Physics 106 Homework Problems, Winter 2009

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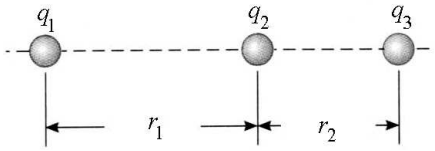
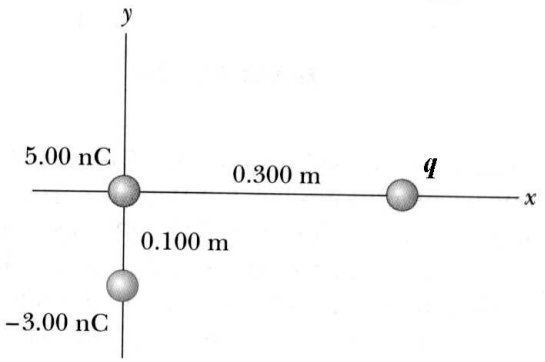
1-1. A 4.51-nC charge is located [01] _____ m from a −2.86-nC charge. Find the magnitude of the electrostatic force exerted by one charge on the other.

1-2. In the figure, $q_1 = 6.27\ \mu$C, $q_2 =$ [02] _____ μC, $q_3 = -2.38\ \mu$C, $r_1 = 3.49$ cm, and $r_2 = 3.22$ cm. Calculate the magnitude and direction of the Coulomb force on (a) q_1, (b) q_2, and (c) q_3. Indicate a force to the right with a + sign and a force to the left with a − sign.



1-3. Three charges are arranged as shown in the figure. Find the (a) magnitude and (b) direction (angle with the positive x axis) of the electrostatic force on the charge at the origin. In the figure, $q =$ [03] _____ nC.

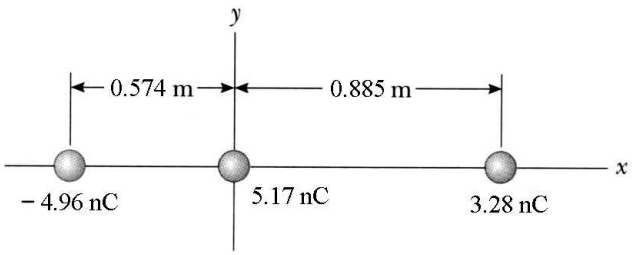


1-4. Two charges, q_1 and q_2, are separated by 35.2 cm. If $q_1 =$ [04] _____ nC, find the electric field at a point midway between the two charges for (a) $q_2 = 64.9$ nC and for (b) $q_2 = -64.9$ nC. Use a positive sign if the field is pointing toward q_2 and a negative sign if the field is pointing toward q_1.

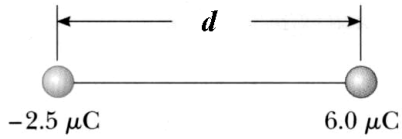
2-1. A proton accelerates from rest in a uniform electric field of [01] _____ N/C. At some later time, its speed is [02] _____ m/s. (a) Find the magnitude of the acceleration of the proton. (b) How long does it take the proton to reach this speed? (c) How far has it moved in this interval? (d) What is its kinetic energy at the later time?

2-2. Each of the protons in a particle beam has a kinetic energy of 3.25×10^{-15} J. The protons are moving to the right. What are the magnitude and direction of the electric field that will stop these protons in a distance of [03] _____ m? Indicate a direction to the right with a + sign and a direction to the left with a − sign.

2-3. Three point charges are aligned along the x axis, as shown in the figure. Find the magnitude and direction of the electric field at the position $x =$ [04] _____ m, $y = 0$. Indicate a field to the right with a + sign and a field to the left with a − sign.



2-4. In the figure, determine the distance from the charge at the left (other than infinity) at which the total electric field is zero. In the figure, $d =$ [05] _____ m.

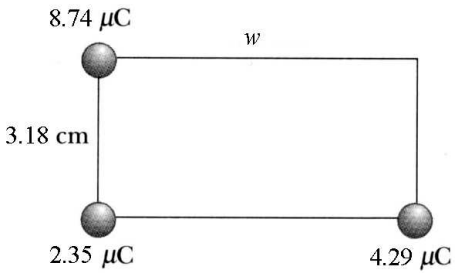


3-1. The difference in potential between the accelerating plates of a television set is 25200 V. If the distance between these plates is [01] _____ cm, find the magnitude of the uniform electric field in this region.

3-2. An electron moves from one plate to another across which there is a potential difference of [02] _____ V. (a) Find the speed with which the electron strikes the positive plate. (b) Repeat part (a) for a proton moving from the positive to the negative plate.

3-3. Two point charges are on the y axis. One charge of 3.18 nC is at the origin and a second charge of 6.35 nC is at the point $y = 29.2$ cm. Calculate the potential at $y =$ [03] _____ cm.

3-4. Find the electric potential at the upper right corner (the corner without a charge) of the rectangle in the figure if the width w of the rectangle is [04] _____ cm.

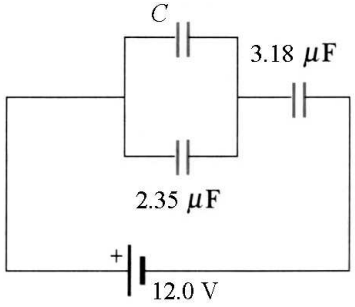


3-5. Calculate the speed of (a) an electron that has a kinetic energy of [05] _____ eV and (b) a proton that has a kinetic energy of [05] _____ eV.

3-6. Suppose an electron is released from rest in a uniform electric field whose strength is [06] _____ V/m. (a) Through what potential difference will it have passed after moving 1.34 cm? (b) How fast will the electron be moving after it has traveled 1.34 cm?

4-1. A parallel-plate capacitor has an area of 2.74 cm^2, and the plates are separated by [01] _____ mm with air between them. How much charge does this capacitor store when connected to a 6.00-V battery?

4-2. (a) Find the equivalent capacitance of the group of capacitors in the figure if C = [02] _____ μF. (b) Find the potential difference across the 2.35 μF capacitor. (c) Find the charge on the 2.35 μF capacitor.



