voltage and then to enter the resistances of the resistors in a vector. The program displays a table with the resistances listed in the first column, the voltage across the resistor in the second, and the power dissipated in the resistor in the third column. Following the table, the program displays the current in the circuit, and the total power.

Execute the file and enter the following data for v_s and the R's.

$v_s = 24\text{V}$, $R_1 = 20\Omega$, $R_2 = 14\Omega$, $R_3 = 12\Omega$, $R_4 = 18\Omega$, $R_5 = 8\Omega$, $R_6 = 15\Omega$, $R_7 = 10\Omega$.

Solution

A script file that solves the problem is shown below.

```
% The program calculates the voltage across each resistor
% in a circuit that has resistors connected in series.
vs=input('Please enter the source voltage ');
Rn=input('Enter the values of the resistors as elements in a
row vector\n');
Req=sum(Rn);                  Calculate the equivalent resistance.
vn=Rn*vs/Req;                 Apply the voltage divider rule.
Pn=Rn*vs^2/Req^2;             Calculate the power in each resistor.
i = vs/Req;                   Calculate the current in the circuit.
Ptotal = vs*i;                Calculate the total power in the circuit.
Table = [Rn', vn', Pn'];      Create a variable table with the
disp(' ')                     vectors Rn, vn, and Pn as columns.
disp(' Resistance Voltage   Power')       Display headings for
disp('    (Ohms)     (Volts)    (Watts)')  the columns.
disp(' ')                     Display an empty line.
disp(Table)                   Display the variable Table.
disp(' ')
fprintf('The current in the circuit is %f Amps.',i)
fprintf('\nThe total power dissipated in the circuit is %f
Watts.',Ptotal)
```

The Command Window where the script file was executed is:

```
>> VoltageDivider                              Name of the script file.
Please enter the source voltage 24      <---   Voltage entered by the user.
Enter the value of the resistors as elements in a row vector
[20  14  12  18  8  15  10]             <---   Resistor values entered as a vector.
```



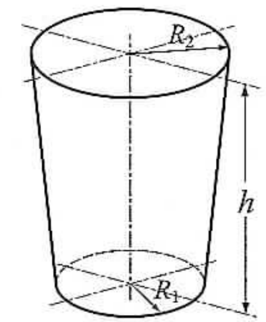
```
 Resistance  Voltage    Power
    (Ohms)    (Volts)   (Watts)
  20.0000     4.9485    1.2244
  14.0000     3.4639    0.8571
  12.0000     2.9691    0.7346
  18.0000     4.4536    1.1019
   8.0000     1.9794    0.4897
  15.0000     3.7113    0.9183
  10.0000     2.4742    0.6122

The current in the circuit is 0.247423 Amps.
The total power dissipated in the circuit is 5.938144 Watts.
```

4.7 Problems

Solve the following problems by first writing a program in a script file and then executing the program.

1. A paper cup shaped as a frustum of cone with $R_2 = 1.25R_1$ is designed to have a volume of 250 cm^3. Determine R_1, R_2, and the surface area, S, of the paper for cups with heights h, of 5, 6, 7, 8, 9, and 10 cm. The volume of the cup, V, and the surface area of the paper are given by:

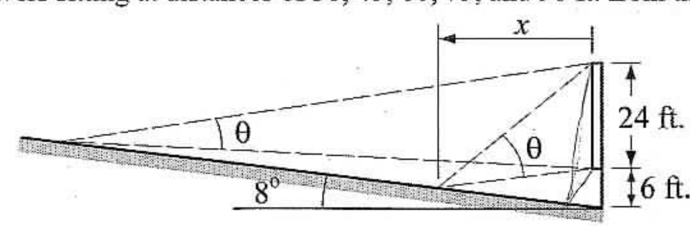


R, as a fn of V, h

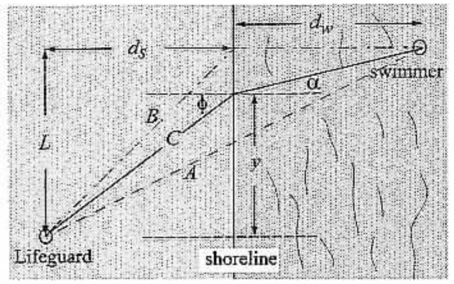
$$V = \frac{1}{3}\pi h(R_1^2 + R_2^2 + R_1 R_2)$$

