```
   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. Body mass index (BMI) of a person is a measure of body fat based on height and weight. In U.S. customary units it is calculated by:

$$BMI = 703\frac{W}{h^2}$$

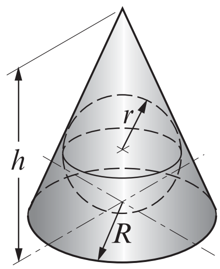
where W is the person's weight in pounds and h is the heights in inches. Write a MATLAB program in a script file that calculates the BMI. For input the program asks the user to enter his/her weight and height. The program then calculates the BMI rounded to the nearest tenth. For output the program displays the message: "The BMI is: XX." where XX is the value of the BMI. Determine the BMI of a 68-in.-tall person that weigh162 lb.

2. The altitude, h, as a function of air pressure can be calculated by:

$$h = 145366.45\left[1 - \left(\frac{p}{1013.25}\right)^{0.190289}\right]$$

where h is in units of feet and the pressure p in units of millibars (mb). Write a MATLAB program in a script file that calculates the h for a given p. For input the program asks the user to enter the pressure in units of millibars. The program then calculates the altitude rounded to the nearest integer. For output the program displays the message: "The altitude is: XX ft." where XX is the calculated value of h. Determine the altitude if the pressure is 394 mb.

3. Write a MATLAB program that determines the radius, r, of the largest sphere that can be inscribed inside a cone with base radius R and height h. For input the program asks the user to enter values for R and h. The program then calculates r rounded to the nearest tenth. For output the program displays the message: "The radius of the largest sphere that can be inscribed inside a cone with a base radius of XX in. and height of XX in., is: XX in." where XX are the corresponding numerical values. Use the



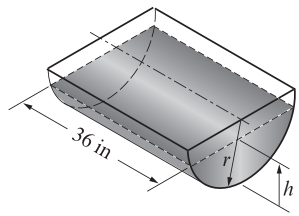
program to determine r for a cone with $R = 8$ in. and $h = 22$ in.

4. Radioactive decay can be modeled by the equation

$$A = A_0 e^{-kt}$$

where A is the amount at time t, A_0 is the amount at time $t = 0$, and k is a constant. Write a MATLAB program that calculates the amount of a radioactive material. When executed, the program asks the user to enter the half-life of the material (in years), the current amount of the material (in lb), and the number of years t from now for which the amount should be calculated. From this information the program first calculates the constant k and then the amount at t years. For output the program displays the message: "The amount of the material after XX years is XX kg" where XX are the corresponding numerical values. Use the program to determine how much plutonium-239 (half-life 24,110 years) will be left from 50 lb after 500 years.

5. A fuel tank is made of a half cylinder ($r = 14$ in.) as shown. Derive an expression for the amount of fuel in gallons as a function of h. Create a vector for h ranging from 0 to 14 in. with increments of 2 in. Then calculate the corresponding volume rounded to the nearest tenth of a gallon. Display the results in a two-column table where in the first column are the values of h and in the second column the associated values of volume (in gallons).



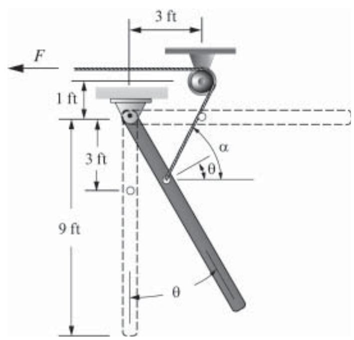
6. A 300-lb garage door is being opened by pulling on the cable as shown. As the door is lifted the force, F, in the cable, as a function of the angle θ, is given by:

$$F = \frac{300 \cdot 4.5 \sin\theta}{3\cos(\alpha - \theta)}$$

where

$$\sin\alpha = \frac{1 + 3\cos\theta}{\sqrt{(1 + 3\cos\theta)^2 + (3 - 3\sin\theta)^2}}$$

Calculate F for θ=0° through 90° with increments of 10°. Display the results in a two-column table.



7. Write a MATLAB program in a script file that calculates the average and the standard deviation of a list of grades as well as the number of grades on the list. The program asks the user (`input` command) to enter the grades as elements of a vector. The program then calculates the required quantities using MATLAB's built-in functions `length`, `mean`, and `std`. The results are displayed in the Command Window in the following format:
"There are XX grades." where XX is the numerical value.

"The average grade is XX." where XX is the numerical value rounded to the nearest tenth.
"The standard deviation is XX." where XX is the numerical value rounded to the nearest tenth.

Execute the program and enter the following grades: 93, 77, 51, 62, 99, 41, 82, 77, 71, 68, 100, 46, 78, 80, and 83.