4-3. A parallel-plate capacitor has 2.46-cm^2 plates that are separated by [03] _____ mm with air between them. If a 12.0-V battery is connected to this capacitor, how much energy does it store?

4-4. Consider Earth and a cloud layer 800 m above Earth to be the plates of a parallel-plate capacitor. The cloud layer has an area of [04] _____ km^2. Assume this capacitor will discharge (that is, lightning occurs) when the electric field strength between the plates reaches 3.0×10^6 N/C. What is the energy released if the capacitor discharges completely during a lightning strike?

5-1. If a current of [01] _____ mA exists in a metal wire, how many electrons flow past a given cross section of the wire in 10.0 min?

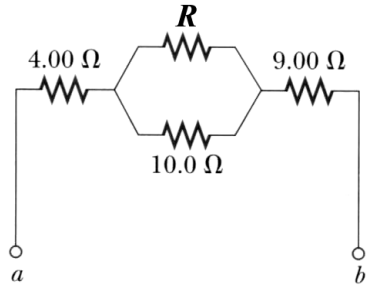
5-2. A 283-km-long high-voltage transmission line 2.58 cm in diameter carries a steady current of [02] _____ A. If the conductor is copper with a free-charge density of 8.53×10^{28} electrons/m^3, how long does it take one electron to travel the full length of the cable?

5-3. A high-voltage transmission-line with a resistance of [03] _____ Ω/km carries 1460 A, starting at 701 kV for a distance of 168 km. (a) What is the power loss due to resistance in the line? (b) What percentage of the initial power does this loss represent?

5-4. A lightbulb has a resistance of [04] _____ Ω when operating at a voltage of 120 V. What is the current through the lightbulb?

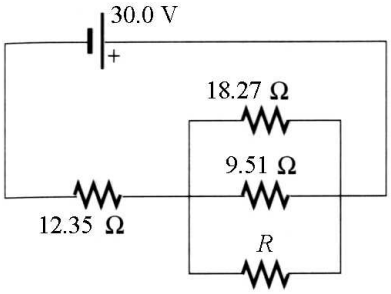
5-5. What is the required resistance of an immersion heater that will increase the temperature of 1.52 kg of water from 11.8°C to 55.3°C in [05] _____ min while operating at 120 V? The specific heat of water is 4186 J/kg·°C.

6-1. (a) Find the equivalent resistance between points a and b in the figure, where $R =$ [01] _____ Ω. (b) Calculate the current in the resister R if a potential difference of 34.0 V is applied between points a and b.

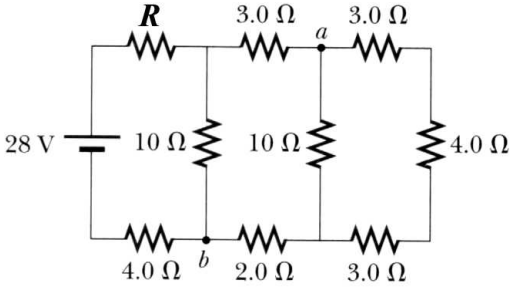


6-2. An 18.3-Ω resistor and a [02] _____-Ω resistor are connected in series across an 18.0-V battery. Find (a) the current and (b) the voltage drop across the 18.3-Ω resistor.

6-3. Find the equivalent resistance of the circuit in the figure if $R =$ [03] _____ Ω.

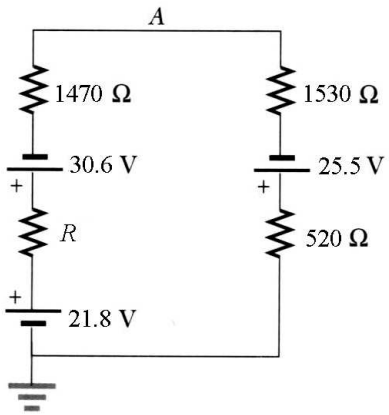


6-4. For the circuit in the figure, where $R =$ [04] _____ Ω, calculate (a) the equivalent resistance of the circuit and (b) the power dissipated by the entire circuit. (c) Find the current in the resistor R.

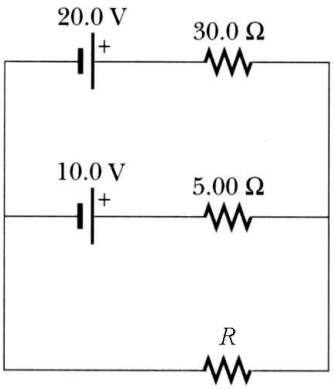


6-5. A lightbulb marked "75 W at 120 V" is screwed into a socket at one end of a long extension cord in which each of the two conductors has a resistance of [05] _____ Ω. The other end of the extension cord is plugged into a 120-V outlet. Find the actual power of the bulb in this circuit.

7-1. The figure shows a circuit diagram. If $R =$ [01] _____ Ω, determine (a) the current, (b) the potential of wire A relative to ground, and (c) the voltage drop across the 1530-Ω resistor.



7-2. If $R = [02]$ _____ Ω in the figure, find the current in the (a) top, (b) middle, and (c) bottom resistors. The algebra in this problem is challenging. Apply the loop rule to the top loop first and then to the bottom loop.



7-3. An uncharged capacitor and a resistor are connected in series to a source of emf. If $\mathcal{E} = 9.00$ V, $C = [03]$ _____ μF, and $R = 127\ \Omega$, find (a) the time constant of the circuit, (b) the maximum charge on the capacitor, and (c) the charge on the capacitor after one time constant.

8-1. Sodium ions (Na^+) move at 0.851 m/s through a blood-stream in the arm of a person standing near a large magnet. The magnetic field has a strength of [01] _____ T and makes an angle of 90° with the motion of the sodium ions. The arm contains 127 cm^3 of blood with 2.84×10^{20} Na^+ ions/cm^3. If no other ions were present in the arm, what would be the magnetic force on the arm? The charge of a sodium ion is equal to the elementary charge e.

8-2. A single circular wire loop of radius [02] _____ cm, carrying a current of 2.38 A, is in a magnetic field of 0.395 T. Find the maximum torque that acts on this loop.

8-3. A 2.53-μC charged particle with a kinetic energy of 0.0929 J is fired into a uniform magnetic field of magnitude 0.147 T. If the particle moves in a circular path of radius [03] _____ m, determine its mass.

