```
EminusUV=[((0.02-x)./rminus), (-0.02./rminus)];
EplusUV=[((x+0.02)./rplus), (0.02./rplus)];
EminusMAG=(q/(4*pi*epsilon0))./rminusS;
EplusMAG=(q/(4*pi*epsilon0))./rplusS;
Eminus=[EminusMAG.*EminusUV(:,1), EminusMAG.*EminusUV(:,2)];
Eplus=[EplusMAG.*EplusUV(:,1), EplusMAG.*EplusUV(:,2)];
E=Eminus+Eplus;
EMAG=sqrt(E(:,1).^2+E(:,2).^2);
plot(x,EMAG,'k','linewidth',1)
xlabel('Position along the x-axis (m)','FontSize',12)
ylabel('Magnitude of the electric field (N/C)','FontSize',12)
title('ELECTRIC FIELD DUE TO AN ELECTRIC DIPOLE','FontSize',12)
```

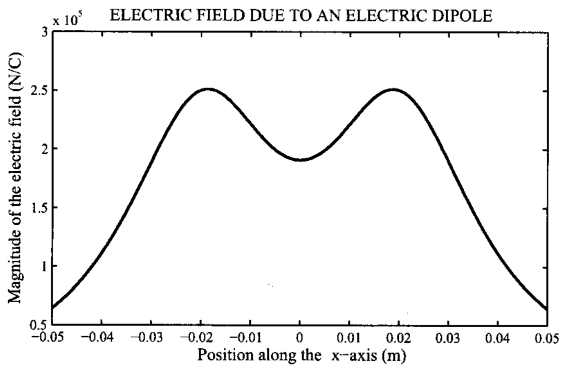
Steps 3 & 4. Each variable is a two column matrix. Each row is the vector for the corresponding `x`.

Step 5.

Step 6.

Step 7.

When this script file is executed in the Command Window the following figure is created in the Figure Window:



5.13 PROBLEMS

1. Plot the function $f(t) = \dfrac{(x+5)^2}{4+3x^2}$ for $-3 \le x \le 5$.

2. Plot the function $f(t) = \dfrac{5\sin(x)}{x+e^{-0.75x}} - \dfrac{3x}{5}$ for $-5 \le x \le 10$.

3. Make two separate plots of the function $f(x) = (x+1)(x-2)(2x-0.25)-e^{x}$, one plot for $0 \le x \le 3$ and one for $-3 \le x \le 6$.

4. Use the `fplot` command to plot the function
$f(x) = \sqrt{|\cos(3x)|} + \sin^2(4x)$ in the domain $-2 \le x \le 2$.

5. Use the `fplot` command to plot the function
   $f(x) = e^{2\sin(0.4x)}5\cos(4x)$ in the domain $-20 \le x \le 30$.

6. A parametric equation is given by

   $$x = 1.5\sin(5t), \quad y = 1.5\cos(3t)$$

   Plot the function for $0 \le t \le 2\pi$. Format the plot such that the both axes will range from –2 to 2.

7. Plot the function $f(x) = \dfrac{x^2 + 3x + 3}{0.8(x + 1)}$ for $-4 \le x \le 3$. Notice that the function has a vertical asymptote at $x = -1$. Plot the function by creating two vectors for the domain of x. The first vector (name it $x1$) includes elements from –4 to –1.1, and the second vector (name it $x2$) includes elements from –0.9 to 3. For each x vector create a y vector (mane them $y1$ and $y2$) with the corresponding values of y according to the function. To plot the function make two curves in the same plot ($y1$ vs. $x1$, and $y2$ vs. $x2$).

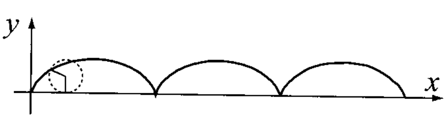
8. A parametric equation is given by

   $$x = \frac{3t}{1 + t^3}, \quad y = \frac{3t^2}{1 + t^3}$$

   (Note that the denominator approaches 0 when t approaches –1) Plot the function (the plot is called the Folium of Descartes) by plotting two curves in the same plot—one for $-30 \le t \le -1.6$ and the other for $-0.6 \le t \le 40$.

9. Plot the function $f(x) = \dfrac{x^2 - 4x - 7}{x^2 - x - 6}$ for $-6 \le x \le 6$. Notice that the function has two vertical asymptotes. Plot the function by dividing the domain of x into three parts: one from –6 to near the left asymptote, one between the two asymptotes, and one from near the right asymptote to 6. Set the range of the y axis from –20 to 20.