8. The reduction of the amount of medication in the body can be modeled by the equation $A = A_0 e^{kt}$, where A is the amount at time t, A_0 is the amount at $t = 0$, and k is the decay constant ($k < 0$). The half-life time of a certain medication is 3.5 h. A person takes 400 mg of the medication at t=0, and then additional 400 mg every 4 h. Determine the amount of the medication in a patient's body 23 h after taking the first dose.

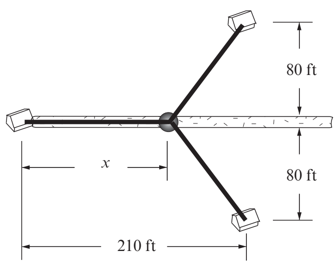
   After determining the value of k, define a vector $t = [23, 19, 15, 11, 7, 3]$ (the time since taking each dose) and calculate the corresponding values of A. Then use MATLAB's built-in function `sum` to determine the total amount.

9. The value of a saving account, V, after t years is given by:

$$V = P\left(1 + \frac{r/100}{n}\right)^{nt}$$

   where P is the initial investment, r is the yearly interest rate in % (e.g., 7.5% entered as 7.5), and n is the number of times per year that the interest is compounded. Write a MATLAB program in a script file that calculates V. When the program is executed, it asks the user to enter the amount of the initial investment, the number of years, the interest rate, and the number of times per year that the interest is compounded. The output is displayed in the following format: "The value of a $XX investment at a yearly interest rate of X.X% compounded X times per year, after XX years is $XXXX.XX", where XXX stands for the corresponding quantities. Use the program to determine the value of a $20,000 investment after 18 years if the yearly interest rate is 3.5% compounded 6 times a year.

10. The electricity supply cables of the three houses shown are connected to a pole as shown. Write a MATLAB program that determines the location of the pole (distance x) that minimizes the total length of the cables needed. In the program define a vector x with values ranging from 50 to 200 with increments of 0.1. Use this vector to calculate the corresponding values of total length of the cables. Then use MATLAB's built-in function `min` to find the value of x that corresponds to the shortest length of cables.

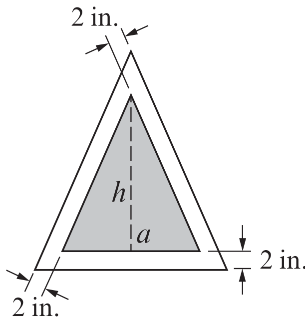


11. Early explorers often estimated altitude by measuring the temperature of boiling water. Use the following two equations to make a table that modern-day hikers could use for the same purpose.

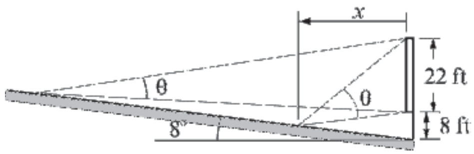
$$p = 29.921(1 - 6.8753 \times 10^{-6}h), \qquad T_b = 49.161 \ln p + 44.932$$

where p is atmospheric pressure in inches of mercury, T_b is boiling temperature in °F, and h is altitude in feet. The table should have two columns, the first altitude and the second boiling temperature. The altitude should range between –500 ft and 10,000 ft at increments of 500 ft.

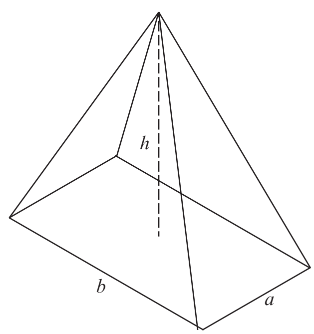
12. An isosceles triangle sign is designed to have a triangular printed area of 600 in.^{2} (shaded area with a base length of a and height of h in the figure). As shown in the figure, there is a 2-in. gap between the sides of the triangles. Write a MATLAB program that determine the dimensions a and h such that the overall area of the sign will be as small as possible. In the program define a vector a with values ranging from 10 to 120 with increments of 0.1. Use this vector for calculating the corresponding values of h and the overall area of the sign. Then use MATLAB's built-in function `min` to find the dimensions of the smallest sign.



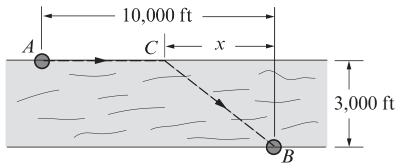
13. The angle θ at which a viewer sees the picture on the screen in a movie theater depends on the distance x from the screen. Write a MATLAB program that determines the angle θ (in degrees) for viewers setting at distances of 20, 26, 32, 38, 44, 50, 56, 62, and 68 ft. Display the results in a two-column table.