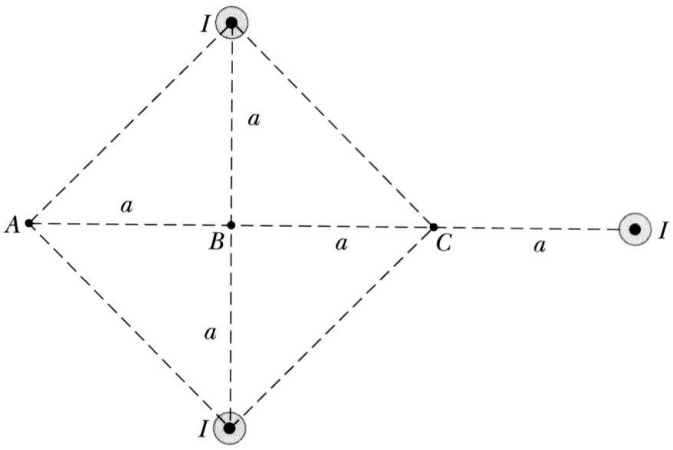
8-4. A singly charged positive ion has a mass of 2.58×10^{-26} kg. After being accelerated through a potential difference of 250 V, the ion enters a magnetic field of [04] _____ T, in a direction perpendicular to the field. Calculate the radius of the ion's path in the field.

8-5. A lightning bolt may carry a current of 1.00×10^4 A for a short period of time. What is the resulting magnetic field [05] _____ m from the bolt? Suppose that the bolt extends far above and below the point of observation.

9-1. At what distance from a long, straight wire carrying a current of [01] _____ A is the magnetic field due to the wire equal to the strength of the Earth's field, approximately 5.0×10^{-5} T?

9-2. What current is required in the windings of a long solenoid that has 1000 turns uniformly distributed over a length of 0.432 m in order to produce a magnetic field of magnitude [02] _____ T at the center of the solenoid?

9-3. Three long, parallel conductors carry currents of $I = 2.22$ A. The figure is an end view of the conductors, with each current coming out of the page. Given that $a =$ [03] _____ cm, determine the magnitude of the magnetic field at points (a) A, (b) B, and (c) C.



9-4. A wire carries a steady current of [04] _____ A. A straight section of the wire is 0.752 m long and lies along the x axis within a uniform magnetic field of magnitude 1.68 T in the positive z direction. If the current is in the $+x$ direction, what is the (a) magnitude and (b) direction of the magnetic force on the section of wire?

9-5. Two parallel wires are 12.3 cm apart, and each carries a current of [05] _____ A. (a) If the currents are in the same direction, find the force per unit length exerted by one of the wires on the other. (b) Are the wires attracted or repelled?

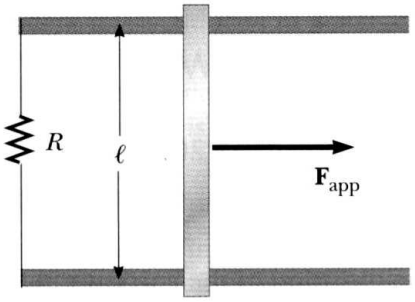
9-6. A solenoid 4.29 cm in diameter and [06] _____ cm long has 250 turns and carries a current of 15.7 A. Calculate the magnetic field through the circular cross-sectional area of the solenoid.

10-1. A circular loop of radius [01] _____ cm is placed in an external magnetic field of strength 0.246 T so that the plane of the loop is perpendicular to the field. The loop is pulled out of the field in 0.308 s. Find the average induced emf during this interval.

10-2. A wire loop of radius 0.374 m lies so that an external magnetic field of strength +0.360 T is perpendicular to the loop. The field changes to −0.218 T in [02] _____ s. (The plus and minus signs here refer to opposite directions through the loop.) Find the magnitude of the average induced emf in the loop during this time.

10-3. A circular coil, enclosing an area of 113 cm^2, is made of 200 turns of copper wire. The wire making up the coil has a resistance of [03] _____ Ω and the ends of the wire are connected to form a closed loop. Initially, a 1.15 T uniform magnetic field points perpendicularly upward through the plane of the coil. The direction of the field then reverses so that the final magnetic field has a magnitude of 1.15 T and points downward through the coil. If the time required for the field to reverse directions is 0.129 s, what average current flows through the coil during this time?

10-4. Consider the arrangement shown in the figure. Assume that $R = 6.39\ \Omega$ and $\ell = 1.22$ m, and that a uniform [04] _____-T magnetic field is directed *into* the page. At what speed should the bar be moved to produce a current of 0.576 A in the resistor?

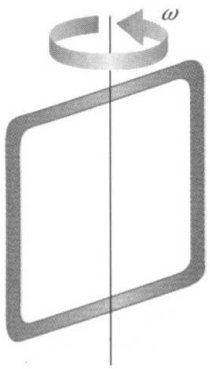


10-5. A helicopter has blades of length 3.31 m, rotating at [05] _____ rev/s about a central hub. If the vertical component of Earth's magnetic field is 5.13×10^{-5} T, what is the emf induced between the blade tip and the central hub?

11-1. A solenoid of radius 2.52 cm has [01] _____ turns and a length of 19.2 cm. Find (a) its inductance and (b) the magnitude of the rate at which current must change through it to produce an emf of 75.7 mV.

11-2. The switch in a series RL circuit in which $R =$ [02] _____ Ω, $L = 3.31$ H, and $\mathcal{E} = 24.7$ V is closed at $t = 0$. (a) What is the maximum current in the circuit? (b) What is the current when $t = \tau = L/R$?

11-3. A 100-turn square wire coil of area 0.0413 m^2 rotates about a vertical axis at [03] _____ rpm, as indicated in the figure. The horizontal component of the Earth's magnetic field at the location of the loop is 2.58×10^{-5} T. Calculate the maximum emf induced in the coil by the Earth's field.



11-4. A Boeing-747 jet with a wing span of 62.4 m is flying horizontally at a speed of [04] _____ m/s over Phoenix, Arizona, at a location where Earth's magnetic field is 51.7 μT at 58.9° below the horizontal. What voltage is generated between the wingtips?

