**Physics Honors Final Review**

13.1 Conceptual Questions

_____ 1) If we double the frequency of a system undergoing simple harmonic motion, which of the following statements about that system are true? (There could be more than one correct choice.)
A) The period is doubled.
B) The angular frequency is doubled.
C) The amplitude is doubled.
D) The period is reduced to one-half of what it was.
E) The angular frequency is reduced to one-half of what it was.

_____ 2) Two simple pendulums, A and B, are each 3.0 m long, and the period of pendulum A is $T$. Pendulum A is twice as heavy as pendulum B. What is the period of pendulum B?
A) $T/\sqrt{2}$
B) $T$
C) $T\sqrt{2}$
D) $2T$
E) $T/2$

_____ 3) Identical balls oscillate with the same period $T$ on Earth. Ball A is attached to an ideal spring and ball B swings back and forth to form a simple pendulum. These systems are now taken to the Moon, where $g = 1.6$ m/s$^2$, and set into oscillation. Which of the following statements about these systems are true? (There could be more than one correct choice.)
A) Both systems will have the same period on the Moon as on Earth.
B) On the Moon, ball A will take longer to complete one cycle than ball B.
C) On the Moon, ball B will take longer to complete one cycle than ball A.
D) On the Moon, ball A will execute more vibrations each minute than ball B.
E) On the Moon, ball B will execute more vibrations each minute than ball A.

_____ 4) Grandfather clocks are designed so they can be adjusted by moving the weight at the bottom of the pendulum up or down. Suppose you have a grandfather clock at home that runs fast. Which of the following adjustments of the weight would make it more accurate? (There could be more than one correct choice.)
A) Raise the weight.
B) Lower the weight.
C) Add more mass to the weight.
D) Remove some mass from the weight.
E) Decrease the amplitude of swing by a small amount.

_____ 5) What is the wavelength of the wave shown in the figure?
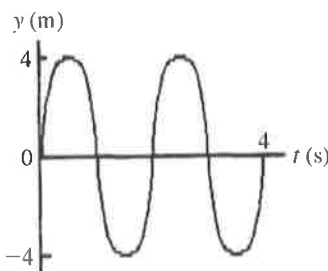


A) 8 m.
B) 4 m.
C) 2 m.
D) 1 m.
E) It cannot be determined from the given information.

13.2 Problems

_____ 6) A leaky faucet drips 40 times in 30.0 s. What is the frequency of the dripping?
A) 1.3 Hz
B) 0.75 Hz
C) 1.6 Hz
D) 0.63 Hz

7) If a floating log is seen to bob up and down 15 times in 1.0 min as waves pass by you, what are the frequency and period of the wave?

_____ 8) The quartz crystal in a digital watch has a frequency of 32.8 kHz. What is its period of oscillation?
A) 30.5 µs
B) 15.3 µs
C) 95.8 µs
D) 0.191 ms
E) 9.71 µs

_____ 9) If your heart is beating at 76.0 beats per minute, what is the frequency of your heart's oscillations in hertz?
A) 4560 Hz
B) 1450 Hz
C) 3.98 Hz
D) 2.54 Hz
E) 1.27 Hz

10) If a pendulum makes 12 complete swings in 8.0 s, what are its (a) frequency and (b) period?

____ 11) A 0.250-kg stone is attached to an ideal spring and undergoes simple harmonic oscillations with a period of 0.640 s. What is the force constant (spring constant) of the spring?
   A) 2.45 N/m
   B) 12.1 N/m
   C) 24.1 N/m
   D) 0.102 N/m
   E) 0.610 N/m

____ 12) In a supermarket, you place a 22.3-N (around 5 lb) bag of oranges on a scale, and the scale starts to oscillate at 2.7 Hz. What is the force constant (spring constant) of the spring of the scale?
   A) 650 N/m
   B) 600 N/m
   C) 330 N/m
   D) 820 N/m
   E) 410 N/m

____ 13) A 51.8-kg bungee jumper jumps off a bridge and undergoes simple harmonic motion. If the period of oscillation is 11.2 s, what is the spring constant (force constant) of the bungee cord?
   A) 16.3 N/m
   B) 19.6 N/m
   C) 26.1 N/m

____ 14) A 34-kg child on an 18-kg swing set swings back and forth through small angles. If the length of the very light supporting cables for the swing is 4.9 m, how long does it take for each complete back-and-forth swing? Assume that the child and swing set are very small compared to the length of the cables.
   A) 4.4 s
   B) 4.8 s
   C) 5.3 s
   D) 5.7 s

____ 15) If both the mass of a simple pendulum and its length are doubled, the period will
   A) be unchanged.
   B) increase by a factor of 2.
   C) increase by a factor of 4.
   D) increase by a factor of $\sqrt{2}$.
   E) increase by a factor of $1/\sqrt{2}$.

