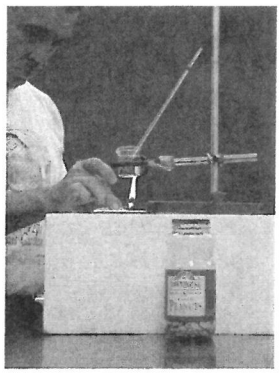
45. Even though metal is a good conductor, frost can be seen on parked cars in the early morning even when the air temperature is above freezing. Provide an explanation.
46. When there is morning frost on the grass in an open park, why is frost unlikely to be found on the ground directly beneath park benches?
47. Why is whitewash sometimes applied to the glass of florists' greenhouses in the summer?
48. On a very cold sunny day, you wear a black coat and a transparent plastic coat. Which coat should be worn on the outside for maximum warmth?
49. If the composition of the upper atmosphere were changed so that it permitted a greater amount of terrestrial radiation to escape, what effect would this have on Earth's climate?
50. Is it important to convert temperatures to the Kelvin scale when we use Newton's law of cooling? Why or why not?
51. Why is the insulation in an attic commonly thicker than the insulation in the walls of a house?
52. Suppose that, at a restaurant, you are served coffee before you are ready to drink it. In order that it be hottest when you are ready for it, should you add cream to the coffee right away or wait until you are ready to drink it?
53. If you wish to save fuel and you're going to leave your warm house for a half hour or so on a very cold day, should you turn your thermostat down a few degrees, turn it off altogether, or let it remain at the room temperature you desire?
54. If you wish to save fuel and you're going to leave your cool house for a half hour or so on a very hot day, should you turn your air-conditioning thermostat up a bit, turn it off altogether, or let it remain at the room temperature you desire?
55. As more energy from fossil fuels and other fuels is released on Earth, the overall temperature of Earth tends to rise. How does temperature equilibrium explain why Earth's temperature cannot rise indefinitely?
56. Make up a multiple-choice question that would test a classmate's understanding of the distinction between conduction and convection. Make another in which the term *radiation* is the correct answer.

PROBLEMS



1. In lab, Will burns a 0.6-g peanut beneath 50 g of water, which increases in temperature from 22°C to 50°C. The amount of heat absorbed by the water can be found with the equation $Q = cm\Delta T$, where Q is the amount of heat, c the specific heat of water, m the mass of water, and ΔT the change in the water's temperature.
   a. Assuming that 40% of the heat released makes its way to the water, show that the food value of the peanut is 3500 calories, or 3.5 Calories.
   b. What is the food value in calories per gram? In Calories per gram?
2. Radioactive decay of granite and other rocks in Earth's interior provides sufficient energy to keep the interior molten, to heat lava, and to provide warmth to natural hot springs. This is due to the average release of about 0.03 J per kilogram each year. Show that a 500°C increase in temperature for a thermally insulated chunk of granite takes about 13.3 million years. (Assume that the specific heat capacity c of granite is 800 J/kg·C°. Use the equation $Q = cm\Delta T$.)
3. In a 25°C room, hot coffee in a vacuum flask cools from 75°C to 50°C in 8 hours. Explain why you predict that its temperature after another 8 hours will be 37.5°C.
4. At a certain location, the solar power per unit area reaching Earth's surface is 200 W/m^2, averaged over a 24-hour day. If the average power requirement in your home is 3 kW and you can convert solar power to electric power with 10% efficiency, how large a collector area will you need to meet all your household energy requirements from solar energy? (Will a collector fit in your yard or on your roof?)

• 5. In lab you submerge 100 g of 40°C iron nails in 100 g of 20°C water (the specific heat of iron is 0.12 cal/g°C.) (a) Equate the heat gained by the water to the heat lost by the nails and show that the final temperature of the water becomes 22.1°C. (b) Your lab partner is surprised by the result and says that since the masses of iron and water are equal, the final water temperature should lie closer to 30°C, half-way between. What is your explanation?