$$S = \pi(R_1 + R_2)\sqrt{(R_2 - R_1)^2 + h^2} + \pi R_1^2$$

2. In a movie theater the angle θ at which a viewer sees the picture on the screen depends on the distance x of the viewer from the screen. For a movie theater with the dimensions shown in the figure, determine the angle θ (in degrees) for viewers sitting at distances of 30, 45, 60, 75, and 90 ft. from the screen.



3. A student has a summer job as a lifeguard at the beach. After spotting a swimmer in trouble he tries to deduce the path by which he can reach the swimmer in the shortest time. The path of shortest distance (path A) is obviously not best since it maximizes the time spent swimming (he can run faster than he can swim). Path B minimizes the time spent swimming but is probably not best since it is the longest (reasonable) path. Clearly the optimal path is somewhere in between paths A and B.



Consider an intermediate path C and determine the time required to reach the swimmer in terms of the running speed $v_{run} = 3$ m/s, swimming speed $v_{swim} = 1$ m/s, the distances $L = 48$ m, $d_s = 30$ m, and $d_w = 42$ m, and the lateral distance y at which the lifeguard enters the water. Create a vector y that ranges between path A and path B ($y = 20, 21, 22, \ldots, 48$ m) and compute a time t for each y. Use MATLAB built-in function `min` to find the minimum time t_{min} and the entry point y for which it occurs. Determine the angles that correspond to the calculated value of y and investigate whether your result satisfies Snell's law of refraction:

$$\frac{\sin\phi}{\sin\alpha} = \frac{v_{run}}{v_{swim}}$$

4. Radioactive decay of radioactive materials can be modeled by the equation $A = A_0 e^{kt}$, where A is the population at time t, A_0 is the amount at $t = 0$, and k is the decay constant ($k \le 0$). Technetium-99 is a radioisotope that is used in imaging of the brain. Its half-life time is 6 hours. Calculate the relative amount of Technetium-99 (A/A_0) in a patient body for 24 hours after receiving a dose. After determining the value of k, define a vector $t = 0, 2, 4, \ldots, 24$ and calculate the corresponding values of A/A_0.

5. Write a script file that determines the balance in a saving account at the end of every year for the first 10 years. The account has an initial investment of $1,000 and interest rate of 6.5% that compounds annually. Display the information in a table.

For an initial investment of A, and interest rate of r, the balance B after n years is given by:

$$B = A\left(1 + \frac{r}{100}\right)^n$$

6. The velocity, v, and the distance, d, as a function of time, of a car that accelerates from rest at constant acceleration, a, are given by:

$$v(t) = at \quad \text{and} \quad d(t) = \frac{1}{2}at^2$$

Determine v and d as every second for the first 10 seconds for a car with acceleration of $a = 1.55$ m/s^2. Display the results in a three-column table in which the first column is time (s), the second distance (m), and the third is velocity (m/s).

7. The variation of vapor pressure p (in units of mm Hg) of benzene with temperature in the range of $0 \le T \le 42$ °C can be modeled with the equation (Handbook of Chemistry and Physics, CRC Press):

$$\log_{10} p = b - \frac{0.05223a}{T}$$

where $a = 34,172$ and $b = 7.9622$ are material constants and T is absolute temperature (K). Write a program in a script file that calculates the pressure for various temperatures. The program creates a vector of temperatures from $T = 0$°C to $T = 42$°C with increments of 2 degrees, and displays a two-columns table of p and T, where the first column are temperatures in °C, and the second column are the corresponding pressures in mm Hg.

