King Fahd University of Petroleum & Minerals
Department of Physics
Phys102 Homework Term 001

Chapter 16

1. The equation of a certain traveling wave on a string is given by

$$y(x,t) = (0.2\text{cm})\sin(0.1x - 120t + 0.4)$$

where x and y are in centimeters and t is in seconds. For this wave, find the following;

(a) the amplitude, the wavelength, the frequency, the speed, the maximum transverse velocity, and the maximum transverse acceleration.

(b) Find the tension in the string if the mass of the string is 100 g and its length is 250 cm.

2. A cetrain string has a linear mass density of 0.25 kg/m and is stretched with a tension of 25 N. One end is given a sinusoidal motion with a frequency of 5 Hz and an amplitude of 0.01m. At t = 0, the end (x = 0) has a displacement (y = 0) and is moving in the positive y direction.

(a) Write the equation of the displacement of the wave as a function of x and t.

(b) Find the transverse velocity and acceleration of the point at x = 0.25 m and time t = 0.1 sec.

3. A transverse harmonic wave moving along a metal wire of circular cross-section (diameter = 2 mm), has a wavelength of 12 cm and a frequency of 400 Hz.

(a) Find the speed of the wave?

(b) What is the volume density of the metal wire in kg/m^3 if the tension in the string is 50 N.

4. A transverse wave moves in a stretched string with a speed of 5 m/s and a maximum transverse acceleration is 80 m/s^2.

(a) Find the amplitude of the wave if its wavelength is 0.5 m.

(b) Write the equation of the displacement of the particles with an initial condition $y(0,0)$ = 0.02 m and the wave is moving to the right.

5. A transverse wave in a 3 m long string is given by the equation

$$y = 0.3\sin[p(x/5 + 6t)]$$

where x and y are in meter and t in sec.

If the string is kept under a constant tension of 62 N, find

(a) The speed of the wave

(b) The power transmitted to the wave.

Chapter 17

1. A person sees a heavy stone strike the concrete pavement. A moment later two sounds are heard from the impact: one travels in the air and the other in the concrete, and they are 1.4 sec apart. How far away did the impact occur. Take the speed of sound in the air to be 343 m/s. Given: For concrete, density $\rho = 2.3 \times 10^3$ kg/m^3 and Young modulus $Y = 2 \times 10^{10}$ N/m^2.

2. A sound wave propagating in water (ρ = 1030 kg/m^3) is described by the pressure wave

$$\Delta P = 2.2 \sin(125\,t + 0.833\,x)$$

where x is in meters, t in seconds, and ΔP in N/m^2.

(a) What is the displacement amplitude for this wave?
(b) Write the equation for the dispacement of the particles as a function of x and t.
(c) What is the maximum transverse speed of the particles?

3. A sound wave has an intensity of 0.32 W/m^2 at a distance r from the source. If the distance is increased by 0.5 m, the sound level is decreased by 2.0 dB. Assume the loudspeaker emits sound in all directions.

(a) Find the distance r.
(b) What is the power emitted by the source?

4. A certain loudspeaker produces a sound with a frequency of 2000 Hz and an intensity of 0.96 W/m^2 at a distance of 6.1 m. Assume the loudspeaker emits sound in all directions. Take density of air ρ = 1.29 kg/m^3 and v_{air} = 343 m/s.

(a) What would be the intensity of sound 30 m from the source?
(b) What is the displacement amplitude at 6.1 m from the source?
(c) What is the pressure amplitude at 30 m from the source?

5. A train approches a tunnel in a vertical cliff perpendicular to the rail road tracks. It sounds its horn with a frequency of 250 Hz. The speed of the train is 100 Km/h. Take the speed of sound to be 430 m/s.

(a) What is the frequency of sound heard by an observer standing at the entrance of the cliff.
(b) What is the frequency of sound reflected by the cliff and heard by an enginner on the train?