CHAPTER 16 ONLINE RESOURCES

PhysicsPlace.com™

Interactive Figures

- 16.12, 16.22

Videos

- The Secret to Walking on Hot Coals
- Air Is a Poor Conductor

Quizzes

Flashcards

Links

PROBLEMS

1. The quantity of heat Q that changes the temperature ΔT of a mass m of a substance is given by $Q = cm\Delta T$, where c is the specific heat capacity of the substance. For example, for H_2O, $c = 1$ cal/g°C. And for a change of phase, the quantity of heat Q that changes the phase of a mass m is $Q = mL$, where L is the heat of fusion or heat of vaporization of the substance. For example, for H_2O, the heat of fusion is 80 cal/g (or 80 kcal/kg) and the heat of vaporization is 540 cal/g (or 540 kcal/kg). Use these relationships to determine the number of calories to change (a) 1 kg of 0°C ice to 0°C ice water, (b) 1 kg of 0°C ice water to 1 kg of 100°C boiling water, (c) 1 kg of 100°C boiling water to 1 kg of 100°C steam, and (d) 1 kg of 0°C ice to 1 kg of 100°C steam.
2. The specific heat capacity of ice is about 0.5 cal/g°C. Supposing that it remains at that value all the way to absolute zero, calculate the number of calories it would take to change a 1-g ice cube at absolute zero (−273°C) to 1 g of boiling water. How does this number of calories compare with the number of calories required to change the same gram of 100°C boiling water to 100°C steam?
3. Find the mass of 0°C ice that 10 g of 100°C steam will completely melt.
4. Consider 50 g of hot water at 80°C poured into a cavity in a very large block of ice at 0°C. What will be the final temperature of the water in the cavity? Show that 50 g of ice must melt in order to cool the hot water down to this temperature.
5. A 50-g chunk of 80°C iron is dropped into a cavity in a very large block of ice at 0°C. Show that 5.5 g of ice will melt. (The specific heat capacity of iron is 0.11 cal/g°C.)
6. If you drop a piece of ice on a hard surface, the energy of impact will melt some of the ice. The higher it drops, the more ice will melt upon impact. Show that to completely melt a block of ice that falls without air drag, it should ideally be dropped from a height of 34 km. [*Hint:* Equate the joules of gravitational potential energy to the product of the mass of ice and its heat of fusion (in SI units, 335,000 J/kg). Do you see why the answer doesn't depend on mass?]
7. A 10-kg iron ball is dropped onto a pavement from a height of 100 m. If half of the heat generated goes into warming the ball, find the temperature increase of the ball. (In SI units, the specific heat capacity of iron is 450 J/kg°C.) Why is the answer the same for a ball of any mass?

• 8. The heat of vaporization of ethyl alcohol is about 200 cal/g. If 2 kg of this fluid were allowed to vaporize in a refrigerator, show that 5 kg of ice would be formed from 0°C water.

CHAPTER 17 ONLINE RESOURCES

PhysicsPlace.com™

Interactive Figure

- 17.16

Videos

- Condensation Is a Warming Process
- Boiling Is a Cooling Process
- Pressure Cooker: Boiling and Freezing at the Same Time

Quizzes

Flashcards

Links

PROBLEMS

1. What is the ideal efficiency of an automobile engine in which fuel is heated to 2700 K and the outdoor air is 270 K?
2. Consider an ocean thermal energy conversion (OTEC) power plant that operates on a temperature difference between deep 4°C water and 25°C surface water. Show that the Carnot efficiency of this plant is 7%.
3. On a chilly 10°C day, your friend who loves cold weather says she wishes it were twice as cold. Taking this literally, show that the temperature she wishes for would be −131.5°C.
4. Imagine a giant dry-cleaner's bag full of air at a temperature of −35°C floating like a balloon with a string hanging from it 10 km above the ground. Estimate what its temperature would be if you were able to yank it suddenly back to Earth's surface.
5. Calculate the ideal efficiency of an engine wherein fuel is heated to 2700 K and the surrounding air is 300 K.
6. Wally Whacko claims to have invented a heat engine that will revolutionize industry. It runs between a hot source at 300°C and a cold sink at 25°C. He claims that his engine is 92% efficient.
   (a) What error did he make in his choice of temperature scales?
   (b) What is the actual maximum efficiency of his engine?
7. A power station with an efficiency of 0.4 generates 10^8 W of electric power and dissipates 1.5×10^8 J of heat energy each second to the cooling water that flows through it, which increases its temperature by 3 Celsius degrees. Knowing that the specific heat of water in SI units is 4184 J/kg·°C, show that 12,000 kg of warmed water flows through the plant each second.
- 8. Construct a table of all the possible combinations of numbers that can come up when you throw two dice. Your friend says, "Yes, I know that 7 is the most likely total number when two dice are thrown. But *why* 7?" Based on your table, answer your friend, and explain that, in thermodynamics, the situations that are likely to be observed are those that can be formed in the greatest number of ways.