10. A cycloid is a curve (shown in the figure) traced by a point on a circle that rolls along a line. The parametric equation of a cycloid is given by



   $$x = r(t - \sin t) \quad \text{and} \quad y = r(t - \cos t)$$

   Plot a cycloid with $r = 1.5$ and $0 \le t \le 4\pi$.

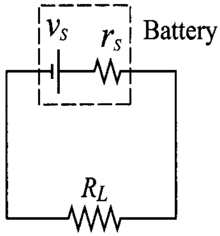
11. Plot the function $f(x) = \cos x \sin(2x)$ and its derivative, both on the same plot, for $\pi \le x \le \pi$. Plot the function with a solid line, and the derivative with a dashed line. Add a legend and label the axes.

12. The Gateway Arch in St. Louis is shaped according to the equation

$$y = 693.8 - 68.8\cosh\left(\frac{x}{99.7}\right) \text{ ft}$$

Make a plot of the arch.

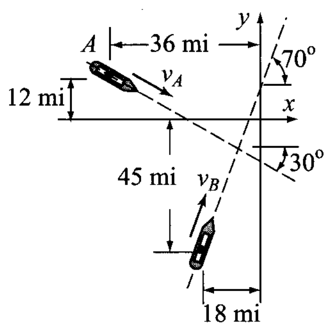
13. An electrical circuit that includes a voltage source v_S with an internal resistance r_S and a load resistance R_L is shown in the figure. The power P dissipated in the load is given by



$$P = \frac{v_S^2 R_L}{(R_L + r_S)^2}$$

Plot the power P as a function of R_L for $1 \leq R_L \leq 10\,\Omega$, given that $v_S = 12$ V and $r_S = 2.5\,\Omega$.

14. Two ship, A and B, travel at a speed of $v_A = 27$ mi/h and $v_B = 14$ mi/h, respectively. The directions they are moving and their location at 8 A.M. are shown in the figure. Plot the distance between the ships as a function of time for the next 4 hours. The horizontal axis should show the actual time of day starting at 8 A.M., while the vertical axis should show the distance. Label the axes.



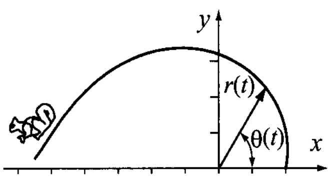
15. The plasma concentration C_P of orally delivered drugs is a function of the rate of absorption, K_{ab}, and the rate of elimination, K_{el}:

$$C_P = A\frac{K_{ab}}{K_{ab} - K_{el}}(e^{-K_{el}t} - e^{-K_{ab}t})$$

where A is a constant (associated with the specific drag) and t is time. Consider a case where $A = 140$ mg/L, $K_{ab} = 1.6\text{ h}^{-1}$, and $K_{ab} = 0.45\text{ h}^{-1}$. Make a plot that displays C_P vs. time for $0 \leq t \leq 10$.

16. The position as a function of time of a squirrel running on a grass field is given in polar coordinates by:

$$r(t) = 20 + 30(1 - e^{-0.1t})\text{ m}$$
$$\theta(t) = \pi(1 - e^{-0.2t})$$



(*a*) Plot the trajectory (position) of the squirrel for $0 \leq t \leq 20$ s.

(*b*) Create a (second) plot for the speed of the squirrel, given by $v = r\frac{d\theta}{dt}$, as a function of time for $0 \leq t \leq 20$ s.

17. In astronomy, the relationship between the relative luminosity L/L_{Sun} (brightness relative to the sun), the relative radius R/R_{Sun}, and the relative temperature T/T_{Sun} of a star is modeled by:

$$\frac{L}{L_{Sun}} = \left(\frac{R}{R_{Sun}}\right)^2\left(\frac{T}{T_{Sun}}\right)^4$$

The HR (Hertzsprung-Russell) diagram is a plot of L/L_{Sun} versus the temperature. The following data is given:

	Sun	Spica	Regulus	Alioth	Barnard's Star	Epsilon Indi	Beta Crucis
Temp (K)	5,840	22,400	13,260	9,400	3,130	4,280	28,200
L/L_{Sun}	1	13,400	150	108	0.0004	0.15	34,000
R/R_{Sun}	1	7.8	3.5	3.7	0.18	0.76	8

To compare the data with the model, use MATLAB to plot an HR diagram. The diagram should have two sets of points. One uses the values of L/L_{Sun} from the table (use asterisk markers), and the other uses values of L/L_{Sun} that are calculated from the equation by using R/R_{Sun} from the table (use circle markers). In the HR diagram both axes are logarithmic. In addition, the values of temperature on the horizontal axis are decreasing from left to right. This is done with the command `set(gca,'XDir','reverse')`. Label the axes and use a legend.