____ 16) In 1851 Jean Bernard Leon Foucault demonstrated the rotation of the earth using a pendulum 11.0 m long, which was set up in the Paris Observatory. How long would it have taken for Foucault's pendulum to make one complete swing back to its starting point if $g = 9.81$ m/s$^2$ at the observatory?
   A) 6.65 s
   B) 5.63 s
   C) 1.79 s
   D) 2.12 s
   E) 2.58 s

17) The figure shows a "snapshot" of a wave at a given instant of time. The frequency of this wave is 120 Hz. What are the (a) amplitude, (b) wavelength, and (c) speed of this wave?
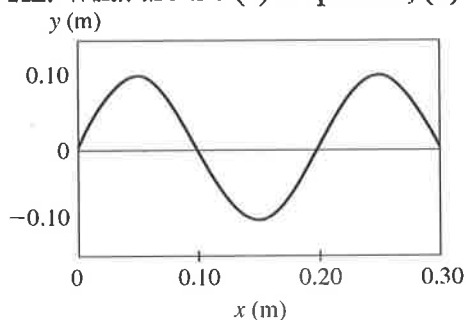


_____  18) The speed of sound in steel is 5000 m/s. What is the wavelength of a sound wave of frequency 660 Hz in steel?
   A)  7.58 m
   B)  2.41 m
   C)  1.21 m
   D)  0.829 m
   E)  0.132 m

_____  19) Crests of an ocean wave pass a pier every 10.0 s. If the waves are moving at 5.6 m/s, what is the wavelength of the ocean waves?
   A)  56 m
   B)  28 m
   C)  64 m
   D)  48 m

14.1 Conceptual Questions

_____  20) Seven seconds after a brilliant flash of lightning, thunder shakes the house. Approximately how far was the lightning strike from the house?
   A)  much closer than one kilometer
   B)  about one kilometer away
   C)  about two kilometers away
   D)  much farther away than two kilometers
   E)  It is impossible to say.

_____  21) What characteristics of a sound wave are related to the "pitch" of a musical note? (There could be more than one correct choice.)
   A)  amplitude
   B)  wavelength
   C)  frequency
   D)  period

_____ 22) Sound A has a high pitch and sound B has a low pitch. Which of the following statements about these two sounds are correct? (There could be more than one correct choice.)
   A) The wavelength of A is longer than the wavelength of B.
   B) The period of A is shorter than the period of B.
   C) The frequency of A is greater than the frequency of B.
   D) Sound B travels faster than sound B through air.
   E) The amplitude of A is larger than the amplitude of B.

_____ 23) You double your distance from a sound source that is radiating equally in all directions. What happens to the intensity of the sound? It reduces to
   A) one-half its original value.
   B) one-fourth its original value.
   C) one-sixteenth its original value.
   D) none of the above

_____ 24) Suppose that a sound source is emitting waves uniformly in all directions. If you move to a point twice as far away from the source, the frequency of the sound will be
   A) unchanged.
   B) half as great.
   C) one-fourth as great.
   D) twice as great.

_____ 25) Two tuning forks have frequencies of 440 and 522 Hz. What is the beat frequency if both are sounding simultaneously?
   A) 962 Hz
   B) 481 Hz
   C) 82 Hz
   D) 55 Hz
   E) 41 Hz

_____ 26) Two pure tones are sounded together and a particular beat frequency is heard. What happens to the beat frequency if the frequency of one of the tones is increased?
   A) It increases.
   B) It decreases.
   C) It does not change.
   D) It could either increase or decrease.

_____ 27) In many cartoon shows, a character runs off a cliff, realizes his predicament, and lets out a scream. He continues to scream as he falls. If the physical situation is portrayed correctly, from the vantage point of an observer at the *top* of the cliff leaning over the edge, the pitch of the scream as he falls should be
   A) higher than the original pitch and constant.
   B) higher than the original pitch and increasing as he falls.
   C) lower than the original pitch and constant.
   D) lower than the original pitch and decreasing as he falls.
   E) It is impossible to predict.

14.2 Problems

28) An elephant can hear sound with a frequency of 15 Hz. What is the wavelength of this wave if the speed of sound in air is 343 m/s?

29) A plucked guitar string produces a sound wave of frequency 0.44 kHz on a day when the speed of sound is 340 m/s.
(a) What is the wavelength of the sound wave?
(b) How much time elapses between the impacts of two adjacent compressions of the sound wave on your eardrum?

15.1  Conceptual Questions

_____ 30) Which one of the following is *not* an electromagnetic wave?
A)  ultraviolet
B)  infrared
C)  radio waves
D)  sound waves
E)  gamma rays

_____ 31) In an electromagnetic wave in free space, the electric and magnetic fields are
A)  parallel to one another and perpendicular to the direction of wave propagation.
B)  parallel to one another and parallel to the direction of wave propagation.
C)  perpendicular to one another and perpendicular to the direction of wave propagation.
D)  perpendicular to one another and parallel to the direction of wave propagation.