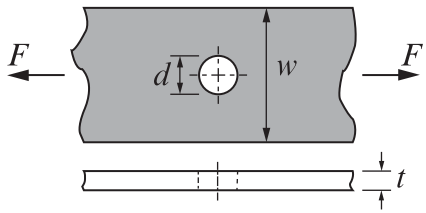
14. A 12-ft (144-in.) wire is cut into eight pieces which are welded together to form a pyramid as shown, such that in the rectangular base $b = 1.9a$. Write a MATLAB program that determines the dimensions a and b such that the volume of the pyramid will be as large as possible. In the program define a vector a with values ranging from 4 to 14 in. with increments of 0.01 in. Use this vector for calculating the corresponding values of b, h and the volume. Then use MATLAB's built-in function `max` to find the dimensions of a and b that correspond to the pyramid with the largest volume.



15. A person at point A spots a child in trouble at point B across the river. The person can run at a speed of 8.6 ft/s and can swim at a speed of 3.9 ft/s. In order to reach the child in the shortest time the person runs to point C and then swims to point B, as shown. Write a MATLAB program that determines the distance x to point C that minimizes the time the person can reach the child. In the program define a vector x with values ranging from 0 to 5,000 with increments of 1. Use this vector to calculate the corresponding values of x.Then use MATLAB's built-in function `min` to find the value of x that corresponds to the shortest time.



16. The maximum stress σ_{max} at the edge of a hole (diameter d) in a thin plate, with width w and thickness t, loaded by a tensile force F as shown is given by:

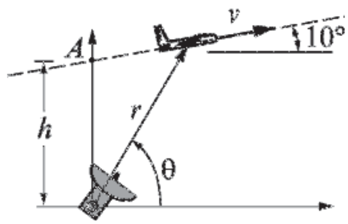


$$\sigma_{max} = K_t \sigma_{nom}$$

where $\sigma_{nom} = \dfrac{F}{t(w-d)}$ and $K_t = 3 - 3.14\left(d/w\right) + 3.667(d/w)^2 - 1.527(d/w)^3$.

Write a program in a script file that calculates σ_{max}. The program should read the values of F, w, d, and t from an ASCII text file using the `load` command. The output should be in the form of a paragraph combining text and numbers— i.e., something like: "The maximum stress in a plate with a width of XX in. and thickness of XX in. and a hole of XX in. in diameter, due to a tensile force of XXX lb is XXXX psi, where XX stands for numerical values." The stress should be rounded to the nearest integer. Use the program to calculate σ_{max} when $w = 2.5$ in., $d = 1.375$ in., $t = 0.1875$ in., and $F = 8000$ lb.

17. The airplane shown is flying at a constant speed of $v = 350$ mi/h along a straight path as shown. The airplane is being tracked by a radar station positioned a distance $h = 1500$ ft below point A. The airplane is at point A at $t = 0$. Write a MATLAB program that calculates θ and r as functions of time for $t = 0, 0.5, 1, 1.5, \ldots, 6$ s. Display the results in a three-column table where the first column is t, the second is the angle θ in degrees, and the third is the corresponding value of r.

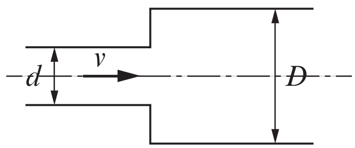


18. The intrinsic electrical conductivity σ of a semiconductor can be approximated by:

$$\sigma = e^{\left(C - \frac{E_g}{2kT}\right)}$$

where σ is measured in $(\Omega - m)^{-1}$, E_g is the band gap energy, k is Boltzmann's constant (8.62×10^{-5} eV/K), and T is temperature in kelvins. For germanium, C = 13.83 and E_g = 0.67 eV. Write a program in a script file that calculates the intrinsic electrical conductivity for germanium for various temperatures. The values of the temperature should be read from an xls spreadsheet using the `xlsread` command. The output should be presented as a table where the first column is the temperature and the second column is the intrinsic electrical conductivity. Use the following values for temperature: 400, 435, 475, 500, 520, and 545 K.