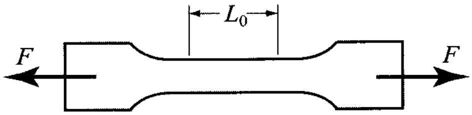
18. The position x as a function of time of a particle that moves along a straight line is given by

$$x(t) = 0.41t^4 - 10.8t^3 + 64t^2 - 8.2t + 4.4 \text{ ft}$$

The velocity $v(t)$ of the particle is determined by the derivative of $x(t)$ with respect to t, and the acceleration $a(t)$ is determined by the derivative of $v(t)$ with respect to t.

Derive the expressions for the velocity and acceleration of the particle, and make plots of the position, velocity, and acceleration as functions of time for $0 \le t \le 8$ s. Use the `subplot` command to make the three plots on the same page with the plot of the position on the top, the velocity in the middle, and the acceleration at the bottom. Label the axes appropriately with the correct units.

19. In a typical tension test a dog bone shaped specimen is pulled in a machine. During the test, the force F needed to pull the specimen and the length L of a gauge section are measured. This data is used for plotting a stress-strain diagram of the material. Two definitions, engineering and true, exist for stress and strain. The engineering stress σ_e and strain ε_e are defined by



$\sigma_e = \frac{F}{A_0}$ and $\varepsilon_e = \frac{L - L_0}{L_0}$, where L_0 and A_0 are the initial gauge length and the initial cross-sectional area of the specimen, respectively. The true stress σ_t and strain ε_t are defined by $\sigma_t = \frac{F}{A_0}\frac{L}{L_0}$ and $\varepsilon_t = \ln\frac{L}{L_0}$.

The following are measurements of force and gauge length from a tension test with an aluminum specimen. The specimen has a round cross section with radius 6.4 mm (before the test). The initial gauge length is $L_0 = 25$ mm. Use the data to calculate and generate the engineering and true stress-strain curves, both on the same plot. Label the axes and label the curves.

Units: When the force is measured in newtons (N), and the area is calculated in m², the unit of the stress is pascals (Pa).

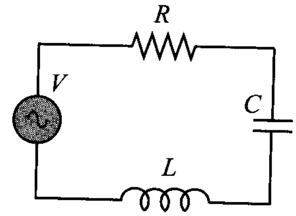
F (N)	0	13,345	26,689	40,479	42,703	43,592	44,482	44,927
L (mm)	25	25.037	25.073	25.113	25.122	25.125	25.132	25.144
F (N)	45,372	46,276	47,908	49,035	50,265	53,213	56,161	
L (mm)	25.164	25.208	25.409	25.646	26.084	27.398	29.150	

20. The area of the aortic valve, A_V in cm^2, can be estimated by the equation (Hakki Formula)

$$A_V = \frac{Q}{\sqrt{PG}}$$

where Q is the cardiac output in L/min, and PG is the difference between the left ventricular systolic pressure and the aortic systolic pressure (in mm Hg). Make one plot with two curves of A_V versus PG, for $2 \le PG \le 60$ mm Hg—one curve for $Q = 4$ L/min and the other for $Q = 5$ L/min. Label the axes and use a legend.

21. A series RLC circuit with an AC voltage source is shown. The amplitude of the current, I, in this circuit is given by



$$I = \frac{v_m}{\sqrt{R^2 + (\omega_d L - 1/(\omega_d C))^2}}$$

where $\omega_d = 2\pi f_d$ in which f_d is the driving frequency; R and C are the resistance of the resistor and capacitance of the capacitor, respectively; and v_m is the amplitude of V. For the circuit in the figure $R = 80\ \Omega$, $C = 18 \times 10^{-6}$ F, $L = 260 \times 10^{-3}$ H, and $v_m = 10$ V.

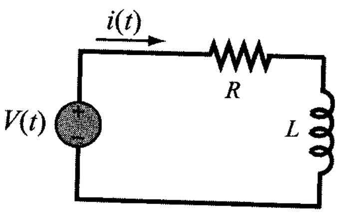
Make a plot of I as a function of f_d for $10 \le f \le 10000$ Hz. Use a linear scale for I and a log scale for f_d.