_____ 32) Which of the following statements about electromagnetic waves in free space are true? (There could be more than one correct choice.)
A)  The higher-frequency travel faster than the lower-frequency waves.
B)  The higher-frequency waves have shorter wavelengths than the lower-frequency waves.
C)  The wavelengths of the visible waves are some of the longest electromagnetic waves.
D)  The wavelengths of the visible waves are some of the shortest electromagnetic waves.
E)  The electric field vector is always at right angles to the magnetic field vector.

_____ 33) Which one of the following types of electromagnetic wave travels through space the fastest?
A)  radio waves
B)  infrared
C)  ultraviolet
D)  microwaves
E)  They all travel through space at the same speed.

## 15.2 Problems

34) A cordless phone operates at 900 MHz. What is the wavelength of the electromagnetic wave used by this phone? ($c = 3.0 \times 10^8$ m/s)

35) An FM radio station broadcasts at 96.7 MHz. What is the wavelength of the radio wave used for this broadcast? ($c = 3.0 \times 10^8$ m/s)

____ 36) The wavelength of an electromagnetic wave is 600 nm. What is its frequency? ($c = 3.0 \times 10^8$ m/s)
   A) $200 \times 10^{12}$ Hz
   B) $300 \times 10^{12}$ Hz
   C) $400 \times 10^{12}$ Hz
   D) $500 \times 10^{12}$ Hz
   E) $600 \times 10^{12}$ Hz

____ 37) The distance between two asteroids is 1600 km. How much time does it take for a light signal to go from one asteroid to the other? ($c = 3.0 \times 10^8$ m/s)
   A) 19 ms
   B) 4.5 ms
   C) 5.3 ms
   D) 13 ms
   E) 19 μs

____ 38) How far does a beam of light travel through space in one 365-day year? ($c = 3.0 \times 10^8$ m/s)
   A) $80 \times 10^{12}$ m
   B) $95 \times 10^{14}$ m
   C) $30 \times 10^8$ m
   D) $20 \times 10^{15}$ m
   E) $36 \times 10^{16}$ m

____ 39) A laser beam takes 24 ms to travel from a rocket to the reflective surface of a planet and back to the rocket. How far is the rocket from this planet's surface? ($c = 3.0 \times 10^8$ m/s)
   A) 2400 km
   B) 1200 km
   C) 1800 km
   D) 3600 km
   E) 4800 km

## 16.1 Conceptual Questions

____ 40) Which one of the following sets of characteristics describes the image formed by a plane mirror?
   A) real and inverted
   B) real and upright
   C) virtual and upright
   D) virtual and inverted
   E) virtual and larger than the object

____ 41) A lighted candle is placed a short distance from a plane mirror, as shown in the figure. At which location will the image of the flame appear to be located?
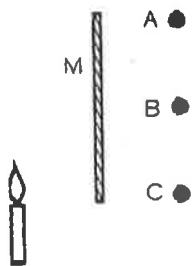
A) at A
B) at B
C) at C
D) at M (at the mirror)

____ 42) Which one of the following numbers is the correct magnification produced by a plane mirror?
A) 1/2
B) 1/4
C) 2
D) 1
E) 3/2

____ 43) As you walk away from a plane mirror on a wall, the height of your image
A) gets smaller.
B) may or may not get smaller, depending on where the observer is positioned.
C) is always a real image, no matter how far you are from the mirror.
D) changes from being a virtual image to a real image as you pass the focal point.
E) is always the same size.

____ 44) Suppose you place an object in front of a concave mirror. Which of the following statements *must* be true? (There could be more than one correct choice.)
A) The image of the object will always be smaller than the object.
B) No matter where you place the object, a real image of the object will be formed.
C) The image of the object will always be inverted.
D) If you position the object between the mirror and the focal point of the mirror, its image must be upright and virtual.
E) No matter where you place the object, the image of the object will always be virtual and upright.

____ 45) Which statements about images are correct? (There could be more than one correct choice.)
A) A virtual image cannot be formed on a screen.
B) A virtual image cannot be viewed by the unaided eye.
C) A virtual image cannot be photographed.
D) A real image must be erect.
E) Mirrors always produce real images because they reflect light.

_____ 46) The focal length of a concave mirror has a magnitude of 20 cm. What is its radius of curvature?
  A) 10 cm
  B) 40 cm
  C) -40 cm
  D) 20 cm
  E) -20 cm

_____ 47) If a spherical concave mirror has a radius of curvature $R$, its focal length is
  A) $R/4$.
  B) $R/2$.
  C) $R$.
  D) $2R$.
  E) $4R$.

_____ 48) Single concave spherical mirrors produce images that
  A) are always smaller than the actual object.
  B) are always larger than the actual object.
  C) are always the same size as the actual object.
  D) could be smaller than, larger than, or the same size as the actual object, depending on the placement of the object.
  E) are always real.