8. The temperature dependence of the heat capacity C_p of many gases can be described in terms of a cubic equation:

$$C_p = a + bT + cT^2 + dT^3$$

The following table gives the coefficients of the cubic equation for four gases. C_p is in Joules/(g mol)(°C) and T is in °C.

gas	a	b	c	d
SO_2	38.91	3.904×10^{-2}	-3.105×10^{-5}	8.606×10^{-9}
SO_3	48.50	9.188×10^{-2}	-8.540×10^{-5}	32.40×10^{-9}
O_2	29.10	1.158×10^{-2}	-0.6076×10^{-5}	1.311×10^{-9}
N_2	29.00	0.2199×10^{-2}	-0.5723×10^{-5}	-2.871×10^{-9}

Calculate the heat capacity for each gas at temperatures ranging between 200 and 400°C at 20°C increments. To present the results, create an 11×5 matrix where the first column is the temperature, and the second through fifth columns are the heat capacities of SO_2, SO_3, O_2, and N_2, respectively.

9. The heat capacity of an ideal mixture of four gases $C_{p_{mixture}}$ can be expressed in terms of the heat capacity of the components by the mixture equation:

$$C_{p_{mixture}} = x_1 C_{p1} + x_2 C_{p2} + x_3 C_{p3} + x_4 C_{p4}$$

where x_1, x_2, x_3, and x_4 are the fraction of the components, and C_{p1}, C_{p2}, C_{p3}, and C_{p4} are the corresponding heat capacities. A mixture of unknown quantities of the four gases SO_2, SO_3, O_2, and N_2 is given. To determine the fraction of the components, the following values of the heat capacity of the mixture were measured at three temperatures:

Temperature °C	25	150	300
$C_{p_{mixture}}$ Joules/(g mol)(°C)	39.82	44.72	49.10

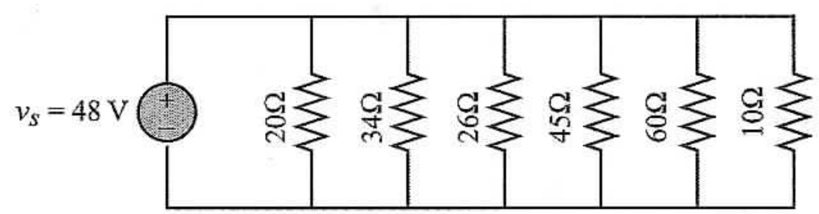
Use the equation and data in the previous problem for determining the heat capacity of the four components at the three temperatures. Then, use the mixture equation to write three equations for the mixture at the three temperatures. The fourth equation is: $x_1 + x_2 + x_3 + x_4 = 1$. Determine x_1, x_2, x_3, and x_4 by solving the linear system of equations.

10. When several resistors are connected in an electrical circuit in parallel, the current through each of them is given by $i_n = \frac{v_s}{R_n}$ where i_n and R_n are the current through resistor n and its resistance, respectively, and v_s is the source voltage. The equivalent resistance, R_{eq}, can be determined from the equation:

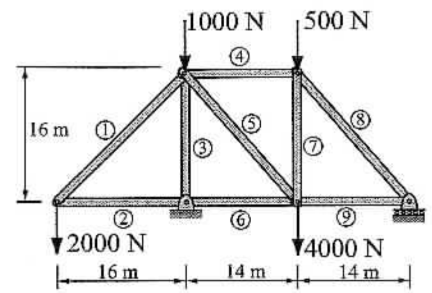
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$$

The source current is given by: $i_s = v_s / R_{eq}$, and the power, P_n, dissipated in each resistor is given by: $P_n = v_s i_n$.

Write a program in a script file that calculates the current through each resistor and the power dissipated in each in a circuit that has resistors connected in parallel. When the script file runs it asks the user first to enter the source voltage and then to enter the resistors' resistance in a vector. The program displays a table with the resistances listed in the first column, the current through the resistor in the second, and the power dissipated in the resistor in the third column. Following the table, the program displays the source current and the total power. Use the script file to solve the following circuit.



11. A truss is a structure made of members jointed at their ends. For the truss shown in the figure, the forces in the nine members are determined by solving the following system of nine equations.



