Instructor’s Manual©

to accompany

Introduction to MATLAB 6 for Engineers

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Solutions to Problems in Chapter One

Test Your Understanding Problems

T1.1-1  a) $6 \times \frac{10}{13} + \frac{18}{5 \times 7} + 5 \times 9^2$. Answer is $410.1297$.
   b) $6 \times 35^{\frac{1}{4}} + 14^{\frac{3}{5}}$. Answer is $17.1123$.

T1.3-1 The session is:
   >> x = [[cos(0):0.02:log10(100)]]; 
   >> length(x)
   ans = 51
   >> x(25)
   ans = 1.4800

T1.3-2 The session is:
   >> roots([1, 6, -11, 290])
   ans =
   -10.000
   2.0000 + 5.0000i
   2.0000 - 5.0000i
   >> poly(ans)
   ans =
   1.0000 6.0000 -11.0000 290.0000

which are the given coefficients. Thus the roots are $-10$ and $2 \pm 5i$.

T1.3-3  a) $z = 00111$
   b) $z = 10000$
   c) $z = 10111$
   d) $z = 00001$

T1.3-4 The session is:
   >> x = [-4, -1, 0, 2, 10]; y = [-5, -2, 2, 5, 9];
   >> x(x>y)
   ans =
   -4 -1 10
   >> find(x>y)
   ans =
   1 2 5
T1.3-5 The session is:

```matlab
t = [0:0.01:5];
s = 2*sin(3*t+2) + sqrt(5*t+1);
plot(t,s),xlabel('Time (sec)'),ylabel('Speed (ft/sec)')
```

![Figure: for Problem T1.3-5](image)

T1.3-6 The session is:

```matlab
x = [0:0.01:1.55];
s = 4*sqrt(6*x+1);
z = polyval([4,6,-5,3],x);
plot(x,y,x,z,'--'),xlabel('Distance (meters)'),ylabel('Force (newtons)')
```

T1.3-7 The session is:

```matlab
A = [6, -4, 8; -5, -3, 7; 14, 9, -5];
b = [112; 75; -67];
x = A\b
```
Thus the solution is \( x = 2 \), \( y = -5 \), and \( z = 10 \).

**T1.4-1** The session is:

```matlab
≫a = 112; b = 75; c = -67;
≫A = [6, -4, 8; -5, -3, 7; 14, 9, -5];
≫bvector = [a; b; c];
≫x = A\bvector
x =
2.0000
-5.0000
10.0000
```

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Thus the solution is \( x = 2, \ y = -5, \) and \( z = 10. \)

**T1.4-2** The script file is:

```matlab
x = -5;
if x < 0
    y = sqrt(x^2+1)
elseif x < 10
    y = 3*x+1
else
    y = 9*sin(5*x-50)+31
end
```

For \( x = -5, \ y = 5.0990. \) Changing the first line to \( x = 5 \) gives \( y = 16. \) Changing the first line to \( x = 15 \) gives \( y = 29.8088. \)

**T1.4-3** The script file is

```matlab
sum = 0;
for k = 1:20
    sum = sum + 3*k^2;
end
sum
```

The answer is \( \text{sum} = 8610. \)

**T1.4-4** The script file is

```matlab
sum = 0;k = 0;
while sum <= 2000
    k = k + 1;
    sum = sum + 3*k^2;
end
k
sum
```

The answers are \( k = 13 \) and \( \text{sum} = 2457. \)

**End-of-Chapter Problems**

1. The session is:
\begin{verbatim}
x = 10; y = 3;
u = x + y
u =
13
v = x*y
v =
30
w = x/y
w =
3.3333
z = sin(x)
z =
-0.5440
r = 8*sin(y)
r =
1.1290
s = 5*sin(2*y)
s =
-1.3971
\end{verbatim}

2. The session is:
\begin{verbatim}
y*x^3/(x-y)
ans =
-13.3333
3*x/(2*y)
ans =
0.6000
3*x*y/2
ans =
15
x^5/(x^5-1)
ans =
1.0323
\end{verbatim}

3. The session is:
\begin{verbatim}
x = 3; y = 4;
1/(1-1/x^5)
ans =
1.0041
3*pi*x^2
\end{verbatim}
4. a) \( x = 2; y = 6x^3 + 4/x \). The answer is \( y = 50 \).
b) \( x = 8; y = (x/4)*3 \). The answer is \( y = 6 \).
c) \( x = 10; y = (4x)^2/25 \). The answer is \( y = 64 \).
d) \( x = 2; y = 2*\sin(x)/5 \). The answer is \( y = 0.3637 \).
e) \( x = 20; y = 7x^{(1/3)} + 4x^{0.58} \). The answer is \( y = 41.7340 \).

