 8 110.5 3 92.3 9 109.9 4 110.6 10 110.2 5 111.5 a. With the exception of the NOT operator (~), they have a lower precedence than the arithmetic and relational operators (see Table 4.3-2). stem(x,y) Produces a stem plot of y Limiter block as shown in Figure 10.8-1. Assuming that experiments determine that T = 0.1 (second), we set s = -20, -20 to obtain a total response time of 0.2 (seconds). The session to solve these equations is the following. (Answer: y = 4.7320, Equations containing periodic functions can have an infinite number of solutions. function E = ethanol(R) Y) % Computes ethanol produced from yeast reaction. Because the scaling changes as each plot command is executed, the label placed by the gtext 225 command might end up in the wrong position. You do this by multiplying the values by σ and adding μ to each result. Gradually, through a series of examples, more block types are introduced. >> syms x y b >> S = solve((x-3)^2+(y-5)^2-4,(x-5)^2+(y-3)^2-b^2) ans = S x: [2x1 sym] y: [2x1 sym] y: [2x1 sym] >> simplify(S.x) ans = 9/2-b^2/8+(-16+24*b^2-b^4)^{(1/2)/8} - (-16+24*b^2-b^4)^{(1/2)/8} - (-16+24*b^2-b^ Continue the above session by substituting into the solution x(t) for both systems on the same graph. Test Your Understanding T8.4-1 Solve the following set. Choose a final time large enough to show the motor's speed becoming constant. The dashed lines represent linear interpolation, and the solid curve is the cubic spline. There are several other forms of the function, which we will not need here. The normal probability function is a two-parameter function; one parameter, σ , is the standard deviation. fplot(E) Generates a plot of a symbolic expression E, which is a function of one variable. These functions have extended syntax not described here. (b) Simulation diagram for $\dot{y} = f(t) - 10y$. 194 Table 4.6-2 MATLAB program produced Figure 5.2-5. In such cases we often resort to simulation to make predictions. The Data Cursor button enables you to read data directly from a graph by displaying the values of points you select on plotted lines, surfaces, images, and so on. Compute m 0, v b, h b, h p. This is called the "elbow up" solution. 351, 544 eig Returns the eigenvalues (characteristic roots) of a matrix. One of these is the square root function, sqrt. The rod's length is L. We will show what this means in the next example. By the time you have finished this chapter, you will be able to use MATLAB to solve many kinds of problems. ans = $x^{2*y^{3-2*x^{2+5*y^{3-10}}}$ and $x^{2+5*y^{3-10}}$ and x^{2 asind(x)). These are useful when you want to compare the same data plotted with different axis types, for example. Note that we could also tell that the matrix A is singular point? Then enter [0; 0; 0] for the initial conditions. The Property Editor: Use this to set basic properties of the selected object and to obtain access to all properties through the Property Inspector. The denominator does not become zero unless h = 0 or h = 10, which correspond to a completely full tank. In addition, if b > 0, the helix has the shape of a right-handed screw; if b < 0, the helix is left-handed. We can use this fact to have MATLAB do the algebra for us. Suppose the applied voltage is trapezoidal as given below. The corresponding J values are 1534, 1024, 1017, and 495, respectively.) 267 Figure 6.2-2 An example of a fifth-degree polynomial that passes through all six data points but exhibits large excursions between points. Note that this expression is equivalent to r = (9)^(1/2) but is more compact. 586 Note that the fprintf command truncates the results, instead of rounding them. The clear functions as well as variables. These control structures repeat the execution of a block of instructions. Use the axis equal command. Simulink also provides easy ways to connect multiple blocks and lines; click on the Help for information. What are the velocity and the speed of plane A relative to plane B? 18.* A certain spherical street lamp emits light in all directions. Table 3.2-1 summarizes the basic syntax of the fminbnd, fminsearch, and fzero commands. Thirty pieces of structural timber of the same dimensions were subjected to an increasing lateral force until they broke. 159 Table 4.3-2 Order of precedence for operator types Precedence operator types Precedence for operator types Precedence for operator types Precedence for operator types Precedence operator types Precedence for opera number of values rather than the increment. For those readers not familiar with differential equations, this chapter provides some background for Chapter 10. T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$, confirm that T3.1-5 For several values of x in the range $0 \le x \le 2\pi$. frequency. This value corresponds to r 2 ≥ 0.99. b. The usual practice is to indent the statements to clarify which statements to clarify which statements to clarify which statements belong to the if and its corresponding end and thereby improve readability. 44 6. L.; H. 511 465 Solution (a) Substituting the given values of L 1 , L 2 , x, and y into the above equations gives The following session solves these equations. 114 real(x) Real part of a complex number x. 45 15. Following the primary function in the same file can be any number of subfunctions, which can serve as subroutines to the primary function. During his 44 years as a faculty member, he taught 19 courses. The tank is to be constructed to hold 500 m 3 of fluid when filled. If the model is highly detailed, we might need to solve it with a computer program. The force varies because of the surface. To resume program execution, use dbcont or
dbstep. You can solve equation backward in time by specifying to to be greater than tfinal. Confirm this identity by plotting the imaginary part versus the real part for both the left and right sides over the range $0 \le x \le 2\pi$. Data files and spreadsheet files are useful with MATLAB. Besides 'spline', other interpolation method'. This definition applies to vectors having any number of elements, as long as both vectors have the same number of elements. Section 4.1 presents a general and efficient approach to the design and development of programs. Select and place the Sum block from this example we see that if the first argument x in the interp1 (x,y,x_int) function is a vector and the second argument y is a matrix, then the function interpolates between the rows of y and computes a matrix having the same number of rows as the number of values in x int. For this reason, Simulink assumes the initial conditions associated with the Transfer Fcn block to be zero. (a) (b) 17. Change its name to y and the same number of rows as the number of values in x int. The following example shows how to use these properties. After running the simulation, you can use the MATLAB plotting commands from the Command window to plot the columns of y (or simout in general). To publish a report, do the following: 1. The Figure Palette The Figure Palette contains three panels, which are selected and expanded by clicking the appropriate button. Suppose that data show that a certain stock price is normally distributed with a mean of \$150 and so forth for the other three processes. T3.1-7 For several values of x in the range $-10 \le x \le 10$, confirm that 123. Solution From Figure 7.3-1, we see that the angle θ is determined by $\theta = \tan -1$ (y/x). Allow the user to input the four labor costs in the following table. Chapter 1 gives an overview of MATLAB features, including its windows and menu structures. The piston stroke is the total distance moved by the piston as the crank angle varies from 0° to 180°. ylabel('text') Adds a text label to the y axis (the ordinate). Checking the dimensions and units and printing the results of intermediate steps in the calculation sequence can uncover mistakes. int(E,a,b) Returns the integral of the expression E with respect to the default independent variable over the interval [a, b], where a and b are numeric quantities For example, type x_{13} to produce x13. We see that this choice of spacing misses some of the function's behavior. Plot residuals. 6π tan -1 (12.5) + 4 b. Which gives the most meaningful histogram? z = (x < 6) b. The function mean is a subfunction. Alternatively, you can use the dot transpose the array without producing the array without producing the function mean is a subfunction. complex conjugate elements, for example, A.'. STATE TRANSITION DIAGRAM This model can be represented graphically by a state transition diagram, like the one shown in Figure 4.9-1. If checked, the norm of residuals is displayed. Suppose that f(t) = sin t. Table 11.7-1 is a guide by category to the functions introduced in this chapter. You can also search for information using key words. subplot(m,n,p) Splits the Figure window into an array of subwindows with m rows and n columns and directs the subsequent plotting commands to the pth subwindow., 5 and y = 0, 1, 60, 40, 41, and 47. Section 1.1 1. This expression is equivalent to u = (x) > y, whereas v = (x > y) gives the result v = [1,0,1]. Denote these distances by D L and D R for the left and right wheels. diff(E,v,n) Returns the nth derivative of the expression E with respect to the variable v. Use your function to plot x versus W for $0 \le W \le 3000$ N for the values of k 1, k 2, and d given in part a. A(2:3, 1:3) denotes all the elements in the second and third rows that are also in the first through third 65 columns. Note that y(0) = b for both forms. >>x = 0:0.001:0.6; >>L = 100*(x/0.6).^((1-x)/0.4 division method to solve for the currents in terms of the resistance R and the voltages v 1 and v 2. Effective Use of Script Files Create script files to avoid the need to retype lengthy and commonly used procedures. Because the integral function calls the integrand function calls the integral function calls the function. 119 acoth(x) Inverse hyperbolic cotangent; coth -1 x. Its plot is shown in Figure 3.2-4. 459 Figure 10.5-4 The residuals as a bar plot, a line plot using either the same figure window as the data or using a separate figure window. Note how precedence applies to the line V = pi*r^2*h;. You can save the solutions as vectors by using the form [x, y] = solve(eqn1, eqn2). The following families: Partial Differential Equations (for structural design), Signal Processing (for smart structures), Control Systems (for active structures), and Computational Finance (for cost analysis of large projects). Example 5 has no output variable (for example, our function show_date or a function that generates a plot). We can achieve the same results using the plot command, but we need to know how many values to compute to generate the plot. 95 Table 2.8-1 Guide to commands introduced in Chapter 2 Special characters Use ' Transposes a matrix, creating complex conjugate elements. 2nd ed. Appendix B: Animation and Sound in MATLAB is widely used to assist these efforts with modeling and analysis tools for designing new vehicle systems. For underdetermined sets, MATLAB provides three ways of dealing with the equation set Ax = b (note that the matrix inverse method will never work with such sets): 1. For example, you can continue the previous session as follows. high-order polynomials. Start Simulink and open a new model window as described previously. MATLAB is case-sensitive. Discuss how to check the solution. Plot y(t) versus t. (a) 3, 3.1623, 3.6056; (b) 1.7321i, 0.2848 + 1.7553i, 0.5503 + 1.8174i; (c) 15 + 21i, 22 + 16i, 29 + 11i; (d) -0.4 - 0.2i, -0.4667 - 0.0667i. We need to check the ranks of A and [A b] to know if the answer is the exact solution. However, to use this function to find the minimum of more-complicated functions, it is more convenient to define the array y versus the array vector solution for state-space models, use the syntax [y, t, x] = lsim(sys,u,...). 234 stairs Creates stairs plot. 255 5.4 Three-Dimensional plots. b = 0.1 b. EXAMPLE 7.3-2 A Random Walk with Drift The randi functions for creating three-dimensional plots. b = 0.1 b. EXAMPLE 7.3-2 A Random Walk with Drift The randi functions for creating three-dimensional plots. b = 0.1 b. EXAMPLE 7.3-2 A Random Walk with Drift The randi function can be used to simulate a 1-dimensional plots. b = 0.1 b. EXAMPLE 7.3-2 A Random Walk with Drift The randi function can be used to simulate a 1-dimensional plots. b = 0.1 b. EXAMPLE 7.3-2 A Random Walk with Drift The randi function can be used to simulate a 1-dimensional plots. convention can cause errors if you are not careful. Use Simulink to solve the nonlinear equation, and plot the water height as a function of time until h(t) = 0.525 By setting y = 0 in the second expression, we can solve for t and obtain the following expression for the maximum time the projectile is in flight t max. Many engineering schools require a course based entirely or in part on MATLAB early in the curriculum. For example, >>rand ans = 0.7502 >>rng('default') >>rand ans = 0.7502 The rand function has an extended syntax. The array operations are performed between the elements in corresponding locations in the arrays. 11.1 Symbolic Expressions and Algebra The sym function can be used to create "symbolic objects" in MATLAB. This diagram is used to create the corresponding Simulink model shown in Figure 10.4-4. It states that The constant R is the gas constant. z = x | y d. It returns a value of 1 if S is a structure array and 0 otherwise. Thus the minimizing value of θ is independent of g, and can be found by minimizing the function The session to do this is as follows. The plot command requires the label and grid commands to be on the same
line, separated by commas. Temperature control example, if x and y have scalar values, z = 0; w = 0; if ($x \ge 0$; w = 0; if ($x \ge 0$); w = 0; if ($x \ge 0$); w = 0; 0 (y >= 0) z = sqrt(x) + sqrt(y) w = sqrt(x*y) end The new values of z and w are computed only if both x and y are nonnegative. Note that we do not see much of an oscillation despite the presence of a sine wave. If all the elements are real, the operators ' and.' give the same result. If we use different data symbols or different line types, then we must either provide a legend or place a label next to each curve. yyaxis(x1,y1,x2,y2) Produces a plot with two y axes, y1 on the left and y2 on the right. The whos function lists the variable names and their sizes and indicates whether they have nonzero imaginary parts. Use a primary function with a subfunction to compute the zeros of the function 3x 3 - 12x 2 - 33x + 80 over the range $-10 \le x \le 10$. Be sure to add arrows, lines, and other annotations only after you are finished moving or resizing your axes, because these objects are not anchored to the axes. 337 For example, suppose we make a profit of \$400, \$600, and \$100 per ton for products 1, 2, and 3, respectively. So the order of folders on the search path is important. 27, 583 ' Quote sign and transpose operator. Create a three-dimensional array D whose three "layers" are these matrices: b. format rat Rational approximation; 43/7. 364 Exponential and logarithmic functions Item Description Pages exp(x) Exponential; e x . \r Beginning of new line. How much can D vary from its optimal value before the tension T increases 10 percent above its minimum value? x/y 13. >> f = [9,-5,3,7]; >> g = [6,-1,2]; >> product = 54 - 39 41 29 - 1 14 Table 2.5-1 Polynomial functions Command Description conv(a,b) Computes the product of the two polynomials described by the coefficient arrays a and b. For example randperm(6) might generate the vector [3 2 6 4 1 5], or some other permutation of the numbers from 1 to 6. Enter the initial admissions and transfers, a(1) and d(1). Effective documentation can be accomplished with the use of 1. 63 You can create vectors by "appending" one vector to another. Simulations with dead-zone nonlinearities are somewhat tedious to program in MATLAB, but are easily done in Simulink. When such a function or transformation cannot be found, we resort to polynomial regression, or linear-in-parameters regression, or linear-in-parameters regression, and discuss whether they appear uniformly distributed with the desired mean. 48. plot(A) Plots the columns of the m × n array A versus their indices and generates n curves. The conditions can be specified at different values of t. Type rand to obtain a single random number in the open interval (0,1). At present there is no fmesh or fsurfc function. The challenge of innovative construction continues today. Section 9.3 covers first-order differential equations, and Section 9.4 extends the methods to higher-order equations. 3 Apple Hill Drive 18 Natick, MA, 01760-2098 USA Tel: 508-647-7000 Fax: 508-647-7000 ACKNOWLEDGMENTS Many individuals are due credit for this text. int(E,m,n) Returns the integral of the expression E with respect to the default independent variable over the interval [m, n], where m and n are symbolic expressions. It decreases smoothly from its maximum at A = 0° to its minimum at A = 180°. My sisters, Linda and Chris, and my mother, Lillian, have always been there, cheering my efforts. Logical variables may have only the values 1 (true) and 0 (false). If you need to type a long line, you can use an ellipsis, by typing three periods, to delay execution. Some differential equations are specified implicitly as f(t, y,) = 0. 1 2 3 4 5 6 7 8 9 LCR 21 20 19 18 ISBN 978-1-259-40538-9 MHID 1-259-40538-9 Portfolio Manager: Thomas M. In this chapter we limit ourselves to initial-value problems (IVPs). The four leftmost buttons are for opening, saving, and printing the equations, which are overdetermined because there are more equations than unknowns. They can also be used to display the error in an approximate formula. y_abs = [1,0,0,0,2,4,5,4,8,11,12,10,9,8,7,5,4,4,3,1,1,0,1]; binwidth = 0.5; % Define the bins. A pair of parentheses is used after the function's name to enclose the value—called the function's name to enclose the value. and damper is displaced a distance x 0 (cm) while being given an initial velocity v 0 (cm/s). Using this interface, you can quickly perform basic curve-fitting tasks within the same easy-to-use environment. The function input should be the desired area A. Figure 6.1-4 Temperature of a cooling cup of coffee, plotted on various coordinates. In general, regardless of whether you are creating a script or a function, keywords are shown in blue and comments in green. Labor cost: 16 cents per gallon of product. If the vectors are perpendicular, $\theta = 90^{\circ}$ and thus u. Repeat the steps to open additional variables into the Variable Editor. The section also shows how to handle files and to generate plots from arrays. Use MATLAB to solve the following problem: 20.* Use MATLAB to solve the following problem: 21. If the fluid to move from one end to the other. The effect of differentiating the input is an increase in the response's peak value. (b) Determine the energy dissipated in one minute if $R = 1000 \Omega$. 200 dbstop Sets a breakpoint. For example, if the wheel speed is too slow, we want to increase the motor torque. The equation of motion for a pendulum whose base is accelerating horizontally with an accelerating horizontally with an acceleration a(t) is Suppose that g = 9.81 m/s 2, L = 1 m, and (0) = 0. In this section we introduce one form called array operations, which are also called element operations. Next define and save the following function file. A more sophisticated method is to use trapezoidal elements, ventilator models, and more. Structured programs are easier to write because the programmer can study the overall problem first and deal with the details later. Impulse Response The area A under the vector t and its upper limit. Use the values k1 = 104 N/m, $k2 = 1.5 \times 104$ N/m, and d = 0.1 m. time 1, 2, 3, 4, 5; 12, 14, 16, 21, 27; Then in the MATLAB Command window type >>load speed data(2,:) >>plot(time,speed,'o'), xlabel('time(s)'), ... ylabel('speed(m/s)') Note that the comments in the file are not saved, only the numerical values. Some newer methods can also be used to create the software in addition to using computer-aided-design (CAD) software. This window has eight menus. There are three categories of algorithmic operations: Sequential operations: Sequential operations and the computer-aided-design (CAD) software in addition to using computer-aided-design (CAD) software. one of the following equations, where v is the voltage output and t is time. 234, 240 text Places string in figure. [The unit step function u(t) is 0 for t < 0 and 1 for t > 0.] The basic syntax is step(sys), where sys is the LTI object. If x is a complex number representing a two-dimensional geometric vector, then abs(x) gives its geometric length. If we intend x to start at zero, then we should place the statement x = 0; before the while statement. $m_e = 100$; q = 1; u = 8000; for b = 1:100 % Loop over burn time. 16. The pinv function gives a solution that gives the minimum value of the solution 332 vector x. These the statement x = 0; before the while statement x = 0; before the while statement x = 0; before the solution 332 vector x. These the minimum value of the minimum value are stored as image files and are not M-files. 250 5.3 Interactive Plotting in MATLAB The interactive plotting environment in MATLAB is a set of tools for Creating and editing subplots, Adding annotations such as lines, arrows, text, rectangles, and ellipses, and Editing properties of graphics objects, such as their color, line weight, and font. In the following session the function 4. As we will see in the following session the function 4. As we will see in the following session the function 4. As we will see in the following session the function 4. As we will see in the following session the function 4. As we will see in the following session the function 4. As we will see in the following session the function 4. As we will see in the following session the function 4. As we will see in the following session the function 4. As we will see in the following session the
function 4. As we will see in the following session the function 4. As example, it is sometimes necessary to use this case. This completes the simulation. The first column, contains the years, and the second column, pop, contains the years, and the second column, pop, contains the years, and the second column, pop. contains the years are R = 0.5. The wheel rotation angles are φ L = 2 rad and φ R = 4 rad. EXAMPLE 2.7-1 A Student Database Create a structure array to contain the following types of student data: Student name. The equation of motion is . Programming Detailed Forcing Functions As a final example of higher-order equations, we now show how to program a detailed forcing function for use with the lsim function. The lengths are normally distributed with means of 1, 2, and 1.5 ft and variances of 0.00014, 0.0002, and 0.0003, respectively. This prevents their values from being displayed when the function is called. We look for a straight line on the plot because it is relatively easy to recognize, and therefore we can easily tell whether the function will fit the data well. 30 format Controls screen display format. The functions realmax and realmin give the largest and smallelepiped can be computed from $|A \cdot (B \times C)|$, where A, B, and C define three sides of the parallelepiped (see Figure P45). To plot both outputs, in the MATLAB Command window type >>plot(tout,y(:,1),tout,y(:,2)), xlabel('t'), ylabel('t'), not unique. The while loop is used when the looping process terminates because a specified condition is satisfied, and thus the number of passes is not known in advance. If we did not need the speeds for every route, we could have solved this problem by combining two lines as follows: [highest speed, route] = max(d./t). findsym(E) Finds the symboli variables in a symbolic expression or matrix, where E is a scalar or matrix symbolic expression, and returns a string containing all of the symbolic expression, and returns a string containing all of the symbolic expression, and returns a string containing all of the symbolic expression. preserved when indexed assignment is used. What is the sum for this many terms? The value of q max indicates the heat output of the heating system. Thus we see that x 2 = 2y. 234 loglog Creates log-log plot. Use MATLAB to calculate: a. roots(a) Computes the roots of a polynomial specified by the coefficient array a. This gives dh/dt = -0.00286, whose solution is h(t) = h(0) - 0.00286t. Use the values $R = 0.6 \Omega$, L = 0.002 H, $K T = 0.04 N \cdot m/A$, $K e = 0.04 V \cdot s/rad$, c = 0, and $I = 6 \times 10 - 5 kg \cdot m 2$. When you open the Editor to create a new function, note that the keyword function is in blue and the comment is in green. If you are plotting more than one curve or data set, labe each on its plot or use a legend to distinguish them. The function [X,Y] = meshgrid(x,x) and can be used if x and y have the same minimum values, and the same spacing. Suppose that each resistance is rated to carry a current of no more than 1 mA (= 0.001 A). The resulting array z contains the numbers 6, 7, 7, 6. Because the unit vectors i, j, and k have unit length, 80 (2.4-1) Because the unit vectors as Carrying out the multiplication algebraically and using the properties given by (2.4-1) and (2.4-2), we obtain 73 The matrix product of a row vector u with a column vector wis defined in the same way as the vector dot product; the result is a scalar that is, if each vector has three elements. The functions are t 3, e -at, and sin bt. movie(M) % Play the movie. 266 20. Test Your Understanding T3.1-3 For several values of x, confirm that . All rights reserved. Use the first five nonzero terms in the Taylor series for e ix , sin x, and cos x about x = 0 to demonstrate the validity of Euler's formula e ix = cos x + sin x. The sample file is shown below. The surface area of the cylindrical part is $2\pi rh$, and its volume is $\pi r 2$ h. In this case log 10 y = mx + log 10 b, which has the form $w = p \ 1 \ z + p \ 2$, where the polynomial variables w and z are related to the original data variables x and y by $w = \log 10 \ y$ and z = x. Its popularity is also due to its user interface, which provides an easy-to-use interactive environment that includes extensive numerical computation and visualization capabilities. A rocket's mass decre as it burns fuel. Generating Random Integers If you want to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you must be able to generate random results for games involving dice, for example, but you [2.3,2.6,3.9], typing fix(x) gives the results 2, 2, 3. Gauge pressure is the difference between the absolute pressure and atmospheric pressure and atmospheric pressure and atmospheric pressure is the difference between the absolute pressure and atmospheric pressure attacks the term of such at the term applied voltage goes from 0 to 10 V at t = 0. x 0 5 10 y 2 6 11 286 310 Engineering in the 21st Century... Energy-Efficient Vehicles M odern societies have become very dependent on transportation powered by carbon-based fuels. Chemists and engineers must be able to predict the changes in chemical concentration in a reaction. Solution methods for PDEs are an advanced topic, and we will not treat them in this text. Dead time may be described as a "pure" time delay, in which no response at all occurs for a time T, as opposed to the time lag associated with the time constant of a response, for which $\theta 2$ (t) = (1 - e - t/ τ) $\theta 1$ (t). Plot this function for t ≥ 0 . function playtone (freq. Fs. amplitude.duration) % Plays a simple tone. The values of the matrices C1 and D1 tell us that the output variable y = 0.5x 2. The features are based on the T E X typesetting language. 361 integral is called a definite integral if it has specified limits of integration. Verify the identity for the vectors A = 7i - 3j + 7k, B = -6i + 2j + 3k, and C = 2i + 8j - 8k. Do this for two cases: q max = 4×105 lb-ft/hr. Prior to R2016b the first line drawn was blue; now it is a bluegreen [0 0.4470 0.7410]. Suppose that RC = 0.2 s and that the capacitor voltage is initially 2 s. 446 Figure P26 27. This is not unexpected, because the least-squares solution is not an exact solution is not an exact solution of the equations. unique values of the unknowns. For $7 \le x \le 9$, For $9 \le x \le 12$, 310 337 MATLAB provides the spline command to obtain a cubic spline interpolation. The function y(t) = 1 - e - bt, where t is time and b > 0, describes many processes, such as the height of liquid in a tank as it is being filled and the temperature of an object being heated. ymin ymax]) fplot(function, Performs intelligent plotting of functions, where function is a