Chapter 18

1. Two waves in a long string are given by

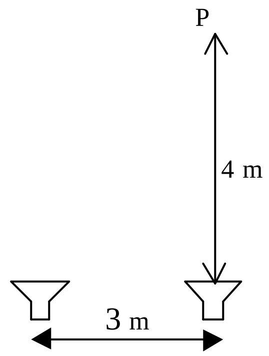
$$y_1 = (0.015\text{m})\sin(\pi x/2 + 40t - \pi/4)$$
$$y_2 = (0.015\text{m})\sin(\pi x/2 + 40t)$$

where x is in meters and t in seconds.

(a) Write the expression of the resultant wave.
(b) What is the speed and wavelength of the resultant wave?
(c) What is the transverse speed for the particles in the wave?

2. Two identical sound sources are placed 3 m apart. A listener, P, stands directly opposite to one of the speakers, at a distance 4 m (see the figure). The sources are driven by a common oscillator at 170 Hz. If the two waves coming from the sources are 180^{o} out of phase when they reach the listerner;

(a) Is the listener going to hear a maximum or a minimum sound?
(b) find the speed of sound in the air.



3. Two harmonic waves travelling in opposite directions interfere to produce a standing wave described by the wave function

$$y(x,t) = (2.5\text{m})\sin(1.2x)\cos(400t)$$

where x is in meters and t in seconds.

(a) Write the wave equation for the two interfering waves.
(b) Find the three smallest values of x corresponding to antinodes.
(c) Find the three smallest values of x corresponding to nodes.

4. If two successive natural frequencies of an closed pipe are determined to be 0.55 kHz and 0.65 kHz, calculate the fundamental frequency and the length of the pipe. Take the speed of sound to be 340 m/s.

5. To maintain the length of a string under tension in a horizontal position, one end of the string is connected to a vibrating blade and the other end passes over a pulley and is attached to a mass *M*. The mass of the string is 10 g while its length is 1.25 m.

(a) When the suspended mass *M* is 5 kg, the string vibrates in its 6th harmonic. Determine the frequency of the vibrating source.
(b) What mass *M* should be attached to the string if it is to vibrate in its 10th harmonic?

Chapter 19

1. Suppose that on a temperature scale X, water boils at -53.5 ^oX and freezes at -170 ^oX. What would a temperature of 340 K be on the X scale?

2. Calculate the change in the length, in two different ways, of a 2 m long aluminum thin wire if it is heated from 41 ^oF to 95 ^oF. $\alpha_{Al} = 23 \times 10^{-6}\ ^oC^{-1}$.

3. A 2000-mL glass cylinder is filled with liquid at 350 K. When the liquid is cooled to 300 K, the cylinder is full only to the 1925-mL mark. What is the volume expansion coefficient of the liquid?

(a) neglect the thermal expansion of the glass compared to that of liquid.
(b) take $\alpha_{glass} = 3.2\ 10^{-6}\ ^oC^{-1}$.

4. A cylinder of compressed air stands 100 cm tall and has a diameter of 20.0 cm. At room temperature (20 ^oC), the pressure in the cylinder is 180 atm.
How many moles of air are in the cylinder?
What volume would this air occupy at 1.0 atm. pressure and room temperature?

5. An iron ball has a diameter of 6 cm and is 0.01 mm too large to pass through a hole in a brass plate when the ball and plate are at a temperature of 30 ^oC. At what temperature should the iron ball and the brass plate be heated so that the ball just pass through the hole? $\alpha_{iron} = 1.2 \times 10^{-5}\ ^oC^{-1}$, $\alpha_{brass} = 1.9 \times 10^{-5}\ ^oC^{-1}$.

Chapter 20

1. How much heat is required to raise the temperature of 3.0-kg of aluminum from 50 ^oC to 90 ^oC?

2. (a) A mass of 20 g of aluminum is at 20 ^oC. How much heat (added or removed) is required to melt it completely.
   (b) What would be the heat (added or removed) if the process in part (a) is reversed?

3. If 100 g of molten lead at 327.3 ^oC is poured into a 300 g casting of iron initially at 20 ^oC, what is the final temperature of the system? (Assume there is no heat loss.)

4. A gas is taken through the cyclic process described in figure 20.1.

   a) Find the net thermal energy transferred to the system during one complete cycle.
   b) Find the net work during one complete cycle.
   c) If the cycle is reversed, that is, the process goes along ACBA, what is the net thermal energy transferred per cycle?