5. The session is:
```plaintext
≫a = 1.12; b = 2.34; c = 0.72; d = 0.81; f = 19.83;
≫x = 1 + a/b + c/f^2
x =
1.4805
≫s = (b-a)/(d-c)
s =
13.556
≫r = 1/(1/a + 1/b + 1/c + 1/d)
r =
0.2536
≫y = a*b/c*f^2/2
y =
715.6766
```

6. The session is:
```plaintext
≫r = 5;
≫V = 4*pi*^3/4;
≫V = 1.3*V;
≫r = ((3*V)/(4*pi))^(1/3);
r =
4.9580
```
The required radius is 4.958.
7. The session is

```matlab
x = -7-5i; y = 4+3i;
x+y
ans =
-3.0000 - 2.0000i
x*y
ans =
-13.0000 -41.0000i
x/y
ans =
-1.7200 + 0.0400i
```

8. The session is:

```matlab
(3+6i)*(-7-9i)
ans =
33.0000 -69.0000i
(5+4i)/(5-4i)
ans =
0.2195 + 0.9756i
3i/2
ans =
0 + 1.5000i
3/2i
ans =
0 - 1.5000i
```

9. The session is:

```matlab
x = 5+8i; y = -6+7i;
u = x + y; v = x*y;
w = x/y; z = exp(x)
r = sqrt(y); s = x*y^2;
```

The answers are $u = -1 + 51i$, $v = -86 - 13i$, $w = 0.3059 - 0.9765i$, $z = -21.594 + 146.83i$, $r = 1.2688 + 2.7586i$, and $s = 607 - 524i$.

10. The session is:

```matlab
n = 1; R = 0.08206; T = 273.2; V=22.41;
a = 6.49; b = 0.0562;
Pideal = n*R*T/V
```

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\begin{align*}
\text{Pideal} &= 1.0004 \\
\Rightarrow \text{P1} &= n*R*T/(V - nb) \\
\text{P1} &= 1.0029 \\
\Rightarrow \text{P2} &= (a*n^{-2})/V^2 \\
\text{P2} &= 0.0129 \\
\Rightarrow \text{P_{waals}} &= \text{P1} + \text{P2} \\
\text{P_{waals}} &= 1.0158
\end{align*}

The ideal gas law predicts a pressure of 1.0004 atmospheres, while the van der Waals model predicts 1.0158 atmospheres. Most of the difference is due to the \text{P2} term, which models the molecular attractions.

11. The ideal gas law gives \( \frac{T}{V} = \frac{P}{nR} = \text{constant} \)

Thus \( T_1/V_1 = T_2/V_2 \), or \( V_2 = V_1T_2/T_1 \). The session is:

\begin{verbatim}
V1 = 28500; T1 = 273.2 - 15; T2 = 273.2 + 31;
V2 = V1*T2/T1
V2 = 3.3577e+4
\end{verbatim}

The volume is \( 3.3577 \times 10^4 \) ft\(^3\).

12. The session is:

\begin{verbatim}
x=[1:.2:5];
y = 7*sin(4*x)
y =
Columns 1 through 7
-5.2976 -6.9732 -4.4189 0.8158 5.5557 6.9255 4.0944
Columns 8 through 14
-1.2203 -5.7948 -6.8542 -3.7560 1.6206 6.0141 6.7596
Columns 15 through 21
y(3)
ans =
-4.4189
\end{verbatim}
There are 21 elements. The third element is $-4.4189$.

13. The session is:

```matlab
gx = [sin(-pi/2):0.05:cos(0)];
length(x)
ans =
41
gx(10)
ans =
0.5500
```

There are 41 elements. The tenth element is 0.55.

14. The session is:

```matlab
gp = ([13,182,-184,2503];
gp = roots(gp)
r =
-15.6850
0.8425 + 3.4008i
0.8425 - 3.4008i
gp=polyval(gp,r)
an =
1.0e-012 *
0.1137 - 0.0001i
0 - 0.0002i
0
```

The roots are $x = -15.685$ and $x = 0.8425 \pm 3.4008i$. When these roots are substituted into the polynomial, we obtain values close to zero, as they should be.