_____ 49) A beam of light that is parallel to the principal axis strikes a concave mirror. What happens to the reflected beam of light?
  A) It also is parallel to the principal axis.
  B) It is perpendicular to the principal axis.
  C) It passes through the center of curvature of the mirror.
  D) It passes through the focal point of the mirror.
  E) It passes between the focal point and the center of curvature of the mirror.

_____ 50) An upright object is 50 cm from a concave mirror of radius 60 cm. The character of the image is
  A) real and upright
  B) real and inverted
  C) virtual and upright
  D) virtual and inverted

_____ 51) Suppose you wanted to start a fire using a mirror to focus sunlight. Which of the following statements is most accurate?
  A) It would be best to use a plane mirror.
  B) It would be best to use a convex mirror.
  C) It would be best to use a concave mirror, with the object to be ignited positioned at the center of curvature of the mirror.
  D) It would be best to use a concave mirror, with the object to be ignited positioned halfway between the mirror and its center of curvature.
  E) One cannot start a fire using a mirror, since mirrors form only virtual images.

## 16.2   Problems

52) David stands 2.5 m in front of a plane mirror.
    (a) How far from David is his image in the mirror?
    (b) If David moves away from the mirror at 1.5 m/s, how fast are David and his image moving apart from each other?
    (c) If David is 180 cm tall, how tall is his image in the mirror?

_____ 53) A laser beam strikes a plane mirror's reflecting surface with an angle of incidence of 43°. What is the angle between the incident ray and the reflected ray?
    A)  43°
    B)  86°
    C)  45°
    D)  90°
    E)  0°

54) An object that is 4.0 cm tall is placed 15 cm in front of a concave mirror of focal length 20 cm.
    (a) Where is the image formed and how far is it from the mirror?
    (b) How tall is the image?

## 17.1   Conceptual Questions

_____ 55) A light beam has speed $c$ in vacuum and speed $v$ in a certain plastic. The index of refraction $n$ of this plastic is
    A)  $n = cv$.
    B)  $n = (v/c)^2$.
    C)  $n = v/c$.
    D)  $n = c/v$.
    E)  $n = (c/v)^2$.

_____ 56) If the index of refraction of a material is 2, this means that light travels
    A)  2 times as fast in air as it does in vacuum.
    B)  2 times as fast in the material as it does in air.
    C)  2 times as fast in vacuum as it does in the material.
    D)  2 times as fast in the material than it does in vacuum.
    E)  1/2 as fast in air as it does in the material.

_____ 57) Light enters air from water.  The angle of refraction will be
    A)  greater than the angle of incidence.
    B)  equal to the angle of incidence.
    C)  less than the angle of incidence.

_____ 58) The index of refraction of a type of glass is 1.50, and the index of refraction of water is 1.33. If light enters water from this glass, the angle of refraction will be
    A)  greater than the angle of incidence.
    B)  equal to the angle of incidence.
    C)  less than the angle of incidence.

59) A thin lens projects an image of a man as shown in the figure. Rays marked A, B, and C travel to the lens from the man's ear. Draw the paths of these three rays after they have passed through the lens. Note that A is parallel to the principal axis, B goes through the center of the lens, C goes through the focal point on the left, and the point marked $f$ is the focal point on the right of the lens.
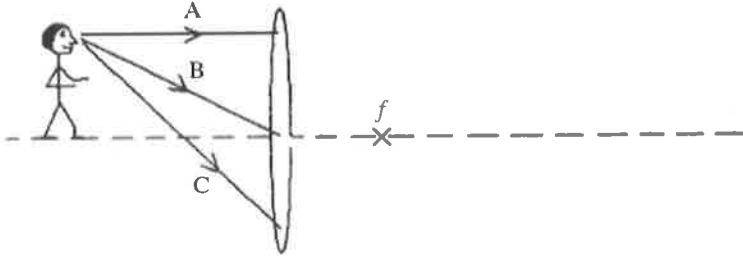


___ 60) Which of the following terms describe lenses that are thicker at the center than at the edges? (There could be more than one correct choice.)
A) converging lenses
B) diverging lenses
C) concave lenses
D) convex lenses

___ 61) A convex lens has focal length $f$. If an object is placed at a distance of $2f$ from the lens on the principal axis, the image is located at a distance from the lens
A) of $2f$.
B) between $f$ and $2f$.
C) of $f$.
D) between the lens and $f$.
E) of infinity.

___ 62) Which of following statements about the image formed by a single converging lens are true? (There could be more than one correct choice.)
A) The image is always real.
B) The image is always virtual.
C) The image is always inverted.
D) The image is always upright.
E) None of the above choices are correct.

___ 63) Is it possible to see a virtual image?
A) No, since the rays that seem to emanate from a virtual image do not in fact emanate from the image.
B) No, since virtual images do not really exist.
C) Yes because the rays that appear to come from a virtual image can be focused by the eye just like those from an object.
D) Yes, but only by using an additional lens to form a real image before the light reaches the eye.