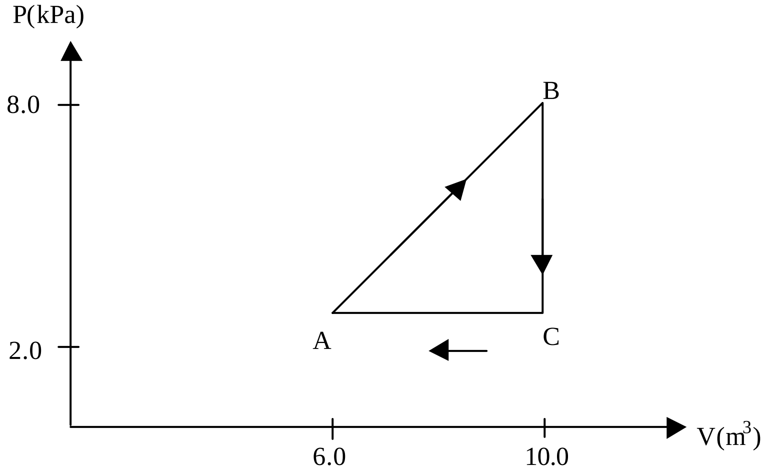


Figure 20.1

5. An ideal gas initially at 300 K undergoes an isobaric expansion at 2.5 kPa. If the volume increases from 1.00 m^3 to 3.00 m^3 and 12.5 kJ of thermal energy is transferred to the gas, find:

   a) the change in its internal energy, and
   b) its final temperature.

Chapter 21

1. A spherical balloon of volume 500 cm^3 contains helium at a pressure of 1.2×10^5 Pa. How many moles of helium are in the balloon if each helium molecule has an average kinetic energy of 3.6×10^{-22} J?

2. A 10.0 liter vessel contains nitrogen gas at 27.0 ^oC and 4.00 atm. Find;
   (a) the total translational kinetic energy of the gas molecules, and
   (b) the average kinetic energy per molecules.

3. One mole of a monoatomic gas is heated at constant pressure from 400 K to 500 K. Calculate
   (a) the heat transferred to the gas
   (b) the increase in its internal energy, and
   (c) the work done by the gas.

4. One mole of air ($c_v = 5/2\ R$) at 300 K confined in a cylinder under a heavy piston occupies a volume of 5.0 liters. Determine the new volume of the gas if 4.4 kJ of heat is transferred to the air.

5. Two moles of an ideal gas ($\gamma = 1.40$) expands slowly and adiabatically from a pressure of 5.00 atm and a volume of 12.0 liters to a final volume of 30.0 liters.
   (a) What is the final pressure of the gas?
   (b) What are the initial and final temperatures of the gas?

Chapter 22

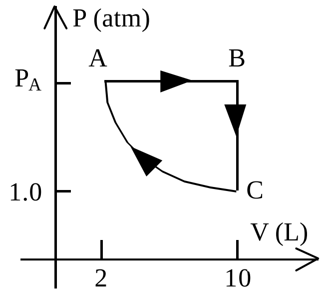
1. A Carnot engine extracts 890 J from a 550-K reservoir during each cycle and reject 470 J to a cooler reservoir.
   (a) How much work does it do each cycle?
   (b) What is the efficiency?
   (c) What is the temperature of the cool reservoir?
   (d) If the engine undergoes 22 cycles per second, what is its (mechanical) power output?

2. A power plant extracts energy from steam at 250^oC and delivers 800 MW of electric power. It discharges waste heat to a river at 30^oC. The overall efficiency of the plant is 28%.
   (a) How does this efficiency compare with the maximum possible at these temperatures?
   (b) What is the rate of waste heat discharge to the river?
   (c) How many houses, each requiring 18 kW of heating power, could be heated with the waste heat from this plant?

3. An industrial freezer operates between 0 ^oC and 32 ^oC consuming electrical energy at the rate of 12 kW. Assuming the freezer is perfectly reversible.
   (a) What is its COP?
   (b) How much water at 0 ^oC can it freeze in 1 hour?