15. The session is:

```matlab
gp = [36, 12, -5, 10];
gp = roots(gp)
an =
-0.8651
0.2659 + 0.5004i
0.2659 - 0.5004i
```

The roots are $-0.8651$ and $0.2659 \pm 0.5004i$. Typing `polyval(p,ans)` returns three values that are close to zero. This confirms that the roots satisfy the equation $36x^3 + 12x^2 - 5x + 10 = 0$.  

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16. The session is:

```
>> r = [3+6i,3-6i,8,8,20];
>> p = poly(r)
 p =
    1 -42 645 -5204 24960 -57600
>> roots(p)
ans =
   20.0000
   3.0000 + 6.0000i
   3.0000 - 6.0000i
   8.0000
   8.0000
```

Because the `roots` command returns the same roots as those given, the answer is correct. It is \(x^5 - 42x^4 + 645x^3 - 5204x^2 + 24960x - 57600\).

17. No solution is needed.

18. a) \(z = [0, 1, 0, 0, 1]\)  b) \(z = 1, 0, 1, 0, 0\)
 c) \(z = 1, 1, 1, 0, 1\)  d) \(z = 0, 0, 0, 1, 0\)
 e) \(z = 0, 0, 1, 1, 1\)

19. The session is:

```
>> x = [-15, -8, 9, 8, 5]; y = [-20, -12, 4, 8, 9];
>> x(x>y)
ans =
   -15 9
>> find(x>y)
ans =
   1 3
```

The first and third elements of \(x\) are greater than the first and third elements of \(y\).

20. The session is:

```
>> t = [1:0.005:3];
>> T = 6*log(t) - 7*exp(-0.2*t);
>> plot(t,T), title('Temperature Versus Time'),...
   xlabel('Time t (minutes)'), ylabel('Temperature T (° C)')
```

The plot is shown in the figure.
21. The session is:

```
x = [0:0.01:2];
u = 2*log10(60*x+1);
v = 3*cos(6*x);
plot(x,u,x,v,'--'),ylabel('Speed (miles/hour)'),...
xlabel('Distance x (miles)')
```

The plot is shown in the figure.
Figure: for Problem 21
22. The session is:

```matlab
x = [-3:0.01:3];
p1 = [3,-6,8,4,90];
p2 = [3,5,-8,70];
y = polyval(p1,x);
z = polyval(p2,x);
plot(x,y,x,z,'--'),ylabel('Current (milliamps)'),...
xlabel('Voltage x (volts)')
```

The plot is shown in the figure.
23. The session is:

\[
\begin{align*}
\text{p} &= [3,-5,-28,-5,200]; \\
\text{x} &= [-1:0.005:1]; \\
\text{y} &= \text{polyval(p,x)};
\end{align*}
\]

```matlab
plot(x,y),ylabel('y'),xlabel('x'),ginput(1)
```

The peak as measured with the mouse cursor is \( y = 200.3812 \) at \( x = -0.0831 \)

![Graph](image)

Figure : for Problem 23

24. The session is:

```
\[
\begin{align*}
\text{A} &= [7,14,-6;12,-5,9;-5,7,15]; \\
\text{b} &= [95;-50;145]; \\
\text{x} &= \text{A}\backslash\text{b}
\end{align*}
\]
```

The answers are \(-3, 10, \) and \( 4 \), which correspond to \( x = -3, \) \( y = 10, \) and \( z = 4 \). Typing \( \text{A*x} \) gives the result 95, -50, 145, which are the right-hand sides of the equations. Thus the values of \( x, y, \) and \( z \) are correct.

25. The script file is:
\[
x = -5;
if x < -1
 \quad y = \exp(x + 1)
elseif x < 5
 \quad y = 2 + \cos(\pi x)
else
 \quad y = 10(x - 5) + 1
end
\]

The answer for \( x = -5 \) is \( y = 0.0183 \). Change the first line to \( x = 3 \) to obtain \( y = 1 \). Then change the first line to \( x = 15 \) to obtain \( y = 101 \).

26. The script file is:

```matlab
sum = 0;
for k = 1:10
    sum = sum + 5*k^3;
end
sum
```

The answer is \( sum = 15125 \).