12-1. The switch in a series RL circuit in which $R =$ [01] _____ Ω, $L = 3.31$ H, and $\mathcal{E} = 24.7$ V is closed at $t = 0$. (a) What is the maximum current in the circuit? (b) What is the current when $t = \tau = L/R$?

12-2. A 227-Ω resistor is connected in series with a [02] _____-μF capacitor and 60.0-Hz, 120-V rms line. If electrical energy costs \$0.0800/kWh, how much does it cost to leave this circuit connected for 24 h?

12-3. What maximum current is delivered by a [03] _____-μF capacitor when connected across (a) a North American outlet having $v_{\text{rms}} = 120$ V, $f = 60.0$ Hz; and (b) a European outlet having $v_{\text{rms}} = 240$ V, $f = 50.0$ Hz?

12-4. What maximum current is delivered by an AC generator with $\Delta V_{\text{max}} = 48.2$ V and $f =$ [04] _____ Hz when connected across a 3.78-μF capacitor?

12-5. An inductor has a [05] _____-Ω reactance at 60.0 Hz. What will be the maximum current if this inductor is connected to a 50.0-Hz source that produces a 100-V rms voltage?

12-6. An RLC circuit is used to tune a radio to an FM station broadcasting at [06] _____ MHz. The resistance in the circuit is 11.8 Ω and the capacitance is 1.39 pF. What inductance should be placed in the circuit?

13-1. A step-down transformer is used for recharging the batteries of portable devices such as tape players. The turns ratio inside the transformer is 13:1 and it is used with 120 V (rms) household service. If a particular ideal transformer draws [01] _____ A from the house outlet, what are (a) the voltage and (b) the current supplied to a tape player from the transformer? (c) How much power is delivered?

13-2. A step-up transformer is designed to have an output voltage of [02] _____ V (rms) when the primary is connected across a 110-V (rms) source. (a) If there are 80 turns on the primary winding, how many turns are required on the secondary? (b) If a load resistor across the secondary draws a current of 1.5 A, what is the current in the primary, assuming ideal conditions?

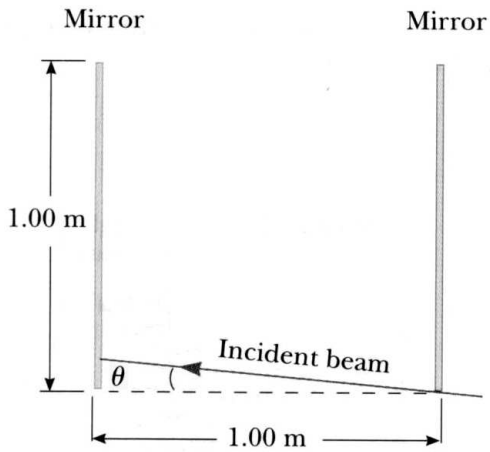
13-3. An AC adapter for a telephone answering unit uses a transformer to reduce the line voltage of 120 V (rms) to a voltage of 9.0 V. The rms current delivered to the answering system is [03] _____ mA. (a) If the primary (input) coil in the transformer in the adapter has [04] _____ turns, how many turns are there on the secondary (output) coil? (b) What is the rms power delivered to the transformer? Assume an ideal transformer.

13-4. An ac power generator produces 45.2 A (rms) at 3630 V (rms). The voltage is stepped up to [05] _____ V (rms) by an ideal transformer, and the energy is transmitted through a long-distance power line that has a resistance of 113 Ω. What percentage of the power delivered by the generator is dissipated as heat in the power line?

14-1. An underwater scuba diver sees the Sun at an apparent angle of [01] _____° from the vertical. What is the actual direction of the Sun? (Give the angle above the horizontal.)

14-2. A cylindrical cistern, constructed below ground level, is 2.78 m in diameter and 1.88 m deep and is filled to the brim with a liquid whose index of refraction is [02] _____. A small object rests on the bottom of the cistern at its center. How far from the edge of the cistern can a girl whose eyes are 1.21 m from the ground stand and still see the object?

14-3. How many times will the incident beam shown in the figure be reflected by the mirror on the left? The mirrors are parallel and $\theta =$ [03] _____°.



14-4. A laser beam is incident at an angle of 30.00° to the vertical onto some transparent material. If the beam is refracted to [04] _____° to the vertical, (a) what is the index of refraction of the material? Suppose the light is red, with vacuum wavelength 632.8 nm. Find its (b) wavelength, (c) frequency, and (d) speed in the material.

14-5. A submarine is 294 m horizontally out from the shore and 113 m beneath the surface of the water. A laser beam is sent from the sub so that it strikes the surface of the water at a point [05] _____ m from the shore. If the beam just strikes the top of a building standing directly at the water's edge, find the height of the building.

15-1. A certain kind of glass has an index of refraction of 1.650 for blue light of wavelength 430 nm and an index of 1.615 for red light of wavelength 680 nm. If a beam containing these two colors is incident at an angle of [01] _____° on a piece of this glass, what is the angle between the two beams inside the glass? (The incident angle is measured from the direction normal to the surface, as in Snell's Law.)

15-2. A plastic light pipe has an index of refraction of [02] _____. For total internal reflection, what is the maximum angle of incidence to the wall of the pipe if the pipe is in (a) air? (b) water? Be careful: The problem asks for the angle with the *wall* of the pipe. This is not the angle in Snell's law. Use $n = 1.333$ for the index of refraction of water.

15-3. Calculate the critical angle for a transparent material surrounded by air. The index of refraction of the material is [03] _____.

15-4. Calculate the critical angle for a transparent material surrounded by water. The index of refraction of the material is [04] _____.

15-5. The index of refraction for red light in water is 1.331, and that for blue light is 1.340. If a ray of white light enters the water at an angle of incidence of [05] _____°, what are the underwater angles of refraction for the (a) blue and (b) red components of the light?

16-1. At an intersection of hospital hallways, a convex mirror is mounted high on a wall to help people avoid collisions. The mirror has a radius of curvature of [01] _____ m.
(a) Locate (distance behind the mirror) the image of a patient 11.8 m from the mirror.
(b) Determine the magnification.