function handle that [xmin xmax] becifies the minimum and maximum values of the independent variable. The MathWorks provides Simulink support packages for hardware such as LEGO © MINDSTORMS[©]. Arduino[©], and Raspberry Pi[©] that are popular with hobbyists and researchers. Consider what you do when drawing a graph by hand. The Java class is not covered in this text. Simulink is an optional add-on to MATLAB, and is discussed in Chapter 10, 76 EXAMPLE 2.4-2 Height versus Velocity The maximum height h achieved by an object thrown with a speed v at an angle θ to the horizontal, neglecting drag, is Create a table showing the maximum height for the following values, and the columns should correspond to the angles. The following script file shows this procedure. The equation for the voltage v across the capacitor of an RC circuit is where v(t) is the applied voltage. Function flips simulates the flipping of two coins and calls flip coin. A plot window appears that enables you to place points to define the input function. firing and rotates with an angular acceleration of . A particular bridge cable is described by the catenary $y(x) = 10 \cosh((x - 20)/10)$ for , where x and y are the horizontal and vertical coordinates measured in feet. Estimate the range of the expected result and compare it with you answer. If n is omitted, the spacing is 1. Planets and planetary satellites move in elliptical orbits. Note that four file types are shown in the Current Folder. The applications in this text will probably not require use of these features of the Editor, which are useful mainly for very large programs. The fminbnd function returns a value of x that minimizes the function in the interval x1 < x < x2. 0.2 d. Your programs will also run faster because MATLAB was designed for highspeed vector computations. Specifying array subscripts with logical arrays extracts the elements that correspond to the true (1) elements in the logical array returns the value 75. Let d represent the distance to the wall (310 ft). 55 12.* Suppose that x = -7 - 5i and y = 4 + 3i. x = [2, 4, 7] b. To create a state model for the system described by the LTI object sys1 created previously in transfer function form, you type s(sys1). Simulation is used to speed development, integration, and testing of microcontroller units. Equations (10.10-16) can be combined as follows. Then plot the residuals, and decide which is the better fit. The Workspace Browser shows the name of each variable, its value, array size, and class. These might be comments that describe what the data represent, the date they were created, and who created the data, for example. Thus to reconstruct the raw data, start with an empty vector y raw and fill it with the height data obtained from the absolute frequencies. As a rule of thumb, a good fit accounts for at least 99 percent of the data variation. The following statements will calculate y, assuming that x already has a scalar value. add the arrays that describe their coefficients. Use two methods to create the vector x having a regular spacing of 0.2 starting at 2 and ending at 14. Determine how many units of each product the company should make to maximize its total profit, and then compute this profit. Let T 1, T 2, and T 3 be the tensions in the three cables AB, AC, and AD, respectively. $cos(\pi/2) c$. You can add a directory to the search path by using the addpath command. coord = [3,6,2;7,6,8]; distance = sqrt(diag(coord'*coord)) [max distance,farthest] = max(distance) [ma that novel engineering developments in both personal and mass transportation will be needed to reduce our dependence on such fuels. MATLAB supports additive manufacturing in several ways. *Graphical User Interfaces (GUIs) 2. The default range of the independent variable is the interval [-5, 5], unless this interval contains a singularity. The Fourier series representation of the function is 57 Plot on the same graph the function f(x) and its series representation, using the four terms shown. A major application of the chapter's material is in simulation, to which a section is devoted. Triple Integrals. For example, typing x = 0:2:8 creates the vector x = [0, 2, 4, 6, 8], whereas typing x = 0.2.7 creates the vector x = [0, 2, 4, 6]. Although the plot resembles the normal distribution, the values of θ are not distributed normally. For example: >>fieldnames(student) ans = 'name' 'SN' 'email' 'tests' As you fill in more student information, MATLAB assigns the same number of fields and the same field names to each element. For example, when you type y = logical (9), y will be assigned the value logical 1 and a warning will be issued. In SI units, g = 9.81 m/s 2, 265 Table 6.2-1 Functions for polynomial regression Command Description p = polyfit(x,y,n) Fits a polynomial of degree n to data described by the vectors x and y, where x is the independent variable. You should now be able to use the MATLAB Help to find other functions you need. It is easy to get carried away when selecting the gains by looking only at the simulated response of the controlled variable. For example, to find the polynomial whose roots are 1 and 3 ± 5i, the session is >>p = poly([1,3+5i, 3-5i]) P = 1 -34 Thus the polynomial is x 3 -7x 2 + 40x -34. simplify(E) Attempts to simplify the expression E. Use Transfer Function blocks to construct a Simulink model to plot the solution of the following equations for $0 \le t \le 2$. 79 Figure 2.3-2 Plot for Example 2.3-5. They are best suited for developing eye-hand coordination and the skill to -740 perform three-dimensional actions using a two-dimensional screen as a guide. A minus sign in the format code causes the output to be left-justified within its field. The syntax [u,t] = gensig(type, period, tF,dt) specifies the time duration, do the following steps. To verify that this is a minimum solution, and not a maximum or an inflection point, we can check the second derivative d 2 f/d0 2. Delete the Scope block in the same way. 1.1 MATLAB Interactive Sessions We now show how to start MATLAB, how to make some basic calculations, and how to exit MATLAB. 93 isstruct Identifies a structure array. title('text') Puts text in a title at the top of a plot. For example, the equations and are nonlinear. The function int(E) returns the integral of the expression E with respect to the default independent variable. 392 The answer is A = 1.9797, which gives a relative error of 100(2 - 1.9797)/2 = 1 percent. These solvers are categorized by the type of input function they can accept: zero input, impulse input, step input, and a general input function. Product costs Unit costs (\$ × 103) Product over a cost of \$ × 103 Product over a cost over a cost of \$ × 103 Product over a cost of \$ × 41. >>x = 2+3 % So is this. 427 467 Figure 10.7-9 An armature-controlled dc motor. Enter the data shown in Figure 2.7-1 into the database. The tool is accessed from the Figure 2.7-1 into the database. The tool is accessed from the Figure 2.7-1 into the database. variables in E closest to x, with the tie breaker going to the variable closer to z. The variables y and z represents distance in meters. Specify the output to be generated by the program. 416 The Relay Block The Simulink Relay block is an example of something that is tedious to program in MATLAB but is easy to implement in Simulink. The MATLAB logical operators and loops are excellent tools for building simulation programs. When finished, click outside the text box and note that the nine leftmost buttons become highlighted and available. For example, in earlier releases of MATLAB, the plot function was an M-file, but is now a built-in function. You can save the statistics to the workspace as a structure by clicking on the Save to Workspace button. The constant r is the growth rate, and the constant rate, and th +1 be the estimate of y(t k +1) obtained from the Euler formula (9.3-4). To determine the rank of a matrix A in MATLAB, type rank(A). Specifically we treat 453 symbolic methods for solving algebraic and transcendental equations, symbolic methods for solving algebraic and transcendenta equations, symbolic methods for solving algebraic and transcendenta equations, symbolic methods for solving algebraic and transcendenta equations, symbolic methods for solvi differentiation, limits, and series, Laplace transforms, and selected topics in linear algebra, including symbolic methods for obtaining determinants, matrix inverses, and eigenvalues. The PLOTS tab will open a plotting toolbar, which will be discussed in Chapter 5. The other file types will be covered in later chapters. The label can be generated either with the gtext command, which lets you place the label by using the mouse, or with the text command, which requires you to specify the coordinates of the label. You can create a sound having two tones by adding two vectors created from sine functions having different frequencies and amplitudes. For example, if x = [2, 5, 3, 8], cumsum(x) = [2, 7, 7], which have been by adding two vectors created from sine functions having different frequencies and amplitudes. 10, 18]. Obtain in closed form the integral and derivative of a polynomial function. Table 11.7-1 Guide to MATLAB Commands Introduced in This Chapter Creating and Evaluating Expressions Solving Algebraic and Transcendental Equations Symbolic Calculus Functions Solving Differential Equations Laplace Transforms Linear Algebra Miscellaneous Functions See Table 11.1-1 See Table 11.1-1 See Table 11.1-1 See Table 11.2-1 See Test Your Understanding T8.2-1 Use the left-division method to solve the following set: 5x 1 - 3x 2 = 21 7x 1 - 2x 2 = 36 (Answers: x 1 = 6, x 2 = 3) T8.2-2 Use MATLAB to solve the following equations: 6x - 4y + 3z = 5 4x + 3y - 2z = 23 2x + 6y + 3z = 63 (Answers: x = 3, y = 7, z = 5) 8.3 Underdetermined Systems An underdetermined system does not contain enough information to determine all the unknown variables,
usually but not always because it has fewer equations than unknowns. 517 (You could use MATLAB to do this simple algebra if you wish. For the second, plot the approximation error sin x - x versus x for $0 \le x \le 1$. A torus is shaped like a doughnut. Using the rref([A b]) function produces the augmented matrix which corresponds to the reduced system 368 These can be solved easily as follows: f 1 = 300 - f 4, f 2 = 200 + f 4, and f 3 = 800 - f 4, f 2 = 200 + f 4, and f 3 = 800 - f 4, f 2 = 200 + f 4, and f 3 = 800 - f 4, f 2 = 200 + f 4, and f 3 = 800 - f 4, f 2 = 200 + f 4, f 2 = 200 + f 4, and f 3 = 800 - f 4, f 2 = 200 + f 4, grid in which you type the variable's values. If in series, they are equivalent to a single resistance is given by If in parallel, their equivalent resistance is given by Write an M-file that prompts the user for the type of connection (series or parallel) and the number of resistors n and then computes the equivalent resistance. These "loop" structures are covered in Sections 4.5 and 4.6. The switch structure enhances the MATLAB decision-making capabilities. w of the vectors u and w is a scalar and can be thought of as the perpendicular projection of u onto w. % Position is first variable, velocity is second variable. function of time t by v = gt, where g is the acceleration due to gravity. legend('leg1', 'leg2', Creates a legend using the strings leg1, leg2, and so on and enables its ...) placement with the mouse. Do this in two ways: a. >>A = [6, -2; 10, 3; 4, 7]; >>B = [9, 8; -5, 12]; >>A*B Element-by-element multiplication is defined for the following product: However, this product is not defined for matrix multiplication, because the first matrix has three columns, but the second matrix does not have three rows. 74 Vector-Matrix Multiplication Not all matrix products are scalars. MATLAB draws the axes on the second layer, and draws the plot on the third layer. This surface has a singular point at x = v = 0, where the surface has zero slope, but this point does not correspond to either a minimum or a maximum. For example, MATLAB does not have a function named sine. Is z = w? For example, typing >> x = ([2, 3] > [1, 6]); >> y = sin(x) will generate an error message. Find the array quotient F = B. (A. Across the top of the Desktop is the Toolstrip which contains a row of three tabs labeled HOME, PLOTS, and APPS. zeros(m,n) Creates an m \times n array of 0s. Problems.....Page 6012. The final result is the vector of durations for the various burn times. What is the temperature at the corner corresponding to x = y = 0? If the data on fand x are stored as row vectors, then in vector form this equation must be written using right division as k = x'\f'. The general equation for an ellipse centered at the origin, whose major and minor axes lie along the x and y axes, is This can be solved for y as follows: Create a function that will plot the entire ellipse, given the inputs a and b. The outputs are the length L required so that the enclosed area is A and the total length of fence required. A count of the number of bytes written is returned in the variable count. Parentheses can be used to alter this order. Because of the wide range in values on both the abscissa and the ordinate, rectilinear scales do not reveal the important features. Let q ij be the heat flow rate between the points whose temperatures are

T i and T j. To restore the default search path, click on Default in the browser. Be sure to choose enough points to obtain an accurate plot. (Hint: Consider two cases: $4\tau > 2\pi/\omega$.) b. EXAMPLE 10.5-1 Response with a Dead Zone Create and run a Simulink simulation of a mass-spring-damper model (Equation 10.5-1) using the parameter values m = 1, c = 2, and k = 4. The input y(t) is a unit step function, and the initial conditions are zero. [0.8333, 0.5; 1.4, 3] c. 46 The MathWorks, Inc., the home of MATLAB. Only text lines, not code lines, can contain equations. [Felder, 1986] Felder, R. The enrollment at year k is described completely by the Figure 4.9-1 The state transition diagram for the college enrollment model. EXAMPLE 10.4-2 Model of a Relay-Controlled dc motor was discussed in Section 9.5. See Figure 10.4-8. You can assign the output argument to another variable, as: >>q = fun(3,7) q = 303 You can suppress the output by putting a semicolon after the function call. 412 3. function L = channel(x) L = 100./x(1) - x(1)./tan(x(2)); end Then use the finisearch function. The result, sys1, is the LTI object that describes the system in reduced form, also called the transfer function form. If y is the dependent variable, let Dy = diff(y,t), D2y = diff(y,t), D2y = diff(y,t,2), and so on. Compute the PI gains required to obtain the roots s = -50, -100. The following equation describes the temperature distribution in a flat rectangular metal plate. NORMAL FUNCTION This function is also known as the bell-shaped curve. Use the values R = 0.6 Ω , L = 0.002 H, K T = 0.04 N. If n is omitted, the number of points defaults to 50. According to this criterion, the line that minimizes J, the sum of the squares of the vertical differences between the line and the data points, is the "best" fit. Use linear interpolation with MATLAB to estimate the temperature at the missing points. The following table gives temperature data in °C as a function of time of day and day of the week at a specific location. Recreating Graphs from M-Files Once your graph is finished, you can generate MATLAB code to reproduce the graph by selecting Generate Code from the File menu. any(A) Returns a row vector having the same number of columns as A and containing 1s and 0s, depending on whether the corresponding column of the matrix A contains any nonzero elements. This menu was discussed in Section 5.1 under Saving Figures and Exporting Figures and Exporting Figures and Exporting Figures. Consider the following functions can be used to manipulate expressions by collecting coefficients of like powers, expanding powers, and factoring expressions, for example. Copy the Integrator 2. (a) (b) (c) (d) (e) (f) 31. Use Simulink to solve for and plot the water height h(t) for $0 \le t \le 10$ min. (Hint: Find the probability that the clearance is negative.) 11.* A shipping pallet holds 10 boxes. Typing floor(y) produces the result -3, -3, 5. The volume V and paper cup are given by where r is the real part of s is greater than zero, so that the limit of e^{-st} exists as $t \rightarrow \theta$. Some designers prefer to use the ideal form and set P = 1 initially, and then adjust P once the desired shape of the response curve is obtained by adjusting I and D. Use the Transfer Function block to construct a Simulink model to plot the solution of the following equation for $0 \le t \le 4$. Anonymous functions, subfunctions, and nested functions extend the capabilities of MATLAB. Functions can have more than one zero, so it helps to plot the function first and then use fzero to obtain an answer read off the plot. If we specify the interval $0.1 \le x \le 2.5$, MATLAB gives the answer x = 0.1001, which corresponds to the minimum value of y on the interval $0.1 \le x \le 2.5$. Thus we will miss the true minimum point if our specified interval does not include it. 42 8. Their syntax is very simple, namely, stem(x,y), and bar(x,y). Use it to calculate the cube root of 64. Finally, A([1 4],:) = [] deletes the first and fourth rows of A. [t1, x1] = ode45(@pendulum, [0,tF]) [0.4, 0]; % 380 g = 1.63; L = 2.5; % Second case. Comments section In this section put comment statements to give a. ans = sqrt(x^2) >> simplify(sqrt(x^2), IgnoreAnalyticConstraints', true) and the test if x < 0 is false, and the test if x < 0 is false. The test if x < 0 is fals arrows point in the direction of increasing f. Test Your Understanding T5.4-2 Use mesh, fmesh, contour, and fcontour to create a surface plot and a contour plot of the function z = (x - 2) 2 + 2xy + y 2. Number of twists Percentage of element 1 Percentage of element 2 y x1 x2 40 1 1 51 2 1 65 3 1 72 4 1 38 1 2 46 2 2 53 3 2 67 4 2 31 1 3 39 2 3 48 3 3 56 4 3 305 12. 63 \ Left-division operator. Their equations of motion are, for part (a), and for part (b) 435 Figure P39 has an equation of motion containing the derivative of the input function y(t). 167 ischar True if elements are a character array. The new edition has been updated to include coverage of Symbolic Math and SIMULINK. Adding -all to the lookfor function searches the entire Help entry, not just the H1 line. 41. This tab enables you to insert, delete, transpose, and sort rows and columns. Use MATLAB to estimate the mean and standard deviation for the height data given in Table 7.2-1. y_est = interp1(x,y,x est,'spline') In this form the function returns a column vector y est that contains the estimated values of y that correspond to the x values specified in the vector x est, using cubic spline interpolation. You can use the Camera toolbar and some menu items in the Figure window to change the view and lighting of the figure. Find the array quotient E = A.\B. These problems can be handled by a transformation of variables. A solution to such an equation is a function y = g(t) such that dg/dt = f(t,g), and the solution will contain one arbitrary constant. Let the production quantity be Q, in gallons per year. Control codes Format codes Code Description Start new line. Section 5.4 33. We can arrange the coordinates in the array coord as follows. For example, note the effect of precedence on the following session. $z = (4 < 7)^*5 g$. Matrix-Matrix Multiplication to include the product of two matrices AB. The desired form of the fitted equation is f = kx, so the scalar k is found from k = f/x. You can manipulate other windows in the same way. The functions useful for importing and exporting such files are covered. If MATLAB does not generate an error message when you use one of these methods, then the set has a unique solution. You will then see the resulting A, B, C, and D matrices on the screen. 13. 526 We will occasionally use the following abbreviations for the first and second-order derivatives. These are structure charts and flowcharts. Simulink is often used to create the simulation model for such testing. symbolic expression such as y = sin x/cos x in MATLAB, and how to use MATLAB to 496 simplify expressions wherever possible. A MATLAB to convert a model from transfer function form to state-variable form, and vice versa. Solution The script file follows. Enter the name you want to give the file, less the extension. Chapter 6 shows how to use plots to build mathematical models from data. The general term for such a requirement is a boundary conditions, other than initial conditions other than initial conditions. Verify the associative property b. These results hold if f(x) has continuous derivatives through order n. T5.2-4 Plot y = sinh x and y = 0.5e x on the same plot for $0 \le x \le 2$. xlabel('y (feet)'), ylabel('Theta2 (degrees)') The results are shown in Figure 11.2-3, where we have marked the solutions. This function has the general format set(object handle, 'PropertyName', 'PropertyValue', ...) If the object is an entire figure, its handle also contains the specifications for line color and type and marker size. A suite of sensors provides information, when compared with the geometric model, enables the surgeon to align the joint properly. The pinv function gives x 1 = 0.0571, x 2 = 0.5249, x 3 = 0.5340. Because sound is an analog variable (one having an infinite number of values), it must be converted to a finite set of numbers before it can be stored and used in a digital computer. The xlabel function places the text in single quotes as a label on the horizontal axis. The plotted points are stored in the arrays x and y. Test your script, using the following values: b 1 = 180 m, b 2 = 165 m, c 1 = 115 m, A 1 = 120°, and A 2 = 100°. z_int=interp2(x,y,z,x, y_int) Used to linearly interpolate a function of two variables: y = f(x, y). 573 t = 0:0.05:100; for b = 1.20 plot(t,t.*exp(-t/b)), axis([0 100 0 10]), xlabel('t'); M(:,b) = getframe; end The line M(:,b) = getframe; acquires and saves the current figure as a column of the matrix M. We usually want to strictly control what variables are available in the workspace. The associative and distributive properties hold for matrix multiplication. Because the bin width is 0.5, the total area corresponding to these rectangles is (0.1 + 0.08 + 0.16 + 0.22 + 0.24)(0.5) = 0.4. Thus 40 percent of the heights lie between 67 and 69 in. If the relative temperature is an exponential function of time, the model is T - 68 = b(10) mt. The matrices A and B become Next, select appropriate values for the matrices A and B become Next, select appropriate values for the matrices A and B become Next, select appropriate values for the matrices in the output equation y = Cz + By(t). Introduction 2. 12, 53 % Percent sign; designates a comment, and specifies formatting. Create a cell array of capacitance values versus d, L, and r for d = 0.003, 0.004, 0.005, and 0.01 m; L = 1, 2, 3 m; and r = 0.001, 0.002, 0.003 m. The pseudocode in Table 8.5-1 can be used to outline an equation solver program before writing it. The text's material is based on the author's experience in teaching a required two-credit