27. The script file is:

```matlab
sum = 0;k = 0;
while sum <= 2000
    sum = sum + 2^k;
end
k
sum
```

The answers are \( k = 10 \) and \( sum = 2046 \).

28. The script file is:

```matlab
amt1 = 1000;amt2 = 1000;
k1 = 0;k2 = 0;
while amt1 < 50000
    k1 = k1 + 1;
    amt1 = amt1*1.055 + 1000;
end
while amt2 < 50000
    k2 = k2 + 1;
    amt2 = amt2*1.045 + 1000;
```

1-15
The answer is \( \text{diff} = 2 \). Thus it takes 2 more years in the second bank.

29. The script file is:

\[
\begin{align*}
a &= 95; b = -50; c = 145; \\
A &= [7, 14, -6; 12, -5, 9; -5, 7, 15]; \\
\text{bvector} &= [a; b; c]; \\
x &= A \backslash \text{bvector}
\end{align*}
\]

The answers for \( x \) are \(-3, 10, 4\), which correspond to \( x = -3, y = 10, \) and \( z = 4 \). Typing \( A \times x \) gives the result \( 95, -50, 145 \), which are the right-hand sides of the equations. Thus the values of \( x, y, \) and \( z \) are correct.

30. The script file is:

\[
\begin{align*}
k &= 0; \\
\text{for } x &= -2:.01:6 \\
& \quad k = k + 1; \\
& \quad \text{if } x < -1 \\
& \quad \quad y(k) = \exp(x+1); \\
& \quad \text{elseif } x < 5 \\
& \quad \quad y(k) = 2 + \cos(\pi x); \\
& \text{else} \\
& \quad \quad y(k) = 10 * (x - 5) + 1; \\
& \text{end} \\
& \text{end} \\
x &= [-2:.01:6]; \\
\text{plot}(x, y), \text{xlabel}('Time x (seconds)'), \text{ylabel}('Height y (kilometers)')
\end{align*}
\]

The figure shows the plot.
Figure: for Problem 30
31. The script file is:

```matlab
x = 0;
y = 0;k = 0;
while y < 9.8
    k = k + 1;
x = x + 0.01;
y(k) = 10*(1-exp(-x/4));
end
xmax = x
x = [0:.01:xmax];
plot(x,y),xlabel('Time x (seconds)'),ylabel('Force y (newtons)')
```

The figure shows the plot.
32. The area is given by

\[ A = WL + \frac{1}{2} \left( \frac{W}{2} \right)^2 \]

which can be solved for \( L \):

\[ L = \frac{A - W^2/8}{W} \]

The perimeter is given by

\[ P = 2L + W + 2 \sqrt{\left( \frac{W}{2} \right)^2 + \left( \frac{W}{2} \right)^2} = 2L + W + 2 \frac{W}{\sqrt{2}} \]

The script file is:

\[
\begin{align*}
W &= 6; A = 80; \\
L &= (A - W^2/8)/W \\
P &= 2*L + W + 2*W/sqrt(2)
\end{align*}
\]

The answers are \( L = 12.58 \) meters and the total length is the perimeter \( P = 39.65 \) meters.

33. Applying the law of cosines to the two triangles gives

\[ a^2 = b_1^2 + c_1^2 - 2b_1c_1 \cos A_1 \]
\[ a^2 = b_2^2 + c_2^2 - 2b_2c_2 \cos A_2 \]

With the given values we can solve the first equation for \( a \), then solve the second equation for \( c_2 \). The second equation is a quadratic in \( c_2 \), and can be written as

\[ c_2^2 - (2b_2 \cos A_2)c_2 + b_2^2 - a^2 = 0 \]

The script file is:

\[
\begin{align*}
b1 &= 180; b2 = 165; c1 = 115; A1 = 120*\pi/180; A2 = 100*\pi/180; \\
a &= \text{sqrt}(b1^2 + c1^2 - 2*b1*c1*cos(A1)); \\
\text{roots([1,-2*b2*cos(A2),b2^2-a^2])}
\end{align*}
\]

The two roots are \( c2 = -228 \) and \( c2 = 171 \). Taking the positive root gives \( c2 = 171 \) meters.

