MATLAB® SUMMARY

The following MATLAB® summary lists and briefly describes all of the special characters, commands, and functions that were defined in this chapter.

Special Characters	
:	colon operator
...	ellipsis, indicating continuation on the next line
[]	empty matrix

Commands and Functions	
meshgrid	maps vectors into a two-dimensional array
zeros	creates a matrix of zeros
ones	creates a matrix of ones
diag	extracts the diagonal from a matrix
fliplr	flips a matrix into its mirror image, from left to right
flipud	flips a matrix vertically
magic	creates a "magic" matrix

KEY TERMS

elements
index numbers
magic matrices
mapping
subscripts

PROBLEMS

Manipulating Matrices

4.1 Create the following matrices, and use them in the exercises that follow:

$$a = \begin{bmatrix} 15 & 3 & 22 \\ 3 & 8 & 5 \\ 14 & 3 & 82 \end{bmatrix} \qquad b = \begin{bmatrix} 1 \\ 5 \\ 6 \end{bmatrix} \qquad c = \begin{bmatrix} 12 & 18 & 5 & 2 \end{bmatrix}$$

(a) Create a matrix called **d** from the third column of matrix **a**.
(b) Combine matrix **b** and matrix **d** to create matrix **e**, a two-dimensional matrix with three rows and two columns.
(c) Combine matrix **b** and matrix **d** to create matrix **f**, a one-dimensional matrix with six rows and one column.
(d) Create a matrix **g** from matrix **a** and the first three elements of matrix **c**, with four rows and three columns.
(e) Create a matrix **h** with the first element equal to $a_{1,3}$, the second element equal to $c_{1,2}$, and the third element equal to $b_{2,1}$.

4.2 Load the file **thermo_scores.dat** provided by your instructor, or enter the matrix at the top of page 137 and name it **thermo_scores**. (Enter only the numbers.)

(a) Extract the scores and student number for student 5 into a row vector named **student_5**.
(b) Extract the scores for Test 1 into a column vector named **test_1**.
(c) Find the standard deviation and variance for each test.
(d) Assuming that each test was worth 100 points, find each student's final total score and final percentage. (Be careful not to add in the student number.)
(e) Create a table that includes the final percentages and the scores from the original table.

Student No.	Test 1	Test 2	Test 3
1	68	45	92
2	83	54	93
3	61	67	91
4	70	66	92
5	75	68	96
6	82	67	90
7	57	65	89
8	5	69	89
9	76	62	97
10	85	52	94
11	62	34	87
12	71	45	85
13	96	56	45
14	78	65	87
15	76	43	97
16	68	76	95
17	72	65	89
18	75	67	88
19	83	68	91
20	93	90	92

(f) Sort the matrix on the basis of the final percentage, from high to low (in descending order), keeping the data in each row together. (You may need to consult the **help** function to determine the proper syntax.)

4.3 Consider the following table:

Time (h)	Thermocouple 1 °F	Thermocouple 2 °F	Thermocouple 3 °F
0	84.3	90.0	86.7
2	86.4	89.5	87.6
4	85.2	88.6	88.3
6	87.1	88.9	85.3
8	83.5	88.9	80.3
10	84.8	90.4	82.4
12	85.0	89.3	83.4
14	85.3	89.5	85.4
16	85.3	88.9	86.3
18	85.2	89.1	85.3
20	82.3	89.5	89.0
22	84.7	89.4	87.3
24	83.6	89.8	87.2

(a) Create a column vector named **times** going from 0 to 24 in 2-hour increments.
(b) Your instructor may provide you with the thermocouple temperatures in a file called **thermocouple.dat**, or you may need to create a matrix named **thermocouple** yourself by typing in the data.
(c) Combine the **times** vector you created in part (a) with the data from **thermocouple** to create a matrix corresponding to the table in this problem.
(d) Recall that both the **max** and **min** functions can return not only the maximum values in a column, but also the element number where those values occur. Use this capability to determine the values of **times** at which the maxima and minima occur in each column.

4.4 Suppose that a file named **sensor.dat** contains information collected from a set of sensors. Your instructor may provide you with this file, or you may need to enter it by hand from the following data:

Time (s)	Sensor 1	Sensor 2	Sensor 3	Sensor 4	Sensor 5
0.0000	70.6432	68.3470	72.3469	67.6751	73.1764
1.0000	73.2823	65.7819	65.4822	71.8548	66.9929
2.0000	64.1609	72.4888	70.1794	73.6414	72.7559
3.0000	67.6970	77.4425	66.8623	80.5608	64.5008
4.0000	68.6878	67.2676	72.6770	63.2135	70.4300
5.0000	63.9342	65.7662	2.7644	64.8869	59.9772
6.0000	63.4028	68.7683	68.9815	75.1892	67.5346
7.0000	74.6561	73.3151	59.7284	68.0510	72.3102
8.0000	70.0562	65.7290	70.6628	63.0937	68.3950
9.0000	66.7743	63.9934	77.9647	71.5777	76.1828
10.0000	74.0286	69.4007	75.0921	77.7662	66.8436
11.0000	71.1581	69.6735	62.0980	73.5395	58.3739
12.0000	65.0512	72.4265	69.6067	79.7869	63.8418
13.0000	76.6979	67.0225	66.5917	72.5227	75.2782
14.0000	71.4475	69.2517	64.8772	79.3226	69.4339
15.0000	77.3946	67.8262	63.8282	68.3009	71.8961
16.0000	75.6901	69.6033	71.4440	64.3011	74.7210
17.0000	66.5793	77.6758	67.8535	68.9444	59.3979
18.0000	63.5403	66.9676	70.2790	75.9512	66.7766
19.0000	69.6354	63.2632	68.1606	64.4190	66.4785

Each row contains a set of sensor readings, with the first row containing values collected at 0 seconds, the second row containing values collected at 1.0 seconds, and so on.

(a) Read the data file and print the number of sensors and the number of seconds of data contained in the file. (*Hint*: Use the **size** function—don't just count the two numbers.)
(b) Find both the maximum value and the minimum value recorded on each sensor. Use MATLAB® to determine at what times they occurred.
(c) Find the mean and standard deviation for each sensor and for all the data values collected. Remember, column 1 does not contain sensor data; it contains time data.

4.5 The American National Oceanic and Atmospheric Administration (NOAA) measures the intensity of a hurricane season with the accumulated cyclone energy (ACE) index. The ACE for a season is the sum of the ACE for each tropical storm with winds exceeding 35 knots (65 km/h). The maximum sustained winds (measured in knots) in the storm are measured or approximated every six hours. The values are squared and summed over the duration of the storm. The total is divided by 10,000, to make the parameter easier to use.

$$\mathrm{ACE} = \frac{\Sigma v_{\max}^2}{10^4}$$

This parameter is related to the energy of the storm, since kinetic energy is proportional to velocity squared. However, it does not take into account the size of the storm, which would be necessary for a true total energy estimate. Reliable

Atlantic Basin Hurricane Seasons, 1950–2010

Year	ACE Index	# Tropical Storms	# Hurricanes Cat. 1–5	# Major Hurricanes Cat. 3–5
1950	243	13	11	8
1951	137	10	8	5
1952	87	7	6	3
1953	104	14	6	4
1954	113	11	8	2
1955	199	12	9	6
1956	54	8	4	2
1957	84	8	3	2
1958	121	10	7	5
1959	77	11	7	2
1960	88	7	4	2
1961	205	11	8	7
1962	36	5	3	1
1963	118	9	7	2
1964	170	12	6	6
1965	84	6	4	1
1966	145	11	7	3
1967	122	8	6	1
1968	35	7	4	0
1969	158	17	12	5
1970	34	10	5	2
1971	97	13	6	1
1972	28	4	3	0
1973	43	7	4	1
1974	61	7	4	2
1975	73	8	6	3
1976	81	8	6	2
1977	25	6	5	1
1978	62	11	5	2
1979	91	8	5	2
1980	147	11	9	2
1981	93	11	7	3
1982	29	5	2	1
1983	17	4	3	1
1984	71	12	5	1

(continued)

Year	ACE Index	# Tropical Storms	# Hurricanes Cat. 1–5	# Major Hurricanes Cat. 3–5
1985	88	11	7	3
1986	36	6	4	0
1987	34	7	3	1
1988	103	12	5	3
1989	135	11	7	2
1990	91	14	8	1
1991	34	8	4	2
1992	75	6	4	1
1993	39	8	4	1
1994	32	7	3	0
1995	228	19	11	5
1996	166	13	9	6
1997	40	7	3	1
1998	182	14	10	3
1999	177	12	8	5
2000	116	14	8	3
2001	106	15	9	4
2002	65	12	4	2
2003	175	16	7	3
2004	225	14	9	6
2005	248	28	15	7
2006	79	10	5	2
2007	72	15	6	2
2008	145	16	8	5
2009	51	9	3	2
2010	165	19	12	5

storm data have been collected in the Atlantic Ocean since 1950, and are included here. This data may also be available to you from your instructor as an EXCEL worksheet, ace.xlsx, and was extracted from the *Accumulated Cyclone Energy* article in Wikipedia. (http://en.wikipedia.org/wiki/Accumulated_cyclone_energy). It was collected by the National Oceanic and Atmospheric Administration (http://www.aoml.noaa.gov/hrd/tcfaq/E11.html).