_____ 64) What type of lens is used to make a magnifying glass?
  A) converging
  B) diverging
  C) Either type would work equally well.
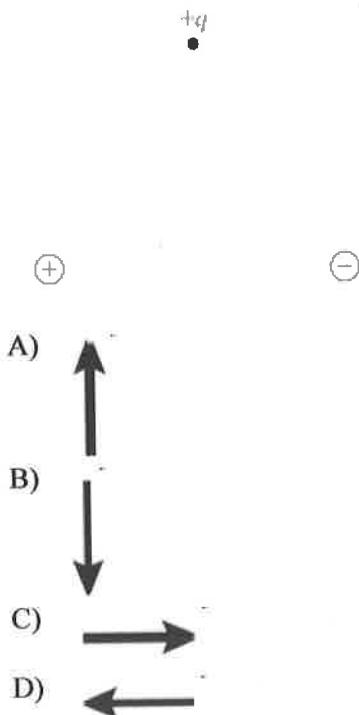
17.2  Problems

_____ 65) Light having a speed in vacuum of $3.0 \times 10^8$ m/s enters a liquid of refractive index 2.0. In this liquid, its speed will be
  A) $6.0 \times 10^8$ m/s
  B) $3.0 \times 10^8$ m/s
  C) $1.5 \times 10^8$ m/s
  D) $0.75 \times 10^8$ m/s
  E) $0.67 \times 10^8$ m/s

_____ 66) The index of refraction of a certain glass is measured to be 1.5. What is the speed of light in that glass? ($c = 3.0 \times 10^8$ m/s)
  A) $1.0 \times 10^8$ m/s
  B) $2.0 \times 10^8$ m/s
  C) $3.0 \times 10^8$ m/s
  D) $4.0 \times 10^8$ m/s
  E) $5.0 \times 10^8$ m/s

19.1  Conceptual Questions

_____ 67) Electrically neutral objects cannot exert an electrical force on each other, but they can exert a gravitational force on each other.
  A) True
  B) False

_____ 68) If two objects are electrically attracted to each other,
  A) both objects must be negatively charged.
  B) both objects must be positively charged.
  C) one object must be negatively charged and the other object must be positively charged.
  D) the objects could be electrically neutral.
  E) None of the above statements are absolutely true.

_____ 69) A plastic rod is charged up by rubbing a wool cloth, and brought to an initially neutral metallic sphere that is insulated from ground. It is allowed to touch the sphere for a few seconds, and then is separated from the sphere by a small distance. After the rod is separated, the rod
  A) is repelled by the sphere.
  B) is attracted to the sphere.
  C) feels no force due to the sphere.

_____ 70) Two tiny beads are 25 cm apart with no other charges or fields present. Bead A carries 10 μC of charge and bead B carries 1 μC. Which one of the following statements is true about the magnitudes of the electric forces on these beads?
  A) The force on A is 10 times the force on B.
  B) The force on B is 10 times the force on A.
  C) The force on A is exactly equal to the force on B.
  D) The force on A is 100 times the force on B.
  E) The force on B is 100 times the force on A.

_____ 71) A hydrogen nucleus, which has a charge $+e$, is situated to the left of a carbon nucleus, which has a charge $+6e$. Which statement is true?
  A) The electrical force experienced by the hydrogen nucleus is to the left, and the magnitude is equal to the force exerted on the carbon nucleus.
  B) The electrical force experienced by the hydrogen nucleus is to the left, and the magnitude is greater than the force exerted on the carbon nucleus.
  C) The electrical force experienced by the hydrogen nucleus is to the left, and the magnitude is less than the force exerted on the carbon nucleus.
  D) The electrical force experienced by the hydrogen nucleus is to the right, and the magnitude is equal to the force exerted on the carbon nucleus.

_____ 72) Two identical small charged spheres are a certain distance apart, and each one initially experiences an electrostatic force of magnitude $F$ due to the other. With time, charge gradually diminishes on both spheres by leaking off. When each of the spheres has lost half its initial charge, what will be the magnitude of the electrostatic force on each one?
  A) $1/16\ F$
  B) $1/8\ F$
  C) $1/4\ F$
  D) $1/2\ F$
  E) $1/\sqrt{2}\ F$

_____ 73) Two point charges, $Q1$ and $Q2$, are separated by a distance $R$. If the magnitudes of both charges are halved and their separation is also halved, what happens to the electrical force that each charge exerts on the other one?
  A) It increases by a factor of 16.
  B) It increases by a factor of 8.
  C) It increases by a factor of 2.
  D) It increases by a factor of 4.
  E) It remains the same.

____ 74) An electron and a proton are released simultaneously from rest and start moving toward each other due to their electrostatic attraction, with no other forces present. Which of the following statements are true just before they are about to collide? (There could be more than one correct choice.)
   A) They are closer to the to the initial position of the electron that to the initial position of the proton.
   B) They are closer to the to the initial position of the proton that to the initial position of the electron.
   C) They are at the midpoint of their initial separation.
   D) They both have the same speed.
   E) The electrostatic force on the proton is greater than the electrostatic force on the electron.