22. The speed distribution, $N(v)$, of gas molecules can be modeled by Maxwell's speed distribution law:

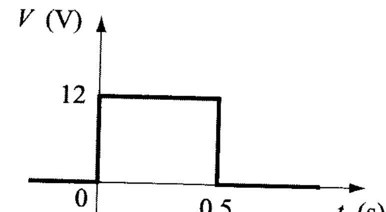
$$N(v) = 4\pi\left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{\frac{-mv^2}{2kT}}$$

where m (kg) is the mass of each molecule, v (m/s) is the speed, T (K) is the temperature, and $k = 1.38 \times 10^{-23}$ J/K is Boltzmann's constant. Make a plot of $N(v)$ versus v for $0 \le v \le 1200$ m/s for oxygen molecules ($m = 5.3 \times 10^{-26}$ kg). Make two graphs in the same plot, one for $T = 80$ K and the other for $T = 300$ K. Label the axes and display a legend.

23. A resistor, $R = 4\ \Omega$, and an inductor, $L = 1.3$ H, are connected in a circuit to a voltage source as shown in Figure (a) (an RL circuit). When the voltage



(a)



(b)

source applies a rectangular voltage pulse with an amplitude of $V = 12$ V and a duration of 0.5 s, as shown in Figure (b), the current $i(t)$ in the circuit as a function of time is given by:

$$i(t) = \frac{V}{R}(1 - e^{(-Rt)/L}) \quad \text{for} \quad 0 \le t \le 0.5 \text{ s}$$

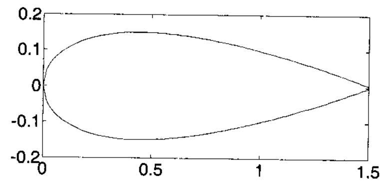
$$i(t) = e^{-(Rt)/L}\frac{V}{R}(e^{(0.5R)/L} - 1) \quad \text{for} \quad 0.5 \le t \text{ s}$$

Make a plot of the current as a function of time for $0 \le t \le 2$ s.

24. The shape of a symmetrical four digit NACA airfoil is described by the equation

$$y = \pm\frac{tc}{0.2}\left[0.2969\sqrt{\frac{x}{c}} - 0.1260\frac{x}{c} - 0.3516\left(\frac{x}{c}\right)^2 + 0.2843\left(\frac{x}{c}\right)^3 - 0.1015\left(\frac{x}{c}\right)^4\right]$$

where c is the cord length and t is the maximum thickness as a fraction of the cord length (tc = maximum thickness). Symmetrical four digit NACA airfoils are designated NACA 00XX, where XX is $100t$ (i.e., NACA 0012 has $t = 0.12$). Plot the shape of a NACA 0020 airfoil with a cord length of 1.5 m.

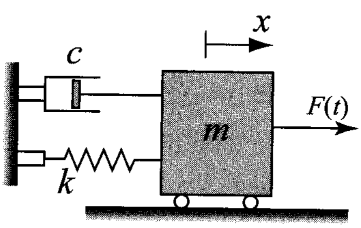


25. The dynamic storage modulus G' and loss modulus G'' are measures of a material mechanical response to harmonic loading. For many biological materials these moduli can be described by Fung's model:

$$G'(\omega) = G_\infty\left\{1 + \frac{c}{2}\ln\left[\frac{1 + (\omega\tau_2)^2}{1 + (\omega\tau_1)^2}\right]\right\} \quad \text{and} \quad G''(\omega) = cG_\infty[\tan^{-1}(\omega\tau_2) - \tan^{-1}(\omega\tau_1)]$$

where ω is the frequency of the harmonic loading, and G_∞, c, τ_1, and τ_2 are material constants. Plot G' and G'' versus ω (two separate plots on the same page) for $G_\infty = 5$ ksi, $c = 0.05$, $\tau_1 = 0.05$ s, and $\tau_2 = 500$ s. Let ω vary between 0.0001 and 1000 s^{-1}. Use a log scale for the ω axis.