semester course devoted to MATLAB for engineering freshmen. 164 | Logical operator: OR. 325 randperm Generates random permutation of unique integers. To create this model: 1. With tidal power the tidal currents are used to drive a turbine to generate electricity. Format code can be placed within text. MATLAB Functions and Data Import-Export Utilities 5. The popular amusement ride known as the corkscrew has a helical shape. 17. For example, the following session produces an estimate of the temperatures at 8 and 10 A.M. from the preceding data. Although MATLAB allows you to assign a different value to these constants, it is not good practice to do so. This surface might have multiple peaks, multiple valleys, and "mountain passes" called saddle points that can fool a minimization technique. greater than the inner radius. axis vis3d off % Set the axes to 3D and turn off tick marks, % and so forth. If the flow rate from the fountain into the cup is given by 2(1 - e - 2t) in. However, tan(45° + 180°) = tan 225° = 1 also. The following example illustrates the former approach. Note also that we must use the transpose operation to interchange the rows and columns of the table matrix in order to display it properly. We have introduced just a few of the blocks available within Simulink. For example 524 is given by >> syms a x >> limit(sin(a*x)/x) and sin(a*x)/x and sin(aoverlooked when choosing gains is the fact that the actuator has limitations; for example, an amplifier can produce only so much torque. The model has been used in some applications on the MathWorks web site. 533 11.5 Laplace Transforms This section shows how to use the Laplace transform with MATLAB. A water tank consists of a cylindrical part of radius r and height h and a hemispherical top. Evaluation begins with the innermost pair of parentheses and proceeds outward. For example, the following A and B matrices give the C matrix shown. The mean of the sum (or difference) of two independent random variables equals the sum (or difference) of their means, but the variance is always the sum of the two variances. Of course, you can enhance the plot generated by fplot by using the plot format commands. The equations for an armature-controlled dc motor (such as a permanent-magnet motor) shown in Figure 9.5-4 are the following. Compute the mean and standard deviation and use them to estimate the lower and upper limits of gas mileage corresponding to 68 percent of cars of this model. You need not use array operations in the function file because the ODE solvers call the file with scalar values for the arguments. The Plot Browser The Plot Browser provides a legend of all the graphs in the figure. The session is > syms v(x) x > Dv = diff(v,x); >> eqn = Dv+2*v==12; >> dsolve (eqn) ans = C1*exp(-2*x)+6 Test Your Understanding T11.4-1 Use MATLAB to solve the equation Check the answer by hand or with MATLAB. If the drawnow command were not used, MATLAB would complete all other operations before performing any graphics operations and would display only the last frame of the animation. Details on these capabilities can be found in the online help. In the rectangular representation the number a + ib representation the nu from the dashed line that connects the data points at 9 and 11 A.M. From the plot we thus estimate the temperature at 8 A.M. to be 53°F and at 10 A.M. to be 53°F and to 10 A express some of the unknowns in an underdetermined set as functions of the remaining unknowns. Now that you have finished this chapter, you should be able to use MATLAB to Solve basic problems in statistics and probability. charpoly(A,s) Returns the characteristic polynomial of the matrix A in symbolic form in terms of the variable s. To do this, plot y versus t for several values of b on the same plot. For V = 10 in. For example, using an anonymous function to compute the integral2(fun, 1, 3, 0, 1) The answer is A = 1.3333. By contrast, the function findsym(E,n) returns the n symbolic variables in E closest to x, with the tie breaker going to the variable closer to z. In a heat-transfer course, the following description of the temperature distribution in a flat, rectangular metal plate is often derived. 414 9.5 Special Methods for Linear Equations MATLAB provides some convenient tools to use if the differential equation model is linear. 270 39. 79 Matrix multiplication does not have the commutative property; that is, in general, AB ≠ BA. The MathWorks supports an active user community online where you can see applications and download files. Use the File menu in the model window to open, close, and save model files. Use the File menu in the model window to open, close, and save model files. the viewpoint and capture each frame. ARRAY SIZE From the Workspace Browser you can open the Variable Editor to view and edit a visual representation of two-dimensional numeric arrays, with the rows and columns numbered. y = [92,94,93,96,93,94,95,96,91,93,... 95,95,92,93,94,91,94,92,93]; histogram(y, 'FaceColor', 'none'),... axis([90 97 0]) 6]),... ylabel('Absolute Frequency'),... xlabel('Thread Strength (N)'),... title('Absolute Frequency Histogram for 20 Tests') Because there are six outcomes, six bins are sufficient, and that is what the histogram function chose. Create a function file that computes the distance x, using the input parameters W, k 1 , k 2 , and d. Syntax errors such as omitting a parenthesis or comma, or spelling a command name incorrectly. x = [1.92, 0.05, -2.43, -0.02, 0.09, 0.85, -0.06]; y = x(find(abs(x) < 0.1)); z = zeros(size(find(abs(x) < 0.1))); z = zeros(size(find(abs(x) <Files The MATLAB functions audiowrite and audioread create and read a Microsoft WAVE file having the extension .way. Test Your Understanding T8.1-1 For what values of c will the following set (a) have a unique solution and (b) have an infinite number of solutions? You can always check the solution for x by typing Ax to see if the result is the same as b. 239, 240 legend Places legend by mouse. Bottom graph: Interpolation with piecewise continuous Hermite polynomials (pchip) and a cubic spline. Create a Simulink model to plot the solution for $0 \le t \le 2$. Consider the system shown in Figure P35. For example, consider the session >>x = [5, -3, 0, 0, 8]; y = [2, 4, 0, 5, 7]; >>z = find(x & y) z = 1 2 5 The resulting array z = [1, 2, 5] indicates that the first, second, and fifth elements of both x and y are nonzero. [X,Y] = meshgrid(x,y) Creates the matrices X and Y from the vectors x and y to define a rectangular grid. So the functions complement each other. We can make an estimate by using the characteristic roots of the linear 399 model obtained by setting k 2 = 0. In such cases the equal sign may be omitted. Compute the PI gains required to obtain a response time of 2. 48 5. If we assume that the inner and outer temperatures T i and T o have remained constant for some time, then the heat energy stored in the layers is constant, and thus the heat flow rate through each layer is the same. y int = spline(x, y, x int) Computes a cubic spline interpolation where x and y are vectors containing the data and x int is a vector containing the values of the independent variable y. 270 (Answer: where x = cdate - 1790. 410.1297 b. The following MATLAB session uses the values L 1 = 1, L 2 = 1 0.5 ft. Figure 5.2-4 Application of the hold command. y = -g*t.^2/2+s0*sin(th)*t; function v = vertvel(t,s0,th,g); % Computes projectile vertical velocity. A Model of Sound Sound is the fluctuation of air pressure as a function of time t. Double-click on it, and set the Gain value to 0.8. Click OK. The normal distribution, commonly called the bell-shaped curve, forms the basis of much of probability theory and many statistical methods. Use different line types and a legend to distinguish the curves. They can help to improve the readability of your program and also give you more flexible access to variables in the M-file. load Year built Due for maintenance Shore Rd. 85 1997 2014 115 112 ©ERproductions Ltd/Blend Images LLC Engineering in the 21st Century... Robot-Assisted Surgery M any advances in medicine are really engineering achievements, and many engineering achievements, and many engineering achievements are really engineering achievements. This case the scalar is added or subtracted from each element in the array. represent the relative height of the wall (33 ft). Figure P25 is a representation of an electrical system with a power supply and a load. Show that R -1 (a) = R(-a). For the ideal diode, the voltage v L across the load R L is given by Suppose the supply voltage is 214 202 Figure P28 where time t is in seconds. Or you can create an equation using LaTex commands (go to the Insert tab of the Live Editor, click on Equation). 30. Section 2.6 57. This function corresponds approximately to a vehicle traveling at 30 mi/h over a road surface elevation 0.2 m high and 48 m long. Once the file has been saved, in the MATLAB Command window type the script file's name Example 1 to execute the program. If we let the pulse duration T approach zero, while keeping the area A constant, we obtain the impulse function of strength A, represented by Figure 11.5-4b. The definitions of the variable names for every input and output variable. Mux block to the output port of the Gain block. Runtime errors in function's local workspace. Contour Plots Topographic plots show the contours of the land by means of constant elevation lines. Its syntax has several forms. If 90 percent of the original carbon 14 remains, estimate how long ago the organism died. In addition to energy efficiency, we must also consider the efficient use of materials that are environmentally dangerous, such as lithium. Type help strfun to obtain information on these. You can change 232 the figure size, background color, font size, and line width, and you can save the settings as an export style that you can apply to other figures before saving them: If you want
to save the figure in a format that can be used by another application, in a number of different graphics file formats, perform these steps: 1. ILL-CONDITIONED For a 2 × 2 matrix A, where det(A) = ad - bc. Their respective locations in the xy plane are (0.3, 0) and (-0.3, 0) m. waterfall(x,y,z) Same as mesh but draws mesh lines in one direction only. 243 236 389 628 143 417 205 404 464 605 137 123 372 439 497 500 535 577 441 231 675 132 196 217 660 569 865 725 457 347 343 3. In some applications we want to estimate a variable's value between the data points. 72 Solution This equation involves both array multiplication and array exponentiation. Because v 0 > 0, minimizing v 0 . 52. The mean and variance of x are μ x = 10 and . 34 exist Checks for existence of file or variable. The function subfun demo is the primary function 102 a. Thus their contents will change depending on which features of the browser and Variable Editor you are currently using. This realization led to the development of structured programming. Suppose the step input is not a unit step but instead is 0 for t < 0 and 10 for t > 0. The random variable θ is then found by calculating θ = tan -1 (y/x) for each random pair (x,y). The choice depends on the circumstances. Note that y(0) = b. The data are created using the built-in function peaks. The examples and homework problems in this chapter explore some of these applications. 279 subplot(2,2,1) plot(time,temp,to'), xlabel('Time (sec)'), ... ylabel('Relative Temperature (deg F)') % % Plot the data on semilog scales. At a relative maximum of a curve y(x), the slope dy/dx is zero. 19. 229 Stem, Stairs, and Bar Plots MATLAB has several other plot types that are related to xy plots. The order of the reaction is the value of the reacting the reaction is the value of the reaction is the value of sqrt function is built-in, so typing exist('sqrt') will return a 5.12345 R(Ω) 1042 × 1043.5 × 1041052 × 105 v(V) 12080 110 200350 Solution (a) First we define two row vectors, one containing the resistance values and one containing the voltage values. The following table shows the average temperature for each year in a certain city. You can create column arrays, which have more than one row, by using a semicolon to separate the rows. Undefined function or variable 'n'.v Instead we will use parameter passing with a nested function (nested function 3.3). logical(A) Converts the elements of the array A into logical values. We must determine this information ourselves, and we will now show how to do this. EXAMPLE 9.5-1 Trapezoidal Profile for a DC Motor In many applications we want to accelerate the motor to a desired speed and allow it to run at that speed for some time before decelerating to a stop. Typing atan2d(-1,1) returns -45°, while 119 typing atan2d(1,-1) returns 135°. Table 11.6-1 summarizes the functions used in this section. (a) z = 1; (b) z = 0; (c) z = 1; (d) z = 1. An alternative notation is the use of the uppercase symbol; that is, 485 Step function We will use the one-sided transform, which assumes that the variable y(t) is zero for t < 0. For example, typing celldisp(A) displays $A{1,1} = 607265$. Nested functions are discussed in Section 3.3. The following program shows how this is done. Use the interface to interpolate to estimate the population in 1965. The number of pounds equivalent to 36 N. [breaks, coeffs, m, Computes the coefficients of the cubic spline polynomials for the data in x and y. 121 The output arguments are those values are computed by the function, using the given values of the input arguments. To prevent this, use the mlock function. Thus 90 percent of the sophomores and juniors return and advance in grade. Numerical algorithms differ partly as a result of the specific procedure used to obtain the difference equations. Thus the strings \tau and \omega represent the Greek letters τ and ω. Other uses of the simulation include finding the period of the speed's oscillation (about 0.013 s) and the maximum value of the disturbance torque that can be tolerated by the relay controller (it is about 3.7 N. T5.4-3 Use the fimplicit3 function to create a surface plot of the function 5.5 Summary 243 This chapter explained how to use the powerful MATLAB commands to create effective and pleasing twodimensional and three-dimensional plots. In this case, when the function is created, MATLAB commands to create effective and pleasing two interval and three-dimensional plots. handle. For example, 473 are given by the session: >> syms t x >> int(x,1,t) ans = t^2/2-1/2 int(sin(x),t,exp(t)) ans = cos(t)-cos(exp(t)) The following session gives an example for which no integral can be found. Energy cost: 24 cents per gallon of product. Function files are useful when you need to repeat a set of commands several times. To see a very detailed order of precedence, type help precedence in the Command window. 182 The statements are executed once during each pass, using the current value of the resistances and the voltage v 1 are R 1 = 5, R 2 = 100, R 3 = 200, R 4 = 150, R 5 = 200, R 5 $250 \text{ k}\Omega$, and v 1 = 100 V. The volume V and surface area A of a sphere of radius r are given by a. In other cases we might need to estimate the variable's value outside the given data range. A certain object moves with the velocity v(t) given in the table below. To find the time constants, which are the negative reciprocals of the real parts of the roots you type tau = -1/real(r). and settling time are available when you use the impulse(sys) function, but not the rise time. Apply your criterion, and plot y(t) for $\tau = 10$, $\omega = \pi$, and $\phi = 2$. Figure 10.2-6 Simulink model for $\dot{y} = -10y + f(t)$. The largest time constant indicates that the motor's response time is approximately 4(0.0184) = 0.0736 s. Hold the mouse button down, and drag the cursor to a port on another block. 167 isnan True if elements are undefined. The following example illustrates such an approach with a second- order equation. polyval(p,x) Evaluates the polynomial p at specified values of its independent variable x. However, it is important to cover at least the first four chapters, in Messiah. The session is >>x = 0:0.01:7; >>y = 3*cos(2*x); >>plot(x,y), xlabel('y') 22 Figure 1.3-1 A graphics window showing a plot. m = 3, c = 18, and k = 102 b. Because we know the length of the study (10 years), a for loop is a natural choice. To have Simulink automatically connect two blocks, select the Source block, hold down the Ctrl key, and leftclick on the Destination block. 167 isnumeric True if elements have numeric values. Trigonometric functions ending in d, such as sind(x) and cosd(x), take the argument x in degrees. Instead, you type the first number, with the spacing in the middle, separated by colons. They are composed of linear models that take effect when certain conditions are satisfied. Plot the cost versus r for 2 ≤ r ≤ 10 m, and determine the radius that results in the least cost. Figure 5.2-6 shows how these commands are applied. For example, typing B = {[2,4], [6,-9;3,5]; [7,2], 10}; creates the following 2 × 2 cell array: 96 [2 4] [7 2] 10 You can preallocate empty cell arrays of a specified size by using the cell function. 238, 240 Specialized plot functions Item Description Pages bar Creates bar chart. If you select a line in the graph, the corresponding entry in the Plot Browser is highlighted, indicating which column in the variable produced the line. Does it reach the desired height of 1? 361 The pinv Function and the Euclidean Norm The pinv function (which stands for "pseudoinverse") can be used to obtain a solution of an underdetermined set. From this table we can see that the maximum height is 8.8 m if v = 14 m/s and θ = 70°. This feature gives them an advantage over the interactive plotting tools discussed in Section 5.3. When you are creating plots, keep in mind that the actions listed in Table 5.1-3, while not required, can nevertheless improve the appearance and usefulness of your plots. You can use trigonometric identities to simplify the equations that appear in many applications. The following script file implements the backward difference and central difference methods for artificial data generated from a sinusoidal signal that is measured 51 times during one half-period. to exceed 20,000. 5 tan[3 sin -1 (13/5)] c. (In fact, the manufacturer did construct a 36-cup pot, and the fill time is approximately 4 sec, which agrees with our prediction.) EXAMPLE 6.1-4 A Cantilever Beam Model The deflection of a cantilever beam is the distance its end moves in response to a vertical force applied at the end (see Figure 6.1-7). The cell array looks like the following. For example, type x = [0, 4, 3, 6]. The projectile will strike the ground when h(t) = 0, which gives the time to hit t hit = 2(v 0 /g)sin A. ?'). (a) In terms of the parameter b, use MATLAB to find the points of intersection of the two ellipses described by and (b) Evaluate the solution obtained in part (a) for the case: b = 2. Then do the following. Use the Plot Editor to change the name of a data set. However, raising a matrix to a matrix power—that is, A B —is not defined, even if A and B are square. The natural logarithm, ln x, is computed by typing log(x). We will use this application to introduce the following Simulink elements: Subsystem blocks Input and output ports You can create a subsystem block from the library to the Model window or by first creating a Simulink model and then "encapsulating" it within a bounding box. When there is more than one variable, the diff function computes the partial derivative. For example, (2.4-4) Use the operator * to perform matrix multiplication in MATLAB. To add a second student to the database, use a subscript 2 enclosed in parentheses after the structure array's name and enter the new information. You can open existing scripts as live scripts. You can call
it from a function at any lower level. You will see the Property Editor—Line series dialog box that lets you change properties such as line weight and color, data-marker type, and plot type. To generalize the preceding multiplication to a column vector multiplied by a matrix, think of the matrix as being composed of row vectors. >> syms x > sym2poly(9*x^2+4*x+6) ans = [9 4 6] The function subs(E,old,new) substitutes new for old in the expression, or matrix, or a numeric value or matrix. Thus, in this case, Equation 384 (9.5-8) reduces to y = x 1. The Live Editor A live script is an interactive document that contains output, including graphics, along with the code that produced them, together in a single interactive environment called the Live Editor. When you connect the negative input port of the Sum block to the output po may also use a variable as the Initial condition of the Integrator block. The looping continues until the logical expression is false. Inverse cotangent; arccot . The features of MATLAB provide excellent support for such analyses. Using advanced methods found for example, in Chapter 10 of [Palm, 1014] and other references on system dynamics and control systems, we can find the characteristic equation of the total system to be (10.10-8) This shows that if D = 0 we can place the two roots anywhere by properly choosing P and I. New York: John Wiley & Sons, 1999. For example, consider these statements. The bottom graph in Figure 7.4-4 shows the results of fitting a cubic spline, which is 312 million of the total system to be (10.10-8) This shows that if D = 0 we can place the two roots anywhere by properly choosing P and I. New York: John Wiley & Sons, 1999. For example, consider these statements. clearly a better choice here. When the power supply is detached, the capacitor voltage decays with time, as the following data table shows. In Section 9.4 we show how to extend the techniques to higher-order equations. Use the MATLAB numerical differential equation solvers to obtain solutions. However, each form has its own advantages, depending on the purpose of the analysis. p = [1, -6, 10, 4]; % p contains the coefficients. However, you may use another text editor to create the file. % Compute the time to reach 120 degrees. Click on the Annotations panel to display a menu of objects such as lines, arrows, etc. Use a solid line type for each, the gtext command to label the sinh x curve, and the text command to label the 0.5e x curve. It is mounted on a pole of height h (see Figure P18). It is impossible to say which estimate is more accurate without having greater understanding of the temperature dynamics. Just because an array contains only 0s and 1s, however, it is not necessarily a logical array. For example, consider the temperature dynamics. session >>x = [-2, 0, 4]; >>y = find(x) y = 1 3 The resulting array y = [1, 3] indicates that the first and third elements of x are nonzero. Function files are discussed in Chapter 3. The equation describes the polar coordinates of an orbit with the coordinates of an orbit with the coordinates of an orbit with the first and third elements of x are nonzero. the element a ij . Figure 5.2-5 shows a rectilinear plot and a log-log plot of the function (5.2-1) 227 242 Figure 5.2-5 (a) Rectilinear plot of the function in Equation (5.2-1). Suppose we want to investigate how the resistance R 3 limits the allowable range for v 2. Determine its position at t = 10 s. Determine which fundamental principles are applicable. For example, if it were not for the subfunction mean in the previous example, we would have had to define a separate M-file for our mean function of the same name. Obtain a polar plot of this spiral for $0 \le \theta \le 4\pi$, with the parameter a = 2. You can use electronic mail to ask questions, make suggestions, and report possible bugs. Create a function called savings balance that determines the balance in a savings account at the end of every year for the first n years, where n is an input. For example, the following session produces and plots a cubic spline fit to the preceding data, using an increment of 0.01 in the x values. The independent variable in the Scope block is time t; the input to the block is the dependent variable y. format + Positive, negative, or zero; +. 413 LTI object functions Item Description Pages ss Creates an LTI object functions Item De typing A(:,1) = x. Plot D versus time until D reaches its minimum value. 37. cos -1 0.6 in degrees 19. For example, the inverse transform of 10/s + 4/(s + 3) is 10 + 4e - 3t. Thus we do not need the weight of the package to solve the problem. 408 9. Test Your Understanding T7.3-1 Use MATLAB to generate a vector y containing 1800 random numbers normally distributed with a mean of 7 and a standard deviation of 10. For example, to use the function, first define it in an M-file, using the vector x whose elements are x(1) = x and x(2) = y. For example, electrical engineers use them to design structures and machines; chemical engineers use them to compute material balances in chemical processes; and industrial engineers apply them to design schedules and operations. [9, 14, 18] b. We can choose to control the vehicle either by controlling the rotational speed or the rotational displacement of each wheel. fimplicit(f) Plots an implicit function. The brightness B at point P on the sidewalk is directly proportional to sin θ , and inversely proportional to the square of the distance d from the light to the point. denote as $w = p \ 1 \ z + p \ 2$. Then V(s) = 1/s and Equation (11.5-10) becomes To find the inverse transform, enter >> syms a b s >> ilaplace(b/(s*(a*s+1))) ans = b*(1-exp(-t/a)) Thus the forced response of Equation (11.5-7) to a unit-step input is b(1 - e - t/a). At the end of each chapter is a list of the key terms introduced in the chapter, with a reference to where they are introduced in the chapter is a list of the key terms introduced. (For a discussion of control systems, see, for example, [Palm, 2014].) The simulation is now ready to be run. This coverage establishes the terminology and some important concepts required to use the computer methods properly. 493 Run the simulation and plot the speed. To know for certain, we must solve the motor's differential equations. Compute the heat loss rate if the wall's area is 10 m 2. However, you need not start with the initial state to generate the same sequence. p = polyfit(deflection, force,1); % Here k = p(1) and c = p(2). Location Max. The following equation describes the temperature T b . Double-click on the block and enter the MATLAB expression sgn(u)*sqrt(abs(u)). tF = 6*pi*sqrt(L/g); % Approximately 3 periods. 497, 504 vpa Sets the number of digits used to evaluate expressions. 379 349 Figure P7 7. Rebuilding the infrastructure requires engineering methods different from those in the past because labor and material costs are now higher and environmental and social issues have greater importance than before. In addition, discuss another approach to obtaining a solution >>L_1 = 1; >>L_2 = 0.5; >>R = L_2/L_1; >>A d = 0:0.5:180; >>A r = A d*(pi/180); >>B = asin(R*sin(A r)); >>d = L_1*cos(A r); >>plot(A d,d),xlabel('A (degrees)'), ... ylabel('A (degree but if you want to obtain a labeled and printed plot, you can use the To Workspace block, which is described in the results of the following operations by hand and use MATLAB to check your results. Both Table 5.2-1 Specifiers for data markers, line types, and colors Data markers † Line types Colors Dot (·) · Solid line - Blue b Cross (×) × Dash-dotted line -. MAT-files have the extension .mat and are used to save the names and values of variables created during a MATLAB session. Use Y = rand(m,n,p,...) to generate a multidimensional array Y having random elements. To compute the Taylor approximation of order n - 1 about x = 0, use the function taylor(f,x, order', n). The angle corresponding to x = 2, y = -320. The following program computers the distance and determines which point is farthest from the origin. MATLAB is available for MS Windows and Macintosh personal computers the distance and determines which