CHAPTER 18 ONLINE RESOURCES

PhysicsPlace.com™

Interactive Figures

- 18.11, 18.13

Video

- Adiabatic Process

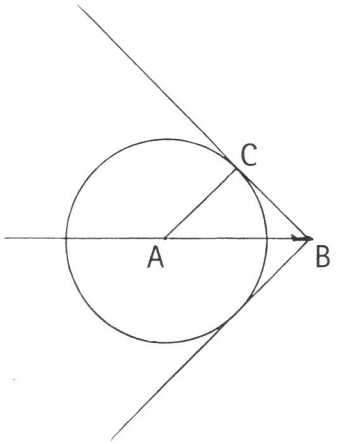
Quizzes

Flashcards

Links

PROBLEMS

1. What is the frequency, in hertz, that corresponds to each of the following periods?
   (a) 0.10 s
   (b) 5 s
   (c) 1/60 s
2. What is the period, in seconds, that corresponds to each of the following frequencies?
   (a) 10 Hz
   (b) 0.2 Hz
   (c) 60 Hz
3. A skipper on a boat notices wave crests passing his anchor chain every 5 s. He estimates the distance between wave crests to be 15 m. He also correctly estimates the speed of the waves. Show that this speed is 3 m/s.
4. A weight suspended from a spring is seen to bob up and down over a distance of 20 cm twice each second. What is its frequency? Its period? Its amplitude?
5. A mosquito flaps its wings 600 vibrations per second, which produces the annoying 600-Hz buzz. Given that the speed of sound is 340 m/s, how far does the sound travel between wing beats? In other words, find the wavelength of the mosquito's sound.
6. On a keyboard, you strike middle C, whose frequency is 256 Hz.
   (a) What is the period of one vibration of this tone?
   (b) As the sound leaves the instrument at a speed of 340 m/s, what is its wavelength in air?
7. As shown in the drawing, the half-angle of the shock wave cone generated by a supersonic airplane is 45°. What is the speed of the plane relative to the speed of sound?



• 8. An astronaut on the Moon attaches a small brass ball to a 1.00-m length of string and makes a simple pendulum. She times 15 complete swings in a time of 75 seconds. From this measurement she calculates the acceleration due to gravity on the Moon. What is her result?

CHAPTER 19 ONLINE RESOURCES

PhysicsPlace.com™

Interactive Figures

- 19.2, 19.6, 19.8, 19.12, 19.13, 19.16, 19.17

Tutorials

- Waves and Vibrations
- Doppler Effect

Videos

- Longitudinal vs. Transverse Waves
- Doppler Effect

Quizzes

Flashcards

Links

PROBLEMS

1. What is the wavelength of a 340-Hz tone in air? What is the wavelength of a 34,000-Hz ultrasonic wave in air?
2. For years, marine scientists were mystified by sound waves detected by underwater microphones in the Pacific Ocean. These so-called T-waves were among the purest sounds in nature. Eventually they traced the source to underwater volcanoes, whose rising columns of bubbles resonated like organ pipes. What is the wavelength of a typical T-wave whose frequency is 7 Hz? (The speed of sound in seawater is 1530 m/s.)
3. An oceanic depth-sounding vessel surveys the ocean bottom with ultrasonic waves that travel 1530 m/s in seawater. The time delay of the echo to the ocean floor and back is 6 s. Show that the depth of the water directly below the vessel is 4590 m.
4. A bat flying in a cave emits a sound and receives its echo 0.1 s later. Show that its distance from the cave wall is 19 m.
5. You watch distant Sally Homemaker driving nails into a front porch at a regular rate of 1 stroke per second. You hear the sound of the blows exactly synchronized with the blows you see. And then you hear one more blow after you see the hammering stop. Explain how you calculate that Sally is 340 m away from you.
6. Imagine a Rip van Winkle type who lives in the mountains. Just before going to sleep, he yells, "WAKE UP," and the sound echoes off the nearest mountain and returns 8 hours later. Show that the distance between Rip and the imaginary mountain is nearly 5000 km (about the distance from New York to San Francisco).
7. What beat frequencies are possible with tuning forks of frequencies 256, 259, and 261 Hz?
- 8. A grunting porpoise emits sound at 57 Hz. What is the wavelength of this sound in water, where the speed of sound is 1500 m/s?