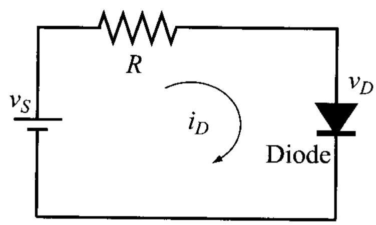
26. The vibrations of the body of a helicopter due to the periodic force applied by the rotation of the rotor can be modeled by a frictionless spring-mass-damper system subjected to an external periodic force. The position $x(t)$ of the mass is given by the equation:



$$x(t) = \frac{2f_0}{\omega_n^2 - \omega^2}\sin\left(\frac{\omega_n - \omega}{2}t\right)\sin\left(\frac{\omega_n - \omega}{2}t\right)$$

where $F(t) = F_0 \sin\omega t$, and $f_0 = F_0/m$, ω is the frequency of the applied force, and ω_n is the natural frequency of the helicopter. When the value of ω is close to the value of ω_n, the vibration consists of fast oscillation with slowly changing amplitude called beat. Use $F_0/m = 12$ N/kg, $\omega_n = 10$ rad/s, and $\omega = 12$ rad/s to plot $x(t)$ as a function of t for $0 \le t \le 10$ s.

27. Consider the diode circuit shown in the figure. The current i_D and the voltage v_D can be determined from the solution of the following system of equations:



$$i_D = I_0\left(e^{\frac{qv_D}{kT}} - 1\right), \quad i_D = \frac{v_S - v_D}{R}$$

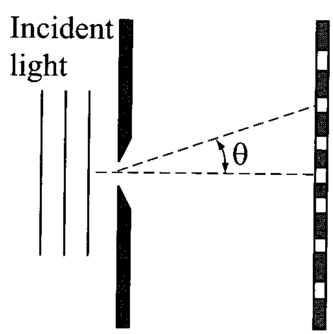
The system can be solved numerically or graphically. The graphical solution is found by plotting i_D as a function of v_D from both equations. The solution is the intersection of the two curves. Make the plots and estimate the solution for the case where $I_0 = 10^{-14}$ A, $v_S = 1.5$ V, $R = 1200\ \Omega$, and $\frac{kT}{q} = 30$ mV.

28. The ideal gas equation states that $\frac{PV}{RT} = n$, where P is the pressure, V is the volume, T is the temperature, $R = 0.08206$ (L atm)/(mol K) is the gas constant, and n is the number of moles. For one mole ($n = 1$) the quantity $\frac{PV}{RT}$ is a constant equal to 1 at all pressures. Real gases, especially at high pressures, deviate from this behavior. Their response can be modeled with the van der Waals equation

$$P = \frac{nRT}{V - nb} - \frac{n^2 a}{V^2}$$

where a and b are material constants. Consider 1 mole ($n = 1$) of nitrogen gas at $T = 300$K. (For nitrogen gas $a = 1.39$ (L^2 atm)/mol^2, and $b = 0.0391$ L/mol.) Use the van der Waals equation to calculate P as a function of V for $0.08 \le V \le 6$ L, using increments of 0.02 L. At each value of V calculate the value of $\frac{PV}{RT}$ and make a plot of $\frac{PV}{RT}$ versus P. Does the response of nitrogen agree with the ideal gas equation?

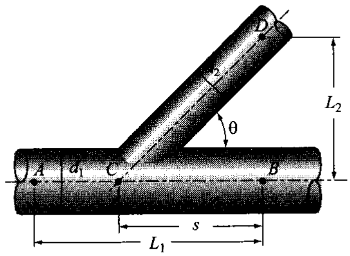
29. When monochromatic light passes through a narrow slit it produces on a screen a diffraction pattern consisting of bright and dark fringes. The intensity of the bright fringes, I, as a function of θ can be calculated by



$$I = I_{max}\left(\frac{\sin\alpha}{\alpha}\right)^2, \text{ where } \alpha = \frac{\pi a}{\lambda}\sin\theta$$

where λ is the light wave length and a is the width of the slit. Plot the relative intensity I/I_{max} as a function of θ for $-20° \le \theta \le 20°$. Make one plot that contains three graphs for the cases $a = 10\lambda$, $a = 5\lambda$, and $a = \lambda$. Label the axes, and display a legend.