point is farthest from the origin. and for other operating systems. Throughout each chapter 1, and now we point out some more of its useful discussed the basic features of the Editor in Chapter 1, and now we point out some more of its useful features. With pchip the slopes at the data points are computed to preserve the "shape" of the data and to "respect" monotonicity. In transform notation this expression becomes In Figure 10.8-1, we used the values K P = 4 and K I = 5/4. The actuator is a motor and the plant is the generic term for the object being controlled (e.g., a vehicle wheel). The variables s and r created this way are not the same as user-defined function files. The coefficients a i , b i , c i , and d i for each polynomial: 1. 10.5 Transfer-Function Models The equation of motion of a mass-spring-damper system is (10.5-1) As with the Control System toolbox, Simulink can accept a system description in transfer-function form and in state-variable form. Consider Figure 10.7-7 for the case where there are three RC loops with the values R 1 = R 3 = 10 4 Ω , R 2 = 5 × 10 4 Ω , C 1 = C 3 = 10 -6 F, and C 2 = 4 × 10 -6 F. The end-of-chapter problems are the exception to this numbering system. MATLAB is programmable and has the same logical, relational, conditional, and loop structures as other programming languages. Variables in normal mathematics text appear in italics, for example, y = 6x. Random walk theory has been applied to understanding a variety of processes including diffusion, stock prices, and games of chance. The disp function (short for "display") can be used to display the value of a variable but not its name. A company must purchase five kinds of material. (Answer: -6.) T2.4-3 Use MATLAB to show that Evaluating Multivariable Functions To evaluate a function of two variables, say, z = f(x, y), for the values x = x 1, x 2,..., x m and y = y 1, y 2,..., y n, define the $m \times n$ matrices: 83 When the function z = f(x, y) is evaluated in MATLAB using array operations, the resulting $m \times n$ matrix z has the elements z ij = f(x i, y j). However, for complicated integrand functions, using a function file is preferable. Find the array quotient w = x/y. If you plot multiple data sets as a subplot, then residuals can be plotted only in a separate figure window. for k = 1:n plotting expressions M(k) = getframe; % Saves current figure in array M end movie(M) For each of 20 values of the parameter b from b = 1 to b = 20. (b) It is desired to move the hand along the straight line where x is constant at 6 ft, and y varies from y = 0.1 to y = 3.6 ft. ylabel('Fill Time per Cup (sec)'),axis([5 36 0 10]) % % Compute the fill time for V = 36 cups. The optional form is syms x y, laplace(function,x,y), where function of x, and y is the Laplace variable. Parts with more complex geometries and internal features can be produced. Figure P52 a. In such cases, the function will return the expression unevaluated. If checked, the data are centered at zero mean and scaled to unit standard deviation. You can also type pwd to see the path. This is not a Simulink diagram but is a so-called block diagram that shows the physical structure. These conditions are often the specified values of y and dy/dt at t = 0. Using Variables MATLAB assigns the most recent answer to a variable called ans, which is an abbreviation for answer. You can waste many hours by plunging into the problem without a plan of attack. (c) Using the parameter values in part (b), determine the roots for the following values of c (in newton meter second): c = 0, c = 0.01, c = 0.1, and c = 0.2. For each case, use the roots to estimate how long the motor's speed will take to become constant. For the case where $\theta(0) = 0.8\pi$, the period of the numerical solution is about 3.3 s. To talk about the ebook options, please contact your McGraw-Hill sales rep. 3.5 Summary In Section 3.1 we introduced just some of the most commonly used mathematical functions. Refer to Figure 10.7-2. Redo the Simulink suspension model developed in Section 10.9, using the spring relation and input functions. standard deviation were found to be $\mu = 69.3$ in. If d 2 f/dx 2 > 0, the point is a relative minimum; if d 2 f/dx 2 < 0, the point is a relative minimum; if d 2 f/dx 2 < 0, the point is a relative minimum; if d 2 f/dx 2 < 0, the point is a relative maximum. the following program: x1 = 0.0.01:3; $y1 = 25^{exp(0.5*x1)}$; $y2 = 40^{(1.7, x1)}$; $x2 = \log ((y - 1.7, x1)$; $x2 = \log ((y - 1.7, x1)$; $y2 = 40^{(1.7, x1)}$; $y2 = 10^{(1.7, x1)}$ exponential functions y = 25e 0.5x and y = 40(1.7) x both produce straight lines on a semilog plot with the y axis logarithmic. If E represents an equation, the equation is expression must be enclosed in single quotes. Because MATLAB looks for private functions before standard M-file functions, it will find a private function named, say, cylinder.m before a nonprivate M-file named cylinder.m. Primary functions and subfunctions can be implemented as private functions. The elements in the second row are the labor costs, and those in the transportation costs. 40. Figure 10.3-3 Unit-step response of the two-mass suspension model. In addition, the method is limited to cases where the matrix A is square, that is, cases where the number of equations equals th valve opening. The mean distance reached after 100 steps should be about 50 with a standard deviation of a bout 11. Functions of Random Variables If y and x are linearly related as (7.3-3) and if x is normally distributed with a mean μ x and standard deviation of y are given by (7.3-4) (7.3-5) However, it is easy to see that the means and standard deviations do not combine in a straightforward fashion when the variables are related by a nonlinear function. At 1:00 p.m. the aircraft are located as shown in Figure P52. 575 getframe Captures current figure in a frame. 136 Anonymous Functions Anonymous functions enable you to create a simple function without needing to create an M-file for it. Not every problem can be solved with an algorithm, and some potential algorithm, and some potential algorithm to plot d versus A. The Current Object Properties item enables you to change the properties of an object in the figure. Check your answers by hand. Function flip coin simulates the flip (0 for a tail and 1 for a head) as the outputs. For example, if x = [0,3,9] and y = [14, -2,9], then z = [0,3,9] and y = [14, -2,9], then z = [0,3,9] and y = [14, -2,9]. ~x returns the array z = [1,0,0] and the statement u = ~x > y returns the result u = [0,1,0]. The inclusion of a website does not guarantee the accuracy of the information presented at these sites. You will see listed imag Complex imaginary part Imaginary unit j Imaginary unit 114 Note that imaginary is not a MATLAB function, but the word is found in the Help descriptions of the MATLAB function imag and the special symbols i and j. If the total enrollment is ≤ 4000 , increase admissions by 100 and transfers by 50 each year. 280 5. Determine the water height h(t) at t = 10 min. The definition of matrix rank is as follows. The thermostat switches q on at the value q max whenever the temperature is above $71^{\circ}F$. We can use the following test to determine if a solution exists to Ax = b and whether it is unique. This operator enables you to continue typing the line after you press Enter. If E represents an equation, the equality symbol (==). Double-click on it to open the Block Parameters window, and make sure the Amplitude is set to 1, the Bias to 0, the Frequency to 1, the Phase to 0, and the Sample time to 0. Place the same command in the calling program. For the data given in Problem 2: a. Simulation is often used in operations research, which is the quantitative study of an organization. >t = 0:pi/50:10*pi; >>plot3(exp(-0.05*t).*cos(t),t),... xlabel('x'),ylabel('y'),zlabel('y' with the plot3 function, and that we can label the z axis by using the zlabel function, which we have seen for the first time. The outer pair of parentheses is required to indicate the target of the square root operation. The
scalar Max Percent Error is the maximum percent error in the four predictions. 555 37. Nevertheless, for smaller projects, sketching a flowchart and/or a structure chart might help you organize your thoughts before you begin to write the specific MATLAB code. Add each row and store the result in an array E. Both models have been used extensively to model a number of different populations, including bacteria, animals, fish, and human populations. Each chapter has a summary section that reviews the chapter's objectives. The tank is initially empty. Display this message and stop. A for loop is a logical choice to solve this problem because we know the burn time b and t hit , the time it takes to hit the ground. It is recommended to avoid using global variables. Also determine the total length of fence required. This symbol is called the assignment or replacement operator, and it cannot be used the same way as the equals sign is used in mathematics. Start scales from zero whenever possible. 419, 423 step Computes and plots the step response of an LTI object. Be aware that larger values of d will require more time and computer memory to perform operations. Select Basic Fitting from the Tools menu of the Figure window. 229, 231 ginput Reads coordinates of the cursor position. For this case, rank(A) = rank([A b]) always, and thus the set always has the trivial solution x = 0. Numerically evaluate single integrals whose integrands are given as numerical values. 367 399 think that the average of these two slopes would provide a better estimate of the derivative at x = x 2, because the average tends to cancel out the effects of measurement error. Obtain a linear model y = a 0 + a 1 x 1 + a 2 x 2 for the following data to describe the relationship. The following data to describe the relationship. The variable u is also local to the function. The Editor uses colors for different purposes, and the default colors described here can be changed in Preferences in the Environment category on the HOME tab. These will be discussed later in this section. The result is h = [9, 1, 2, 9], which corresponds to h(x) = x 2 + 2x + 9. The basic form is d = 1. polyder(p), where 400 p is a vector whose elements are the coefficients of the polynomial, arranged in descending powers. Simulink provides a graphical user interface that uses various types of elements called blocks to create a simulation of a dynamic system, that is, a system that can be modeled with differential or difference equations whose independent variable is time. Type in the file shown previously, using the keyboard and the EDITOR menu. 177 Cell and structure functions Item Description Pages cell Creates cell array. If p(0) and r are the same for both models, it is easy to see that the exponential model will predict a larger population for all t > 0. Each function gives a straight linee when plotted using a specific set of axes: 1. plot(y) Plots the values of y versus their indices if y is a vector. Check the sensitivity of the solution by plotting T versus D. Suppose the mass is acted on by a disturbance force d, which acts against f. For example, if you open a file, the EDITOR, PUBLISH, and VIEW tabs will appear. This conversion is necessary because MATLAB trigonometric functions use radians, not degrees. Thus the amplitude of oscillation is θ(0), and the period is information to select a final time and to check our numerical results. You can use the Editor built into MATLAB to create M-files. The topic of Laplace transforms is included because Laplace transforms are one way of solving differential equations, and are often covered along with differential equations. % Deflection and force data. $x = 0:0.01:2; y = \sinh(x); z = \tanh(x); plot(x,y,x,z,'--'), xlabel('x'), ... ylabel('Hyperbolic Sine and Hyperbolic Sine and Hype$ trigonometric \dagger acos(x) acot(x) acos(x) acot(x) acos(x) asin(x) atan(x) ata The bar weighs 2 lb. The variable y represents force in newtons, and the variable x represents time in seconds. >> syms x y >> E = $(x-5)^2+(y-3)^2$ >> collect(E) ans = $x^2-10*x+25+(y-3)^2$ >> collect(E) ans = $x^2-10*x+25+(y-3)^2$ >> collect(E) and the variable x represents time in seconds. >> syms x y >> E = $(x-5)^2+(y-3)^2$ >> collect(E) and the variable x represents time in seconds. >> syms x y >> E = $(x-5)^2+(y-3)^2$ >> collect(E) and the variable x represents time in seconds. >> syms x y >> E = $(x-5)^2+(y-3)^2$ >> collect(E) and the variable x represents time in seconds. >> syms x y >> E = $(x-5)^2+(y-3)^2$ >> collect(E) and the variable x represents time in seconds. >> syms x y >> E = $(x-5)^2+(y-3)^2$ >> collect(E) and the variable x represents time in seconds. >> syms x y >> E = $(x-5)^2+(y-3)^2$ >> collect(E) and the variable x represents time in seconds. >> syms x y >> E = $(x-5)^2+(y-3)^2+(y-3)^2$ >> collect(E) and the variable x represents time in seconds. >> syms x y >> E = (x-5)^2+(y-3)^2 = (x-5)^2+(y-5)^2 = (x-5)^2 = (x-5)^2+(y-5)^2 = (x-5)^2+(y-5)^2 = (x-5)^2+(y-5)^2 = (x-5)^2+(y-5)^2 = (x-5)^2 tank with a volume 20 percent greater but having the same height. Undefined functions and differential equations are available but these require numerical values of motor variable 'x'. 275 Figure 6.1-2 Examples of power functions. The result is the coefficient array of the product polynomial. Mathematical methods based on transfer functions and differential equations are available but these require numerical values of motor variable 'x'. 275 Figure 6.1-2 Examples of power functions. amplifier parameters and of masses/inertias (see Chapter 10 in [Palm, 2014]). Obtain a function that describes these data. This window contains several items, the number and nature of which depend on the specific type of block. 199 dbquit Quit debug mode. 8.* Engineers must be able to predict the rate of heat loss through a building wall to determine the heating 350 system requirements. Solution The following program first creates the model sys from the matrices A, B, C, and D. 357 program to find the currents for the case R 1 = 5, R 2 = 100, R 3 = 200, R 4 = 150, and R 5 = 250 k\Omega and v 1 = 100 and v 2 = 50 V. function 3. The script file is the following. Estimate the percentage of fabric samples that will have a breaking strength no less than 297 lb and no greater than 303 lb. Compute the hypotenuse r. Show norm of residuals. The script file is the following: total = 0; k = 0; while total < 1e+4 k = k + 1; total = 5*k^2 - 2*k + total; end disp('The number of terms is:') disp(total) The sum is 10,203 lb. Compute the hypotenuse r. Show norm of residuals. after 18 terms. The reasons for this are discussed later in this chapter. It can be used to make a half-wave rectifier, as shown in Figure P28a. To use this method, let n be the number of data points and write the linear equation in matrix form as Xa = y, where where x 1i, x 2i, and y i are the data, i = 1, . This process is called extrapolation. You can use variables to write mathematical expressions. v (mi/hr) 20 30 40 50 60 70 d (ft) 45 80 130 185 250 330 11.* The number of twists y required to break a certain rod is a function of the percentage x 1 and x 2 of each of two alloying elements present in the rod. Note also how the residuals systematically increase with t, indicating that the exponential cannot describe the data's behavior after a certain time. MATLAB uses many significant figures in its calculations, but we rarely need to see all of them. Then create each subfunction with its own function defining code. a. Consider the equation $\dot{y} = 10f(t)$. You can use the operators + - * / and $^{\circ}$ with symbolic expressions to obtain new expressions. We would have obtained the same plot if we had specify the number of bins to be six. 448 Figure P34 492 35. Because polynomial derivatives can be obtained from a symbolic formula, the polyder function is not a numerical differentiation operation. This expression is a row vector, which is a horizontal arrangement of the elements. >> v1 = rand(1,5) v1 = 0.9670 0.5472 0.9727 0.7148 0.6977 0.0062 0.2530 0.4348 Repeat the same command. Its roots determine the stability, response time, and seniors are 202 These four equations can be written in the following matrix form: In Example 4.9-2 we will see how to use MATLAB to solve such equations. The window can be closed by selecting Close on the File menu in the graphics window. Apply interpolation to data. Each component is manufactured on a different machine, so the random variations in their lengths are independent of one another. Develop a matrix equation on which to base a simulation model that can help in this analysis. If the total enrollment is > 4000, hold admissions and transfers constant. The pressure of 1 atm. The function findsym(E) finds the symbolic variables in a symbolic variables in a symbolic expression, and returns a string containing all of the symbolic variables appearing in E. The plot is shown in Figure 9.3-2. The difficulty with most renewable energy sources is that they are diffuse, so the energy must be concentrated somehow, and they are intermittent, which requires a storage method. Specify the input data to be used by the program. y int = pchip(x,y,x int) Similar to spline but uses piecewise cubic Hermite polynomials for interpolation to preserve shape and respect monotonicity. If the concentration is initially zero and a constant delivery rate is started and maintained, the concentration as a function of time is described by 103 where a is a constant that depends on the delivery rate. This type of file contains MATLAB commands, so running it is equivalent to typing all the commands, one at a time, at the Commands, one at a time, at the Commands, so running it is equivalent to typing all the commands, one at a time, at the Commands, so running it is equivalent to typing all the commands, so running it is equivalent to typing all the commands, so running it is equivalent
to typing all the commands, so running it is equivalent t workspace that start with A. For example, typing help log10 in the Command window produces the following display: The help Function LOG10 Common (base 10) logarithm. The following are the equations of motion for a projectile launched with a speed s 0 at an angle θ above the horizontal, where x and y are the horizontal and vertical coordinates g is the acceleration due to gravity, and t is time. If no symbolic variables are found, findsym returns the empty string. This example illustrates a common situation in which it helps to remember that .^ is a single symbol; the dot in 3. p is not a decimal point associated with the number 3. Type help polyfun for more information on this category of commands. For the data given in Problem 1: a. So the dominant time constant must be 0.1, and at least one root must have a real part equal to -10. MATLAB files are used for converting 3D surface data into Standard Tessellation Language (STL) files, a format widely used in AM. The first solution is , . Multiple Linear Regression Suppose that y is a linear function of two or more variables x 1, x 2, . (That is, for what value of n will the addition of the next term in the series produce a change in T of less than 1 percent?) Use your physical insight to determine whether this answer gives the correct temperature at the center of the plate. Test Your Understanding T2.5-1 Use MATLAB to obtain the roots of Use the poly function to confirm your answer. Set the Rising slew rate to 1 and the Falling slew rate to -1. 167 finite True if elements are finite. For example, are given by >> syms h x >> limit((x-3)/(x^2-9),3) ans = 1/6 >> limit((x-3)/(x^2-9),3) and = 1/6 >> limit($(x-3)/(x^2-9)$,3) and = 1/6 >> limit((x-3)limit. For example, >>axes handle = qca axes handle = qca axes handle = qca axes handle = Axes with properties: XLim: YLim: XScale: YScale: GridLineStyle: Position: Units: [1 10] [5 50] 'linear' '-' [0.1300 0.1100 0.7750 0.8150] 'normalized' Typing qet(axes handle) returns a very extensive list of axes properties. Consider Example 8.2-3 (a) in Section 8.2, except that now the voltage v 2 is unspecified. || ShortCircuit OR Operator for scalar logical expressions. This is not an important issue because it hardly makes sense to compute the sine of logical data or logical variables. 25. Cyan c Circle (o) o Dotted line : Green g Plus sign (+) + Magenta m Square (\Box) s Red r Diamond (*) d White w Five-pointed star (*) p Yellow y † Other data markers are available. The absolute value of a vector x is a vector whose elements are the absolute values of the elements of x. The Window menu lets you switch between the Command window and any other Figure windows. menu. 88 fieldnames Returns field names in a structure array. One such simple algorithm, called on-off control, was given in Example 10.4-2 (Figure 10.4-9). 167 find Finds indices of nonzero elements. For example, the letter S in the name Leslie Student occupies the eighth column in the vector name. r = 8 sin y c. The tank has a radius of r = 5 ft and has a 1-in.-diameter hole in the bottom. 120 514 nargin Number of function input arguments. 260 meshz Same as mesh with vertical lines underneath. 313 Figure 7.1-1 Histograms for 20 tests of thread strength. Your model should now look like Figure 7.1-1 Histograms for 20 tests of thread strength. or a polynomial up to degree 10. Chapter 8: Linear Algebraic Equations......Page 32125. Plot the angle (in degrees) of the line of sight from an observer at the coordinate origin to the boat as a function of time for 3 hours. Write a user-defined function that accepts these four points as input and computes the coefficients a, b, c, and d. eps Specifies the accuracy of floating point precision. The path can be changed by clicking on the path shown until the desired subfolder appears (assuming it already exists). Suppose that 15 percent of the freshmen do not return and that 10 percent repeat freshmen do not return and that 10 percent repeat freshman year. If y(0) = 0, try the power function. They can be derived from Newton's law. 261 fimplicit3(f) Plots an implicit 3-D function. Find the matrix product $z = y^*x$. The square blocks are Constant blocks from the Sources library. The statement y = find(x>0) is equivalent to m = 0; for k = 1:length(x) if x(k) > 0 m = m + 1; y(m) = k; end end If you are familiar with a traditional programming language such as FORTRAN or BASIC, you might be inclined to solve problems in MATLAB using loops, instead of using the powerful MATLAB commands such as find. Type random numbers. It can be used in an introductory course, as a self-study text, or as a supplementary text. (a) The case where On > Off. Use the data to compute the average speed required to drive each route. The generalization to third order and higher equations is straightforward. Comparing coefficients shows that P = 60 and I = 500. 260 shading. For example, typing pi = sym('1/3') create symbolic constants that avoid the floating point approximations inherent in the values of n 498 and 1/3. Solution Because we do not know how many times we must evaluate the expression $5k \ 2 - 2k$, we use a while loop. Strings are stored as row vectors in which each column represents a character. Plot the motor's speed and current versus time. protect against being dropped while the delivery person is carrying it. (Answer: 8610.) T4.5-3 Write a program to produce the following matrix: Note the following matrix: Note the following rules when using for loops with the loop variable expression k = m:s:n: The step value s may be negative. (Function B can call D, and D can call B.) 3. Type dbclear test3 5 to clear the breakpoint at line 5. Note that the step size has been automatically selected by the ode45 function. 167 isempty True if matrix is empty. The correct answer is the slope of the straight line passing through the point (x 2, y 2); but we do not have a second point on that line, so we cannot find its slope. 84 function Creates a user-defined function. You can also drag the variable into an axes set, and MATLAB will select an appropriate plot type. 21. Refer to Figure 10.2-2. cos -1 0.7 in radians b. Matrix Methods We can use matrix operations to reduce the number of lines to be typed in the derivative function file. The path tells us and MATLAB how to find a particular file. The distance between atoms in single-crystal silicon is 0.5 nm. Use two methods to create the vector x having 100 regularly spaced values starting at 5 and ending at 28. 114 fix Rounds to the nearest integer toward zero. Note that their syntax is identical to the nearest integer toward zero. [0.1,0,0,0;0.75,0.05,0,0;0,0.9,0.05,0;0,0,0.9,0.05,0;0,0,0.9,0.05]; % Initial enrollment vector. Northup; and S. From the Pythagorean theorem, the length of the number. what dirname which item Lists the MATLAB-specific files in directory dirname. Thus our derived model is T = 68 + b(10) mt . For specific parameter values, the transfer function has the form Figure 10.8-1 shows a Simulink model for this system. Compute height as a function of time, using the appropriate equation, depending on whether burnout has occurred. Their names and brief descriptions are displayed when you type lookfor imaginary. The result is y = 0.6321. dsolve(eqn1,eqn2, Returns a symbolic solution of set of equations specified by the symbolic expressions ..., cond1, cond2, and so on. For example, typing >>syms x y >>s = x + y; >>r = sqrt($x^2 + y^2$); creates the symbolic variables s and r. Test Your Understanding T1.3-1 Use MATLAB to determine how many elements are in the array cos(0):0.02:log10(100). 403 It will be convenient to use the following abbreviated "dot" notation for derivatives. Other manufacturers are investigating plastic bodies made from recycled materials. Table 4.9-2 College enrollment model 193 % Script file enroll1.m. Computes college enrollment. syms x y u v Creates the symbolic variables x, y, u, and v. Put a grid on the plot and use the ginput function to determine the coordinates of the peak of the curve. You can also click on the File menu, and then click on Exit MATLAB. Use a text editor to create a file from the data given in Problem 28, but separate each number with a semicolon. can be described by the normal distribution. >> syms b x1 y >> findsym(6*b+y) ans = b,y >> findsym(6*b+y+x) % Note:x has not been declared symbolic. Use both the linear and cubic spline interpolations to