19. The pressure drop Δ*p* in pascals (Pa) for a fluid flowing in a pipe with a sudden increase in diameter is given by:

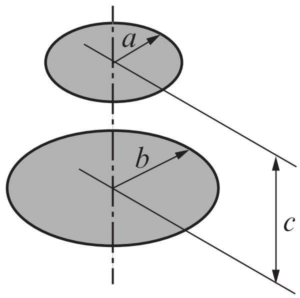


$$\Delta p = \frac{1}{2}\left[1 - \left(\frac{d}{D}\right)^2\right]^2 \rho v^2$$

where ρ is the density of the fluid, *v*, the velocity of the flow, and *d* and *D* are defined in the figure. Write a program in a script file that calculates the pressure drop Δ*p*. When the script file is executed, it requests the user to input the density in kg/m^3, the velocity in m/s, and values of the nondimensional ratio d / D as a vector. The program displays the inputted values of ρ and *v* followed by a table with the values of d / D in the first column and the corresponding values of Δ*p* in the second column.

Execute the program assuming flow of gasoline (ρ = 737 kg/m^3) at *v* = 5 m/s and the following ratios of diameters $d / D = 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3$.

20. The net heat exchange by radiation from plate 1 with radius *b* to plate 2 with radius *a* that are separated by a distance *c* is given by:



$$q = \sigma \pi b^2 F_{1-2}\left(T_1^4 - T_2^4\right)$$

where T_1 and T_2 are the absolute temperatures of the plates, $\sigma = 5.669 \times 10^{-8}$ W/(m^2-K^4) is the Stefan-Boltzmann constant, and F_{1-2} is a shape factor which, for the arrangement in the figure, is given by:

$$F_{1-2} = \frac{1}{2}\left[Z - \sqrt{Z^2 - 4X^2Y^2}\right]$$

where $X = a/c$, $Y = c/b$, and $Z = 1 + (1 + X^2)Y^2$. Write a script file that calculates the heat exchange q. For input the program asks the user to enter values for T_1, T_2, a, b, and c. For output the program prints a summary of the geometry and temperatures and then prints the value of q. Use the script to calculate the results for $T_1 = 400\text{K}$, $T_2 = 600\text{K}$, $a = 1\text{ m}$, $b = 2\text{ m}$, and $c = 0.1$, 1, and 10 m.

21. The equation of a circle in a plane with radius R and a center at point (x_0, y_0) is given by:

$$(x - x_0)^2 + (y - y_0)^2 = R^2$$

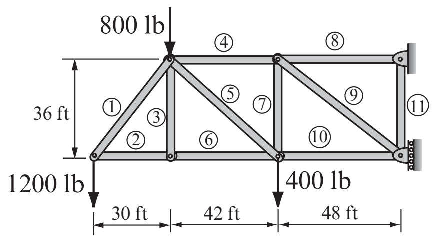
The equation can also be written in the form:

$$-2x_0x - 2y_0y + c = -(x^2 + y^2) \text{ where } c = x_0^2 + y_0^2 - R^2$$

Given the coordinates of three points (x_1, y_1), (x_2, y_2), and (x_3, y_3) it is possible to determine the radius and the coordinates of the center of the circle that passes through the three points. This is done by substituting the coordinate of each of the points in the equation and solving the system of three linear equations for x_0, y_0, and c.

Write a program in a script file that calculates the coordinates of the center and the radius of a circle that passes through three given points. When executed the program asks the user to enter the coordinates of the three points. The program then calculates the center and radius and displays the results in the following format: "The coordinates of the center are (xx.x, xx.x) and the radius is xx.x.", where xx.x stands for the calculated quantities rounded to the nearest tenth. Execute the program entering the following three points: (11.5, 5), (3.2, 8.6), and (–4.5, –6.8).

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



$F_1\cos 50° + F_2 = 0$, $F_1\sin 50° - 400 = 0$, $-F_2 + F_6 = 0$

$-F_1\cos 50° + F_4 + F_5\cos 41° = 0$,

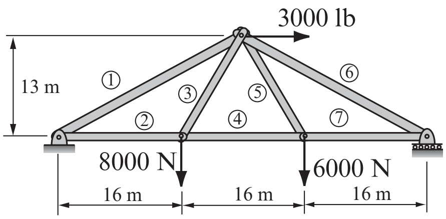
$-F_1\sin 50° + F_3 + F_5\sin 41° - 800 = 0$, $-F_5\cos 41° - F_6 + F_{10} = 0$,

$F_5\sin 41° + F_7 - 1200 = 0$, $-F_4 + F_8 + F_9\cos 37° = 0$, $-F_7 - F_9\sin 37° = 0$,

$-F_9\cos 37° - F_{10} - 4933 = 0$, $F_9\sin 37° + F_{11} = 0$

Write the equations in 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 where the first column displays the member number and the second column displays the corresponding force.

