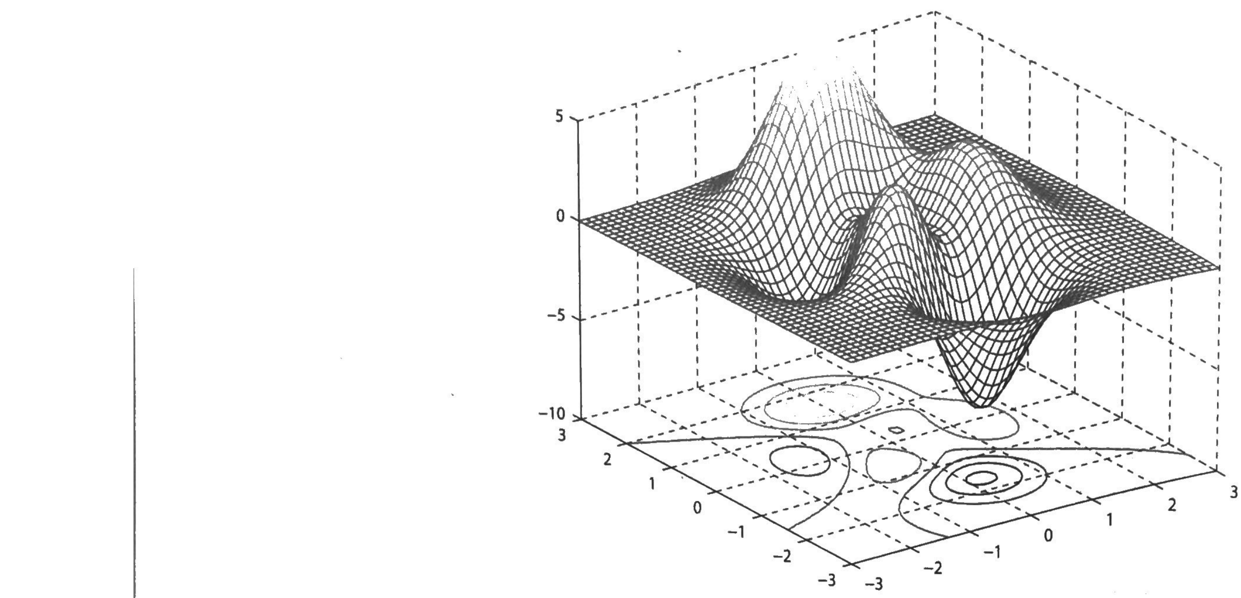


Figure 2.4. A three-dimensional MATLAB plot.

produce the plot in figure 2.4. In order to understand this plot, search MATLAB documentation for the commands `meshgrid`, `peaks`, `meschc`, and `axis`. While this chapter will get you started using MATLAB, effective use of the MATLAB documentation will be the key to proceeding to more complicated programs.

2.14 CHAPTER 2 EXERCISES

1. Run the examples in this chapter using MATLAB to be sure that you see the same results.
2. With the matrices and vectors

$$A = \begin{pmatrix} 10 & -3 \\ 4 & 2 \end{pmatrix}, \quad B = \begin{pmatrix} 1 & 0 \\ -1 & 2 \end{pmatrix}, \quad \mathbf{v} = \begin{pmatrix} 1 \\ 2 \end{pmatrix}, \quad \mathbf{w} = \begin{pmatrix} 1 \\ 1 \end{pmatrix},$$

compute the following *both* by hand and in MATLAB. For the MATLAB computations, use the `diary` command to record your session.

(a) $\mathbf{v}^T\mathbf{w}$
(b) $\mathbf{v}\mathbf{w}^T$
(c) $A\mathbf{v}$
(d) $A^T\mathbf{v}$
(e) AB
(f) BA
(g) A^2 $(= AA)$
(h) the vector $\mathbf{y}$ for which $B\mathbf{y} = \mathbf{w}$
(i) the vector $\mathbf{x}$ for which $A\mathbf{x} = \mathbf{v}$

3. Use MATLAB to produce a single plot displaying the graphs of the functions $\sin(kx)$ across $[0, 2\pi]$, for $k = 1, \ldots, 5$.
4. Use MATLAB to print a table of values x, $\sin x$, and $\cos x$, for $x = 0, \frac{\pi}{6}, \frac{2\pi}{6}, \ldots, 2\pi$. Label the columns of your table.

