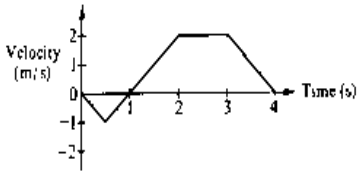
1984 AP Physics B Multiple Choice
Exam

1984 B Physics Multiple-Choice

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then blacken the corresponding space on the answer sheet.

1. If the mass of a simple pendulum is doubled but its length remains constant, its period is multiplied by a factor of
   (A) $\frac{1}{2}$
   (B) $\frac{1}{\sqrt{2}}$
   (C) 1
   (D) $\sqrt{2}$
   (E) 2

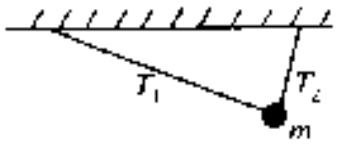
2. A railroad flatcar of mass 2,000 kilograms rolls to the right at 10 meters per second and collides with a flatcar of mass 3,000 kilograms that is rolling to the left at 5 meters per second. The flatcars couple together. Their speed after the collision is
   (A) 1m/s
   (B) 2.5m/s
   (C) 5 m/s
   (D) 7 m/s
   (E) 7.5m/s



3. The graph above shows the velocity versus time for an object moving in a straight line. At what time after time = 0 does the abject again pass through its initial position?
   (A) Between O and 1 s
   (B) 1 s
   (C) Between 1 and 2 s
   (D) 2 s
   (E) Between 2 and 3 s

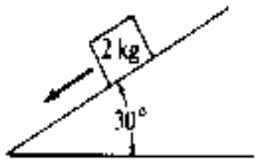
4. Which of the following is true for a system consisting of a mass oscillating on the end of an ideal spring?
   (A) The kinetic and potential energies are equal at all times.
   (B) The kinetic and potential energies are both constant.
   (C) The maximum potential energy is achieved when the mass passes through its equilibrium position.
   (D) The maximum kinetic energy and maximum potential energy are equal, but occur at different times.
   (E) The maximum kinetic energy occurs at maximum displacement of the mass from its equilibrium position.

5. A hall of mass m is suspended from two strings of unequal length as shown above. The tensions T_1 and T_2 in the strings must satisfy which of the following relations?
   (A) $T_1 = T_2$
   (B) $T_1 > T_2$
   (C) $T_1 < T_2$
   (D) $T_1 + T_2 = mg$
   (E) $T_1 - T_2 = mg$



Questions 6-7

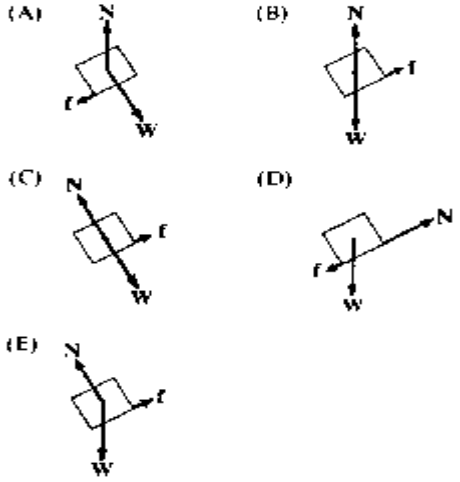
A 2-kilogram block slides down a 30° incline as shown above with an acceleration of 2 meters per second squared.



6. Which of the following diagrams best represents the gravitational force **W**, the frictional force **f**, and the normal force **N** that act on the block?

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

7. The magnitude of the frictional force along the plane is most nearly
   (A) 2.5 N
   (B) 5 N
   (C) 6 N
   (D) 10 N
   (E) 16 N