16-2. A concave spherical mirror has a radius of curvature of 23.7 cm. Locate the image for an object [02] _____ cm from the mirror. (a) What is the distance from the image to the mirror? (b) Is the image in front of or behind the mirror? (c) Is the image real or virtual? (d) Is the image upright or inverted? (e) Find the magnification.

16-3. A spherical Christmas tree ornament is 6.54 cm in diameter. What is the magnification of an object placed [03] _____ cm away from the ornament?

17-1. A diverging lens has a focal length of [01] _____ cm. (a) If the object is 41.6 cm from the lens, locate the image (value of q). (b) Find the magnification. (c) If the object is 12.9 cm from the lens, locate the image (value of q). (d) Find the magnification.

17-2. A converging lens has a focal length of [02] _____ cm. (a) If the object is 41.6 cm from the lens, locate the image (value of q). (b) Find the magnification. (c) If the object is 12.9 cm from the lens, locate the image (value of q). (d) Find the magnification.

17-3. A child holds a candy bar [03] _____ cm in front of a convex mirror and notices that the image is only one-half the size of the candy bar. What is the radius of curvature of the mirror?

18-1. An individual is nearsighted; his near point is 13.5 cm and his far point is [01] _____ cm. (a) What lens power is needed to correct his nearsightedness?
(b) When the lenses are in use, what is this person's near point?

18-2. A lens having a focal length of [02] _____ cm is used as a simple magnifier.
(a) What is the angular magnification obtained when the image is formed at the normal near point ($q = -25.0$ cm)? (b) What is the angular magnification produced by this lens when the eye is relaxed (image formed at infinity)?

18-3. An elderly sailor is shipwrecked on a desert island but manages to save his eyeglasses. The lens for one eye has a power of +1.24 diopters, and the other lens has a power of +[03] _____ diopters. (a) what is the magnifying power of the telescope he can construct with these lenses? (b) How far apart are the lenses when the telescope is adjusted so that the eye is relaxed?

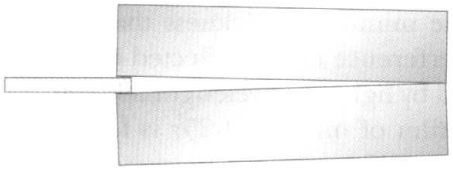
19-1. If the distance between two slits is [01] _____ mm and the distance to a screen is 2.53 m, find the spacing between the first- and second-order bright fringes for yellow light of 615 nm.

19-2. A Young's interference experiment is performed with blue-green laser light. The separation between the slits is [02] _____ mm, and the interference pattern on a screen 3.31 m away shows the first maximum 3.45 mm from the center of the pattern. What is the wavelength of the laser light?

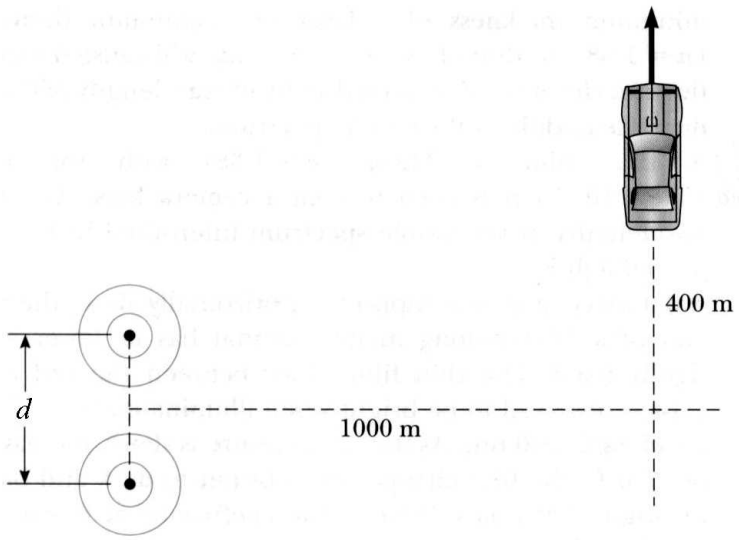
19-3. Light of wavelength [03] _____ nm falls on a 0.427-mm-wide slit and forms a diffraction pattern on a screen 1.46 m away. Find the distance on the screen from the central maximum to the first dark band on either side of it.

19-4. Light of wavelength 587.5 nm illuminates a single [04] _____-mm-wide slit. At what distance from the slit should a screen be placed if the first minimum in the diffraction pattern is to be 0.851 mm from the central maximum?

19-5. Two rectangular optically flat plates ($n = 1.52$) are in contact along one end and are separated along the other end by a [05] _____-μm-thick spacer (see figure). The top plate is illuminated by monochromatic light of wavelength 546.1 nm. Calculate the number of dark parallel bands crossing the top plate (including the dark band at zero thickness along the edge of contact between the two plates).



19-6. Two radio antennas separated by $d = [06]$ _____ m, as shown in the figure, simultaneously transmit identical signals of the same wavelength. A radio in a car traveling due north receives the signals. (a) If the car is at the position of the second maximum, what is the wavelength of the signals? (b) How much farther must the car travel to encounter the next minimum in reception?



19-7. Microwaves of wavelength 5.17 cm enter a long, narrow window in a building that is otherwise essentially opaque to the microwaves. If the window is [07] _____ cm wide, what is the distance from the central maximum to the first-order minimum along a wall 6.54 m from the window?

20-1. A thin layer of liquid methylene iodide ($n = 1.756$) is sandwiched between two flat parallel plates of glass ($n = 1.518$). What would be the minimum thickness of the liquid layer if normally incident light with $\lambda = [01]$ _____ nm in air is to be strongly reflected?

20-2. A thin layer of oil ($n = 1.252$) is floating on water. What is the minimum thickness of the oil in the region that strongly reflects light with a wavelength of [02] _____ nm (in air)? Use $n = 1.333$ for the index of refraction of water. Be careful about using Eqs. [24.9] and [24.10] in the textbook. Read the paragraph following Eq. [24.10].

20-3. Nonreflective coatings on camera lenses reduce the loss of light at the surfaces of multi-lens systems and prevent internal reflections that might mar the image. Find the minimum thickness of a layer of magnesium fluoride ($n = 1.38$) on flint glass ($n = 1.66$) that will cause destructive interference of reflected light of wavelength [03] _____ nm.