____ 75) Two equal and opposite charges are a small distance apart, forming an electric dipole. A positive charge $+q$ is placed above these charges, as shown in the figure, equidistant from both of them. Which diagram below best gives the direction of the net force the dipole exerts on the charge $+q$?

$+q$
•

$(+)$                    $(-)$

A) ↑

B) ↓

C) →

D) ←

19.2  Problems

____ 76) How many electrons are necessary to produce 1.0 C of negative charge? ($e = 1.60 \times 10^{-19}$ C)
   A) $6.3 \times 10^{18}$
   B) $6.3 \times 10^{9}$
   C) $1.6 \times 10^{19}$
   D) $1.6 \times 10^{9}$
   E) $6.0 \times 10^{23}$

_____ 77) What is the charge on 1.0 kg of protons?($e = 1.60 \times 10^{-19}$ C, $m$proton $= 1.67 \times 10^{-27}$ kg)

    A) 1.0 C

    B) 1000 C

    C) $9.6 \times 10^7$ C

    D) $6.0 \times 10^{26}$ C

    E) $6.0 \times 10^{23}$ C

_____ 78) If a charge generator builds a negative static charge of -7.00 μC, how many electrons are transferred to it during this process. ($e = 1.60 \times 10^{-19}$ C)

    A) $4.38 \times 10^{13}$

    B) 7.0

    C) $1.12 \times 10^{-18}$

    D) 43.8

_____ 79) Two point charges each experience a 1-N electrostatic force when they are 2 cm apart. If they are moved to a new separation of 8 cm, what is the magnitude of the electric force on each of them?

    A) 2 N

    B) 1/2 N

    C) 1/4 N

    D) 1/8 N

    E) 1/16 N

20.1 Conceptual Questions

_____ 80) A negatively-charged plastic rod is brought close to (but does not touch) a neutral metal sphere that is connected to ground. After waiting a few seconds, the ground connection is removed (without touching the sphere), and after that the rod is also removed. The sphere is now

    A) negatively charged.

    B) positively charged.

    C) neutral.

____ 81) X and Y are two initially uncharged metal spheres on insulating stands, and they are in contact with each other. A positively charged rod $R$ is brought close to X as shown in part (a) of the figure. Sphere Y is now moved away from X, as shown in part (b). What are the final charge states of X and Y?

(a)

(b)
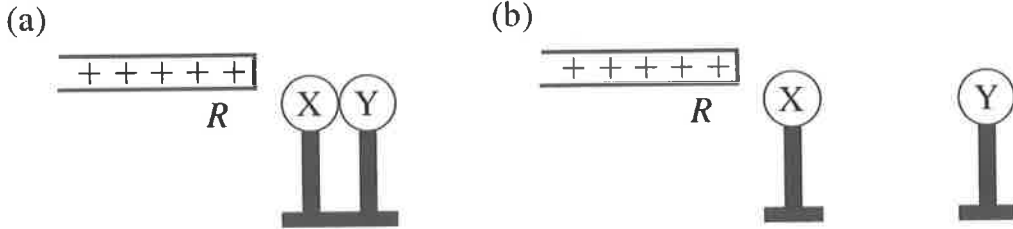


A) Both X and Y are neutral.
B) X is positive and Y is neutral.
C) X is neutral and Y is positive.
D) X is negative and Y is positive.
E) Both X and Y are negative.

____ 82) An electron is initially moving to the right when it enters a uniform electric field directed upwards, as shown in the figure. Which trajectory (**X, Y, Z,** or **W**) will the electron follow in the field?
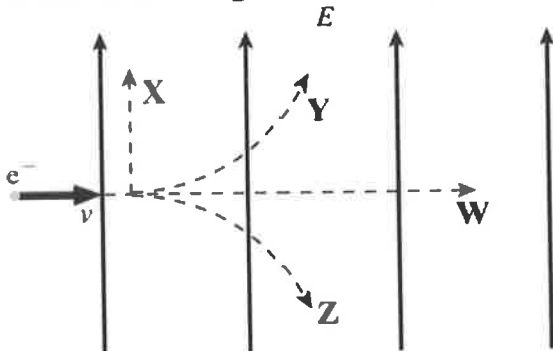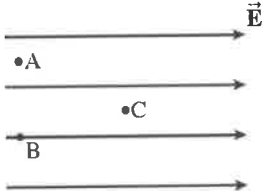