4. A 5.0 mol sample of an ideal diatomic gas (C_v = 5/2 R) is initially at 1.0 atm pressure and 300 K. What is the entropy change if the gas is heated to 500 K.
   (a) At constant volume,
   (b) At constant pressure, and
   (c) adiabatically?

5. **5.** One mole of an ideal monatomic gas is taken through the reversible cycle shown in the Figure. The process CA is a reversible isothermal compression.
   (a) Find the actual efficiency of the cycle.
   (b) Find the efficiency of a Carnot engine operating between the same temperature extremes.
   (c) Why are the two efficiencies different?
   (d) Find the entropy change of the gas during the isothermal compression process.



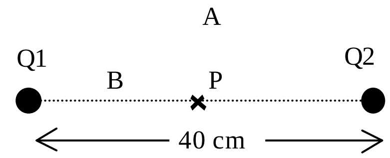
Chapter 23

1. Two charges, one twice as large as the other, are located 15 cm apart and experience a repulsive force of 95N.
   (a) What is the magnitude of the larger charge?
   (b) What should be the separation between the two charges so that the electric force between them is 264 N?

2. A 7.0 μC charge is held at rest, while a small charged sphere of mass 2.0 g is released 50 cm away. Immediately after its release, the sphere accelerates toward the charge at 340 m/s^2.
   (a) What is the sphere's charge?
   (b) Does the acceleration of the charged sphere stay constant and Why ?

3. Three charges are located on xy-plane as follows: q_1 = 10 μC at (0, 4 m), q_2 = 17 μC at (7 m, 4 m), and q3 at (7 m, 0). If the net electric force on q_1 points in the positive y direction,
   (a) Find the charge q_3.
   (b) What is the magnitude of the force on q_1?

4. In the Figure, point P is midway between the two charges (Q1 = 8 μC and Q2 = 12 μC). Find the electric field in the plane of the page:
   (a) 10 cm directly above point P (at point A),
   (b) 10 cm directly to the left of point P (at point B), and
   (c) at point P.



5. A uniform electric field E = 2100 N/C is set up between two metal plates of length L = 10 cm and spacing d = 4 mm. An electron enters the region midway between the plates moving horizontally with speed v. the minimum speed, v, the electron needs to get through the region without hitting either plate. Neglect gravity.

Chapter 24

1. A small sphere whose mass is 1.0×10^{-3} g carries a charge q of 2.0×10^{-8} C. It hangs from a silk thread which makes an angle of 30° with a large, charged, non-conducting sheet as shown in Figure 1. Calculate the surface charge density σ for the sheet.

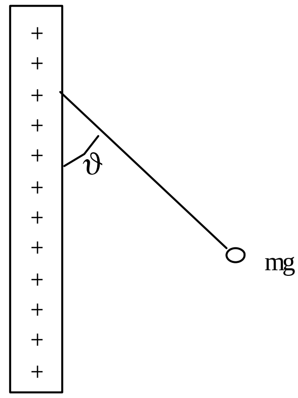


Figure 1

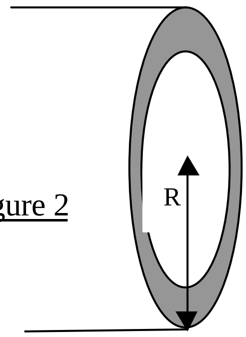
2. Charge is distributed uniformly throughout an infinitely long cylinder of radius R.
(a) Show that the E at a distance r from the cylinder axis ($r < R$) is given by

$$E = \rho \frac{r}{2\varepsilon_0}$$

where ρ is the charge density in C/m^3.
(b) What result do you expect for $r > R$.

3. Figure 2 shows a section through a long thin-walled metal tube of radius R carrying a charge per unit length λ on its surface. Derive an expression for E when
(a) $r > R$,
(b) $r < R$.
(c) Plot your results for the range $r = 0$ to $r = 5$ cm, assuming that $\lambda = 2.0 \times 10^{-8}$ C/m and $R = 3$ cm.