20-4. Suppose a thin film has an index of refraction of 1.36 and is surrounded by air on both sides. Find the minimum thickness that will produce constructive interference in the reflected light when the film is illuminated by light of wavelength [04] _____ nm.

20-5. A soap bubble ($n = 1.333$) is floating in air. If the thickness of the bubble wall is [05] _____ nm, what is the wavelength of the visible light that is most strongly reflected?

20-6. A transparent oil of index of refraction 1.29 spills on the surface of water (index of refraction 1.333), producing a maximum of reflection with normally incident light of wavelength [06] _____ nm in air. Assuming the maximum occurs in the first order, determine the thickness of the oil slick.

20-7. A possible means for making an airplane invisible to radar is to coat the plane with an antireflective polymer. If radar waves have a wavelength of [07] _____ cm and the index of refraction of the polymer is $n = 1.57$, how thick would you make the coating?

21-1. The index of refraction of a transparent plate is [01] _____. What is the Brewster's angle when the plate is (a) in air? (b) in water?

21-2. The angle of incidence of a light beam in air onto a reflecting surface is continuously variable. The reflected ray is found to be completely polarized when the angle of incidence is [02] _____°. (a) What is the index of refraction of the reflecting material? (b) If some of the incident light passes into the material below the surface, what is the angle of refraction?

21-3. A light beam is incident on some transparent material ($n =$ [03] _____) at the polarizing angle. Calculate the angle of refraction for the transmitted ray.

21-4. Unpolarized light passes through two polaroid sheets. The axis of the first is vertical, and that of the second is at [04] _____ ° to the vertical. What fraction of the initial light is transmitted?

22-1. The average lifetime of a pi meson in its own frame of reference (i.e., the proper lifetime) is 26 ns. If the meson moves with a speed of [01] _____c, what is (a) its mean lifetime as measured by an observer on Earth and (b) the average distance it travels before decaying as measured by an observer on Earth? (c) What distance would it travel if time dilation did not occur?

22-2. If astronauts could travel at $v =$ [02] _____c, we on Earth would say it takes about four years to reach Alpha Centauri, 4.21 lightyears away. The astronauts disagree. (a) How much time passes on the astronaut's clocks? (b) What is the distance to Alpha Centauri as measured by the astronauts? Caution: Do not use four years as the time interval measured on Earth. That is only approximate.

22-3. A friend in a spaceship travels past you at a high speed. He tells you that his ship is 20.23 m long and that the identical ship you are sitting in is [03] _____ m long. According to your observations, (a) how long is your ship, (b) how long is his ship, and (c) what is the speed of your friend's ship?

22-4. A space vehicle is moving at a speed of $0.754c$ with respect to an external observer. An atomic particle is projected at [04] _____c in the same direction as the spaceship's velocity with respect to an observer inside the vehicle. What is the speed of the projectile as seen by the external observer?

23-1. An unstable particle at rest breaks up into two fragments of unequal mass. The mass of the lighter fragment is 2.50×10^{-28} kg, and that of the heavier fragment is 1.67×10^{-27} kg. If the lighter fragment has a speed of [01] _____c after the breakup, what is the speed of the heavier fragment? Hint: Use conservation of relativistic momentum. Since the initial momentum is zero (before the particle breaks up), the momentum of the heavier fragment must be equal in magnitude and opposite in direction to the momentum of the lighter fragment.

23-2. If an electron-positron pair with a total kinetic energy of [02] _____ MeV is produced, find (a) the energy of the photon that produced the pair and (b) its frequency.

23-3. A proton moves with a speed of [03] _____c. Calculate its (a) kinetic energy and (b) total energy.

23-4. A mass of [04] _____ kg is converted completely into energy of other forms. (a) How much energy of other forms is produced and (b) how long would this much energy keep a 100-W light bulb burning?

23-5. In a color television tube, electrons are accelerated through a potential difference of [05] _____ V. With what speed do the electrons strike the screen?

23-6. Determine the energy required to accelerate an electron from $0.500c$ to [06] _____c.

24-1. A quantum of electromagnetic radiation has an energy of [01] _____ keV. What is its wavelength?

24-2. Electrons are ejected from a metallic surface with speeds ranging up to [02] _____ m/s when light with a wavelength of $\lambda = 625$ nm is used. (a) What is the the work function of the surface? (b) What is the cutoff frequency for this surface?

24-3. X-rays are scattered from electrons in a carbon target. The measured wavelength shift is [03] _____ nm. Calculate the scattering angle.

24-4. Calculate (a) the energy and (b) the momentum of a photon of wavelength [04] _____ nm.

24-5. What minimum accelerating voltage would be required to produce an x-ray with a wavelength of [05] _____ nm?

25-1. Calculate the de Broglie wavelength of a proton moving (a) at [01] _____ m/s and (b) at [02] _____ m/s. Note that in part (b) the velocity is relativistic. You must use the relativistic momentum in calculating the de Broglie wavelength.

25-2. Suppose Fuzzy, a quantum-mechanical duck, lives in a world in which $h = 2\pi$ J·s. Fuzzy has a mass of 2.00 kg and is initially known to be within a pond [03] _____ m wide. (a) What is the minimum uncertainty in his speed? (b) Assuming this uncertainty in speed to prevail for 5.00 s, determine the uncertainty in position after this time.

25-3. A 50.0-g ball moves at [04] _____ m/s. If its speed is measured to an accuracy of 0.10%, what is the minimum uncertainty in its position?

25-4. Calculate the de Broglie wavelength for an electron that has kinetic energy [05] _____ eV.

26-1. The half-life of an isotope of phosphorus is 14.2 days. If a sample contains [01] _____ such nuclei, determine its activity.

26-2. A radioactive sample contains [02] _____ μg of pure $^{11}_{6}$C, which has a half-life of 20.4 min. (a) How many moles of $^{11}_{6}$C are present initially? (The atomic mass of $^{11}_{6}$C is in Appendix B of the textbook.) (b) Determine the number of nuclei present initially. What is the activity of the sample (c) initially and (d) after 8.23 h?

26-3. Suppose that you start with 1.000 mg of a pure radioactive substance and 2.09 h later determine that only [03] _____ mg of the substance remains. What is the half-life of this substance?