A) trajectory **W**
B) trajectory **X**
C) trajectory **Y**
D) trajectory **Z**

____ 83) Which one of the arrows shown in the figure best represents the direction of the electric field between the two uniformly charged metal plates?
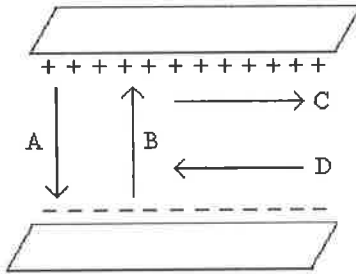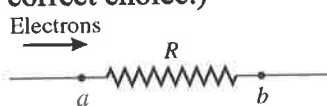


A) A
B) B
C) C
D) D
E) None of the above

____ 84) As a proton moves in the direction the electric field lines
A) it is moving from low potential to high potential and gaining electric potential energy.
B) it is moving from low potential to high potential and losing electric potential energy.
C) it is moving from high potential to low potential and gaining electric potential energy.
D) it is moving from high potential to low potential and losing electric potential energy.
E) both its electric potential and electric potential energy remain constant.

____ 85) As an electron moves in the direction the electric field lines
A) it is moving from low potential to high potential and gaining electric potential energy.
B) it is moving from low potential to high potential and losing electric potential energy.
C) it is moving from high potential to low potential and gaining electric potential energy.
D) it is moving from high potential to low potential and losing electric potential energy.
E) both its electric potential and electric potential energy remain constant.

____ 86) As a proton moves in a direction perpendicular to the electric field lines
A) it is moving from low potential to high potential and gaining electric potential energy.
B) it is moving from low potential to high potential and losing electric potential energy.
C) it is moving from high potential to low potential and gaining electric potential energy.
D) it is moving from high potential to low potential and losing electric potential energy.
E) both its electric potential and electric potential energy remain constant.

_____ 87) A proton is accelerated from rest through a potential difference $V0$ and gains a speed $v0$. If it were accelerated instead through a potential difference of $2V0$, what speed would it gain?
A) $8v0$
B) $4v0$
C) $2v0$
D) $v0\sqrt{2}$

_____ 88) Two protons are released from rest, with only the electrostatic force acting. Which of the following statements must be true about them as they move apart? (There could be more than one correct choice.)
A) Their electric potential energy keeps increasing.
B) Their kinetic energy keeps increasing.
C) Their electric potential energy keeps decreasing.
D) Their kinetic energy keeps decreasing.
E) Their acceleration keeps decreasing.

_____ 89) Two protons are fired toward each other in a particle accelerator, with only the electrostatic force acting. Which of the following statements must be true about them as they move closer together? (There could be more than one correct choice.)
A) Their electric potential energy keeps increasing.
B) Their kinetic energy keeps increasing.
C) Their electric potential energy keeps decreasing.
D) Their kinetic energy keeps decreasing.
E) Their acceleration keeps decreasing.

_____ 90) A region of space contains a uniform electric field, directed toward the right, as shown in the figure. Which statement about this situation is correct?



A) The potential at all three locations is the same.
B) The potentials at points A and B are equal, and the potential at point C is higher than the potential at point A.
C) The potentials at points A and B are equal, and the potential at point C is lower than the potential at point A.
D) The potential at point A is the highest, the potential at point B is the second highest, and the potential at point C is the lowest.

20.2 Problems

____ 91) A proton that is initially at rest is accelerated through an electric potential difference of magnitude 500 V. What speed does the proton gain? ($e = 1.60 \times 10^{-19}$ C , $m$proton $= 1.67 \times 10^{-27}$ kg)
   A) $2.2 \times 10^5$ m/s
   B) $3.1 \times 10^5$ m/s
   C) $9.6 \times 10^5$ m/s
   D) $1.1 \times 10^5$ m/s

21.1 Conceptual Questions

____ 92) If a quantity you calculated has units of A • s, what is that quantity?
   A) potential
   B) resistivity
   C) resistance
   D) capacitance
   E) charge

____ 93) When a current flows through a metal wire, the moving charges are
   A) only protons.
   B) only electrons.
   C) both protons and electrons.
   D) positive metal ions.
   E) negative metal ions.

____ 94) When a current flows through an ionic liquid such as salty water, the moving charges are
   A) only protons.
   B) only electrons.
   C) only negative ions.
   D) only positive ions.
   E) both positive and negative ions.

____ 95) The figure shows electrons passing through a resistor. The arrow shows the direction in which the electrons are moving. Which of the following statements are correct? (There could be more than one correct choice.)



   A) The electrons are moving slower at point $b$ than at point $a$.
   B) The electric potential is higher at point $b$ than at point $a$.
   C) The electric potential is lower at point $b$ than at point $a$.
   D) The electrons are losing electric potential energy as they move through the resistor from $a$ to $b$.
   E) The speed of the electrons at point $b$ is the same as it is at point $a$.

___ 96) For the graph shown in the figure, what physical quantity does the slope of the graph represent for ohmic material?