CHAPTER 20 ONLINE RESOURCES

PhysicsPlace.com™

Interactive Figures

- 20.16, 20.17, 20.18

Videos

- Refraction of Sound
- Resonance
- Resonance and Bridges
- Interference and Beats

Quizzes

Flashcards

Links

34. The note middle C on a piano has a fundamental frequency of about 262 Hz. What is the frequency of the second harmonic of this note?
35. If the fundamental frequency of a guitar string is 220 Hz, what is the frequency of the second harmonic? Of the third harmonic?
36. If the fundamental frequency of a violin string is 440 Hz, what is the frequency of the second harmonic? Of the third harmonic?
37. How many nodes, not including the endpoints, are in a standing wave three wavelengths long? How many nodes are in a standing wave four wavelengths long?
38. How can you tune the note A_3 on a piano to its proper frequency of 220 Hz with the aid of a tuning fork whose frequency is 440 Hz?
39. At an outdoor concert, the pitch of musical tones is *not* affected on a windy day. Explain.
40. A trumpet has keys and valves that permit the trumpeter to change the length of the vibrating air column and the position of the nodes. A bugle has no such keys and valves, yet it can sound various notes. How do you think the bugler achieves different notes?
41. The human ear is sometimes called a Fourier analyzer. What does this mean, and why is it an appropriate description?
42. The width of a laser beam is significant in reading CDs and DVDs. The thinner the beam, the closer the series of pits can be. Why will blue laser light allow closer pits than red laser light?
43. Do all the people in a group hear the same music when they listen attentively as in Figure 21.11? Do all see the same sight when viewing a painting? Do all taste the same flavor when sipping the same wine? Do all perceive the same aroma when smelling the same perfume? Do all feel the same texture when touching the same fabric? Do all come to the same conclusion when listening to a logical presentation of ideas?
44. Why is it a safe prediction that you, presently reading this, will have a significantly greater loss of hearing in your later years than your grandparents experienced?
45. Make up a multiple-choice question that distinguishes between any of the terms listed in the Summary of Terms.

PROBLEMS

1. The highest frequency humans can hear is about 20,000 Hz. What is the wavelength of sound in air at this frequency? What is the wavelength of the lowest sounds we can hear, about 20 Hz?
2. A violin string playing the note "A" oscillates at 440 Hz. What is the period of the string's oscillation?
3. The string of a cello playing the note C oscillates at 264 Hz. What is the period of the string's oscillation?
4. How much more intense than the threshold of hearing is a sound of 10 dB? 30 dB? 60 dB?
5. How much more intense is sound at 40 dB than sound at 0 dB?
6. How much more intense is a sound of 40 dB than a sound of 30 dB?
7. A certain note has a frequency of 1000 Hz. What is the frequency of a note one octave above it? Two octaves above it? One octave below it? Two octaves below it?
- 8. Starting with a fundamental tone, how many harmonics are between the first and second octaves? Between the second and third octaves? (See Figure 21.5 to get started.)

CHAPTER 21 ONLINE RESOURCES

PhysicsPlace.com™

Quizzes

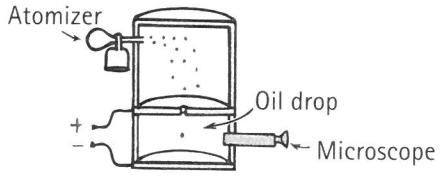
Links

Flashcards

58. An electron volt, eV, is a unit of energy. Which is larger, a GeV or a MeV?
59. Would you feel any electrical effects if you were inside the charged sphere of a Van de Graaff generator? Why or why not?
60. A friend says that the reason one's hair stands out while touching a charged Van de Graaff generator is simply that the hair strands become charged and are light enough so that the repulsion between strands is visible. Do you agree or disagree?