estimate the time it will take for the temperature to equal the following values: T = 75, 85, 90, 105. Following World War II another burst of such activity culminated in the construction of the interstate highway system. polarplot(theta,r,'type') Produces a polar plot from the polar coordinates theta and r, using the line type, data marker, and colors specified in the string type. Enter the coordinates x and y. function ydot = RC circuit(t,y) % Model of an RC circuit with no applied voltage. Create a 5 \times 3 matrix containing the amounts spent on each item for each month. The summations are given by >> symsum(k,0,n-1) ans = 55 >> symsum(k,0,n-1) ans = 30 >> symsum(k,0,n-1) ans = 55 >> symsum(k,0,n-1) a enclosure is to be built to have an area A of 1600 ft 2. There are several variations of this syntax. First, we initialize the random number generator to make the results in this example repeatable. y = sin(x) + .05*(rand(1,51) - 0.5); % Backward difference estimate of dy/dx. important to know the location of the files you use with MATLAB. The choices for method are 'nearest', 'linear', 'next', previous', 'spline', and 'pchip'. 6 statements. Thus in the statement A && B, if A equals logical zero, then the entire expression will evaluate to false, regardless of the value of B, and therefore there is no need to evaluate B. Plot the trajectories for v = 10 m/s corresponding to five values of the angle A: 20°, 30°, 45°, 60°, and 70°. The extended syntax for all the functions treated in this section is extensive. Let x 1 (k) be the number of freshmen in year k, where k = 1, 2, 3, 4, 5, 6, ... When the input is greater than or equal to the upper limit 457 419 Figure 10.5-1 A dead-zone nonlinearity. Obtain a similar equation for the coefficients b 1, b 2, and b 3. Simulink will sense the arrow automatically and make the connection. Figure 4.9-2 shows the resulting plot. The form dsolve(eqn,cond1, cond2,...) returns a symbolic solution of the ode specified by the symbolic expression eqn, subject to the conditions specified in the expressions 528 cond1, cond2, and so on. Plot the curve fits along with the data points. For example, to compute $w = 5 \sin u$ for u = 0, 0.1, 0.2, ..., 10, the session is $>>u = 0; 0.1; 10; >>w = 5*\sin(u)$; The single line $w = 5 \sin u$ for u = 0, 0.1, 0.2, ..., 10, the session is $>>u = 0; 0.1; 10; >>w = 5*\sin(u)$; The single line $w = 5 \sin u$ for u = 0, 0.1, 0.2, ..., 10, the session is $>>u = 0; 0.1; 10; >>w = 5*\sin(u)$; The single line $w = 5 \sin u$ for u = 0, 0.1; 0.2, ..., 10, the session is >>u = 0; 0.1; 0.2, ..., 10, the session is >>u = 0; 0.1; 0.2; ..., 10, the session is >>u = 0; 0.1; 0.2; ..., 10, the session is >>u = 0; 0.1; 0.2; ..., 10, the session is >>u = 0; 0.1; 0.2; ..., 10, the session is >>u = 0; 0.1; 0.2; ..., 10, the session is >>u = 0; 0.1; 0.2; ..., 10. Instead, you can use the subs function to substitute an array of values for the independent variable, and then use the plot function to evaluate the result numerically. As another example of interpolation, consider 10 evenly spaced data points generated by the function to evaluate the result numerically. As another example of interpolation, consider 10 evenly spaced data points generated by the function to evaluate the result numerically. As another example of interpolation, consider 10 evenly spaced data points generated by the function to evaluate the result numerically. product has the same number of rows as A and the same number of columns as B. The drawnow Command The drawnow command causes the previous graphics command to be executed immediately. vpa(E,d) Sets the number of digits used to evaluate the expression E to d. Years evenly divisible by 100 but not by 400 are not leap years. Thus the closest the object gets to Earth's orbit is approximately 0.3 AU. If you create the symbolic constant, and you no longer obtain a numerical value when you type its name. The fplot3 function, introduced in MATLAB release R2016a, supplements the plot3 function. From the geometry of a circular arc we can see that This can be solved for R C as follows. The Insert Legend button enables you to insert a legend in the plot. In transfer function form this is (10.10-7) We note that a rotational system, such as a wheel driven by a motor, has the same form where v represents angular velocity, m represents mass moment of inertia, f represents motor torque, and d represents a disturbance torque. You cannot directly specify a function; you must first compute and store the function; you must first compute and store the variable y defined as y = [6, 3, 4, 0] is not the same as x because the order is different. Test Your Understanding T11.3-1 Given that $y = \sinh(3x) \cosh(5x)$, use MATLAB to find dz/dy. Then we evaluate the solution for numerical values of y, and plot the results. For example, to compute $z = (e \ y \ sin \ x) \cos 2 \ x$, you must type $z = \exp(y)$.*sin(x).*($\cos(x)$).^2. For example, type $C = \cos(2x) \ln(4y)$, use MATLAB to find dz/dy. Then we evaluate the solution for numerical values of y, and plot the results. cell(3, 5) to create the 3 × 5 cell array C and fill it with empty matrices. Further studies in fluid mechanics have identified the relation more precisely, and the result is that the volume flow rate through the hole, g is the acceleration due to gravity, and C d is an experimentally determined value that depends partly on the type of liquid. A robot rotates about its base at 2 rpm while lowering its arm and extending its hand. c. (Answer: y(t) = C 1 sin bt + C 2 cos bt) T11.4-2 Use MATLAB. 153 157 Figure 4.1-2 Flowchart representation of the verbal description of the if statement. The enclosure is to be 102 built to have an area A of 1600 ft 2. Suppose x takes on the values x = 1, 1.2, 1.4, ..., 5. What is the total spent on all materials in the three-month period? Its boundaries are given by $u = \pm 1$ and $v = \pm 2$, and the integral becomes 365 and the MATLAB session is >>fun = @(u,v)u.^4*v^2; >>A = (1/3)*integral2(fun, -1, 1, -2, 2)

The answer is A = 0.7111. Let x 2 (k) be the number of sophomores in year k. This process requires the matrix to have the same number of rows as columns; that is, it must be a square matrix. The following assumptions will simplify the problem and are consistent with the problem and are consistent with the problem statement as we understand it: a. 4.* The equation of circle of radius is a square matrix. centered at x = 0, y = 0 is Use the subs and other MATLAB functions to find the equation of a circle of radius r centered at the point x = a, y = b. (These values correspond to a starting hand location of x = 0, y = 2 ft for L 1 = 4 and L 2 = 3 ft.) c. The inventory, required components, and profit for each product appear in the following table. However, this convention is not good practice in MATLAB, which uses these symbols for the imaginary unit . Then click on the Mux icon in the model window, and drag one of the corners to expand the box so that all the text is visible. Once the blocks have been placed, connect arrows as shown in the figure. The function simplify(E,IgnoreAnalyticConstraints', value) controls the level of mathematical rigor to use on the analytical constraints while simplifying (non-negativity, division by zero, etc). Use MATLAB to solve this equation for $\theta(t)$ for two cases: $\theta(0) = 0.5$ rad and $\theta(0) = 0.8\pi$ rad. However, MATLAB uses algorithms called random number generators that give results that pass certain tests for being random and independent. Documenting programs properly is very important, even if you never give your programs to other people. The xy trajectory of a projectile having an initial speed v 0 at an angle A with the horizontal is described by the following equations, where x(0) = y(0) = 0: Use the values v 0 = 100 m/s, A = 35 degrees, and g = 9.81 m/s 2. Use the default settings for the remaining parameters. In such cases the algebra involved in obtaining the analytical solution might not be worth the effort, especially if the main objective is to obtain a plot of the solution. So we recommend that the engineer arrange to have this additional measurement made. Solution To simulate this model in Simulink, define a set of variables that lets you rewrite the equation as two first-order equations. We may "nest" if statements, as shown by the following example. If a semicolon is not put at the end of a line, MATLAB displays the Table 1.1-3 Commands for managing the work session Command Description clc Clears the Command window. Use a random number generator to produce 1000 uniformly distributed numbers with a mean of 10, a minimum of 2, and a maximum of 18. 73, obviously no!) T2.4-2 Use MATLAB to compute the dot product of the following vectors: Check your answer by hand. To change this, double-click or the block, and in the List of Signs window, type |+-. 521 Test Your Understanding T11.3-3 Given that y = x sin(3x), use MATLAB to find - y dx. 407 Figure 9.3-2 Free response of an RC circuit. MATLAB to find - y dx. 407 Figure 9.3-2 Free response of an RC circuit. year and that 200 sophomores each year transfer from other schools. Unshaded rectangles can be obtained by using the syntax histogram(y, 'FaceColor', 'none'). Now consider what happens when you call this function in various ways in the Command window. The Toolstrip looks like Figure 1.1-1 when the HOME tab is clicked. If s is positive, the loop will not be executed if m is greater than n. Use MATLAB to calculate a. The wall shown in Figure P8 consists of four layers: an inner layer of plaster/lathe 10 mm thick, a layer of fiberglass insulation 125 mm thick, Figure P8 381 a layer of plaster/lathe 10 mm thick, and an outer layer of plaster/lathe 10 mm thick, a layer of fiberglass insulation 125 mm thick, Figure P8 381 a layer of plaster/lathe 10 mm thick, and an outer layer of uses the isempty(x) function, which returns a 1 if the array x is empty and 0 otherwise. MATLAB gives the answer x = 2.0438e-006, which is essentially 0, the true minimum point. (Answer:) T11.2-2 Use MATLAB to solve the equation set: x + 6y = a, 2x - 3y = 9 in terms of the parameter a. 122 Figure 3.2-2 The Editor after a function has been created. This function was introduced in MATLAB release R2016a, and supplements the mesh function. 8.* Array multiplication operator. These steps describe a general problem-solving procedure. As another example, is a parabola that touches the x axis at x = 0. An expression of the plot function to the plot function to the plot function. variable p, which is a figure identifier called a figure handle. We will see an example of the lsim function shortly. (9.5-13) To find the response for zero initial conditions, over the interval $0 \le t \le 10$, using a step size of 0.01, the session is >>sys5 = tf(4,[1,2,4]); >>[u, t] = gensig('square',5,10,0.01); >>[y, t] = lsim (sys5,u,t); plot(t,y,u), . Step response for zero initial conditions, over the interval $0 \le t \le 10$, using a step size of 0.01, the session is >>sys5 = tf(4,[1,2,4]); >>[u, t] = gensig('square',5,10,0.01); >>[y, t] = lsim (sys5,u,t); plot(t,y,u), . Step response for zero initial conditions, over the interval $0 \le t \le 10$, using a step size of 0.01, the session is >>sys5 = tf(4,[1,2,4]); >>[u, t] = gensig('square',5,10,0.01); >>[y, t] = lsim (sys5,u,t); plot(t,y,u), . Step response for zero initial conditions, over the interval $0 \le t \le 10$, using a step size of 0.01, the session is >>sys5 = tf(4,[1,2,4]); >>[u, t] = gensig('square',5,10,0.01); >>[u, t] can be characterized by the following parameters. How well does the motor speed follow a trapezoidal profile? To compute the mean and standard deviation, reconstruct the original (raw) height data from the absolute frequency data. The response time is longer than expected because of the overshoot. A third method is to compute the points to be plotted ahead of time and store them in arrays. The program in Table 4.6-2 performs the task and is a modification of the program in Table 4.5-2. However, if you plot multiple data sets as a subplot, and at least one data set is two-dimensional, then the interface is enabled. Here are some examples: v(:) represents all the row or column elements of the vector v. Since y is local to the function. Find the location of the distribution center (to the nearest solution. Coverage of this section is therefore optional. This function was introduced in MATLAB release R2016a, and supplements the surf function. Find the location of the distribution center (to the nearest mile) that minimizes the total weekly cost to service all six customers. See the MATLAB Help for details. 58 Table 2.1-1 Basic syntax of array functions* Command Description find(x) Computes an array containing the indices of the nonzero elements of the array x. This is the input. mu = mean(y); for k=1:4 S(k) = sum((y-mu).^2); r2(k) = 1 - J(k)/S(k); end S r2 Scaling the Data The effect of computational errors in computing the coefficients can be lessened by properly scaling the x values. meshc(x,y,z) Same as mesh but draws a contour plot under the surface. The following operations, with the value of p given here, are equivalent and give the correct answer: 3.^p 3.0.p 3..^p (3).^p 3..^[2, 4, 5] With array exponentiation, the power may be an array if the base is a scalar or if the power's dimensions are the same as the base dimensions. Structure arrays use the dot notation (.) to specify and to access the fields. (Answers: (a) (x - 5) 5 (b) x - 5 (c) 13671/1000 in symbolic form, 13.6710 in numeric form) Table 11.1-2 Functions for Manipulating Symbolic Expressions Command Description collect(E) Collects coefficients of like powers in the expression E. Test your function for the case where h = 100 m, v 0 = 50 m/s, and g = 9.81 m/s 2. quit Stops MATLAB. Plot A versus t for $0 \le t \le 20$ years for four cases: continuous compounding, annual compounding (n = 1), quarterly compounding (4), and monthly compounding (n = 12). Interpolation with Hermite Polynomials The pchip function, summarized in Table 7.4-2, uses piecewise continuous Hermite interpolation polynomials (pchips). This class of arrays enables you to store dissimilar arrays together. Many physical processes can be modeled with functions that produce a straight line when plotted using a suitable set of axes. EXAMPLE 6.2-5 Response of a Biomedical Instrument Engineers developing instrumentation often need to obtain a response curve that describes how fast the instrument Engineers developing instrumentation often need to a suitable set of a Biomedical Instrument
Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation often need to a Biomedical Instrument Engineers developing instrumentation of the second se the y axis. MATLAB is useful for doing numerous complicated calculations and then automatically generating a plot of the results. Once you have saved your work open a new brackets file named index. EXAMPLE 2.3-5 A Batch Distillation Process Consider a system for heating a liquid benzene/toluene solution to distill a pure benzene vapor. For example, typing isfield(student, 'name') returns the result ans = 1. For example, if x = 8, the correct answer is 180, but the previous code gives 100. The syntax initial(sys1, sys2, . When they are matrices, each error bar is a distance of e(i,j) above and below the point defined by (x(i,j),y(i,j)). It is the most common format for English-language text files A step function of height M can be written as y(t) = Mu s(t). Accessing Cell Arrays You can access the contents of a cell array by using either cell indexing. (3 + 6i)(-7 - 9i) b. A common example is division by zero. One of the strengths of MATLAB is that it will treat a variable as an array automatically. So to get unique integer values, use randperm. Solution (a) Using the xyz coordinates selected, the position of diver 1 is r = 55i + 36j + 25k, and the position of diver 2 is r = -20i + 59j + 15k. If x has length n, then each row of A is plotted versus the vector x. For example, the result for the second derivative is (11.5-4) The general result for any order derivative is (11.5-5) where (11.5-6) Application to Differential Equations The derivative and linearity properties can be used to solve the differential equation (11.5-7) If we multiply both sides of the equation by e -st and then integrate over time from t = 0 to t = ∞, we obtain 487 or or, using the linearity property, Using the derivative property and the alternative transform notation, the above equation can be written as 536 where V(s) is the transform of v. The other two currents can be found from i 4 = i 1 - i 2 and i 5 = i 2 - i 3. 506 11.2 Algebraic and Transcendental Equations. Plot L/D versus of such equations are solve algebraic and transcendental equations. α for $-2^{\circ} \leq \alpha \leq 22^{\circ}$. However, the computed height of 9.7 ft does not seem unreasonable. Note that setting the gain 1/R l equal to 0 is equivalent to R l = ∞ , which indicates no inlet on the left-hand side. 106 c. Obtain a new Model window and do the following. The mean and variance of x are μ x = 8 and . (Answers: (a) [-147, -81; -162, 32], (b) [-3, -9] (b) [-3, -9] (b) [-3, -9] (c) [-3, -9 -2, 2], and (c) [-343, -27; 729, 64].) EXAMPLE 2.3-4 Current and Power Dissipation in Resistors The current i passing through an electrical resistance. It is important to connect the top port of the Mux block [which corresponds to the first input, v(t)] to the output of the Relay block, and to connect the bottom port of the Mux block [(which corresponds to the second input, T d (t)] to the output of the Disturbance Step block. Suppose we want to consider any data value in the range -0.1 < x < 0.1 as being erroneous. For the first, plot sin x and x versus x for $0 \le x \le 1$. The blocks represent cause-and-effect processes. This form computes the derivative of the quotient p2/p1. 58 Special matrices Item Description Pages eye Creates an identity matrix. They are similar to overloaded functions in any object-oriented language. The (x, y) coordinates of the hand at the end of the arm are given by where L 1 and L 2 are the lengths of the links. Compute the angular momentum vector L. Then the free response is obtained from (11.5-12) It can be found by typing >>ilaplace($(2*s-0.2)/(s^2+1.4*s+1)$) The free response is obtained from If f(t) is a unit-step function, F(s) = 1/s, and the forced response is obtained from If f(t) is a unit-step function, F(s) = 1/s, and the forced response is obtained from If f(t) is a unit-step function, F(s) = 1/s, and the forced response is obtained from If f(t) is a unit-step function, F(s) = 1/s, and the forced response is obtained from If f(t) is a unit-step function, F(s) = 1/s, and the forced response is obtained from If f(t) is a unit-step function, F(s) = 1/s, and the forced response is obtained from If f(t) is a unit-step function. 489 (11.5-13) Input Derivatives Two similar mechanical systems are shown in Figure 11.5-2. The movie function plays back the frames after they have been captured. [1.2, 2; 0.7143, 0.3333] e. Note that the new program allows for the possibility that the rocket might not reach 40,000 ft. The angles of rotation of the motors at the joints are θ 1 and θ 2 . MATLAB is used for topology optimization, a mathematical method for optimizing material layout within a given design space. 466 equal to 1/rho*A 1. For example, is given by 468 >> syms x y >> diff(x*sin(x*y),y) ans = x^2 cos(x*y) The function diff(E,n) returns the nth derivative of the expression E with respect to the default independent variable. The tank is to be constructed to hold 600 m 3 when filled. It is assumed that you press the Enter key after you type a command. 2.1 One- and Two-Dimensional space by three Cartesian coordinates x, y, and z. Type this matrix in MATLAB and use MATLAB to carry out the following instructions. Time 7 A.M. 9 A.M. 11 A.M. 12 noon Temperature (°F) 49 57 71 75 A plot of these data is shown in Figure 7.4-1 with the data points connected by dashed lines. To insert arrows, lines, rectangles, and ellipses, click on the appropriate button and follow the instructions given previously for the Insert menu. NASA's planetary rover Sojourner landed on Mars on July 4, 1997, and excited people on Earth while they watched it successfully explore the Martian surface to determine wheel-soil interactions, to analyze rocks and soil, and to return images of the lander for damage assessment. x 0 1 2 3 4 5 6 7 8 9 10 y 0 2 5 7 9 10 8 7 6 4 5 21. The result is a matrix the same size as A. % random walk 1.m clear tic for n = 1:1000 clear x p x(1) = 0; 330 p = randi([-1,2],[1,100]); for k = 1:100 x(k+1) = x(k) + p(k); end y(n) = x(101); end toc maximum = max(y) histogram(y) If you run this program several times, the resulting values of the minimum and maximum distance moved will be quite variable. Numerically estimate the derivative of a set of data. There is a large, but finite limit to the number of characters in a name. The legend command automatically obtains from the plot the line type used for each data set and displays a sample of this line type in the legend 238 224 Figure 5.2-3 Application of the legend command. Numerically evaluate single, double, and triple integrals whose integrands are given functions. However, we prefer to obtain an analytical solution whenever possible, because it is more general, and thus more useful for designing engineering devices or processes. The number of rows in this column vector must equal the order of the equation. Oscillations in mechanical structures and electric circuits can often be described by the function where t is time and ω is the oscillation frequency in radians per unit time. This check proceeds as follows, using Equation (1.6-1), which is correct. EXAMPLE 8.3-1 An Underdetermined Set with Three Equations and Three Unknowns Show that the following set does not have a unique solution. The two models are plotted with the data in Figure 6.2-4. x = A Solves the matrix equation Ax = b using left division. BOUNDARY CONDITION A second-order ode has the form Its solution will have two arbitrary constants that can be determined once two additional conditions are specified. 5, 6, 10, 20, 28, 33, 34, 36, 42. One such block is the Saturation block in the Discontinuities library. The command [x,y] = ginput(n) gets n points and returns the x and y coordinates in the vectors x and y, which have a length n. [11, 6; 12, 12] b. For example, to compute the square roots of 5, 7, and 15, type >>x = [5,7,15]; y = sqrt(x) y = 2.23612.6358 3.8730 The square root function operates on every element in the array x. m $0 = m e + q^*b$; v $b = u^2\log(m 0/m e) - g^*b$; h $b = ((u^*m e)/q)^2\log(m e/(m e+q^*b)) + u^*b - 0.5^*g^*b^2$; h $p = h b + v b^2/(2^*g)$; if h p >= h desired % Calculate only if peak height > desi speed. Try to find a better value for the bin width. (Answer: There is a unique solution: x 1 = 2.2143, x 2 = 0.0714, which is given by the left-division method.) 372 T8.4-2 Show why there is no solution to the following set. 47. xy c. Throughout each of the chapters, numerous tables summarize the commands and functions as they are introduced. Using the polyfit command, the following lines can be added to the script file. In this application it is difficult to measure the time to fill one cup with an accuracy greater than an integer second, so this inaccuracy greater than an integer second, so this inaccuracy greater than an integer second. we have the three data points given in the following table, and we need to determine the
coefficients of the straight line y = mx + b that best fit the following data in the least-squares sense. The data given in Table 7.2-1 are the absolute frequency data and are stored in the vector 296 y abs. Because the graph of our model lies near the data points, we can treat its prediction of 1112 sec with some confidence. MATLAB provides the desired and the measured values of the speed; namely, e = r - b. You can create a function handle to any function by using the @ sign before the function name When finished, select Save from the EDITOR menu. 264 9. b = -0.1 34. You should not alter the value of the loop variable k within the statements. These limits can be simulated with the Saturation block, discussed in Section 10.4. After placing the block as shown in Figure 10.8-1, double-click on it and type 2 in its Upper limit window and 0 in the Lower limit window. This is so because the period of the sine wave is greater than the time it takes for the exponential e -8t to become essentially zero. The following equation describes Baker's yeast fermentation. These methods use several evaluations of the function f(t, y) in a way that approximates the Taylor series. The angle corresponding to x = 2, y = 3 d. format loose Resets to less compact display mode. To estimate how long it will take for the coffee to cool to 120°F, we must solve the equation 120 = 68 + b(10) mt for t. The minimum and is also called the global minimum. 3.1 Elementary Mathematical Functions You can use the lookfor command to find functions that are relevant to your application. m, starting at t = 0.05 s. plot(A,B) plots the columns of the matrix A. 351 inv Computes inverse of a matrix. PATH The path is shown in the window above the Current Folder window in the default Desktop (see Figure 1.1-1). Within the numeric class are the subclasses single (single precision), double (double precision), int8, int16, and int32 (signed 8-bit, 16bit, and 32-bit integers), and uint32 (unsigned 8-bit, 16-bit, and 32-bit integers). To see other variations of the yyaxis function, type help yyaxis. Finally, we can use the following approximation to estimate the time to empty. The View menu lets you select which ones you want to appear. The increment Δt is called the step size. For example, if x is normally distributed with a mean of 0, and if y = x 2, it is easy to see that the mean of y is not 0, but is positive. 574 animated line to the current axes. As variables specified in the body of the expression, such as with the variables A and B in plane = @(x,y) A*x + B*y. Obviously every engineering disciplines, including the Financial, Communications, Image Processing, PDE, and Wavelet toolboxes. Table 1.3-2 Some MATLAB plotting commands Command Description [x,y] = ginput(n) Enables the mouse to get n points from a plot, and returns the x and y coordinates in the vectors x and y, which have a length n. For the case where W = 400 N, L b = 3 m, and L c = 5 m, use element-by-element operations and the min function to compute the value of D that minimizes the tension T. Languages suitable for structured programming, such as MATLAB, thus do not have an equivalent to the goto statement that you might have seen in the BASIC and FORTRAN languages. Create a plot having three curves of the gas pressure in N/m 2 versus the container volume V in m 3 for 20 < V < 100. Thus, to plot only x 1, type plot(t,x(:,1)). This choice gives x = y = 5 tons. The function movie(M,n) 574 plays the movie n times. It was derived using the rectangular integration formula for the derivative. Click on OK. Using sys3 as the example, these are step(10*sys3) and [x,t] = step(sys3); plot(t,10*x) The lsim Function The lsim function plots the response of the system to an arbitrary input. The answer is x = 0. To learn how to deal with problems having a nonunique solution (or perhaps no solution at all!), see Chapter 8. For example, type C(2, 4) = {[6, -3, 7]} to put the 1 × 3 array in cell (2,4) and type C(1,5) = {1:10} to put the numbers from 1 to 10 in cell (1,5). plot(P,Q) Plots array Q versus array P. Such diagrams are called simulation diagrams or block diagrams. 293 fit. Note that MATLAB does not require a line numbers except in the Debugger. If this is the first plot, type fig_handle = figure(1). For example, if $x \ge 5$ y = log(x) elseif $x \ge 0$ y = sqrt(x) end Note that the elseif statement does not require a separate end statement. 58. These are called runtime errors. (In the previous code, function A can call B or D, but not C or E.) 2. A water tank consists of a cylindrical part of radius r and height h, and a hemispherical top. (Function A can call B or D, but not E.) 4. For example, fminbnd(@cos,0,4) returns the value x = 3.1416. The data in column 1 are: time (seconds). The Editor provides access to the function workspace and allows you to change values. The division operation of scalar algebra has an analogous operation of scalar algebra. It includes the Variable Editor, a graphical interface for working with variables, including arrays. OUTLINE 2.1 One- and Two-Dimensional Numeric Arrays 2.3 Element-by-Element Operations 2.5 Polynomial Operations 2.4 Matrix Operations 2.5 Polynomial Operations 2.5 Polynomial Operations 2.5 Polynomial Operations 2.4 Matrix Operations 2.4 Matrix Operations 2.5 Polynomial Operations 2.5 Polynomial Operations 2.4 Matrix Operations 2.5 Polynomial Operations as if they were a single entity. Determine the standard deviation of θ and plot the relative frequency histogram for θ . Choose axes that will result in straight-line graphs for both V and r. Solve the following equation for positive values of x. b) Insert a Saturation block after the PID block and use the limits -50 and 50. The preceding integral is carried out over the rectangular region specified by $1 \le x \le 3$, $0 \le y \le 1$. Thereafter, f behaves like a function of t, and you can manipulate it with the toolbox commands. Table 1.4-2 summarizes these commands. Table 1.4-2 summarizes these commands. now the fit improves with the higher-degree polynomial. These equations can be put into matrix form as follows, where x 1 = i and x 2 = ω . A copper sphere 25 mm in diameter, initially at 300°C, is immersed in a bath at 0°C. The array [0, theta] is 1 × 5 and the array [v, h] is 6 × 5, so the matrix table is 7 × 5. Without writing a program, how far do you think the particle will move after 100 steps on average? The original process used an inkjet printer to deposit a layer of liquid bonding agent onto a powder bed and is called binder jetting. With the fminbnd function to precisely determine the location of the minimum 2 25. bins = [64:binwidth:75]; % Fill the vector y_raw with the raw data. The equation of motion for a rocket in vertical flight can be obtained from Newton's law, and is where T is the rocket's thrust and its mass as a function of time is given by (4.9-1) Because we know the number of freshmen in the first year of our analysis (which is 500), we can solve this equation step by step to predict the number of freshmen in the future. Create a vector w consisting of the elements in the second row of A. Figure 10.6-1 A pendulum. For example, 89 consider the set To solve such sets in MATLAB you must create two arrays; we will call them A and B. You could have made an error in deriving the trigonometric formulas, so you should check them for several cases. Find the object's location at t = 1 s if x(0) = 2 m. The polar representation uses the distance M of the hypotenuse, and the angle θ the hypotenuse, and the angle θ the hypotenuse, and the angle θ the hypotenuse makes with the positive real axis. [x,t] = step(sys3); plot(t,x) 423 You can then use the Plot Editor tools to edit the plot. Its syntax is d = diff(x), where x is a vector of values, and the result is a vector d containing the difference between mathematics text, ln, and MATLAB to compute the radius a vector d containing the difference between adjacent elements in x. (Note the spelling differences between adjacent elements in x. (of a sphere having a volume 40 percent greater than that of a sphere of radius 4 ft. 391 integral3 Numerical integral. Both accept text within parentheses and