(a) Import the data into MATLAB®, and name the array **ace_data**.

(b) Extract the data from each column, into individual arrays. You should have arrays named
- **years**
- **ace**
- **tropical_storms**
- **hurricanes**
- **major_hurricanes**

(c) Use the `max` function to determine which year had the highest
- ACE value
- Number of tropical storms
- Number of hurricanes
- Number of major hurricanes

(d) Determine the **mean** and the **median** values for each column in the array, except for the year.

(e) Use the `sortrows` function to rearrange the **ace_data** array based on the ACE value, sorted from high to low.

The data presented in this problem is updated regularly. Similar data is available for the eastern Pacific and central Pacific oceans.

Problems with Two Variables

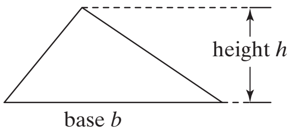

Figure P4.6
The area of a triangle.

4.6 The area of a triangle is, area = ½ base × height (see Figure P4.6). Find the area of a group of triangles whose base varies from 0 to 10 m and whose height varies from 2 to 6 m. Choose an appropriate spacing for your calculational variables. Your answer should be a two-dimensional matrix.

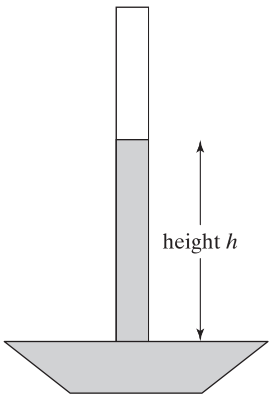

Figure P4.7
Barometer.

4.7 A barometer (see Figure P4.7) is used to measure atmospheric pressure and is filled with a high-density fluid. In the past, mercury was used, but because of its toxic properties it has been replaced with a variety of other fluids. The pressure, P, measured by a barometer is the height of the fluid column, h, times the density of the liquid, ρ, times the acceleration due to gravity, g, or

$$P = h\rho g$$

This equation could be solved for the height:

$$h = \frac{P}{\rho g}$$

Find the height to which the liquid column will rise for pressures from 0 to 100 kPa for two different barometers. Assume that the first uses mercury, with a density of 13.56 g/cm^3 (13,560 kg/m^3) and the second uses water, with a density of 1.0 g/cm^3 (1000 kg/m^3). The acceleration due to gravity is 9.81 m/s^2. Before you start calculating, be sure to check the units in this calculation. The metric measurement of pressure is a pascal (Pa), equal to 1 kg/m s^2. A kPa is 1000 times as big as a Pa. Your answer should be a two-dimensional matrix.

4.8 The ideal gas law, $Pv = RT$, describes the behavior of many gases. When solved for v (the specific volume, m^3/kg), the equation can be written

$$v = \frac{RT}{P}$$

Find the specific volume for air, for temperatures from 100 to 1000 K and for pressures from 100 kPa to 1000 kPa. The value of R for air is 0.2870 kJ/(kg K). In this formulation of the ideal gas law, R is different for every gas. There are other formulations in which R is a constant, and the molecular weight of the gas must be included in the calculation. You'll learn more about this equation in chemistry classes and thermodynamics classes. Your answer should be a two-dimensional matrix.

Special Matrices

4.9 Create a matrix of zeros the same size as each of the matrices **a, b,** and **c** from Problem 4.1. (Use the **size** function to help you accomplish this task.)

4.10 Create a 6 × 6 magic matrix.

(a) What is the sum of each of the rows?
(b) What is the sum of each of the columns?
(c) What is the sum of each of the diagonals?

4.11 Extract a 3 × 3 matrix from the upper left-hand corner of the magic matrix you created in Problem 4.9. Is this also a magic matrix?

a	**2*a**
a^2	**a+2**

Figure P4.12
Create a matrix out of other matrices.

4.12 Create a 5×5 magic matrix named **a**.

(a) Is **a** times a constant such as 2 also a magic matrix?
(b) If you square each element of **a**, is the new matrix a magic matrix?
(c) If you add a constant to each element, is the new matrix **a** magic matrix?
(d) Create a 10×10 matrix out of the following components (see Figure P4.12):

- The matrix **a**
- 2 times the matrix **a**
- A matrix formed by squaring each element of **a**
- 2 plus the matrix **a**

Is your result a magic matrix? Does the order in which you arrange the components affect your answer?

4.13 Albrecht Durer's magic square (Figure 4.8) is not exactly the same as the 4×4 magic square created with the command

magic(4)

(a) Recreate Durer's magic square in MATLAB® by rearranging the columns.
(b) Prove that the sum of all the rows, columns, and diagonals is the same.