PROBLEMS

1. Two point charges are separated by 6 cm. The attractive force between them is 20 N. Find the force between them when they are separated by 12 cm. (Why can you solve this problem without knowing the magnitudes of the charges?)
2. Suppose that the charges attracting each other in the preceding problem have equal magnitude. Rearrange Coulomb's law and show that the magnitude of each charge is 2.8×10^{-6} C (2.8 microcoulombs).
3. Two pellets, each with a charge of 1 microcoulomb (10^{-6} C), are located 3 cm (0.03 m) apart. Show that the electric force between them is 10 N. What would be the mass of an object that would experience this same force in Earth's gravitational field?
4. Electronic types neglect the force of gravity on electrons. To see why, compute the force of Earth's gravity on an electron and compare it with the force exerted on the electron by an electric field of magnitude 10,000 V/m (a relatively small field). The mass and charge of an electron are given on the inside back cover.
5. Atomic physicists ignore the effect of gravity within an atom. To see why, calculate and compare the gravitational and electrical forces between an electron and a proton separated by 10^{-10} m. The charges and masses are given on the inside back cover.
6. A droplet of ink in an industrial ink-jet printer carries a charge of 1.6×10^{-10} C and is deflected onto paper by a force of 3.2×10^{-4} N. Show that the strength of the electric field to produce this force is 2 million N/C.
7. The potential difference between a storm cloud and the ground is 100 million V. If a charge of 2 C flashes in a bolt from cloud to Earth, what is the change of potential energy of the charge?
8. An energy of 0.1 J is stored in the metal sphere on top of a Van de Graaff generator. A spark carrying 1 microcoulomb (10^{-6} C) discharges the sphere. Show that the sphere's potential relative to ground is 100,000 V?
9. Find the voltage change when (a) an electric field does 12 J of work on a 0.0001-C charge; (b) the same electric field does 24 J of work on a 0.0002-C charge.
- **10.** In 1909, Robert Millikan was the first to find the charge of an electron in his now-famous oil-drop experiment. In that experiment tiny oil drops were sprayed into a uniform electric field between a horizontal pair of oppositely charged plates. The drops were observed with a magnifying eyepiece, and the electric field was adjusted so that the upward force on some negatively charged oil drops was just sufficient to balance the downward force of gravity. That is, when suspended, upward force qE just equaled mg. Millikan accurately measured the charges on many oil drops and found the values to be whole-number multiples of 1.6×10^{-19}C—the charge of the electron. For this he won the Nobel Prize.
   a. If a drop of mass 1.1×10^{-14} kg remains stationary in an electric field of 1.68×10^{5} N/C, what is the charge of this drop?
   b. How many extra electrons are on this particular oil drop (given the presently known charge of the electron)?



CHAPTER 22 ONLINE RESOURCES

PhysicsPlace.com™

Interactive Figures

- 22.1, 22.2, 22.7, 22.8, 22.12, 22.17, 22.18

Tutorial

- Electrostatics

Videos

- Electric Potential
- Van de Graaff Generator

Quizzes

Flashcards

Links

58. Figure 23.19 shows a fuse placed in a household circuit. In what other locations might a fuse be placed in this circuit to be useful, melting only if a problem arises?
59. Is the resistance of a 100-W bulb greater or less than the resistance of a 60-W bulb? Assuming the filaments in each bulb are of the same length and made of the same material, which bulb has the thicker filament?
60. If a 60-W bulb and a 100-W bulb are connected in series in a circuit, across which bulb will there be a greater voltage drop? How about if they are connected in parallel?

PROBLEMS

1. What is the effect on the current in a wire if both the voltage across it and its resistance are doubled? If both are halved?
2. The wattage marked on a lightbulb is not an inherent property of the bulb, but depends on the voltage to which it is connected, usually 110 or 120 V. How many amperes flow through a 60-W bulb connected in a 120-V circuit?
3. Rearrange the equation current = voltage/resistance to express *resistance* in terms of current and voltage. Then solve the following: A certain device in a 120-V circuit has a current rating of 20 A. What is the resistance of the device (how many ohms)?
4. Using the formula power = current × voltage, find the current drawn by a 1200-W toaster connected to 120 V. Then, using the method from the previous problem, show that the resistance of the toaster is 12 Ω.
5. The total charge that an automobile battery can supply without being recharged is given in terms of ampere-hours. A typical 12-V battery has a rating of 60 ampere-hours (60 A for 1 h, 30 A for 2 h, and so on). Suppose that you forget to turn the headlights off in your parked automobile. If each of the two headlights draws 3 A, how long will it be before your battery is "dead"?
6. Show that operating a 100-W lamp continuously for 1 week when the power utility rate is 15¢/kWh costs $2.52.
7. A 4-W night-light is plugged into a 120-V circuit and operates continuously for 1 year. Find the following: (a) the current it draws, (b) the resistance of its filament, (c) the energy consumed in a year. (d) Then show that for a utility rate of 15¢/kWh the cost for a year's operation is $5.25.
8. An electric iron connected to a 110-V source draws 9 A of current. Show that the amount of heat it generates in a minute is nearly 60,000 J.
9. Show in the previous problem that 540 C of charge flow through the iron in 1 minute.
- **10.** In periods of peak demand, power companies lower their voltage. This saves them power (and saves you money!). To see the effect, consider a 1200-W coffeemaker that draws 10 A when connected to 120 V. Suppose the voltage is lowered by 10% to 108 V. By how much does the current decrease? By how much does the power decrease? (*Caution:* The 1200-W label is valid only when 120 V is applied. When the voltage is lowered, it is the resistance of the toaster, not its power, that remains constant.)