26-4. A patient swallows a radiopharmaceutical tagged with phosphorus-32 ($^{32}_{15}$P), a β^- emitter with a half-life of 14.3 days. The average kinetic energy of the emitted electrons is 700 keV. If the initial activity of the sample is [04] _____ MBq, determine (a) the number of electrons emitted in a 10-day period, (b) the total energy deposited in the body during the 10 days, and (c) the absorbed dose if the electrons are completely absorbed in 126 g of tissue.

27-1. The mass of $^{56}_{26}$Fe is 55.9349 u and the mass of $^{56}_{27}$Co is 55.9399 u. (a) Which isotope decays into the other, and (b) by what process?

27-2. Identify X (chemical symbol and mass number) in each of the following decays:

(a) $^{12}_{5}\mathrm{B} \rightarrow X + \mathrm{e}^- + \bar{\nu}$

(b) $^{234}_{90}\mathrm{Th} \rightarrow ^{230}_{88}\mathrm{Ra} + X$

(c) $X \rightarrow ^{14}_{7}\mathrm{N} + \mathrm{e}^- + \bar{\nu}$

Type the chemical symbol followed by the mass number (no spaces). For example `Na23`, not `Na 23` or `na23` or `NA23`.

27-3. Identify X (chemical symbol and mass number) in each of the following decays:

(a) $^{212}_{83}\mathrm{Bi} \rightarrow X + ^{4}_{2}\mathrm{He}$

(b) $^{95}_{36}\mathrm{Kr} \rightarrow X + \mathrm{e}^- + \bar{\nu}$

(c) $X \rightarrow ^{4}_{2}\mathrm{He} + ^{140}_{58}\mathrm{Ce}$

Type the chemical symbol followed by the mass number (no spaces). For example `Na23`, not `Na 23` or `na23` or `NA23`.

27-4. Identify X (chemical symbol and mass number) in each of the following reactions:

(a) $X + {}^{4}_{2}\mathrm{He} \rightarrow {}^{24}_{12}\mathrm{Mg} + {}^{1}_{0}\mathrm{n}$

(b) ${}^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{90}_{38}\mathrm{Sr} + X + 2{}^{1}_{0}\mathrm{n}$

Type the chemical symbol followed by the mass number (no spaces). For example `Na23`, not `Na 23` or `na23` or `NA23`.

27-5. Identify X (chemical symbol and mass number) in each of the following reactions:

(a) $X + {}^{14}_{7}\mathrm{N} \rightarrow {}^{1}_{1}\mathrm{H} + {}^{17}_{8}\mathrm{O}$

(b) ${}^{7}_{3}\mathrm{Li} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + X$

Type the chemical symbol followed by the mass number (no spaces). For example `Na23`, not `Na 23` or `na23` or `NA23`.

27-6. A by-product of some fission reactors is the isotope ${}^{239}_{94}\mathrm{Pu}$, an alpha emitter having a half-life of 24120 yr:

$$ {}^{239}_{94}\mathrm{Pu} \rightarrow {}^{235}_{92}\mathrm{U} + \alpha. $$

Consider a sample of [01] _____ kg of pure ${}^{239}_{94}\mathrm{Pu}$ at $t = 0$. Calculate (a) the number of nuclei present at $t = 0$ and (b) the initial activity in the sample. (c) How long does the sample have to be stored if a "safe" activity level is 0.100 Bq?

Answers to Homework Problems, Physics 106, Winter Semester, 2009

1-1. 4.00×10^{-9}, 8.00×10^{-9} N
1-2a. -10.0, -70.0 N
1-2b. 60.0, 140.0 N
1-2c. -50.0, -80.0 N
1-3a. 1.40×10^{-5}, 1.70×10^{-5} N
1-3b. 230.0, 250.0°
1-4a. -7000, -13000 ± 100 N/C
1-4b. 24000, 31000 ± 100 N/C
2-1a. 4.50×10^{10}, 7.00×10^{10} m/s^2
2-1b. 16.0, 30.0 μs
2-1c. 9.0, 18.0 m
2-1d. 1.00×10^{-15}, 1.50×10^{-15} J
2-2. -10000, -21000 ± 100 N/C
2-3. 8.0, 30.0 N/C
2-4. 1.40, 2.20 m
3-1. 1.20×10^{6}, 2.60×10^{6} N/C
3-2a. 2.30×10^{7}, 3.30×10^{7} m/s
3-2b. 5.00×10^{5}, 8.00×10^{5} m/s
3-3. 600, 900 V
3-4. 2.50, 3.20 MV
3-5a. 5.00×10^{5}, 9.00×10^{5} m/s
3-5b. 1.00×10^{4}, 2.00×10^{4} m/s
3-6a. 40.0, 90.0 V
3-6b. 3.00×10^{6}, 6.00×10^{6} m/s
4-1. 5.50, 10.00 pC
4-2a. 1.80, 2.40 μF
4-2b. 3.60, 4.50 V
4-2c. 8.50, 11.00 μC
4-3. 2.60×10^{-11}, 5.30×10^{-11} J
4-4. 3.0×10^{10}, 9.9×10^{10} J
5-1. 2.20×10^{20}, 3.40×10^{20}
5-2. 70, 110 years
5-3a. 70.0, 150.0 MW
5-3b. 7.0, 14.0 %
5-4. 0.300, 0.600 A
5-5. 30.0, 50.0 Ω
6-1a. 15.0, 20.0 Ω
6-1b. 1.00, 1.50 A
6-2a. 0.550, 0.650 A
6-2b. 10.2, 11.6 V
6-3. 15.40, 15.90 Ω
6-4a. 10.0, 20.0 Ω
6-4b. 40, 70 W
6-4c. 1.50, 2.50 A
6-5. 70.0, 75.0 W
7-1a. 2.90, 3.30 mA
7-1b. -18.0, -20.0 V
7-1c. 4.5, 5.0 V
7-2a. 0.350, 0.380 A
7-2b. 0.130, 0.290 A
7-2c. 0.490, 0.670 A
7-3a. 1.90, 3.20 ms
7-3b. 130, 230 μC
7-3c. 80, 150 μC
8-1. 700, 1200 ± 10 N
8-2. 0.200, 1.500 N·m
8-3. 4.50×10^{-12}, 9.50×10^{-12} kg
8-4. 1.00, 5.00 cm
8-5. 10, 70 μT
9-1. 1.0, 6.0 cm
9-2. 30.0, 70.0 mA
9-3a. 60.0, 99.0 μT
9-3b. 20.0, 40.0 μT
9-3c. 0, 0 μT
9-4a. 2.00, 7.00 N
9-5a. 1.50×10^{-4}, 7.00×10^{-4} N/m
9-6. 0.0180, 0.0330 T
10-1. 25.0, 110.0 mV
10-2. 120, 260 mV
10-3. 2.60, 8.10 A
10-4. 1.00, 1.60 m/s
10-5. 1.00, 4.00 mV
11-1a. 1.00, 3.30 mH
11-1b. 23.0, 65.0 A/s
11-2a. 3.50, 5.00 A
11-2b. 2.00, 3.50 A
11-3. 11.0, 23.0 mV
11-4. 0.500, 0.900 V
12-1a. 3.50, 5.00 A
12-1b. 2.00, 3.50 A
12-2. 1.50, 3.00 cents
12-3a. 100, 300 mA
12-3b. 200, 500 mA
12-4. 50.0, 90.0 mA