Potential



Current
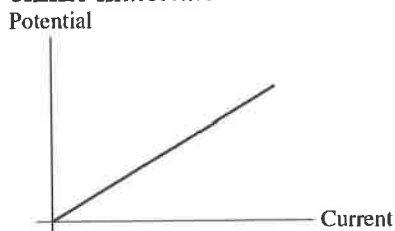
A) power
B) resistivity
C) 1/(resistivity)
D) resistance
E) 1/(resistance)

___ 97) Which one of the following quantities is equivalent to 1 W?
A) 1 V/A
B) 1 $\Omega \cdot$ m
C) 1 V $\cdot$ A
D) 1 V/$\Omega$
E) 1 A $\cdot$ s

___ 98) Four unequal resistors are connected in series with each other. Which one of the following statements is correct about this combination?
A) The equivalent resistance is equal to that of any one of the resistors.
B) The equivalent resistance is equal to average of the four resistances.
C) The equivalent resistance is less than that of the smallest resistor.
D) The equivalent resistance is less than that of the largest resistor.
E) The equivalent resistance is more than the largest resistance.

___ 99) Four unequal resistors are connected in a parallel with each other. Which one of the following statements is correct about this combination?
A) The equivalent resistance is less than that of the smallest resistor.
B) The equivalent resistance is equal to the average of the four resistances.
C) The equivalent resistance is midway between the largest and smallest resistance.
D) The equivalent resistance is more than the largest resistance.
E) None of the other choices is correct.

___ 100) When unequal resistors are connected in parallel in a circuit,
A) the same current always runs through each resistor.
B) the potential drop is always the same across each resistor.
C) the largest resistance has the largest current through it.
D) the power generated in each resistor is the same.

___ 101) When unequal resistors are connected in series across an ideal battery,
A) the same power is dissipated in each one.
B) the potential difference across each is the same.
C) the current flowing in each is the same.
D) the equivalent resistance of the circuit is less than that of the smallest resistor.
E) the equivalent resistance of the circuit is equal to the average of all the resistances.

____ 102) As more resistors are added in series to a constant voltage source, the power supplied by the source
A) increases.
B) decreases.
C) does not change.
D) increases for a time and then starts to decrease.

____ 103) As more resistors are added in parallel across a constant voltage source, the power supplied by the source
A) increases.
B) decreases.
C) does not change.
D) increases for a time and then starts to decrease.

____ 104) When different resistors are connected in parallel across an ideal battery, we can be certain that
A) the same current flows in each one.
B) the potential difference across each is the same.
C) the power dissipated in each is the same.
D) their equivalent resistance is greater than the resistance of any one of the individual resistances.
E) their equivalent resistance is equal to the average of the individual resistances.

____ 105) The lamps in a string of decorative lights are connected in parallel across a constant-voltage power source. What happens if one lamp burns out? (Assume negligible resistance in the wires leading to the lamps.)
A) The brightness of the lamps will not change appreciably.
B) The other lamps get brighter equally.
C) The other lamps get brighter, but some get brighter than others.
D) The other lamps get dimmer equally.
E) The other lamps get dimmer, but some get dimmer than others.

____ 106) A 9-V battery is hooked up to two resistors in series using wires of negligible resistance. One has a resistance of 5 $\Omega$, and the other has a resistance of 10 $\Omega$. Several locations along the circuit are marked with letters, as shown in the figure. Which statements about this circuit are true? (There could be more than one correct choice.)
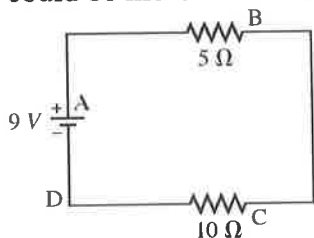


A) The current is exactly the same at points A, B, C, and D.
B) The current at A is greater than the current at B, which is equal to the current at C, which is greater than the current at D.
C) The current at A is greater than the current at B, which is greater than the current at C, which is greater than the current at D.
D) The potential at B is equal to the potential at C.
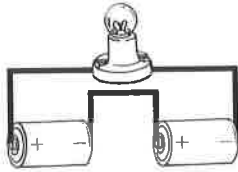E) The potential at D is equal to the potential at C.

____ 107) Identical ideal batteries are connected in different arrangements to the same light bulb, as shown in the figure. For which arrangement will the bulb shine the *brightest*?
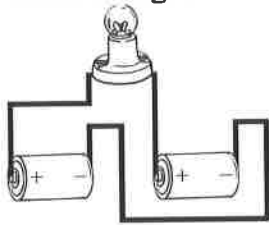


A) A
B) B
C) C

21.2 Problems

108) A 10-A current flows through a wire for 2.0 min. ($e = 1.60 \times 10^{-19}$ C)
(a) How much charge has passed through this wire?
(b) How many electrons have passed any point in the wire?

109) What potential difference is required across an 8.0-$\Omega$ resistor to cause 2.0 A to flow through it?

110) The current through a piece of lab equipment must be limited to 2.75 A when it is run by a 120-V dc power supply. What must be the resistance of this equipment?