Figure 2



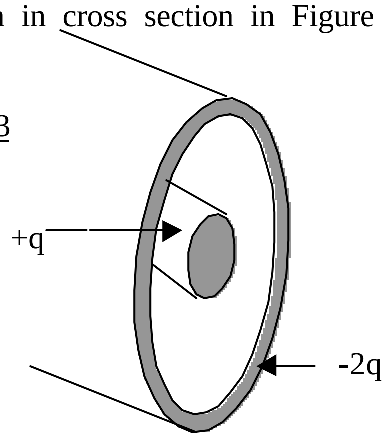
4. A thin metallic spherical shell of radius a carries a charge q_a. Concentric with it is another thin, metallic spherical shell of radius b ($b > a$) carrying a charge q_b. Use

(a) $r < a$,
(b) $a < r < b$,
(c) $r > b$.

5. A long conducting cylinder carrying a total charge $+q$ is surrounded by a conducting cylindrical shell of total charge $-2q$, as shown in cross section in Figure 3. Use

(a) the electric field strength at points outside the conducting shell,
(b) the distribution of the charges on the conducting shell, and
(c) the electric field strength in the region between the cylinders.

Figure 3



Chapter 25

1. A 5-cm radius conducting sphere carries a charge of 2.0×10^{-8} C. It is surrounded by $\times 10^{-8}$ C. Find

(a) the potential difference between the two conductors,
(b) the potential then the electric field strength at r = 6 cm and r = 10 cm.

2. What is the potential difference between a point

(a) 1 Angstrom (10^{-8} cm) from a proton and a point 2 Angstroms from the same proton.
(b) 2 Angstroms from the proton and a point infinitely remote.
(c) In moving from a great distance to within 1 Angstrom of the proton, does an electron gain or lose potential energy? How much? Express the answer in eV.

3. A water droplet of radius 5.0×10^{-4} m carries a net charge of 500 electrons.

(a) Find its electric potential (the potential at the surface of the droplet).
(b) If this droplet coalesces with an identical droplet, also carrying 500 excess electrons, find the potential of the new larger droplet.

4. A point charge has $q = +1.0 \times 10^{-6}$ C. Consider point A which is 2.0 m distant and point B which is 1.0 m distant in a direction diametrically opposite, as in Figure 1.

(a) What is the potential difference $V_A - V_B$?
(b) Repeat if points A and B are located as in Figure 2.

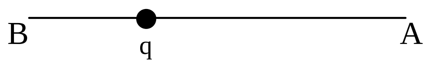


Figure 1

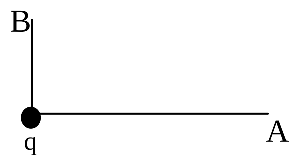


Figure 2

5. The electric potential inside a 10-cm conducting sphere is 10 V. This sphere is connected to another sphere of radius 20 cm and electric potential 20 V.

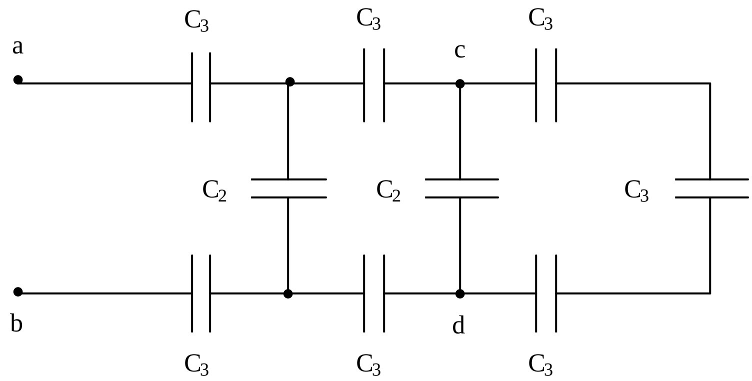
(a) Calculate the electric potential inside the two spheres, and
(b) their charges after connection.

Chapter 26

1. An air capacitor consisting of two closely spaced parallel plates has a capacitance of 1000 pF. The charge on each plate is 1.0 μC.
   (i) What is the potential difference between the plates?
   (ii) If the charge is kept constant, what will be the potential difference between the plates if the separation is doubled?
   (iii) How much work is required to double the separation?

2. A 1.0 μF capacitor and a 2.0 μF capacitor are connected in series across a 1200-V supply line.
   (i) Find the charge on each capacitor and the voltage across each.
   (ii) The charged capacitors are disconnected from the line and from each other, and reconnected with terminals of like sign together. Find the final charge on each and the voltage across each capacitor.