MATLAB'S ORIGINS

Cleve Moler is chairman and chief scientist at MathWorks. In the mid to late 1970s, he was one of the authors of LINPACK and EISPACK, Fortran libraries for numerical computing. To give easy access to these libraries to his students at the University of New Mexico, Dr. Moler invented MATLAB. In 1984, he cofounded The MathWorks with Jack Little to commercialize the MATLAB program. Cleve Moler received his bachelor's degree from California Institute of Technology, and a Ph.D. from Stanford University. Moler was a professor of math and computer science for almost 20 years at the University of Michigan, Stanford University and the University of New Mexico. Before joining The MathWorks full-time in 1989, he also worked for the Intel Hypercube Company and Ardent Computer. Dr. Moler was elected to the National Academy of Engineering in 1997. He also served as president of the Society for Industrial and Applied Mathematics (SIAM) during 2007–2008 [68]. (Photo courtesy of Cleve Moler.)

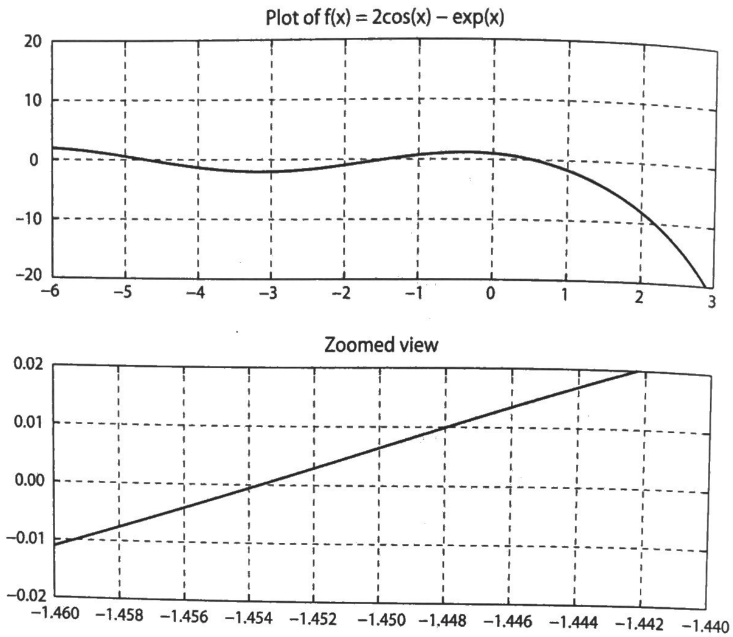
5. Download the file `plotfunction1.m` from the book's web page and execute it. This should produce the two plots on the next page. The top plot shows the function $f(x) = 2\cos(x) - e^x$ for $-6 \le x \le 3$, and from this plot it appears that $f(x)$ has three roots in this interval. The bottom plot is a zoomed view near one of these roots, showing that $f(x)$ has a root near $x = -1.454$. Note the different vertical scale as well as the different horizontal scale of this plot. Note also that when we zoom in on this function it looks nearly *linear* over this short interval. This will be important when we study numerical methods for approximating roots.

   (a) Modify this script so that the bottom plot shows a zoomed view near the leftmost root. Write an estimate of the value of this root to at least 3 decimal places. You may find it useful to first use the zoom feature in MATLAB to see approximately where the root is and then to choose your axis command for the second plot appropriately.

   (b) Edit the script from part (a) to plot the function

$$f(x) = \frac{4x\sin x - 3}{2 + x^2}$$

   over the range $0 \le x \le 4$ and also plot a zoomed view near the leftmost root. Write an estimate of the value of the root from the plots that is accurate to 3 decimal places. Note that once you have defined the vector x properly, you will need to use appropriate componentwise



multiplication and division to evaluate this expression:

```
y = (4*x.*sin(x) - 3) ./ (2 + x.^2);
```

6. Plot each of the functions below over the range specified. Produce four plots on the same page using the `subplot` command.