34. The area is given by

\[ A = 2RL + \frac{1}{2} \pi R^2 \]

which can be solved for \( L \):

\[ L = \frac{A - \pi R^2/2}{2R} \]

The cost is given by

\[ C = 30(2R + 2L) + 40\pi R \]

The script file is given below. Several guesses for the range of \( x \) had to be made to find the range where the cost showed a minimum value.
clear
A = 1600; k = 0;
for x = 5:0.01:30
k = k + 1;
R(k) = x;
L(k) = (A - 0.5*pi*x^2)/(2*x);
C(k) = 30*(2*x + 2*L(k)) + 40*pi*x;
end
plot(R,C,R,20*L),xlabel('0 Radius (ft)'),ylabel('0 Cost ($)'),...
[rmin,costmin] = ginput(1)
Lmin = (A - 0.5*pi*rmin^2)/(2*rmin)
r1 = 0.8*rmin;r2 = 1.2*rmin;
L1 = (A - 0.5*pi*r1^2)/(2*r1);
L2 = (A - 0.5*pi*r2^2)/(2*r2);
cost1 = 30*(2*r1 + 2*L1) + 40*pi*r1
cost2 = 30*(2*r2+2*L2) + 40*pi*r2

The figure shows the plot. Using the cursor to select the minimum point on the curve, we obtain the optimum value of the radius $R$ to be $r_{min} = 18.59$ feet, and the corresponding cost is $cost_{min} = $5140. The corresponding length $L$ is $L_{min} = 28.4$ feet. The costs corresponding to a $\pm 20\%$ change from $r = 18.59$ are $cost_1 = $5288 (a 3\% increase) and $cost_2 = $5243 (a 2\% increase). So near the optimum radius, the cost is rather insensitive to changes in the radius.
Figure: for Problem 34
35. Typing `help plot` gives the required information. Typing `help label` obtains the response `label not found`. In this case we need to be more specific, such as by typing `help xlabel`, because `label` is not a command or function, or we can type `lookfor label`. Similarly, typing `help cos` gives the required information, but typing `help cosine` obtains the response `cosine not found`. Typing `lookfor cosine` directs you to the `cos` command. Typing `help :` and `help *` gives the required information.

36. (a) If we neglect drag, then conservation of mechanical energy states that the kinetic energy at the time the ball is thrown must equal the potential energy when the ball reaches the maximum height. Thus
\[ \frac{1}{2}mv^2 = mgh \]
where \( v \) is the initial speed and \( h \) is the maximum height. We can solve this for \( v \): \( v = \sqrt{2gh} \). Note that the mass \( m \) cancels, so the result is independent of \( m \).

For \( h = 20 \) feet, we get \( v = \sqrt{2(32.2)(20)} = 35.9 \) feet/second. Because speed measured in miles per hour is more familiar to most of us, we can convert the answer to miles per hour as a “reality check” on the answer. The result is \( v = 35.9(3600)/5280 = 24.5 \) miles per hour, which seems reasonable.

(b) The issues here are the manner in which the rod is thrown and the effect of drag on the rod. If the drag is negligible and if we give the mass center a speed of 35.9 feet/second, then the mass center of the rod will reach a height of 20 feet. However, if we give the rod the same kinetic energy, but throw it upward by grasping one end of the rod, then it will spin and not reach 20 feet. The kinetic energy of the rod is given by
\[ KE = \frac{1}{2}mv_{mc}^2 + \frac{1}{2}I\omega^2 \]
where \( v_{mc} \) is the speed of the rod’s mass center. For the same rotational speed \( \omega \) and kinetic energy \( KE \), a rod with a larger inertia \( I \) will reach a smaller height, because a larger fraction of its energy is contained in the spinning motion. The inertia \( I \) increases with the length and radius of the rod. In addition, a longer rod will have increased drag, and will thus reach a height smaller than that predicted using conservation of mechanical energy.

37. (a) When \( A = 0^\circ \), \( d = L_1 + L_2 \). When \( A = 180^\circ \), \( d = L_1 - L_2 \). The stroke is the difference between these two values. Thus the stroke is \( L_1 + L_2 - (L_1 - L_2) = 2L_2 \) and depends only on \( L_2 \).

b) The MATLAB session looks like the one shown in the text, except that \( L_1 = 0.6 \) is used for the first plot and \( L_1 = 1.4 \) for the second plot. The plots are shown in the two figures. Their general shape is similar, but they are translated vertically relative to one another.
Figure: for Problem 37
Figure : for Problem 37