3. In the figure below, each capacitance C_3 is 3.0 μF and each capacitance C_2 is 2.0 μF.
   (i) Compute the equivalent capacitance of the Network between points a and b.
   (ii) Compute the charge on each capacitors near a and b when V_{ab} = 900 V.
   (iii) With 900 V across a and b, compute V_{cd}.



4. A parallel plate air capacitor is made using plates 0.20 m square, spaced 1.0 cm apart. It is connected to a 50 V battery.
   (i) What is the capacitance?
   (ii) What is charge on each plates?
   (iii) What is electric field between the plates?
   (iv) What is the energy stored in the capacitor?
   (v) If the battery is disconnected and then the plates pulled apart to separation of 2.0 cm, what are the answers to parts (i), (ii), (iii) and (iv)?

5. A 20 μF capacitor is charged to a potential difference of 1000 V. The terminals of the charged capacitor are connected to those of an uncharged 5.0 μF capacitor. Compute:
   (i) The original charge of the system.
   (ii) The final potential difference across each capacitor.
   (iii) The final energy of the system, and
   (iv) The decrease in energy when the capacitors are connected.

Chapter 27

1. A wire m long and 2.0 mm in diameter has a resistivity of 4.8×10^{-8} Ωm.
(a) What is the resistance of the wire?
(b) A second wire of the same material has the same mass as the 100-m length, but twice its diameter. What is its resistance?

2. The following measurements were made on a Thyrite resistor:

I (A)	V_{ab} (V)
0.5	4.76
1.0	5.81
2.0	7.05
4.0	8.56

(a) Make a graph of V_{ab} as a function of I. Does Thyrite have constant resistance?
(b) Construct a graph of the resistance R as a function of I.
(c) Find the dynamic resistance at 2.0 A, and compare with resistance values found in part (b).

3. The region between two concentric conducting spheres of radii r_a and r_b is filled with a conducting material of resistivity ρ.

(a) Show that the resistance between the spheres is given by

$$R = (\rho / 4\pi) (1/r_a \qquad _b)$$

(b) Derive an expression for the current density as a function of radius, if the potential difference between the spheres is V_{ab}.

4. A toaster using a Nichrome heating element operates on a 120 volts. When it is switched on a 0^oC, it carries an initial current of 1.5 A. A few seconds later the current reaches the steady value of 1.33 A. What is the final temperature of the element ? The average value of the temperature coefficient of Nichrome over the temperature range is 0.00045 $(^oC)^{-1}$.

Chapter 28

1. A battery has a emf of 4.2 V and internal resistance r. Its terminals are connected to a load resistance R. The power dissipated in the load is 12.0 W and the current is 4.0 A. Calculate the internal resistance.

2. In the following figure 1, if $R = 4\Omega$. Find V_A B.

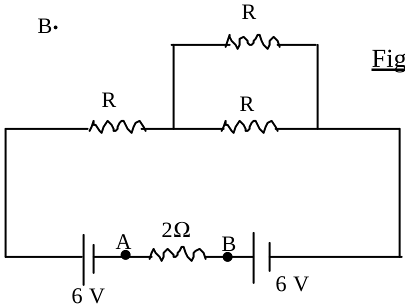


Figure 1

3. The two branch currents in the circuit shown in figure 2, are $I_1 = 1/3$ A and $I_2 = 1/2$ A.
(a) Determine the emfs, E_1 and E_2.
(b) Find V_a V_b .

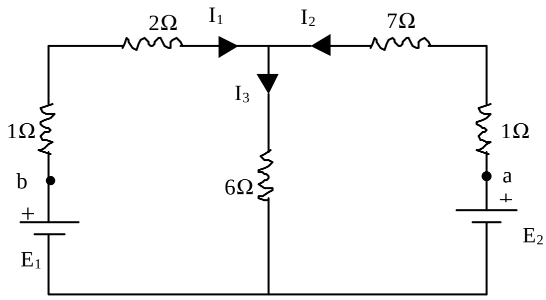


Figure 2

4. Consider the circuits shown in figure 3.
(a) Find the value of I_1, I_2, and I_3.
(b) What is the total power lost in the resistors?
(c) What is the total power delivered by the batteries?
(d) What is your comment for the conservation of energy?