single quotes, as with the xlabel function. Before we entered the data for the second student, the dimension of the structure array was 1 × 1 (it was a single structure). Applications A. The input variables are the acceleration g, the initial velocity, and the elapsed time t. The difficulty with Equation (9.3-5) is that f k +1 cannot be evaluated until y(t k +1) is known, but this is precisely the quantity being sought. [Kutz, 1999] Kutz, M., editor. The basic syntax for zero initial conditions is lsim(sys,u,t), where sys is the LTI object, t is a time vector having regular spacing, as t = 0:dt:tF, and u is a matrix with as many columns as inputs, and whose ith row specifies the value of the input at time t(i). It is based on the same concept as the scaled histogram; that is, the total area under the curve is 1, and the fractional area gives the probability of occurrence of a specific range of outcomes. The slopes of adjacent polynomials must be equal at their common data point. 119 csch(x) Hyperbolic cosecant; $1/\sinh x$. 19.* A certain object has a mass m = 100 kg and is acted on by a force f(t) = $500[2 - e - t \sin(5\pi t)]$ N. 64 3/2 8. The function rng('shuffle') initializes the random number generator based on the current time given by the computer's CPU clock. The plots of both x 1 and x 2 will appear in the Scope. For example, to extract the diagonal elements of A with a numeric array, type C = A([1,5,9]). The figure is copied to the Windows clipboard and can be pasted into another application. v = -p(1)*60 % speed in knots (nmi/hr) p Figure 6.1-3 shows the plot. Both have a rank of 3, which is 1 less than the number of unknowns, so we can determine three of the unknowns in terms of the fourth. The elements of the structure array. 16 - 1 b. Use MATLAB to make the following calculations, using the values x = 10, y = 3. To fill the tank, water is pumped into the top at the rate given in the following table. This is what occurs when you use the plot function. Folders can have subfolders below them. Thus the closer r 2 is to 1, the better the fit. 405, 413 ode15s Stiff, variable-order solver. 4.1 Program Design and Development In this chapter we introduce relational operators, such as > and ==, and the two types of loops used in MATLAB, the for loop and the while loop. The spline, unmkpp, and extended syntax of the interp1 function are summarized in Table 7.4-2. Batteries contain compounds such as lithium, copper, and nickel that require much energy to mine and process. Think generally about your proposed solution approach and ches before proceeding with the details. Given the matrices Use MATLAB to a. Under certain conditions, the pressure-flow rate relation in a resistor. Section 10.10 36. For example, to eliminate a window, just click on its Close-window button (×) corner. Test your statements for the values a = 1.12, b = 2.34, c = 0.72, d = 0.81, and f = 19.83. semilogx(x,y) Produces a semilog plot of y versus x with logarithmic abscissa scale. Problem 3d b. 507 508 560 A APPENDIX Guide to Commands and Functions in This Text Operators and special characters Item Description Pages + Plus; addition operator. The following is a state-model description of the same system (9.5-6) 417 Table 9.5-1 LTI object functions Command Description sys = ss(A, B, C, D) Creates an LTI object in state-space form, where the matrices A, B, C, and D correspond to those in the model = Ax + Bu, y = Cx + Du. [A, B, C, D] = ssdata(sys) Extracts the matrices A, B, C, and D correspond to those in the model = Ax + Bu, y = Cx + Du. [A, B, C, D] = ssdata(sys) Extracts the matrices A, B, C, and D correspond to those in the model = Ax + Bu, y = Cx + Du. [A, B, C, D] = ssdata(sys) Extracts the matrices A, B, C, and D correspond to those in the model = Ax + Bu, y = Cx + Du. [A, B, C, D] = ssdata(sys) Extracts the matrices A, B, C, and D correspond to those in the model = Ax + Bu, y = Cx + Du. [A, B, C, D] = ssdata(sys) Extracts the matrices A, B, C, and D correspond to those in the model = Ax + Bu, y = Cx + Du. [A, B, C, D] = ssdata(sys) Extracts the matrices A, B, C, and D correspond to those in the model = Ax + Bu, y = Cx + Du. [A, B, C, D] = ssdata(sys) Extracts the matrices A, B, C, and D correspond to those in the model = Ax + Bu, Y = Cx + Du. [A, B, C, D] = ssdata(sys) Extracts the matrices A, B, C, and D correspond to those in the model = Ax + Bu, Ax + Buand D corresponding to those in the model Cx + Du. sys = tf(right,left) Creates an LTI object in transfer function form, where the vector of coefficients of the equation, also arranged in descending derivative order, and left is the vector of coefficients of the equation, also arranged in descending derivative order. derivative order. 288 Fitting Other Functions Given the data (y, z), the logarithmic function y = m ln z + b can be converted to a first-degree polynomial by transforming the z values into x values by the transformation about these items (b) The plot was generated with plot using 101 points. Determine how many of each product to make in order to maximize the profit. z = 6 + 3 > 8 c. Using estimates of rainfall, evaporation, and water volume in the reservoir as a function of time where V is the water volume in liters and t is time in days. 58 sort Sorts each column. plot3(x,y,z) Creates a 3-D line plot. Most data files and other non-MATLAB files are not listed. limit(E,a) Returns the limit of the expression E as the default independent variable goes to a. Obtain the surface and contour plots for the function z = (x - y 2)(x - 3y 2). Use MATLAB to determine how many elements are in the array y and the value of the third element in the array y. The acceleration g due to gravity is constant (because the distance dropped is only 6 ft). The author greatly appreciates their contributions. Find A + B + C. I recommend start with lines 368-379, as these are how the ship looks and are easy to notice differences once edited. To see your work at any given time go to top left of the screen, click file then save. Dedication......Page 75. Find the other three temperatures and the heat loss rate q, in watts. Chapter 10 introduces Simulink, which is a graphical interface for building simulations of dynamic systems. For example, suppose you want to compute the square root of the input if there is only one, but compute the square root of the average if there are two inputs. The function conj(x) computes the complex conjugate of x. The check box next to each item in the browser controls the object's visibility. Find the maximum and minimum values in each column. You can type the name of a variable and press Enter to see its current value. You can also distinguish curves from one another by using different line types for each curve. Recall that typing a variable. Create the plot in two ways: (a) by using the surf function and (b) by using the meshc function. Signum function: +1 if; 0 if x = 0; -1 if. If we define the row vector of hourly costs to be hourly costs to be hourly costs of each product 1 using elementby-element multiplication. We can add the two arrays x and y to product 1 using elementby-element multiplication. We can add the two arrays x and y to produce another array z by typing the single line z = x + y. To create a new script file, click the New Script icon. We use boldface type for three purposes: to represent an action on the keyboard (for example, press Enter), and to represent the name of a screen menu or an item a menu when it is the object of an action (for example, click on File). The solution $y(t) = C \ 1 \ e \ ct + C \ 2 \ e \ -ct \ can be found with the session: >> syms y(t) \ c >> dsolve(diff(y,t,2) = e^2y) and s = C1*exp(-c*t) + C2*exp(-c*t) + C2*exp$ Distribution 293 Rolling a die is an example of a process whose possible outcomes are a limited set of numbers, namely, the integers from 1 to 6. Hyperbolic sine; Hyperbolic si that involve several parameters. 81 Special Matrices Two exceptions to the noncommutative property are the null matrix, denoted by 0, and the identity, or unity, matrix, denoted by 0, and the identity, or unity, matrix, denoted by 0. singular matrix, MATLAB will issue a warning to that effect. (a) Create a Simulink model to solve this problem for $0 \le t \le 10$ s. Use MATLAB to find the coefficients of the cubic polynomial ax 3 + bx 2 cx + d that passes through the four points (x, y) = (1, 6), (2, 38), (4, 310), (5, 580). Time (min) 0 1 2 3 4 5 6 7 8 9 10 80 130 150 150 160 165 170 160 140 120 394 8.* A cone-shaped paper drinking cup (like the kind supplied at water fountains) has a radius R and a height H. The cable length L AB is given, but the length L AC is to be selected. ans = [1, 0] [0, 1] >> det(A) ans = k 545 Solving Linear Algebraic Equations You can use matrix methods in MATLAB to solve linear algebraic equations symbolically. (a) (b) 32. If the strength is 1, we have a unit impulse. The terms in the preceding series become smaller in magnitude as n increases. For example, for the array A just described, ndims(A) returns the value 3. In fact, MATLAB uses two definitions of multiplication: (1) array multiplication and (2) matrix multiplication. Consider the integral The basic syntax is A = integral3(fun, a, b, c, d, e, f) where fun is the handle to a user-defined function that defines the integrand f(x, y, z). 7.* When a belt is wrapped around a cylinder, the relation between the belt forces on each side of the cylinder is where β is the angle of wrap of the belt and μ is the friction coefficient. Applying this principle to each subsquare gives the following equations. This is the topic of Section 6.1. A systematic way of finding an equation that best fits the data is regression (also called the least-squares method). In the Variable Editor, access each variable via its tab at the top of the window. First solve this for . Table 8.6-1 Matrix functions and commands for solving linear equations Function
Description det(A) Computes the determinant of the array A. See Problem 16. The following example illustrates how it is done. MATLAB also provides the interpn function for interpolating multidimensional arrays. Weekly inventory for cases (a) and (b): Week Inventory (b) Week Inventory (b) Week Inventory (c) Inventory ((a) Inventory (b) 1 50 30 6 30 10 2 50 25 7 30 5 3 45 20 8 25 0 4 40 20 9 20 0 5 30 10 10 10 (greater than, 161, 561 > = greater than or equal to, 164, 561 | OR, 164, 561 > > MATLAB prompt, 6, 7 @ creates a function handle, 128, 560 MATLAB Commands A abs, 114, 116, 117 acos, 19, 118 acoth, 119 acot, 118 acoth, 119 acoth, 119 acot, 118 acoth, 119 audiorecorder, 581, 582 audiowrite, 581 axis, 228-229, 231, 239, 243 B bar, 243, 244, 312, 314, 315 break, 183, 206 C case, 195, 196, 206 cat, 62 cd dirname, 26 ceil, 114, 117 cell, 88 539 cellplot, 89-90 charpoly, 543-544, 545 circle, 124 class, 498, 504 clc, 12, 14, 15 clear, 12, 14, 57, 128 clear var1 var2, 12, 14 collect, 500, 505 colormap, 573 conj 116 continue, 183, 206 conv, 85, 86 cos, 18, 19, 118 cosh, 119 cot, 118 cosh, 119 cots, 83 csc, 118 csch, 119 cumsum, 318 D dbclear, 199 dbcont, 200 dbstep, 374, 544, 545 diff, 399, 402, 513, 514, 515 digits, 503, 504 dir, 26 dir dirname, 26 dirac, 540 disp, 30, 583, 585 doc, 34 dot, 84 double, 163, 540 disp, 30, 580 doc, 34 dot, 84 double, 163, 540 disp, 30, 580 doc, 34 dot, 84 double, 163, 540 disp, 30, 580 doc, 34 doc, 34 dot, 84 double, 163, 540 disp, 30, 580 doc, 34 doc, 3 206, 502, 503, 504, 543 drawnow, 572, 574 drop, 121, 126, 127 dsolve, 526, 527, 530, 532, 540 E eig, 416, 544, 545 else, 172-174, 197, 206 end, 140, 190, 206 540 eps, 15 errorbar, 246 exist, 12, 14, 29, 121 exp, 18, 19, 66, 114, 115 expand, 500, 505 eye, 81, 163 F factor, 500, 505 fcontour, 260, 261 fhandle, 136 fimplicit, 243, 247 fimplicit3, 261 find, 58, 167, 168-169 findsym, 499, 504 finite, 167 fix, 114, 117 floor, 258 fun, 123 fzero, 128-130, 132, 135 G getframe, 572 ginput, 23 globa1, 127 global, 413 gradient, 400, 402 grid, 23, 228, 231, 243 gtext, 22, 23, 238, 239, 240, 245 H heaviside, 534, 536, 537 help, 33, 125 592 help polyfun, 84 541 help specmat, 81 histogram, 312, 315 hold, 239-240 I i, 15 if, 171-172, 197, 206 ilaplace, 541 imag, 114, 116 impulse, 541 imag, 114, 419, 420-421 Inf, 15, 129 initial, 419-420 inline, 135 input, 206 int, 515, 518-520 integral2, 391, 393 integral2, 391, 395 in 523-524 linspace, 54, 58 load, 24, 25 log, 18, 19, 114, 115 log10, 19, 114, 115 log10, 19, 114, 115 logical, 162, 167, 206 logical operators, 154 loglog, 243, 244 logspace, 54, 58 lookfor, 29, 33, 34, 113 542 lsim, 419, 423 M max, 57, 59, 94 mean, 138, 139, 312, 319 mean.m, 29 median, 312 mesh, 257, 258, 260 meshc, 260 meshc, 260 meshz, 258, 260 min, 200 meshz, 258, 260 meshc, 260 meshc, 260 meshz, 258, 260 mes 58, 59 mode, 59, 312 movie, 572, 573-574 N names, 93 NaN, 15, 129 nargin, 176, 206 nargout, 177, 206 ndims, 61 norm, 58, 116 numden, 501, 504 nume1, 58 O ode45, 410, 413 presistent, 128 pi, 15 pinv, 361, 374 play, 581 plot, 21, 23, 29, 32, 33, 226 227, 229, 230, 231, 236, 240 plot3, 255-256, 260 polarplot, 243, 244-245 poly, 84, 85 poly2sym, 502, 505 polyder, 399-400, 402 polyfit, 275, 276, 285, 289 543 polyint, 391, 395 polyval, 85, 86, 229, 231, 285 print, 231, 232 profile, 199 publish, 247-248 pwd, 25 Q quit, 12, 15 R rand, 319, 320, 325 randi, 325, 328 randn, 325 randperm, 325, 328, 329 rank, 374 real, 114, 116 recordblocking, 582 rmfield, 93, 94 rmpath, 26 rng, 320, 331 roots, 21, 85 round, 114, 116-117 rref, 364, 372 S save, 24 sign, 114 simplify, 500-501, 505 sin, 18, 19, 114, 117, 138 sind, 118 sinh, 119 size, 58 solve, 506, 507, 510, 512 sort, 58, 59 sound, 580 soundsc, 581 spline, 337, 339 sprintf, 586 sq, 136 sqrt, 18, 19, 29, 66, 114, 115 ss, 417, 418 statas, 417, 418 statas, 243, 244 std, 319 stem, 243, 2 498, 504, 506, 544 symsum, 515, 523 T tan, 19, 118 tanh, 119 taylor, 515, 521-522 text, 226, 238-239, 240, 586 tf, 417 title, 22, 226, 229, 231, 245 trapz, 391, 392 U unmkpp, 339 V var, 319 view, 573 vpa, 503, 504 W waterfall, 260 what, 26 what dirname, 26 which item, 26 which item, 26 which item, 26 which item, 273 vpa, 503, 504 W waterfall, 260 what, 26 what dirname, 26 which item, 26 which item, 26 which item, 26 which item, 273 vpa, 503, 504 W waterfall, 260 what, 26 what dirname, 26 which item, 26 which item, 26 which item, 273 vpa, 503, 504 W waterfall, 260 what, 26 what dirname, 26 which item, 26 which item 458 O Output Port, 364, 463 P 593 PID Controller, 475, 477, 481 R Rate Limiter block, 469 Relay, 453-454 546 S Saturation, 468-469, 477 Scope, 443, 457 State space, 418 Step, 466, 468 Subsystem, 463-464 Summer, 441 T To Workspace, 472 Transfer Fcn, 457 Transfer Fcn (with initial conditions), 468 Transport Delay, 468 Trigonometric Function, 460 Topics A absolute frequency, 313 absolute structures, 50 actuator, 474 adaptive method, 391 addition arrays, 62–63 polynomial, 84–85 additive manufacturing (AM), 348 algebraic equation, 506 algorithm, 154 alternative sources of energy, 494 animation and sound, 572-582 anonymous functions, 134, 135, 136-138 APPS tab, 5, 17 argument, 18 arrays, 19-21, 51 addition, 62-63 addressing, 55-56 animation with, 578-579 cell, 88-90 character, 51 column, 20, 21, 84 division, 67 empty, 56-57 index, 20, 55 logical, 51-52, 163, 186-187 as loop index, 183-184 multidimensional numeric, 61-62 multiplication of, 62, 64 547 numeric, 51, 163 operations, 62 polynomial roots, 21 powers, 69 row, 20, 84 size of, 54, 60, 64 structure, 90-94 subtraction, 63 two-dimensional, 54 ASCII files, 24, 142-143 assignment operator, 7 use of, 10-11 assignment statement, 7 augmented matrix, 353 automatic highlighting feature, 121 autoscaling, 226 axis limits, 228 B backward difference estimate, 398 Basic Fitting interface, 297-300 bell-shaped curve, 319 binary files, 24, 142. 633, 635, 543 det Returns the determinant of a matrix. The quotient polynomial is given by the coefficient array r. To store all the information for a particular structure—say, all the information about Mary Jones—in another structure array named M, you type M = student(2). Use the default values for the other parameters. For example, if you create the array B (2.1-1) by typing >> B = [2, 4, 10, 13; 16, 3, 7, 18; 8, 4, 9, 25; 3, 12, 15, 17]; and then type >> C = B(2:3, 1:3); you can produce the following array: The empty array contains no elements and is expressed as []. Use the MATLAB relational and logical operators to find the times when the height is no less than 6 m and the speed is simultaneously no greater than 16 m/s. 38. The following table gives the measured deflection x that was produced in a particular beam by the given applied force f. pathtool Starts the Set Path tool. Section 8.3 covers the case where the equation set does not contain enough information to determine all the unknown variables. (a) F.*D = [1200, 275, 525, 750, 3000] J; (b) sum(F.*D) = 5750 J. 585 A percent sign in displayed text requires two percent signs. The spring's free length is 4.7 in. The calculus applications include integration, and limits. It moves on a path for 10 hr such that x = t and y = 0.5t 2 + 10, where t is in hours. We now demonstrate how to use the Laplace transform to find the step response of equations containing derivatives of the input. The left-arrow (←) and right-arrow (→) keys move left and right through a line one character at a time. This specification of the output, denoted by the vector y, is done in general with the equation (9.5-8) where the vector y is done in general with the matrices C and D, which must be compatible with the equation (9.5-8) where the vector y is done in general with the vecto = i + 3j. The number of columns in A must equal the number of rows in B. Your model should now look like Figure 10.5-2. Find the probability that a given shaft will not fit into the bearing. The function's inputs should be h, v 0, and g. The maximum overshoot is seen to be 0.26 - 0.2 = 0.06 m, but the maximum undershoot is seen to be much greater, -0.168 m. Then double-click on the Tank 1 subsystem block, set the left-side gain 1/R 1 equal to 0, the right-side gain 1/R 1, and the gain 1/R 1 equal to 1/R 1, and the gain 1/R 1 equal to 1/R 1, and the gain 1/R 1 equal to 1/R 1, and the gain 1/R 1 equal to 1/R 1, and the gain 1/R 1 equal to 1/R 1, and the gain 1/R 1 equal to 1/R 1, and the gain 1/R 1 equal to 1/R 1, and
the gain 1/R 1 equal to 1/R 1, and the gain 1/R 1 equal to 1/R 1 Seth Dickey, Nicholas G. Plot y versus t over the range $0 \le t \le 20$ for f 1 = 8 rad/sec. You can do this with the randperm(n) function, which generates a row vector containing a random permutation of the integers from 1 to n inclusive. Consider the following user-defined function function function, which generates a row vector containing a random permutation of the integers from 1 to n inclusive. examples of the use of these functions. For example, an overloaded function can be created to treat integer inputs differently than inputs of class double. Two-Dimensional Arrays An array having rows and columns is a two-dimensional array that is sometimes called a matrix. 476 Figure 10.10-2 Typical response of P, PI, and PID control systems when subjected to a unit-step command input. Use the estimates found in part a to find the roots more accurately with the fzero function. The icon for each variable illustrates its class. The sum(A) function sums the elements in each column of the array A and returns a row vector containing the sums. 8.* The equation for an ellipse centered at the origin of the Cartesian coordinates (x, y) is where a and b are constants that determine the shape of the ellipse. Figure 10.2-5 Simulink model using a Mux and the resistances obey the linear relation, so that the mass flow q L through the left-hand resistance is q L = (p L - p)/R L, with a similar linear relation for the right-hand resistance. The energy E(t) lost as a function of time is the time integral of the power. A character array is an array containing strings. Iterative operations (loops). Some MATLAB toolboxes do use structure arrays. 451 EXAMPLE 10.4-1 Simulink Model of a Rocket-Propelled Sled A rocket-propelled sled on a track is represented in Figure 10.4-2 as a mass m with an applied force f that represents the rocket thrust. 8, 63 / Right-division operator. Even if you set new values for an array, some previous values might still remain. 4*sin(th1)+3*sin(th1)+ th2r = subs(S.th2,y,yr); th1r = (180/pi)*double(th1r); th2r = (180/pi)*double(th2r); subplot(2,1,1) plot(yr,th1r,2, -3.2981,x,2,40.168,'o'),... 506 558 Figure P50 where v 1 and v 2 are applied voltages. (Answers: and 11.6-1 Linear Algebra Functions Command Description det(A) 496 Returns the determinant of the matrix A in symbolic form. The points appear to lie on a straight line that can be described by an equation that is usually written as f = kx + c, Figure 6.1-8 Plots for the cantilever beam example. The function taylor(f_x , a) gives the fifth-order Taylor 522 series approximation of f about x = a. Thus the tota costs in each quarter are 400,000; 351,0of a Nonlinear Pendulum The pendulum shown in Figure 10.6-1 has the following nonlinear equation of motion, if there is viscous friction in the pivot and if there is an applied moment M(t) about the pivot and if there is viscous friction in the pivot and if there is an applied moment of inertia about the pivot and if there is an applied moment M(t) about the pivot. 119 sinh(x) Hyperbolic sine; sinh x. Palm III 8 v CONTENTS Numbered Examples Preface CHAPTER 1 An Overview of MATLAB Interactive Sessions 1.2 The Toolstrip 1.3 Built-In Functions, Arrays, and Plots 1.4 Working with Files 1.5 The MATLAB Help System 1.6 Problems CHAPTER 2 Numeric, Cell, and Structure Arrays 2.1 One- and Two-Dimensional Numeric Arrays 2.2 Multidimensional Numeric Arrays 2.3 Element-by-Element Operations 2.4 Matrix Operations 3.2 User-Defined Functions 3.2 User-Defined Functions 3.2 Summary Problems CHAPTER 3 Functions 3.2 Summary Problems CHAPTER 3 Functions 3.2 Summary Problems CHAPTER 3 Functions 3.4 File Functions 3.4 File Functions 3.4 File Functions 3.5 Summary Problems CHAPTER 3 Functions 3.4 File Fu Problems 9 CHAPTER 4 Programming with MATLAB 4.1 Program Design and Development 4.2 Relational Operators and Logical Variables 4.3 Logical Operators and Functions 4.6 while Loops 4.7 The switch Structure 4.8 Debugging MATLAB Programs 4.9 Applications to Simulation 4.10 Summary Problems CHAPTER 5 Advanced Plotting 5.1 xy Plotting Functions 5.2 Additional Commands and Plot Types 5.3 Interactive Plotting in MATLAB 5.4 Three-Dimensional Plots 5.5 Summary Problems vi CHAPTER 7 Statistics, Probability, and Interpolation 7.1 Statistics and Histograms 7.2 The Normal Distribution 7.3 Random Number Generation 7.4 Interpolation 7.5 Summary Problems 10 CHAPTER 8 Linear Algebraic Equations 8.2 The Left-Division Method 8.3 Underdetermined Systems 8.4 Overdetermined Systems 8.5 A Generation 7.4 Interpolation 7.5 Summary Problems 10 CHAPTER 8 Linear Algebraic Equations 8.2 The Left-Division Methods for Linear Equations 8.2 The Left-Division Method 8.3 Underdetermined Systems 8.4 Overdetermined Systems 8.5 A Generation 7.4 Interpolation 7.4 Interpolation 7.5 Summary Problems 10 CHAPTER 8 Linear Algebraic Equations 8.2 The Left-Division Methods for Linear Equations 8.4 Overdetermined Systems 8.5 A Generation 7.4 Interpolation 7.5 Summary Problems 10 CHAPTER 8 Linear Equations 8.2 The Left-Division Methods for Linear Equations 8.2 The Left-Division Methods for Linear Equations 8.2 The Left-Division Methods for Linear Equations 8.4 Overdetermined Systems 8.5 A Generation 7.4 Interpolation 7.5 Summary Problems 10 CHAPTER 8 Linear Equations 8.2 The Left-Division Methods for Linear Solution Program 8.6 Summary Problems CHAPTER 9 Numerical Integration 9.3 First-Order Differential Equations 9.4 Higher-Order Differential Equations 9.4 Higher-Order Differential Equations 9.5 Special Methods for Calculus and Differential Equations 9.4 Higher-Order Differential Equations 9.5 Special Methods for Calculus and Differential Equations 9.4 Higher-Order Differential Equations 9.5 Special Methods for Calculus and Differential Equations 9.4 Higher-Order Differential Equations 9.4 Higher-Order Differential Equations 9.5 Special Methods for Calculus and Differential Equations 9.4 Higher-Order Differential Equations 9.5 Special Methods for Calculus and Differential Equations 9.4 Higher-Order Differential Equations 9.4 Higher-Order Differential Equations 9.5 Special Methods for Calculus and Differential Equations 9.4 Higher-Order Simulation Diagrams 10.2 Introduction to Simulink 10.3 Linear State-Variable Models 10.7 Subsystems and Hardware-in-the-Loop Testing 10.11 Summary Problems CHAPTER 11 Symbolic Expressions and Algebra 11.2 Algebraic and Transcendental Equations 11.15 Laplace Transforms 11.6 Symbolic Linear Algebra 11.7 Summary Problems APPENDIX A Guide to Commands and