$\cos(45°)F_1 + F_2 = 0$

$F_4 + \cos(48.81°)F_5 - \cos(45°)F_1 = 0$

$-\sin(48.81°)F_5 - F_3 - \sin(45°)F_1 = 1000$

$\cos(48.81°)F_8 - F_4 = 0$,

$-\sin(48.81°)F_8 - F_7 = 500$

$F_9 - \cos(48.81°)F_5 - F_6 = 0$, $\quad F_7 + \sin(48.81°)F_5 = 4000$

$\sin(48.81°)F_8 = -1107.14$, $\quad -\cos(48.81°)F_8 - F_9 = 0$

Write the equations in a matrix form and use MATLAB to determine the forces in the members. A positive force means tensile force and a negative force means compressive force. Display the results in a table.

12. The graph of the function $f(x) = ax^4 + bx^3 + cx^2 + dx + e$ passes through the points (–3, 6.8), (–1.5, 15.2), (0.5, 14.5), (2, -21.2), and (5, 10). Determine the constants a, b, c, d, and e. (Write a system of five equations with five unknowns and use MATLAB to solve the equations.)

13. During a golf match, a certain number of points are awarded for each eagle and a different number for each birdie. No points are awarded for par, and a certain number of points are deducted for each bogey and a different number deducted for each double bogey (or worse). The newspaper report of an important match neglected to mention what these point values were, but did provide the following table of the results:

Golfer	Eagles	Birdies	Pars	Bogeys	Doubles	Points
Fred	1	5	10	2	0	18
Wilma	2	3	11	1	1	15
Barney	0	3	10	3	2	0
Betty	1	4	10	2	1	12

From the information in the table write four equations in terms of four unknowns. Solve the equations for the unknown points awarded for eagles and birdies and deducted for bogeys and double bogeys.

14. The dissolution of copper sulfide in aqueous nitric acid is described by the following chemical equation:

$$aCuS + bNO_3^- + cH^+ \rightarrow dCu^{2+} + eSO_4^{2-} + fNO + gH_2O$$

where the coefficients a, b, c, d, e, f, and g are the numbers of each molecule participating in the reaction and are unknown. The unknown coefficients are determined by balancing each atom on left and right and then balancing the ionic charge. The resulting equations are:

$a = d$, $a = e$, $b = f$, $3b = 4e + f + g$, $c = 2g$, $-b + c = 2d - 2e$

There are seven unknowns and only six equations. A solution can still be obtained, however, by taking advantage of the fact that all the coefficients must be positive integers. Add a 7th equation by guessing $a = 1$ and solve the system of equations. The solution is valid if all the coefficients are positive integers. If this is not the case take $a = 2$ and repeat the solution. Continue the process until all the coefficients in the solution are positive integers.

Chapter 5

Two-Dimensional Plots

Plots are a very useful tool for presenting information. This is true in any field, but especially in science and engineering where MATLAB is mostly used. MATLAB has many commands that can be used for creating different types of plots. These include standard plots with linear axes, plots with logarithmic and semi-logarithmic axes, bar and stairs plots, polar plots, three-dimensional contour surface and mesh plots, and many more. The plots can be formatted to have a desired appearance. The line type (solid, dashed, etc.), color, and thickness can be prescribed, line markers and grid lines can be added, as well as titles and text comments. Several graphs can be plotted in the same plot and several plots can be placed on the same page. When a plot contains several graphs and/or data points, a legend can be added to the plot as well.

I wasn't aware

This chapter describes how MATLAB can be used to create and format many types of two-dimensional plots. Three-dimensional plots are addressed separately in Chapter 9. An example of a simple two-dimensional plot that was created with MATLAB is shown in Figure 5-1. The figure contains two curves that show the variation of light intensity with distance. One curve is constructed from data points measured in an experiment, and the other curve shows the variation of light as predicted by a theoretical model. The axes in the figure are both linear, and different types of lines (one solid and one dashed) are used for the curves. The theoretical curve is shown with a solid line, while the experimental points are connected with a dashed line. Each data point is marked with a circular marker. The dashed line that connects the experimental points is actually red when the plot is displayed in the Figure Window. As shown, the plot in Figure 5-1 is formatted to have a title, axes' titles, a legend, markers, and a boxed text label.