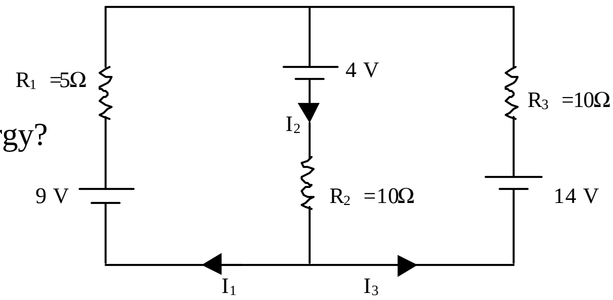


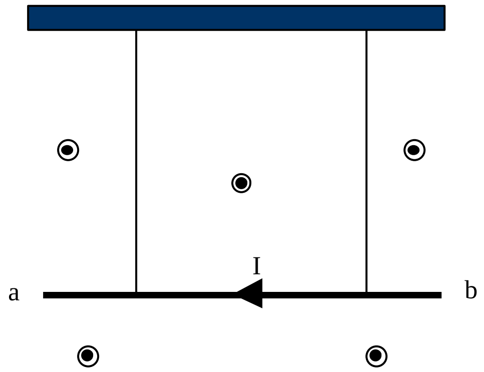
Figure 3

5. A 3×10^{-9} F capacitor with an initial charge of 6.2×10^{-6} C is charged through a 1500 Ω resistor.
(a) Calculate the time constant.
(b) What is the maximum current through the resitor?
(c) Calculate the current through the resistor 9×10^{-6} s after the resistor is connected across the terminals of the capacitor.
(d) What charge remains on the capacitor after 9×10^{-6} s?

Chapter 29

1. An electron is projected into a uniform magnetic field given by **B** = (1.4 **i** + 2.1 **j** + 3.5 **k**) T. Find the vector expression for the force on the electron when its velocity is **v** = 3.7×10^5 (1.1 **i** + 2.1 **j**) m/s.

2. A wire ab, mass = 50 g and length = 40 cm, is suspended horizontally by two vertical wires which conduct a current *I* = 8.0 A, as shown in Figure. The magnetic field in the region is out from the paper and has a magnitude of 60 mT. What is the tension in the two vetical wires?



3. A circular coil of wire of radius 1 cm has 100 turns of wire and carries a current of 0.5 A.
   (a) What is the magnetic moment of the coil?
   (b) What torque will be exerted on the coil when it is placed in a magnetic field of 5×10^{-3} T which makes an angle of 60^o with the plane of the coil?

4. A proton, with a velocity of 6.0×10^6 m/s, travels at right angles to the magnetic field of 0.5 orbit ? [$q_p = 1.6 \times 10^{-19}$ C, $m_p = 1.67 \times 10^{-27}$ kg]

5. A particle #1 (of mass m and charge q) and another particle #2 (of mass $2m$ and charge q) are accelerated through a common potential difference V. The two particles enter a uniform magnetic field B along a direction perpendicular to B. If particle #1 moves in a circular path of radius (r_1), and particle #2 moves in a circular path of radius (r_2), find the ratio of r_1 / r_2.

Chapter 30

1. μT is horizontal and directed due north. Suppose the net field is zero exactly 8.0 cm above a straight wire that carries a constant current. What are (a) the magnitude and (b) the direction of the current?

2. Use the Biot-Sarvart law to calculate the magnetic field **B** at point C, the common center of the semicircular are AD and HJ in Figure 1. The two arcs, of radii R_2 and R_1, respectively, form part of the circuit ADJHA carrying current i.

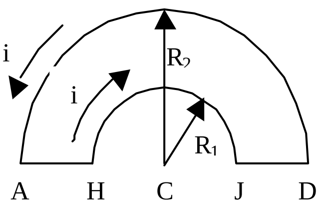


Figure 1

3. In Figure 2, the long straight wire carries a current of 30 A and the rectangular loop carries a current of 20 A. Calculate the resultant force acting on the loop. Assume that a = 1.0 cm, b = 8.0 cm, and L = 30 cm.