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



$F_1 \cos 28.5° + F_2 - 3000 = 0$,

$F_1 \sin 28.5° + 6521 = 0$,

$-F_1 \cos 28.5° - F_3 \cos 58.4° + F_5 \cos 58.4° + F_6 \cos 28.5° + 3000 = 0$,

$-F_1 \sin 28.5° - F_3 \sin 58.4° - F_5 \sin 58.4° - F_6 \sin 28.5° = 0$

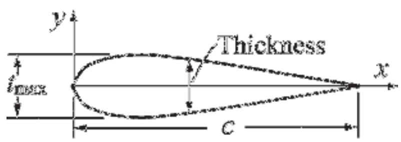
$-F_4 - F_5 \cos 58.4° + F_7 = 0$, $F_6 \sin 28.5° + 7479 = 0$ $-F_7 - F_6 \cos 28.5° = 0$

Write the equations in 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 where the first column displays the member number and the second column displays the corresponding force.

24. The graph of the function $f(x) = ax^3 + bx^2 + cx + d$ passes through the points (–1.2, 18.8), (0.2, 5), (2, 16), and (3.5, 15). Determine the constants a, b, c, and d. (Write a system of four equations with four unknowns, and use MATLAB to solve the equations.)

25. The graph of the function $f(x) = ax^4 + bx^3 + cx^2 + dx + e$ passes through the points (–2.5, –62), (–1.5, –7.2), (–0.5, 8.3), (1, 3.7), and (3, 45.7). Determine the constants a, b, c, d, and e. (Write a system of five equations with four unknowns, and use MATLAB to solve the equations.)

26. The surface of many airfoils can be described with an equation of the form



$$y = \pm \frac{tc}{0.2}\left[a_0\sqrt{x/c} + a_1(x/c) + a_2(x/c)^2 + a_3(x/c)^3 + a_4(x/c)^4\right]$$

where t is the maximum thickness as a fraction of the chord length c (e.g., $t_{max} = ct$). Given that $c = 1$ m and $t = 0.2$m, the following values for y have been measured for a particular airfoil:

x (m)	0.15	0.35	0.5	0.7	0.85
y (m)	0.08909	0.09914	0.08823	0.06107	0.03421

Determine the constants a_0, a_1, a_2, a_3, and a_4. (Write a system of five equations and five unknowns, and use MATLAB to solve the equations.)

27. 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
A	1	2	10	1	1	5
B	2	3	11	0	1	12
C	1	4	10	1	0	11
D	1	3	10	2	0	8

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 points deducted for bogeys and double bogeys.

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

$$a\,\mathrm{CuS} + b\,\mathrm{NO_3^-} + c\,\mathrm{H^+} \rightarrow d\,\mathrm{Cu^{2+}} + e\,\mathrm{SO_4^{2-}} + f\,\mathrm{NO} + g\,\mathrm{H_2O}$$

where the coefficients a, b, c, d, e, f, and g are the numbers of the various molecules 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:

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

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 seventh 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.

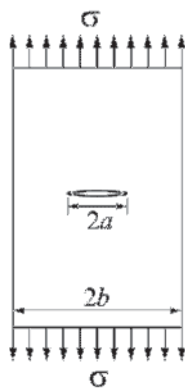
29. The heat index HI, calculated from the air temperature and relative humidity, is the apparent temperature felt by the body. An equation used by the National Weather Service for calculating the HI is given by:

$$HI = -42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783\times10^{-3}T^2$$
$$-5.481717\times10^{-2}R^2 + 1.22874\times10^{-3}T^2R + 8.5282\times10^{-4}TR^2 - 1.99\times10^{-6}T^2R^2$$

where T is the temperature in °F, and R is the relative humidity in integer percentage. Write a MATLAB program in a script file that displays the following chart of heat index for given air temperature and relative humidity in the Command Window:

```
                                Temperature (F)
             80       82       84       86       88       90       92       94
Relative
Humidity
  (%)
   50        81       83       85       88       91       95       99      103
   55        81       84       86       89       93       97      101      106
   60        82       84       88       91       95      100      105      110
   65        82       85       89       93       98      103      108      114
   70        83       86       90       95      100      106      112      119
   75        84       88       92       97      103      109      116      124
```

30. The stress intensity factor K at a crack is given by $K = C\sigma\sqrt{\pi a}$ where σ is the far-field stress, a is the crack length, and C is a parameter that depends on the geometry of the specimen and crack. For the case of the edge crack shown in the figure, C is given by:



$$C = \frac{1-(a/b)/2+0.326(a/b)^2}{\sqrt{1-a/b}}$$

Write a script file that will print out a table of values with the ratio a/b in the first column and the corresponding parameter C in the second column. Let a/b range between 0.05 and 0.80 with increments of 0.05.