   (a) $f(x) = |x - 1|$ for $-3 \leq x \leq 3$. (Use `abs` in MATLAB.)
   (b) $f(x) = \sqrt{|x|}$ for $-4 \leq x \leq 4$. (Use `sqrt` in MATLAB.)
   (c) $f(x) = e^{-x^2} = \exp(-x^2)$ for $-4 \leq x \leq 4$. (Use `exp` in MATLAB.)
   (d) $f(x) = \dfrac{1}{10x^2 + 1}$ for $-2 \leq x \leq 2$.

7. Use MATLAB to plot the circles

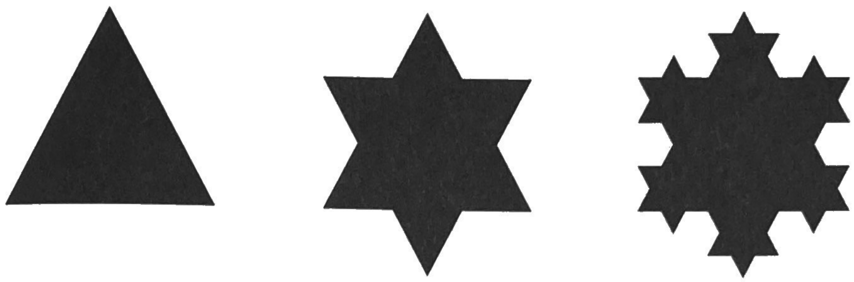
$$(x-2)^2 + (y-1)^2 = 2,$$
$$(x-2.5)^2 + y^2 = 3.5$$

   and zoom in on the plot to determine approximately where the circles intersect.
   [Hint: One way to plot the first circle is:

```
theta = linspace(0, 2*pi, 1000);
r = sqrt(2);
x = 2 + r*cos(theta);
y = 1 + r*sin(theta);
plot(x,y)
axis equal     % so the circles look circular!
```

   Use the command `hold on` after this to keep this circle on the screen while you plot the second circle in a similar manner.]

8. In this exercise, you will plot the initial stages of a process that creates a fractal known as *Koch's snowflake*, which is depicted below.



Stage 0 Stage 1 Stage 2

This exercise uses the MATLAB M-file `koch.m`, which you will find on the web page. The M-file contains all the necessary commands to create the fractal, except for the necessary plotting commands. Edit this M-file so that each stage of the fractal is plotted. [Hint: This can be accomplished by adding a plot command just before the completion of the outer `for` loop.] Add the following commands to keep consistency between plots in the animation.

```
axis([-0.75 0.75 -sqrt(3)/6 1]);
axis equal
```

Note that the `cla` command clears the axes. Finally, add the command `pause(0.5)` in appropriate places to slow the animation. (The `fill` command, as opposed to `plot`, produced the filled fractals depicted above.) We will create fractals using Newton's method in chapter 4.

9. A magic square is an arrangement of the numbers from 1 to n^2 in an n by n matrix, where each number occurs exactly once, and the sum of the entries in any row, any column, or any main diagonal is the same. The MATLAB command `magic(n)` creates an n by n (where $n > 2$) magic square. Create a 5 by 5 magic square and verify using the `sum` command in MATLAB that the sums of the columns, rows and diagonals are equal. Create a log of your session that records your work. [Hint: To find the sums of the diagonals, read the documentation for the `diag` and the `flipud` commands.]
10. More advanced plotting commands can be useful in MATLAB programming.

    (a) In the MATLAB command window type

    ```
    [X,Y,Z] = peaks(30);
    surf(X,Y,Z);
    ```

    (b) Give this plot the title "3-D shaded surface plot".
    (c) Type `colormap hot` and observe the change in the plot.
    (d) Print the resulting plot with the given title.

11. Computer graphics make extensive use of matrix operations. For example, rotating an object is a simple matrix–vector operation. In two dimensions, a curve can be rotated counterclockwise through an angle θ about the