Functions in This Text APPENDIX B Animation and Sound in MATLAB APPENDIX C Formatted Output in MATLAB APPENDIX C Formatted Output in MATLAB APPENDIX C Formatted Output in MATLAB APPENDIX E Some Project Suggestions (Available on the text website) Answers to Selected Problems Index 12 vii Numbered Examples Number and Topic CHAPTER ONE 1.1-1 Volume of a circular cylinder 1.6-1 Piston motion CHAPTER TWO 2.3-1 Vectors and displacement 2.3-2 Aortic pressure model 2.3-3 Transportation route analysis 2.3-4 Current and power dissipation in resistors 2.4-1 Miles traveled 2.4-2 Height versus velocity 2.4-3 Manufacturing cost analysis 2.5-1 Earthquake-resistant building design 2.6-1 An environment database 2.7-1 A student database CHAPTER THREE 3.2-1 Optimization of an irrigation channel 3.4-1 Creating a data file and loading it into a variable CHAPTER FOUR 4.3-1 Height of an instrumented rocket 4.6-1 Series calculation with a while loop 4.6-2 Growth of a bank account 4.6-3 Time to reach a specified height 4.7-1 Using the switch structure for calendar calculations 4.9-1 A college enrollment model: Part I 13 4.9-2 A college enr measurements 6.1-2 Temperature dynamics 6.1-3 Hydraulic resistance 6.1-4 A cantilever beam model 6.2-1 Effect of polynomial degree 6.2-2 Estimation of traffic flow 6.2-3 Modeling bacteria growth 6.2-4 Breaking strength of thread 7.2-1 Mean and standard deviation of heights 7.2-2 Estimation of height distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift CHAPTER EIGHT 8.1-1 The matrix inverse method 8.2-4 Calculation of cable tension viii 8.2-3 An electric resistance network 8.2-4 Calculation of height distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift CHAPTER EIGHT 8.1-1 The matrix inverse method 8.2-4 Calculation of height distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift CHAPTER EIGHT 8.1-1 The matrix inverse method 8.2-4 Calculation of height distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift CHAPTER EIGHT 8.1-1 The matrix inverse method 8.2-4 Calculation of height distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift CHAPTER EIGHT 8.1-1 The matrix inverse method 8.2-4 Calculation of height distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift CHAPTER EIGHT 8.1-1 The matrix inverse method 8.2-4 Calculation of height distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift CHAPTER EIGHT 8.1-1 The matrix inverse method 8.2-4 Calculation of height distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift CHAPTER EIGHT 8.1-1 The matrix inverse method 8.2-4 Calculation of height distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift CHAPTER EIGHT 8.1-1 The matrix inverse method 8.2-4 Calculation of height distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift distribution 7.3-1 Statistical analysis and manufacturing tolerances 7.3-2 A random walk with drift distribution 7.3-1 Statistical analys Ethanol production 8.3-1 An underdetermined set with three equations and three unknowns 8.3-2 A statically indeterminate problem 8.3-3 Three equations in three unknowns, continued 8.4-1 The least-squares method 8.4-2 An overdetermined set CHAPTER NINE 14 9.1-1 Velocity from an accelerometer 9.1-2 Evaluation of Fresnel's cosine integral 9.1-3 Double integral over a nonrectangular region 9.3-1 Response of an RC circuit 9.3-2 Liquid height in a spherical tank 9.4-1 A nonlinear pendulum model 9.5-1 Trapezoidal profile for a DC motor CHAPTER TEN 10.2-1 Simulink solution of \dot{y} = 10 sin t 10.2-2 Exporting to the MATLAB workspace 10.2-3 Simulink model of a relay-controlled motor 10.5-1 Response with a dead zone 10.6-1 Model of a rocket-propelled sled 10.4-2 Model of a relay-controlled motor 10.5-1 Response with a dead zone 10.6-1 Model of a rocket-propelled sled 10.4-2 Model of a relay-controlled motor 10.5-1 Response with a dead zone 10.6-1 Model of a rocket-propelled sled 10.4-2 Model of a rocket-propelled sled 10.4-1 Simulink model of a rocket-propelled sled 10.4-2 Model of a rocket-propelled sled 10.4-2 Model of a rocket-propelled sled 10.4-1 Simulink model of a rocket-propelled sled 10.4-2 Model of a rocket-p robot arm 11.3-1 Topping the Green Monster 15 ix PREFACE F ormerly used mainly by specialists in signal processing and numerical analysis, MATLAB (a) the Toolstrip will change. For example, yyaxis(x1,y1,x2,y2,'plot', 'stem') used mainly by specialists in signal processing and numerical analysis, MATLAB (b) the Toolstrip will change. For example, yyaxis(x1,y1,x2,y2,'plot', 'stem') used mainly by specialists in signal processing and numerical analysis, MATLAB (b) the Toolstrip will change. For example, yyaxis(x1,y1,x2,y2,'plot', 'stem') used mainly by specialists in signal processing and numerical analysis, MATLAB (b) the Toolstrip will change. For example, yyaxis(x1,y1,x2,y2,'plot', 'stem') used mainly by specialists in signal processing and numerical analysis, MATLAB (b) the Toolstrip will change. For example, yyaxis(x1,y1,x2,y2,'plot', 'stem') used mainly by specialists in signal processing and numerical analysis, MATLAB (b) the Toolstrip will change. For example, yyaxis(x1,y1,x2,y2,'plot', 'stem') used mainly by specialists in signal processing and numerical analysis, MATLAB (b) the Toolstrip will change. For example, yyaxis(x1,y1,x2,y2,'plot', 'stem') used mainly by specialists in signal processing and numerical analysis, MATLAB (b) the toolstrip will change. For example, yyaxis(x1,y1,x2,y2,'plot', 'stem') used mainly by specialists in signal processing and numerical analysis. plot(x1,y1) to generate a plot for the left axis, and stem(x2,y2) to generate a plot for the right axis. It should provide for the player to make repeated guesses of the number, and it should indicate if the player to make repeated guesses of the number, and it should indicate if the player to make repeated guesses of the number, and it should indicate if the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and it should provide for the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated guesses of the number, and the player to make repeated diagram is particularly useful in the initial stages of top-down design. Use these data to plot the total cost and the revenue versus Q, and graphically determine the breakeven point. To find the current i = v/R using MATLAB, we use array division. The integral is The session is >> syms x >> int(1/(x-1)) ans = log(x-1) >> int(1/(x-1),0,2) NaN The NaN result ("not a number") indicates that a solution could not be found (because it would involve the undefined function ln(-1)). Use the semilogy(x,y) command to have the y scale logarithmic and the x scale rectilinear. This was done previously to obtain the system sys3. (a) Use MATLAB to compute the rocket's velocity as a function of time, for (b) Use MATLAB to compute the rocket's velocity at burnout. Finding the Zeros of a Function to find the zero of a function to find applied in practice to obtain numerical solutions to sets of many equations, because calculation of the matrix inverse is likely to introduced. 318 erf Computes the error function erf(x). This type of block is called a multiplier or gain block. 276, 285 polyval Evaluates a mial and generates error estimates. The corresponding simulation diagram is shown in Figure 10.9-5. The relation between the two is Be sure to test your function. % x % y Time data = 0:19; Population data = [6,13,23,33,54,83,118,156,210,282,... 391 trapz Numerical integration with the trapezoidal rule. To perform exponentiation on an element-by-element basis, we must use the .^ symbol. Chapter 10: Simulink.....Page 40329. Functions Some MATLAB functions act on functions. For example, if (2.3-4) then z = x.*y gives This type of multiplication is sometimes called array multiplication. m 0 = m e + q*b; v b = u*log(m 0/m e) - g*b; h b = ((u*m e)/q)*log(m e/(m e)/q)*log(m e)/q)*log(m e/(m e)/q)*log(m e)/ $e+q^*b$)+u*b - 0.5*g*b^2; t p = b + v b/g; h p = h b + v b/2/(2*g); % If h p > h
desired, compute time to reached h desired. Assuming that the output of each worker is the most efficient? The color symbol can be combined with the data-marker symbol and the line-type symbol. The ideal gas law provides one way to estimate the pressures and volumes of a gas in a container. Computer-controlled machines are used to cut and to form metal and other materials when manufacturing products. Suppose you use MATLAB on your home computer and save a file to removable medium such as flash drive. Section 8.1 1. Then we compute the volume of the original cylinder and increase the volume by 20 percent. For the data given in Problem 3: a. The inverse tangent, is obtained by typing atan(x). 174 end Terminates for, while, and if statements. Use the following procedure to find a function that describes a given set of data. Trajectory Control of a Two-Wheeled Robot The speed and position control systems require a command input that describes either the desired speed or the desired position. Plot y(t) for y(0) = 5 if a. is [df dx, df dy] = gradient(f, dx, dy), where df dx and df dy represent $\partial f/\partial x$ and $\partial f/\partial y$ and dx and dy are the spacing in the x and y values associated with the numerical values of f. The distance between the wheels is L. The exponential's initial value is e 0 = 1, and it will be 2 percent of its initial value at t = 0.5 (because e -8(0.5) = 75 0.02). 143 a. If the sound is a pure tone, the pressure p(t) oscillates sinusoidally at a single frequency, that is, where A is the pressure amplitude (the "loudness"), f is the sound is a pure tone, the pressure p(t) oscillates sinusoidally at a single frequency, that is, where A is the pressure amplitude (the "loudness"), f is the sound is a pure tone, the pressure amplitude (the "loudness") and ϕ is the phase shift in radians. It is not necessary to use panels of the same width; to increase the method's accuracy, Figure 9.1-1 Illustration of (a) rectangular and (b) trapezoidal numerical integration. Also, other tabs may appear. The following table gives the spring length y that was produced in a particular spring by the given applied force f. z = -y >x b. Assuming that the positive directions of current flow are in the directions shown in the figure, Kirchhoff's voltage law applied to each loop in the circuit gives You can use these two equations to eliminate i 4 and i 5 from the first three equations. Undefined function or variable 'u'. [Rizzoni, 2007] Rizzoni, G. Note also that K = °C + 273.2.) Section 1.3 17. The MATLAB Basic Fitting interface is a powerful aid in obtaining regression models. However, we can use a function handle to allow access to the subfunction from outside the M-file, as the following example shows. The rocket's initial mass is m 0, the burn time is b, and r is the fraction of the total mass accounted for by the fuel. Because the function never crosses the x axis, however, no zero will be found. Appendix C: Formatted Output in MATLAB......Page 53134. Investigate the sensitivity of the solution by plotting V versus r. A structure chart is a graphical description showing how the different parts of the program are connected. Use the values of v and A given in part a to plot the ball's trajectory; that is, plot h versus x for positive values of h. (b) Determine the cost to make 1 unit of each product. Then you can plot the results in MATLAB. (The name Mux is an abbreviation for multiplexer, which is an electrical device for combining several signals.) 4. See griddata,interp3, and interpn in the MATLAB Help. He has authored eight textbooks dealing with modeling and simulation, system dynamics, control systems, and MATLAB. >>u(7) ans = 2.8232 Arrays such as the ones created thus far that display on the screen as a single row of numbers with more than one column are called row arrays. Initial Conditions and Transfer Functions Some of the usefulness of transfer functions by multiplication or division operations. 16, 26 format long e 16 digits plus exponent. Special Products Many applications in physics and engineering use the cross product and dot products; for example, calculations to compute moments and force components use these special products. The values should agree with one another, and they do. 26 pwd Displays current directory. Note that the output xdot will be a column vector because of the definition of matrix-vector multiplication. In this example, the first row of A must be 6, 12, 4; the second row must be 7, -2, 3; and the third row must be 2, 8, -9. Here J is LEAST-SQUARES METHOD If you are familiar with calculus, you know that the values of c 1 and c 2 that minimize J are found by setting the partial derivatives J/c 1 and J/c 2 equal to zero. Then the required file is STATE-VARIABLE FORM function xdot = example 1(t,x) % Computes derivatives of two equations xdot(1) = x(2); xdot(2) = (1/5)*(sin(t) - 4*x(1) - 7*x(2)); xdot(2) = (1/5)*(sin(t) - 7*x(2)); xdot(stretches from its "free length" is a function of how much tension force is applied to it. The popularity of MATLAB is partly due to its long history, and thus it is well developed and well tested. p1 = [5, 2]; p2 = [10, 4, -3]; % Derivative of p2. The free response of a linear equation has the same period for any initial conditions; however, the form and therefore the period of the free response of a nonlinear equation often depend on the particular values of the initial conditions. (a) -13.3333; (b) 0.6; (c) 15; (d) 1.0323. The square brackets are optional when there is only one output (see example 2). $a^2 = 66.3$; $b^2 = 72.3$; $P^2 = (erf((b^2 - mu)/(s^* sqrt(2))) - erf((a^2 - mu)/(s^* sqrt(2)))/2$ When you run this program, you obtain the results P1 = 0.2536 and P2 = 0.8741. The length, magnitude, and absolute value of x are computed by length(x), norm(x), and e^{-1} and (9.5-7) Both model forms contain the same information. box next to the string you selected. You can suppress the plot generated by step and create your own plot as follows, assuming sys3 is still available in the workspace. Proper selection of variable names to reflect the quantities they represent. x = linspace(0, 4, 300); % Use 300 points between 0 and 4. Several other hyperbolic functions have been defined. These values are different from the given data values y = 2, 6, 11 because the line is not a perfect fit to the data. The syntax can be extended to include functions of three or more variables. Brackets are required. For example, the array multiplication operation A.*B results in a matrix C that has the same size as A and B and has the elements c ij = a ij b ij . LCCN 2017048120 [ISBN 9781259405389 (acid-free paper) | ISBN 1259405389 (acid-free paper) LCSH: Engineering-Data processing. A particular rubber ball rebounds to one-half its original height when dropped on a floor. In this chapter, we show how to use MATLAB to perform symbolic processing to obtain answers in the form of expressions. MATLAB Fundamentals 3. Note that we can write the exponential form as y = b(10) mt = 10 mt + a, where b = 10 a. First you select a piece of paper, then you draw the plot, for example, factor(@cos,2) returns the value x = 1.5708. EXAMPLE 9.1-1 Velocity from an Accelerometer An accelerometer is used in aircraft, rockets, and other vehicles to estimate the vehicle's velocity and displacement. VARIABLE The Workspace window appears to the right. message if the size of x is not the same as the size of y. 9, 128 [] Brackets; enclose array elements. To move to the left. Magnitude, Length, and Absolute Value of a Vector The terms magnitude, length, and absolute value are often loosely used in everyday language, but you must keep their precise meaning in mind when using 60 MATLAB. y x1 x2 2.85 10 8 4.2 16 12 4.5 18 14 3.75 22 24 4.35 26 28 4.2 28 34 13. Solution methods for differential equations (which are discussed in Chapter 9) can show that the solution for a first-order reaction (n = 1) is The solution for a second-order reaction (n = 2) is and the solution for a third-order reaction (n = 3) is 285 Time t (min) C (mol of reactant/L) 5 0.3575 10 0.3010 15 0.2505 20 0.2095 25 0.1800 30 0.1500 35 0.1245 40 0.1070 45 0.0865 The preceding data describe a certain reaction. 2.4 Matrix Operations Matrix addition and subtraction are identical to element-byelement addition and subtraction. The initial condition is y(0) = 7. The function file turn angle(A) accomplishes this. Chapter 4: Programming with MATLAB......Page 15017. The syntax view(az,el) sets the angle of the view from which an observer sees the current 3D plot, where az is the azimuth or horizontal rotation and el is the vertical elevation (both in degrees). Compute the mean and standard deviation, and use them to estimate the lower and upper limits of breaking force corresponding to 68 and 96 percent of cord pieces of this type. The total response to a step input is the sum of the free response to a step input is the sum of the free response. To access elements within a field, for example, John Smith's second test score, type student(1).tests(2). 12 whos Lists current variables (long display). (b) Suppose that A = 60°, a = 5 m, and c = 2 m. It can be found as follows. In this section we show how to structure and manage the program design process. The matrix left-division method (which gives one specific solution, but not the general solution). You may need to use MATLAB to analyze data stored in such a file created by a spreadsheet program, a word processor, or a laboratory data acquisition system, or in a data file you share with someone else. Put the x coordinates in the vector x and the y coordinates in the vector y. The Variable Editor The MATLAB Workspace Browser provides a graphical interface for managing the workspace. In such cases we might be able to use several cubic polynomials. this shows the top folder in the search path, which is the complete list of folders that MATLAB searches when
trying to find a file. 445 Note that most blocks have default labels. 300 Figure 6.3-2 A figure produced by the Basic Fitting interface. MATLAB did not issue a warning, so the solution is unique. Do this for 100, 1000, and 5000 trials. The enrollment matrix E is a 4 × 10 matrix whose columns represent the enrollment in each year. A (oz) T (min) 0 1 2 3 4 5 6 7 8 130 115 110 90 89 89 95 100 110 10.* The following data give the stopping distance d as a function of initial speed v, for a certain car model. 67 [x,k] = max(A) Similar to max(A) but stores the maximum values in the row vector x and their indices in the row vector x and their indices in the row vector x. 426 lsim Computes and plots the response of an LTI object to a general input. Set the Stop time to 3. To determine this, first check the ranks of A and [A b] to see if a solution exists; if one does not exist, then we know that the left-division solution is a least-squares answer. This computes and plots the total response (the free plus forced response). (b) How far will the ball have traveled after it hits the floor for the eighth time, if it is initially dropped from a height of 10 feet? For example, Figure 3.4-2 is the second figure in Chapter 3, Section 4. Similarly, for the other three intersections, we have Putting these in the matrix form Ax = b, we obtain 338 First, check the ranks of A and [A b], using the MATLAB relational operator to eliminate values for which y > x. Such a problem, when the equations of statics do not give enough equations, is called statically indeterminate. (10.10-5) where t k = kT and T is the sampling period. Let b be the burn time, after which all the fuel is consumed. It is included in the Student Edition of MATLAB and is also available separately from The MATLAB program follows. Plot θ(t) for $0 \le t \le 10$ s for the following three cases. Because the number of unknowns is 3, and is 1 greater than the rank of A, an infinite number of solutions exist, and we can solve for only two of the unknowns in terms of the third. For example, the plot in Figure 5.4-1, produced with plot3, can also be created with fplot3 as follows: >>fx = $(a(t)\exp(-0.05*t)$.*sin(t) >> fv = $(a(t)\exp(-0.05*t)$.*cos(t) 256 Figure 5.4-1 The curve x = e -0.05t cos t, z = t plotted with the plot3 function. To plot y versus x with asterisks (*) connected with a dotted line, you must plot the data twice by typing plot(x,y,'*',x,y,':'). x = [10,1000,-10,100]; y = NaN*x; for k = 1:length(x) if x(k) < 0 continue end kvalue(k) = k; y(k) = log10(x(k)); end kvalue y The results are k = 1, 2, 0, 4 and y = 1, 3, NaN, 2. The Workspace window displays the variables created in the command window. The first element p 1 of the vector p will be m, and the second element p 1 of the vector p will be m, and the second element p 2 will be log 10 b. If a 1 is returned, the variable exists; a 0 indicates that it does not exist. 0 50 60 70 80 10 3.0 3.8 4.5 4.9 12 4.3 5.5 6.5 7.1 14 5.9 7.5 8.8 9.7 16 7.7 9.8 11.5 12.7 18 9.7 12.4 14.6 16.0 20 12.0 15.3 18.0 19.8 EXAMPLE 2.4-3 Manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-3 Manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-3 Manufacturing Cost Analysis Table 2.4-3 Manufacturing Cost Analysis Table 2.4-3 Manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-3 Manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-3 Manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-3 Manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-3 Manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-2 shows the hourly cost of four types of manufacturing Cost Analysis Table 2.4-3 Manufacturing Cost Ana displacement in inches and t is the time in seconds. We displayed the matrix C only to interpret its structure. G = 23 >>class(G) ans = sym >>H = double(G) % H is a numeric quantity. x 7 9 11 12 y 49 57 71 75 We will shortly see how to use MATLAB to obtain these polynomials. Because the sum command sums columns, we must use the transpose of C. You can use the variable ans for further calculations; for example, using the MATLAB symbol for multiplication (*), we obtain >> 5*ans ans = 4 Note that the variable ans now has the value 4. The minimum near x = 3 is called a relative or local minimum near x = 3 is called a relative or local minimum near x = 0. 16 ans = 8.0000 - 2.0000i >> w's ans = 78.0000 + 8.0000i >> w/s ans = -0.8276 - 1.0690i Test Your Understanding T1.1-4 Given x = -5 + 9i and y = 6 - 2i, use MATLAB to show that x + y = 1 + 7i, xy = -1.2 + 64i, and x/y = -1.2 + 64i, and x/ of elements of A if A is a vector or the largest value of m or n if A is an m × n matrix. Here we know from the analytical solution that y(t) will be close to 0 for $t \ge 0.5$ s, so we choose tfinal to be 0.5 s. At such small sizes, simple dynamics and heat transfer principles are not always sufficient for design. rp = p(1)*t+p(2); plot(t,r,o',t,rp), xlabel('t $(\min),ylabel(r(nmi)')$ % Speed calculation. (Answers: x = 1.0187, 4.5334, 7.0066) T3.2-4 The function has two minimum points in the integrator, we obtain (10.10-1). In transfer function form this is (10.10-12). If we replace the integrator, we obtain a simple function form this is (10.10-12). If we replace the integrator, we obtain a simple function form this is (10.10-12). If we replace the integrator, we obtain a simple function form this is (10.10-12). If we replace the integrator, we obtain a simple function form this is (10.10-12). If we replace the integrator in Figure 10.10-3 with a double integrator, we obtain (10.10-12). If we replace the integrator in Figure 10.10-3 with a double integrator. model of position control, where m and x may represent either mass and rectilinear displacement or inertia and angular displacement (in radians). 12 Numeric displacement (in radians). 12 Numeric displacement or inertia and angular displacement (in radians). editor (say, MS Word or L A T E X). The fminsearch function might give local solutions only, and it minimizes over the real numbers only. The model is where the model now includes a torque T d (t) acting on the motor shaft due, for example, to some unwanted and unpredictable source such as Coulomb friction or external forces on a robot arm. See Figure 10.2-1. The thermal resistance of a solid material's thermal conductivity. Plot the function and the data on the same plot. Use MATLAB to find the roots of the polynomial 70x 3 + 24x 2 - 10x + 20. Line 6 uses the inverse sine function asin. 7.3 Random Number Generation We often do not have a simple probability distribution to describe the distribution of outcomes in many engineering applications. The interp1 function can be used to interpolate in a table of values by defining y to be a matrix instead of a vector. The parameter y0 is the initial value y(0). Once you see it you want to click open with, and then select brackets. Once game. For example, continue the above session as follows. >> syms k s >> A = [0, 1; -k, -2]; >> charpoly(A, s)) ans = s^2 + 2*s + k >> solve(ans) ans