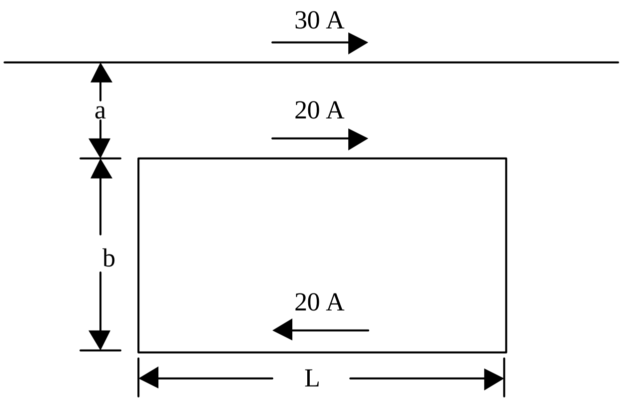


Figure 2

4. A solenoid 1.30m long and 2.60 cm in diameter carries a current of 18.0 A. The magnetic field inside the solenoid is 23.0 mT. Find the length of the wire forming the solenoid.

5. A length of wire is formed into a closed circuit with radii a and b, as shown in Figure 3, and carries a current i. What are the magnitude and direction of **B** at point p?

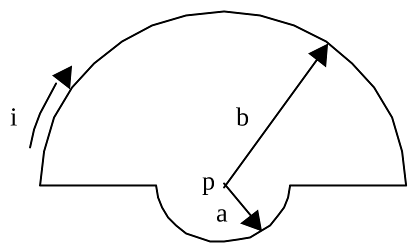


Figure 3

Chapter 31

1. The magnetic flux through the loop shown in Figure 1, increases according to the relation $\phi_B = 6t^2 + 7.0t$, where ϕ_B is in milliwebers and t is in seconds. (a) What is the magnitude of the emf induced in to loop when t = 2.0s? (b) What is the direction of the current through R?

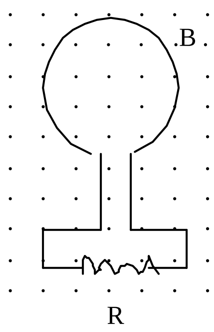


Figure 1

2. A long solenoid with a radius of 25mm has 100 turns/cm. A single loop of wire of radius 5.0 cm is placed around the solenoid, the central axes of the loop and the solenoid coinciding. In 10 ms the current in the solenoid is reduced from 1.0 A to 0.50 A at a uniform rate. What emf appears in the loop?

3. A toroid having a 5.00 cm square cross section and an inside radius of 15.0 cm has 500 turns of wire and carries a current of 0.800 A. What is the magnetic flux through the cross section?

4. A rectangular loop of wire with length a, width b, and resistance R is placed near an infinitely long wire carrying current i as shown in Figure 2. The distance from the long wire to the center of the loop is r. Find (a) the magnitude of the magnetic flux through the loop and (b) the current in the loop as it moves away from the long wire with speed v.

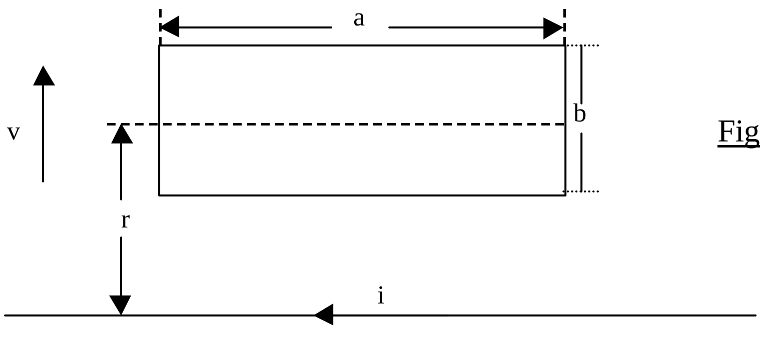


Figure 2

5. A small loop of area a is inside of, and has its axis in the same direction as, a long solenoid of n turns per unit length and current i. If $i = i_o \sin \omega t$, find the emf in the loop.