CHAPTER 23 ONLINE RESOURCES

PhysicsPlace.com™

Interactive Figures

- 23.17, 23.18

Tutorial

- Electricity and Circuits

Videos

- Ohm's Law
- Handling Electric Wires
- Birds and High-Voltage Wires
- Alternating Current
- Electric Circuits

Quizzes

Flashcards

Links

A loudspeaker consists of a cone attached to a current-carrying coil located in a magnetic field. What is the relationship between vibrations in the current and vibrations of the cone?

Will a superconducting magnet use less electric power than a traditional copper-wire electromagnet of the same field strength? Defend your answer.

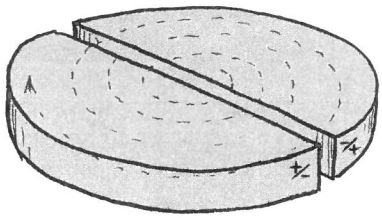
When iron-hulled naval ships are built, the location of the shipyard and the orientation of the ship in the shipyard are recorded on a brass plaque permanently attached to the ship. Why?

A beam of electrons passes through a magnetic field without being deflected. What can you conclude about the orientation of the beam relative to the magnetic field? (Neglect any other fields.)

Can an electron at rest in a magnetic field be set into motion by the magnetic field? What if it were at rest in an electric field?

A proton moves in a circular path perpendicular to a constant magnetic field. If the field strength of the magnet is increased, does the diameter of the circular path increase, decrease, or remain the same?

A cyclotron is a device for accelerating charged particles to high speed as they follow an expanding spiral-like path. The charged particles are subjected to both an electric field and a magnetic field. One of these fields increases the speed of the charged particles, and the other field causes them to follow a curved path. Which field performs which function?



A magnet can exert a force on a moving charged particle, but it cannot change the particle's kinetic energy. Why not?

A beam of high-energy protons emerges from a cyclotron. Do you suppose that there is a magnetic field associated with these particles? Why or why not?

Two charged particles are projected into a magnetic field that is perpendicular to their velocities. If the particles are deflected in opposite directions, what does this tell you about them?

A magnetic field can deflect a beam of electrons, but it cannot do work on the electrons to change their speed. Why?

39. Inside a laboratory room there is said to be either an electric field or a magnetic field, but not both. What experiments might be performed to establish what kind of field is in the room?

40. Residents of northern Canada are bombarded by more intense cosmic radiation than residents of Mexico. Why is this so?

41. Why do astronauts keep to altitudes beneath the Van Allen radiation belts when doing space walks?

42. What changes in cosmic-ray intensity at Earth's surface would you expect during periods in which Earth's magnetic field passed through a zero phase while undergoing pole reversals?

43. In a mass spectrometer (Figure 34.14), ions are directed into a magnetic field, where they curve and strike a detector. If a variety of singly ionized atoms travel at the same speed through the magnetic field, would you expect them all to be deflected by the same amount, or would different ions be bent different amounts? Defend your answer.

44. One way to shield a habitat in outer space from cosmic rays is with an absorbing blanket of some kind, which would function much like the atmosphere that protects Earth. Speculate on a second way for shielding the habitat that would also be similar to Earth's natural shielding.

45. If you had two bars of iron—one magnetized and one unmagnetized—and no other materials at hand, how could you determine which bar was the magnet?