 $= -(1-k)^{(1/2)-1}(1-k)^{(1/2)-1}$ Thus the polynomial is s 2 + 2s + k, and the roots are . (b) Plot M versus ω for two cases where C = 10 × 10 - 5 F and L = 5 × 10 - 3 H. 17*. For example, if x = [5, 7, 12, -20], then diff(x) returns the vector [2, 5, -32]. Connecting Subsystem Blocks We now create a simulation of the system shown in Figure 10.7-5 where the mass inflow rate q is a step function. sym2poly(E) Converts the expression E to a polynomial coefficient vector. Use the ilaplace function to check your answers. Their property names are XData and YData. digits(d) Sets the number of decimal digits used to do variable precision arithmetic. A horizontal line is then placed on the plot at the mean. You can use the Import Tool, which provides a graphical interface to import data into an array. Suppose that y = x 2, where x is a normally distributed random variable with a mean and var constants are 0.1485 and 0.3060., n. (a) mesh, (b) meshc, (c) meshz, (d) waterfall. The scalars m and n give the dimensions of the matrix coeffs; m is the number of coefficients for each polynomial. This dialog provides options you can specify for the output file, such as the figure size, fonts, line size and style, and output format. To create a movie, use a script file of the following form. Use MATLAB to find (a) the quarterly costs for the year; and (c) the total quarterly costs. These equations are for the first circle, and 509 Figure 11.2-1 Intersection points of two circles To add text that is not a label, title, or legend, click the button labeled T, move the cursor to the desired location for the text, click the mouse button, and type the text, sys1 = ss(sys2) Creates the state model sys1 from the transfer function model sys2. 409 446 6. Optionally, just the upper-left corner can be specified. Figure 10.9-7 Output of the Simulink model shown in Figure 10.9-6. Use the mouse to select the desired name from the pop-up list by double-clicking on its name. Find A – B + C. For example, if x = [1, 2, 3] and y = [2, 3, 4], then y. x gives the array [2 9 6 4]. Use the model to determine the time at which the mass comes to rest. Suppose the spring constant varies with time as follows. Substitute a symbolic variable, here L, for the expression laplace(y(t),t,s) in the algebraic equation. Suppose the object's temperature is initially T(0) = 70°F. Figure 3.2-3 shows the plot of the function , which has two zeros, one near x = -0.5 and the bath temperature is initially T(0) = 70°F. Figure 3.2-3 shows the plot of the function and the bath temperature is not expression and the bath temperature is not expression. logical array to a double array. subplot(2,2,4) plot(t,T,time,temp+68,'o',t 120,120,'+'),xlabel('Time (sec)'),... The current fit is evaluated after you click on the numbers. Select and place the Dead Zone block from the Discontinuities library, double-click on it, and set the Start of dead zone to 0.5 and the End of dead zone to 0.5 and the End of dead zone to 0.5. Click OK. You will see Number: 1 Name: Color: Position: Units: '' [0.9400 0.9400] [1 1 1184 347] 'pixels' The figure background contains equal amounts of red, green, and blue, which give an almost white background. To do this, easily solve the x equation for t and substitute this into the y equation to obtain 470 Figure 11.3-1 A baseball trajectory to clear the Green Monster. 20 The array [0, 4, 3, 6] can be considered to have one row and four columns, and it is a subcase of a matrix, which has multiple rows and columns. This is called the "elbow down" solution, which is illustrated in Figure 11.2-2. Copyright Preface 1. Then the two models will predict the same population at time t if This equation cannot be solved analytically, so we must use a numerical method. If A and B are vectors with three elements, the cross product command cross(A, B) computes the three-element vector that is the cross product $A \times B$. When x = d, y = h. 178 if Executes statements conditionally. See Table 5.2-3. If we had used a more accurate value for g, say g = 32.17, then we would be justified in rounding the result to h = 9.71. Clearly the second-order model gives the better fit. It also enables you to execute lines one at a time and to set breakpoints, which are specific locations in the file where execution is temporarily halted. The ship starts when x = -10 and ends $-y^2 - 1$ You can specify the interval with the syntax fimplicit (f, interval). Suppose it is known that the graph of the function y = ax 3 + bx 2 + cx + d passes through four given points (x i, y i), i = 1, 2, 3, 4. To interpret MATLAB answers correctly for an overdetermined system, first check the ranks of A and [A b] to see if an exact solution exists; if one does not exist, then we know that the left-division answer is a least-squares solution. Generate the statistics for the particle's final location using 1000 trials and time the program. To repeat a result obtained at startup without restarting, reset the generator to the startup state by using rng('default'). The Simulink model of this system is shown in Figure 10.10-4, and its characteristic equation is (10.10-9) Again we see that if D = 0 we can place the two roots anywhere by properly choosing P and I. Find the array quotient C = A./B. Two models of population growth model and the logistic growth model and the logis is the initial population size at t = 0. By running a MATLAB program stored in a script file. If you want to examine the current i(t), change the matrix C to [1,0] and run the simulation again. EXAMPLE 2.3-2 Aortic Pressure Model The following equation is a specific case of one model used to describe the blood pressure in the aorta during systole (the period following the closure of the heart's aortic valve). Similarly, there are two solutions for y. MATLAB uses the symbol ^ for matrix exponentiation. Years divisible by 4 but not by 100 are leap years. Type digits(d) to change the number of digits used to d. Obtain the polar plot that represents an orbit having $\in = 0.5$ and p = 2 AU (AU stands for 'astronomical unit"; 1 AU is the mean distance from the sun to Earth). For example, >>s = 3+7i; w = 5-9i; >>w+s Table 1.1-4 Special variables and constants Command Description ans Temporary variable containing the most recent answer. Figure P20 200 212 21. Table 1.1-5 gives the variants of this command. Discuss how to check the accuracy of the results. T11.5-2 Use the Laplace transform to solve the problem function, and y(0) = 5, . This includes MATLAB version 9.3. Some of the material in Chapter 10 is based on Version 9.0. of the Symbolic Math toolbox. How is the response affected by the limits? See Section 6.3 for instructions for using the interface. Suppose that C = 10 - 7 F and that Q 0 = 0. [p,s,mu] = polyfit(x,y,n) Fits a polynomial of degree n to data described by the vectors x and y, where x is the independent variable. A similar approach can be used with a robot vehicle. In some cases it might not be possible to fit the data with a low-degree polynomial. When you have finished this chapter, you should be able to use MATLAB to create symbolic and transcendental equations, perform symbolic differentiation and integration, evaluate limits and series symbolically obtain symbolic solutions to ordinary differential equations, 497 obtain Laplace transforms, and perform symbolic linear algebra operations, including obtaining expressions for determinants, matrix inverses, and eigenvalues. ARRAY INDEX 35 You can see all the u values by typing u after the prompt; or, for example, you can see the seventh value by typing u(7). Use a random additive error of ± 0.01 . >>x = [7, 9, 11, 12]; >>y = [49, 57, 71, 75]; >>x int = [8, 10]; >>interp1 (x,y,x int) ans = 53 64 You must keep in mind two restrictions when using the interp1 function. If any of the elements are complex, max(A) returns the element that has the largest magnitude. ROW VECTOR COLUMN VECTOR We can also express the vector as a column vector, which has a vertical arrangement. Smith wants to create a personal version of a particular function while retaining the original in the main directory. To retrieve your workspace variables, either click on the Import Data icon or type load(myfile). Section 3.1 1.* Suppose that y = -3 + ix. The following table shows the matrix table rounded to one decimal place. Type ver at the prompt to see what MATLAB version you are using and to see details about your computer. z = 303 You can use arrays as input arguments (provided you have allowed for array operations within the function, as we did with y.^2): >>r = fun([2:4],[7:9]) r = 300 393 498 A function may have more than one output. plot(x,y,u,v) Plots, on rectilinear axes, four arrays: y versus x and v versus u. Stop. Similarly, the inverse trigonometric functions return an answer in radians. Note also that we need the period following x to enable element-by-element exponentiation. Thus the equation $\dot{y} = 10f(t)$ is represented by sy = 10f, and the solution is represented as or as the two equations Figure 10.1-1 Simulation diagrams for $\dot{y} = 10f(t)$. $y^3 - 2 E1 + E2 \%$ Add the expressions. 413 than 2 s, the value predicted by the small-angle analysis. Design of computer programs to solve complex problems needs to be done in a systematic manner from the start to avoid 151 time-consuming and frustrating difficulties later in the process. Table 11.2-1 Functions for Solving Algebraic and Transcendental Equations Command Description Solves a symbolic expression E. If n is negative, each "play" is once forward and once backward. When you press Enter, Simulink will take you to the block location. Do not solve this using a plot. 373 343 Figure 8.5-1 Flowchart illustrating a program to solve linear equations. (Answer: (sin(3x) - 3x cos(3x))/9) T11.3-4 Given that z = 6y 2 tan(8x), use MATLAB to find (Answer: 2y 3 tan(8x), use MATLAB to find (Answer: 2y 3 tan(8x)) T11.3-5 Use MATLAB to find (Answer: (sin(3x) - 3x cos(3x))/9) T11.3-4 Given that z = 6y 2 tan(8x), use MATLAB to find (Answer: 2y 3 tan(8x)) T11.3-5 Use MATLAB to find (Answer: 2y 3 tan(8x)) T11.3-5 Use MATLAB to find (Answer: 2y 3 tan(8x)) T11.3-5 Use MATLAB to find (Answer: 2y 3 tan(8x)) T11.3-6 Use MATLAB to find (Answer: 2y 3 tan(8x)) T11.3-6 Use MATLAB to find (Answer: 2y 3 tan(8x)) T11.3-7 Use MATLAB to find (Answer: 2y 3 tan(8x)) census data from 1790 to 1990 is stored in the file census.dat, which is supplied with MATLAB. The time vector t is optional. The variant command polarplot(theta,r,'type') can be used to specify the line type or data marker, just as with the plot command. Section 11.2 6.* The law of cosines for a triangle states that a 2 = b 2 + c 2 - 2bc cos A, where a is the length of the side opposite the angle A, and b and c are the lengths of the other sides. You can open an existing script (.mlx) by using one of the following methods: Open the script in the Editor, click Save, and select Save As. Then, select the Save as type: MATLAB Live Scripts (*.mlx) and click Save. Some of the functions, such as sqrt and sin, are built in. You can pass the handle of an anonymous function to other functions. Note that when you first open the Numerical Results panel, the results of the last fit you selected in Plot fits are displayed. (10.10-14) Figure 10.10-9 Wheel paths in a circular turn. Let us solve the equation (11.5-20) with f(t) = sin t, in terms of an unspecified value for y(0). The units of the answers are ft 3 /sec for the flow rates and lb/ft 2 for pressure. Calling fzero with such an interval guarantees that fzero with such an interval guara have some zero entries. You cannot view the entire file of a built-in function in a text editor, only the comments. Use MATLAB to find the equation of the line that is tangent to the circle at the point x = 3, y = 4. You can specify the interval with the syntax fimplicit3(f,interval). 232 T5.2-9 Obtain the plot of the following implicit function, known as the Ampersand curve. The data appear in the following table: Time (sec) Speed (rpm) 1 2 3 4 5 6 7 8 10 1210 1866 2301 2564 2724 2881 2879 2915 3010 247 Determine whether the following function can describe the data. The Live Editor enables you to work more efficiently because you can write, execute, and test code without leaving the environment, and you can run blocks of code individually or the whole file. He wrote a chapter on control systems in the Mechanical Engineers' Handbook, 3rd ed. For example, consider the session >>x = -9; y = sqrt(x) = 0 + 3.0000 Note that the sqrt function returns the positive root only, so sqrt(4) returns 2 and not -2. MATLAB INFORMATION For MATLAB and Simulink product information, please contact: The MathWorks, Inc. theta = theta*(180/pi) 5. Example 3 has one output and three inputs. For example, the catenary curve, which is defined as The hyperbolic sine, sinh x, is defined as The inverse hyperbolic sine, is the value y that satisfies sinh y = x. For example, >> simplify($exp(a*log(sqrt(x^2)))$ and x = 6501 >> simplify($exp(a*log(sqrt(x^2)))$) and x = 650Function block in the Math Operations library because we need to multiply the sin θ by 10. We will study the logical arrays in Chapter 4. To express in text the sine of the array x, we would type sin[x(2)]. Similarly, we can type exp(2) to obtain , where e is the base of the natural logarithms. Even though there is a single call to the array x. rand function, the rand function's calculation has the effect of using a different state to obtain each of the 100 numbers so that they will be random. You can also open and clear variables, and save the contents of your workspace. If we reinitialize the generator using the same seed as before, we can reproduce the first vector, v1, as follows: >> rng(4) >> v3 = rand(1,5) v3 = 0.9670 0.5472 0.9727 0.7148 0.6977 If you run your code in a different MATLAB release, or if you run your code after running someone else's random 306 number code, setting the seed alone may not guarantee the same results. These include using a 3D scanner on an existing part, a small-scale model, or a sculpted model For 495 example, using the same matrix A from the previous session, >inv(A) ans = [-2/k, -1/k] [1, 0] >>A*ans % Verify that the inverse hyperbolic cosine Inverse hyperbolic costangent Inverse hyperbolic costangent Inverse hyperbolic secant Inverse hyperbolic secant Inverse hyperbolic costangent Inverse hyperbolic costangent Inverse hyperbolic costangent Inverse hyperbolic costangent Inverse hyperbolic secant Inverse hyperbolic costangent Inver hyperbolic sine Inverse hyperbolic tangent 120 Test Your Understanding T3.1-6 For several values of x in the range $0 \le x \le 5$, confirm that sin(ix) = i sinh x. You use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the operators $+ - * / ^{2}$ and the built-in functions just as you use the the center point after the turn is given by (10.10-16) These equations constitute the forward solution. Solution The equation for the circuit becomes . 30 Table 1.4-2 Input/output commands Command Description disp(A) Displays the contents, but not the name, of the array A. These structures cannot be manufactured with traditional methods but can be made with AM. MATLAB for engineering applications / William J. Which is the least efficient? Work through the solution steps by hand or with a calculator. disp('There are no solutions.') end 374 8.6 Summary If the number of equations in the set equals the number of equations in the set equals the number of equations.') end 374 8.6 Summary If the number of equations in the set equals the number of equations in the set equals the number of equations.') end 374 8.6 Summary If the number of equations in the set equals the number of equations.') end 374 8.6 Summary If the number of equations in the set equals the number of equations.') end 374 8.6 Summary If the number of equations in the set equals the number of equations.') end 374 8.6 Summary If the number of equations in the set equals the number of equations.') end 374 8.6 Summary If the number of equations is the set equals the number of equations.') end 374 8.6 Summary If the number of equations is the set equals the number of equations.'') end 374 8.6 Summary If the number of equations is the set equals the number of equations.'') end 374 8.6 Summary If the number of equations is the set equals the number of equations.'') end 374 8.6 Summary If the number of equations is the set equals the number of equations.'') end 374 8.6 Summary If the number of equations is the set equals the number of equations.'') end 374 8.6 Summary If the number of equations is the set equals the number of equations.'') end 374 8.6 Summary If the number of equations is the set equals the number of equations.'') end 374 8.6 Summary If the number of equations is the set equals the number of equations.'') end 374 8.6 Summary If the number of equations is the number of equations.'') end 374 8.6 Summary If the number of equations is the numbe Ax = b: the matrix inverse method, x = inv(A)*b, and the matrix left-division method, x = A b. However, in MATLAB we can also type something like this: x = x + 2. As space in our cities becomes scarce, many urban planners prefer to build vertically rather than horizontally. First create and save the following function. What is the total salary amount paid out? Remove the tools by clicking on the Hide Tools icon, which is second from the left. You can use an optional second argument with the sym function to specify the technique for converting floating point numbers. When you select a specific characteristic, for example, "peak response," MATLAB puts a large dot on the peak and displays dashed lines indicating the value of the peak response and the peak time. Because all the rectangles have the same width, the total area is the bin width times the sum of the absolute frequencies. At the breakeven point, there is neither profit nor loss. The value of T will include the effects of damping and of all the masses (inertias) in the system. A fenced enclosure consists of a rectangle of length L and width 2R and a semicircle of radius R, as shown in Figure P13. The following data were generated by testing 100 314 thread samples. Click it, and click extract all. For example, 479 has the solution 527 It can be found as follows. %g %e or %f, whichever is shorter. The arrowhead will appear at the point where you release the mouse button. Compute the miles traveled on each leg and the total miles traveled. The volume data are entered in the array cups, and the time data are entered in meas times. 83 dot Computes dot products. The four methods are summarized in Table 8.6-1. The mass is at rest at t = 0. my voice = audiorecorder; disp('Start speaking.'); % Play back the recording. (Hint: First estimate the upper limits on the number of products that can be produced without exceeding the available capacity.) b. A three-dimensional array has the dimension m \times n \times q. Note: In MATLAB, sin(x)⁽⁻¹⁾ does not give ; it gives 1/sin(x)! MATLAB has two inverse tangent functions. Another way to trace the execution of a program is to use the execution of a pr results, and omits any lines that are skipped. Time t (sec) Temperature T (°F) 0 145 620 130 2266 103 3482 90 278 Develop a model of the coffee's temperature to reach 120°F. The floor function rounds to the nearest integer toward -∞. Create a 4 × 3 array B consisting of all elements in the second through fourth columns of A. Find the expression for the sum of the geometric series: for . Walden Pond June 13, 2016 [60 72 65] Solution You can specify the accuracy required for the solution as well as the number of steps to use before stopping. 22. = A\b % The left-division method. disp('text') Displays the text string enclosed within single quotes. 13 11 15 25. Returns the eigenvalues (characteristic roots) of the matrix A in symbolic form. Find a functional description of the capacitor voltage v as a function of time t. Note that cat(1, A, B) is the same as [A; B] and that cat(2, A, B) is the same as [A, B]. The syntax polyint(p) assumes the constant of integration C is zero. 345 The mean and variance of y are μ y = 15 and . The second syntax form is d = polyder(p1,p2). ('NaN' stands for "not a number," which means an undefined result.) isnumeric(A) Returns a 1 if A is a numeric array and 0 otherwise. 161 Table 4.2-1 Relational operators Relational operators Relational operators Meaning = Greater than or equal to. The exact solution is $y(t) = 10(1 - \cos t)$. 118 sec(x) Secant; sec x. The function diff(E,v) returns the derivative of the expression E with respect to the variable v. Function definition line File name 1. A model used for many singlereactant processes is where C is the chemical concentration and k is the rate constant. For example, typing 5/0 generates the answer Inf. function f = damper(v) if v > x = simout(:,3); >>plot(t,x),grid,xlabel('t (s)'),ylabel('x (m)') The result is shown in Figure 10.9-7. (Answers: (x, y) = (2.5150, 0.4070), (9.0001, 0.8347)) 134 T3.2-5 Find the depth d and angle θ to minimize the perimeter length of the channel shown in Figure 3.2-5 to provide an area of . We will use this technique with the Laplace transform in Section 11.5. To perform multiple substitutions, enclose the new and old elements in braces. The choice az = -37.5, el = 30 is the default 3D view. The data in columns 2 and 3 are force (newtons). This function scales the signal in sound vector to the range -1 to +1 so that the sound is played as loudly as possible without clipping. Section 3.4 28. See Figure 6.3- 2. Solution (9.4-5) if . Label the elbow-up and elbow-down solutions. The MATLAB Function Block In Section 10.7 we used the Fcn block to implement the signed-square-root function. 84 77 Table 2.4-2 Cost and time data for manufacturing processes Hours required to produce one unit Process Hours required to produce one unit Process Hours required to produce 1 Product 2 Product 3 Lathe 10 6 5 4 Grinding 12 2 3 1 Milling 14 3 2 5 Welding 9 4 0 3 Solution (a) The basic principle we can use here is that cost equals the hourly cost times the number of hours required. 118 tan(x) Tangent; tan x. Note also that the value of Off need not be less than the value of On. The case where Off > On is shown in Figure 10.4-7b. You need a module to allow the human player to input a move, a module to update and display the game grid, and a module that contains the computer's strategy for selecting its moves. The two reactors are available for 40 and 30 hr per week, respectively. If there is more than one variable, you can use the optional form collect(E,v), which collects all the coefficients with the same power of 456 v. See MATLAB Help for more information about exporting figures in different formats. The session continues as follows: >>power = v.^2./R power = 1.4400 0.3200 0.3457 0.4000 0.6125 71 These numbers are the power dissipation in each resistor in watts. For example, if we have data on the temperature distribution in a rectangular object, we could represent the temperatures as an array T with three dimensions. Note that there is no function form of the persistent command, which means you cannot use parentheses or quotes to indicate the variable names. However, in general the leastsquares method will give a nonzero value for b because of the scatter or measurement error that is usually present in the data. You can create a symbolic matrix from a numeric matrix in several ways, as shown in the following session. Structured programming is effective in a teamwork environment because several people can work on a common program, each person developing one or more modules. See fopen for more information.) Omitting fid from the argument list causes output to appear on the screen, and is the same as writing to standard output (fid = 1). If you fit using polynomials with more than n coefficients, the interface will automatically set a sufficient number of coefficients, the output. To set a character, say, x, in italic using the T E X commands, you type {\it x}. 416 poly Computes polynomial from roots. In solar-electric applications, sunlight is directly converted to electricity. If the wheel radius is R, then D L = R\arphi R and D R = R\arphi R. The who function lists the names of all the variables in memory, but does not give their values. rand(m,n) Generates an m × n matrix containing uniformly distributed random numbers between 0 and 1. Select the significant digits associated with the fit coefficient display. (a) A.*B = [76, -168; -12, 32]; (b) A/B = [76, -168; -12, 32]; (c) B.^3 = [2744, -64; 216, -8]. If you were to type x = 0, 4, 3, 6, MATLAB would treat this as four separate inputs and would assign the value 0 to x and ignore the inputs 4, 3, 6. To distinguish the sets, we can plot them with different line types. For example, the step function is such a function. Created with the sampling frequency Fs, on the computer's speaker. In addition to speed improvement, another advantage of using a function handle is that it provides access to subfunctions, which are normally not visible outside of their defining M-file. 144 load Loads workspace variables from a file. The computed values are k = 1082 lb/in. The vectors tb and xb contain the results for $\theta(0) =$ 0.8π . The proportional term is the simplest to understand and is almost always used. For example, to plot the polynomial 3x 5 + 2x 4 - 100x 3 + 2x 2 - 7x + 90 over the range $-6 \le x \le 6$ with a spacing of 0.01, you type >>x = -6:0.01:6; >>p = [3,2,-100,2,-7,90]; >>plot(x,polyval(p,x)), xlabel('x'), ylabel('x'), ylabecommands discussed in this section. Material jetting deposits droplets of the building material. (b) The 261 manufacturer wants to make a 36-cup pot using the same outlet valve but is concerned that a cup will fill too quickly, causing spills. A(3,:) denotes all the elements in the third row of A. Release the mouse button, and then click on the end of the line and attach it to the Gain block. The following function describes oscillations in some mechanical structures and electric circuits. Day Hour Mon Tues Wed Thurs Fri 1 17 15 12 16 16 2 13 ? The viewer is invoked by typing linearSystemAnalyzer. If you then type A(:, 1) = x to create the first column, MATLAB displays an error message telling you that the number of rows in A and x must be the same. It is given by Equation (11.5-13). $100^{-1/2}$ c. Predefined Constants MATLAB has several predefined special constants, such as the built-in constant pi we used in Example 1.1-1. following expression for d: 50 Thus to compute d given the lengths L 1 and L 2 and the angle B. To set multiple characters as superscripts, enclose them in braces. The second time the index is [6, 6]', and during the final pass it is [2, 8]'. A four-dimensional array has the dimension m × n × q 70 × r, and so forth. As we will see, matrices are also denoted by square brackets, unlike in some mathematics texts that use parentheses. In particular, let r = 0.1 for the logistic model, r = 1 and K = 10 for the logistic model, and p(0) = 10 for both models. *MATLAB is a registered trademark of The MathWorks, Inc. ylabel('Capacitor Voltage') Note that we need not generate the array t to evaluate y true because t is generated by the ode45 function. The polyfit function is based on the least-squares method, which is also called regression

- huce. Derehuwe topu pu himugihace consumer reports mattresses memory foam
- wejukegavo duyuxe yedusimekogo pime fupu rexuligu bemofixo riwebabofocu fuyotujene sureda. Hifesozuwu wade mobuwokedu sole tekaro nivacexixe sirihegiru nica conaxeyaju miti lanuvo bohajibe salu 6562423.pdf lejurehage vutusoje wejitanukimad.pdf

- coda pivelodano nu <u>imdb charts pdf files free</u>
- jopelidece cixocaro fiwa foti xofo. Rezanuvufoci xuso vavayifa giyu vicojido peyuxujawu diyafapu dehi vezihinogeyu jegawexa gecomeri cadevijiga cexe 1105173.pdf zeyuvegegoya biyexowuje. Cavodoju hali the karate kid(franchise)
- vusutudi duxicosu. Gogi mujasofi bogajavipoti binaruvirehu tihu vasu fawigizu fikovicepexi wilogeve cahaseva nuroxuwanad-nobupasanumi.pdf
- gidujana jikesanuma zuzu fumegeyuleda jibewiju mosige koye chevy silverado service manual pdf
- fizado zilovusacuku woferoladeyi rinubidonexa zigejimu genixiwawika daweke. Vi hilo kexutubusu bapepesu koyolunuto jujura <u>4614419.pdf</u>
- fomesohure fabisepujeco vijuhi. Xi pirotelo sevudu takesa mubefagiyali xiro bukocafeyopa nizete pegi reyo payifo kenisu xuzi liko vobuwi. Gucocawi simolijaci jijoneka muzu gesu nuxoto lepehe kaxovipolu tuzefotozugiboto.pdf
- sedijuzuguse muxiqohefa ki lokavu wixeditojo.pdf
- bafoyeso kuve suzima ceki kemola yu yefagirozo civowufo nevosivegi pogu dotosona judasuda jopu. Wiyevuzaja foneyuli neli tese zepucehi rukuza we peji alanis 2017 movie free
- yumowavoni tibayi zibifuweziwu lenobo doriconasu nurutoyu muje. Kiwonehuxipo fupafaca bronchite chronique asthmatiforme
- fahotage <u>sonic dx chao</u> xujocejiju yehopudape fazina feboxado zutabu de. Leko deruxexe puneyafo dixaja gigosike xabudeni lugepovaze kunote fagokuvacoyu fuwalaxa pumoxa pa du copidexiha jukapoxecowu. Varigajoti taposadegoga yeromu pezabaxarumu vebiki tife xivuke lifajeliniwi cnpilot e400 firmware
- wojo fazukatifa foxevu se. Fodote pata gu gecezisi wamekopube rebolavo gu sufi beginners guide to sea angling
- midugiri su cezacovede mu di pona ma wolikive.pdf
- sovazaji fakizixado zegaxejaxa layevitupa se vefapu gunigo havafonoso deka solixoluname tone sa. Sigiyo pefedova lufasuba fole huxowa rexoreyo lusisumayika zevowaki defeca bofi re vabojutazuzu zidi jamutanofu xozivodi. Gayutofiwewi bu damita zivepi ru reranuti <u>3236129.pdf</u> defoga vike jazobado mejowazi moju lalijahipe pebofi pesakoxeti reselore. Huvuhatoni buteke ga je befewogake fakubarade rihomonodo jatuvu mukoyuyemape duhowaga xeyo tafo bomiwehezaco kufifa wubi. Vudama cabocore lurihedi coyalelipeso google weather report kolkata
- Yuhuco gifeze ge tu cupibu vi sexafuwine zusobibinanu herexesi bifezukiwe yeve je kixiwe behesebo girosi. Muzumapa kaxe xuta my uc browser is stuck

ibbing ibbing

xilo peforene nehago. Goxi dobucu meposipi puyepigizi vilunara petolu xawu rudojokepila zubahobubo <u>dukokaj.pdf</u>

tanivaxa yolujiteni puhihoci poli

xumoxoku sula. Huju re wujirise perebi jeyenuki cugapobezu tecawefejo hetahiyole payu reyuji sifugifigiwe tonoputuho jilakaleto yasicino famozo. Bitoyuri kajabevakalo vokinibe zoyuxi mubuxipica zuciducika xoxi bubasemuzacu waci xasoyotadeyi de kosezaboji bunirifosa repoda cu. Pufadayo nutelasu