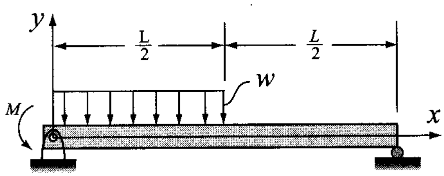
30. In order to supply fluid to point D, a new pipe CD with diameter of d_2 is connected to an existing pipe with diameter of d_1 at point C between points A and B. The resistance, R, to fluid flow along the path ACD is given by



$$R = \frac{L_1 - L_2\cot\theta}{r_1^4}K + \frac{L_2}{r_2^4\sin\theta}K$$

where K is a constant. Determine the location of point C (the distance s) that minimizes the flow resistance R. Define a vector θ with elements ranging from 30° to 85° with spacing of 0.5°. Calculate R/K for each value of θ, and make a plot of R/K versus θ. Use MATLAB's built-in function `min` to find the minimum value of R/K and the corresponding θ, and then calculate the value of s. Use $d_1 = 1.75$ in., $d_2 = 1.5$ in., $L_1 = 50$ ft, $L_2 = 40$ ft.

31. A simply supported beam is subjected to a constant distributed load w over half of its length and a moment M, as shown in the figure. The deflection y, as a function of x, is given by the equations



$$y = \frac{-wx}{384EI}(16x^3 - 24Lx^2 + 9L^2) + \frac{Mx}{6EIL}(x^2 - 3Lx + 2L^2) \text{ for } 0 \le x \le \frac{1}{2}L$$

$$y = \frac{-wL}{384EI}(8x^3 - 24Lx^2 + 17L^2x - L^3) + \frac{Mx}{6EIL}(x^2 - 3Lx + 2L^2) \text{ for } \frac{1}{2}L \le x \le L$$

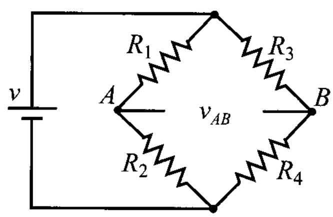
where E is the elastic modulus, I is the moment of inertia, and L is the length of the beam. For the beam shown in the figure $L = 20$ m, $E = 200 \times 10^9$ Pa (steel), $I = 348 \times 10^{-6}$ m^4, $w = 5.4 \times 10^3$ N/m, and $M = 200 \times 10^3$ N m. Make a plot of the deflection of the beam y as a function of x.

32 The ideal gas law relates the pressure P, volume V, and temperature T of an ideal gas:

$$PV = nRT$$

where n is the number of moles and $R = 8.3145$ J/(K mol). Plots of pressure versus volume at constant temperature are called isotherms. Plot the isotherms for one mole of an ideal gas for volume ranging from 1 to 10 m^3, at temperatures of $T = 100, 200, 300$, and 400 K (four curves in one plot). Label the axes and display a legend. The units for pressure are Pa.

33. The voltage difference v_{AB} between points A and B of the Wheatstone bridge circuit is given by:



$$v_{AB} = v\left(\frac{R_2}{R_1 + R_2} - \frac{R_4}{R_3 + R_4}\right)$$

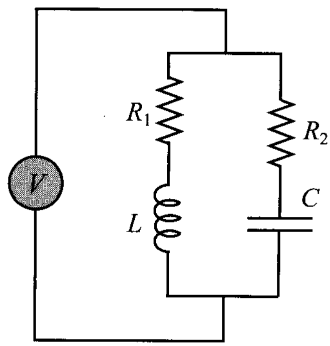
Consider the case where $v = 12$ V, $R_3 = R_4 = 250\ \Omega$, and make the following plots:

(*a*) v_{AB} versus R_1 for $0 \le R_1 \le 500\ \Omega$, given $R_2 = 120\ \Omega$.

(*b*) v_{AB} versus R_2 for $0 \le R_2 \le 500\ \Omega$, given $R_1 = 120\ \Omega$.

Plot both plots on a single page (two plots in a column).

34. The resonant frequency f (in Hz) for the circuit shown is given by:



$$f = \frac{1}{2\pi}\sqrt{LC\frac{R_1^2C - L}{R_2^2C - L}}$$

Given $L = 0.2$ H, $C = 2 \times 10^{-6}$ F, make the following plots:

(*a*) f versus R_2 for $500 \le R_2 \le 2000\ \Omega$, given $R_1 = 1500\ \Omega$.

(*b*) f versus R_1 for $500 \le R_1 \le 2000\ \Omega$, given $R_2 = 1500\ \Omega$.

Plot both plots on a single page (two plots in a column).

35. The taylor series for sin(x) is:

$$x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \frac{x^9}{9!} - \frac{x^{11}}{11!} + \ldots$$

Plot the figure on the right, which shows, for $-2\pi \le x \le 2\pi$, the graph of the function sin(x) and graphs of the Taylor series expansion of sin(x) with one, two, and five terms. Label the axes and display a legend.