46. Historically, replacing dirt roads with paved roads reduced friction on vehicles. Replacing paved roads with steel rails reduced friction further. What recent step eliminates rail friction of vehicles? What friction remains after rail friction is eliminated?

47. Will a pair of parallel current-carrying wires exert forces on each other?

48. What is the magnetic effect of placing two wires with equal but oppositely directed currents close together or twisted about each other?

49. When a current is passed through a helically coiled spring, the spring contracts as if it's compressed. What's your explanation?

50. When preparing to undergo an MRI scan, why are patients advised to remove eyeglasses, watches, jewelry, and other metal objects?

CHAPTER 24 ONLINE RESOURCES

PhysicsPlace.com™

ractive Figures

l.2, 24.7, 24.15, 24.19

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agnetic Fields

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ersted's Discovery
agnetic Forces on Current-Carrying Wires

Quizzes

Flashcards

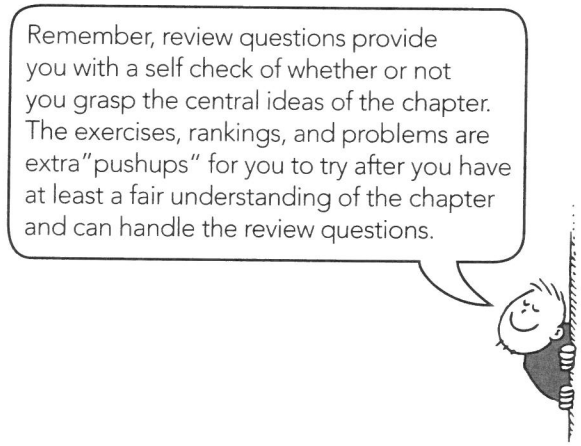
Links

37. Can an efficient transformer step up energy? Defend your answer.
38. If a bar magnet is thrown into a coil of high-resistance wire, it will slow down. Why?
39. Your physics instructor drops a magnet through a long vertical copper pipe and it moves slowly compared with the drop of a nonmagnetized object. Provide an explanation.
40. This exercise is similar to the previous one. Why will a bar magnet fall slower and reach terminal velocity in a vertical copper or aluminum tube but not in a cardboard tube?
41. Although copper and aluminum are not magnetic, why is a sheet of either metal more difficult to pass between the pole pieces of a magnet than a sheet of cardboard?
42. A metal bar, pivoted at one end, oscillates freely in the absence of a magnetic field. But when it oscillates between the poles of a magnet, its oscillations are quickly damped. Why? (Such magnetic damping is used in a number of practical devices.)
43. The metal wing of an airplane acts like a "wire" flying through Earth's magnetic field. A voltage is induced between the wing tips, and a current flows along the wing, but only for a short time. Why does the current stop even though the airplane continues flying through Earth's magnetic field?
44. What is wrong with this scheme? To generate electricity without fuel, arrange a motor to operate a generator that will produce electricity that is stepped up with transformers so that the generator can operate the motor and simultaneously furnish electricity for other uses.
45. We know that the source of a sound wave is a vibrating object. What is the source of an electromagnetic wave?
46. With no magnets in the vicinity, why will current flow in a large coil of wire waved around in the air?
47. What does an incident radio wave do to the electrons in a receiving antenna?
48. How do you suppose the frequency of an electromagnetic wave compares with the frequency of the electrons it sets into oscillation in a receiving antenna?
49. A friend says that changing electric and magnetic fields generate one another and that this gives rise to visible light when the frequency of change matches the frequencies of light. Do you agree? Explain.
50. Would electromagnetic waves exist if changing magnetic fields could produce electric fields, but changing electric fields could not, in turn, produce magnetic fields? Explain.

PROBLEMS

1. The primary coil of a step-up transformer draws 100 W. How much power is provided by the secondary coil?
2. An ideal transformer has 50 turns in its primary and 250 turns in its secondary. 12 V ac is connected to the primary.
   a. Find the volts ac available at the secondary.
   b. Show that a 10-Ω device connected to the secondary draws a current of 6 A.
   c. How much power is supplied to the primary?
3. A model electric train requires 6 V to operate. If the primary coil of its transformer has 240 windings, how many windings should the secondary have if the primary is connected to a 120-V household circuit?
4. Neon signs require about 12,000 V for their operation. What should be the ratio of the number of loops in the secondary to the number of loops in the primary for a neon-sign transformer that operates from 120-V lines?