12-5. 2.00, 4.00 A
12-6. 1.80, 3.80 μH
13-1a. 8.00, 9.50 V
13-1b. 3.00, 6.00 A
13-1c. 20.0, 60.0 W
13-2a. 1000, 2500 ± 10 turns
13-2b. 20.0, 50.0 A
13-3a. 10, 30 turns
13-3b. 1.0, 6.0 W
13-4. 0.040, 0.200 %
14-1. 15.0, 45.0°
14-2. 1.80, 3.80 m
14-3. 5, 30 times
14-4a. 1.300, 2.000
14-4b. 300, 500 nm
14-4c. 4.00×10^{14}, 5.00×10^{14} Hz
14-4d. 1.50×10^{8}, 2.50×10^{8} m/s
14-5. 20, 150 m
15-1. 0.20, 0.60°
15-2a. 44.0, 52.0°
15-2b. 17.0, 34.0°
15-3. 30.0, 45.0°
15-4. 40.0, 70.0°
15-5a. 40.00, 50.00°
15-5b. 40.00, 50.00°
16-1a. 0.200, 0.400 m
16-1b. 0.0100, 0.0300
16-2a. 15.0, 20.0 cm
16-2e. −0.300, −0.700
16-3. 0.100, 0.150
17-1a. −10.0, −20.0 cm
17-1b. 0.200, 0.400
17-1c. −6.00, −9.00 cm
17-1d. 0.500, 0.700
17-2a. 20.0, 70.0 cm
17-2b. −0.50, −2.00
17-2c. −20.0, −95.0 cm
17-2d. 2.00, 8.00
17-3. −20.0, −30.0 cm
18-1a. −1.60, −2.50 diopters
18-1b. 17.0, 21.0 cm
18-2a. 2.00, 3.00
18-2b. 1.00, 2.00
18-3a. 5.60, 9.70
18-3b. 0.80, 1.00 m
19-1. 2.50, 4.00 cm
19-2. 400, 650 nm
19-3. 1.70, 2.40 mm
19-4. 0.80, 1.30 m
19-5. 5, 40
19-6a. 30, 60 m
19-6b. 100, 150 m
19-7. 70, 120 cm
20-1. 70.0, 100.0 nm
20-2. 200, 240 nm
20-3. 50, 150 nm
20-4. 50, 150 nm
20-5. 500, 650 nm
20-6. 150, 250 nm
20-7. 0.400, 0.700 cm
21-1a. 55.0, 65.0°
21-1b. 45.0, 55.0°
21-2a. 1.00, 1.50
21-2b. 35.0, 45.0°
21-3. 30.0, 33.0°
21-4. 0.300, 0.500
22-1a. 100, 160 ns
22-1b. 30.0, 45.0 m
22-1c. 7.0, 8.0 m
22-2a. 1.00, 1.60 years
22-2b. 1.00, 1.50 light years
22-3a. 20.00, 21.00 m
22-3b. 18.00, 19.00 m
22-3c. 0.34, 0.46c
22-4. 0.970, 0.999c
23-1. 0.230, 0.360c
23-2a. 3.00, 4.50 MeV
23-2b. 7.00×10^{20}, 9.90×10^{20} Hz
23-3a. 1600, 3000 ±10 MeV
23-3b. 2500, 4000 ±10 MeV
23-4a. 1.8×10^{16}, 6.3×10^{16} J
23-4b. 5.0, 20.0 million years
23-5. 0.230, 0.310c
23-6. 0.120, 0.270 MeV

24-1. 0.50, 1.00 nm
24-2a. 1.40, 1.90 eV
24-2b. 3.40×10^{14}, 4.60×10^{14} Hz
24-3. 50.0, 80.0°
24-4a. 1.00, 2.00 eV
24-4b. 7.00×10^{-28}, 9.50×10^{-28} kg·m/s
24-5. 30.0, 70.0 kV
25-1a. 1.50×10^{-11}, 2.70×10^{-11} m
25-1b. 0.80×10^{-15}, 2.30×10^{-15} m
25-2a. 0.100, 0.300 m/s
25-2b. 2.00, 3.00 m
25-3. 1.0×10^{-32}, 4.0×10^{-32} m
25-4. 0.100, 0.400 nm
26-1. 0.30, 0.70 Ci
26-2a. 2.20×10^{-7}, 4.10×10^{-7} mol
26-2b. 1.30×10^{17}, 2.50×10^{17}
26-2c. 7.0×10^{13}, 14.0×10^{13} Bq
26-2d. 4.0×10^{6}, 8.0×10^{6} Bq
26-3. 0.90, 1.20 h
26-4a. 6.00×10^{11}, 9.90×10^{11}
26-4b. 0.050, 0.150 J
26-4c. 50, 100 rad
27-6a. 2.00×10^{24}, 6.00×10^{24}
27-6b. 2.00×10^{12}, 6.00×10^{12} Bq
27-6c. 1.00×10^{6}, 1.50×10^{6} yr