• 5. 100 kW (10^5 W) of power is delivered to the other side of a city by a pair of power lines between which the voltage is 12,000 V.
   a. How much current is carried in the lines?
   b. Each of the two lines has a resistance of 10 Ω. What is the voltage difference between the two ends of each line? (Think carefully. This voltage is not that between the two lines.)
   c. What power is wasted as heat in both lines together (distinct from power delivered to customers)? How does this compare with the power being delivered?



CHAPTER 25 ONLINE RESOURCES

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Interactive Figures

- 25.6, 25.7

Videos

- Faraday's Law
- Application of E&M Induction

Quizzes

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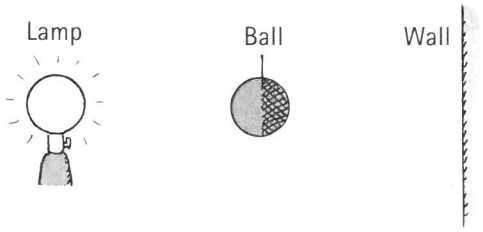
44. Light from a camera flash weakens with distance in accord with the inverse-square law. Comment on an airline passenger who takes a flash photo of a city at nighttime from a high-flying plane.
45. Ships determine the ocean depth by bouncing sonar waves from the ocean bottom and measuring the round-trip time. How do some airplanes similarly determine their distance to the ground below?
46. The planet Jupiter is more than 5 times as far from the Sun as planet Earth. How does the brightness of the Sun appear at this greater distance?
47. When you look at the night sky, some stars are brighter than others. Can you correctly say that the brightest stars emit more light? Defend your answer.
48. When you look at a distant galaxy through a telescope, how is it that you're looking backward in time?
49. When we look at the Sun, we are seeing it as it was 8 minutes ago. So we can only see the Sun "in the past." When you look at the back of your own hand, do you see it "now" or in "the past"?
50. "20/20 vision" is an arbitrary measure of vision—meaning that you can read what an average person can read at a distance of 20 feet in daylight. What is this distance in meters?

PROBLEMS

1. In 1676, the Danish astronomer Ole Roemer had one of those "aha" moments in science. He concluded from accumulated observations of eclipses of Jupiter's moon at different times of the year that light must travel at finite speed and needed 1300 s to cross the diameter of Earth's orbit around the Sun. Using 300,000,000 km for the diameter of Earth's orbit, calculate the speed of light based on Roemer's 1300-s estimate. How does it differ from a modern value for the speed of light?
2. More than 200 years later, Albert A. Michelson sent a beam of light from a revolving mirror to a stationary mirror 15 km away. Show that the time interval between light leaving and returning to the revolving mirror was 0.0001 s.
3. The Sun is 1.50×10^{11} m from Earth. How long does it take for the Sun's light to reach Earth? How long does it take light to cross the diameter of Earth's orbit? Compare this time with the time measured by Roemer in the 17th century (Problem 1).
4. Show that it would take 2.5 s for a pulse of laser light to reach the Moon and to bounce back to Earth.
5. The nearest star beyond the Sun is Alpha Centauri, 4.2×10^{16} m away. If we were to receive a radio message from this star today, show that it would have been sent 4.4 years ago.
6. A ball with the same diameter as a lightbulb is held halfway between the bulb and a wall, as shown in the sketch. Construct light rays (similar to those in Figure 26.14) and show that the diameter of the umbra on the wall is the same as the diameter of the ball and that the diameter of the penumbra is 3 times the diameter of the ball.



7. A certain radar installation tracks airplanes by transmitting electromagnetic radiation of wavelength 3 cm. (a) Show that the frequency of this radiation is 10 GHz. (b) Show that the time required for a pulse of radar waves to reach an airplane 5 km away and return is 3.3×10^{-5} s.
- 8. The wavelength of light changes as light goes from one medium to another, while the frequency remains the same. Is the wavelength longer or shorter in water than in air? Explain in terms of the equation speed = frequency × wavelength. A certain blue-green light has a wavelength of 600 nm (6×10^{-7} m) in air. What is its wavelength in water, where light travels at 75% of its speed in air? In Plexiglas, where light travels at 67% of its speed in air?

CHAPTER 26 ONLINE RESOURCES

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- 26.2, 26.3, 26.4, 26.13, 26.14

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