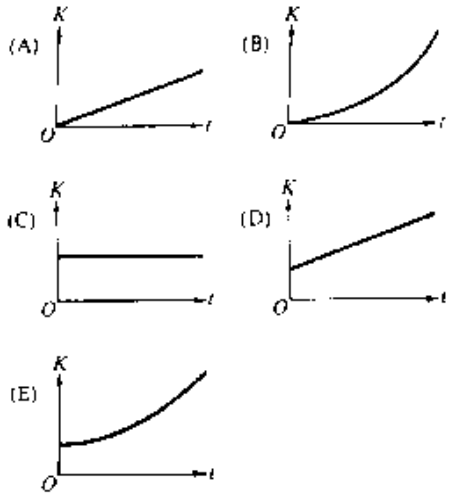


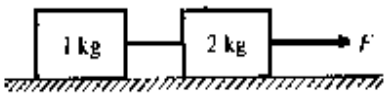
8. When a person stands on a rotating merry-go-round, the frictional force exerted on the person by the merry-go-round is
   (A) greater in magnitude than the frictional force exerted on the person by the merry-go-round
   (B) opposite in direction to the frictional force exerted on the merry-go-round by the person
   (C) directed away from the center of the merry-go-round
   (D) zero if the rate of rotation is constant
   (E) independent of the person's mass

9. Each of five satellites makes a circular orbit about an object that is much more massive than any of the satellites. The mass and orbital radius of each satellite are given below. Which satellite has the greatest speed?

	Mass	Radius
(A)	$\frac{1}{2}m$	R
(B)	m	$\frac{1}{2}R$
(C)	m	R
(D)	m	$2R$
(E)	$2m$	R

10. From the top of a high cliff, a ball is thrown horizontally with initial speed v_0. Which of the following graphs best represents the ball's kinetic energy ***K*** as a function of time t?

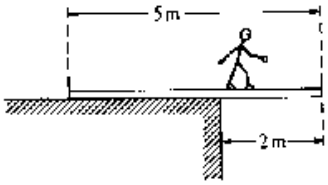




Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

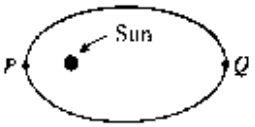
11. When the frictionless system shown above is accelerated by an applied force of magnitude F, the tension in the string between the blocks is
    (A) $2F$
    (B) F
    (C) $\frac{2}{3}F$
    (D) $\frac{1}{2}F$
    (E) $\frac{1}{3}F$

12. When a mass is attached to a spring, the period of oscillation is approximately 2.0 seconds. When the mass attached to the spring is doubled, the period of oscillation is most nearly
    (A) 0.5 s
    (B) 1.0 s
    (C) 1.4 s
    (D) 2.0 s
    (E) 2.8 s



13. A 5-meter uniform plank of mass 100 kilograms rests on the top of a building with 2 meters extended over the edge as shown above. How far can a 50-kilogram person venture past the edge of the building on the plank before the plank just begins to tip?
    (A) $\frac{1}{2}m$
    (B) 1 m
    (C) $\frac{2}{3}m$
    (D) 2 m
    (E) It is impossible to make the plank tip since the person would have to he more than 2 meters from the edge of the building.

14. An asteroid moves in an elliptic orbit with the Sun at one focus as shown above. Which of the following quantities increases as the asteroid moves from point P in its orbit to point Q?
    (A) Speed
    (B) Angular momentum
    (C) Total energy
    (D) Kinetic energy
    (E) Potential energy



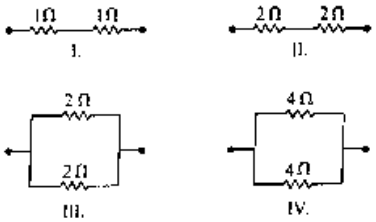
15. The electron volt is a measure of
    (A) charge
    (B) energy
    (C) impulse
    (D) momentum
    (E) velocity

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

16. A solid conducting sphere is given a positive charge *Q*. How is the charge *Q* distributed in or on the sphere?
    (A) It is concentrated at the center of the sphere.
    (B) It is uniformly distributed throughout the sphere.
    (C) Its density decreases radially outward from the center.
    (D) Its density increases radially outward from the center.
    (E) It is uniformly distributed on the surface of the sphere only.

17. A parallel-plate capacitor is charged by connection to a battery. If the battery is disconnected and the separation between the plates is increased, what will happen to the charge on the capacitor and the voltage across it?
    (A) Both remain fixed.
    (B) Both increase.
    (C) Both decrease.
    (D) The charge increases and the voltage decreases.
    (E) The charge remains fixed and the voltage increases.

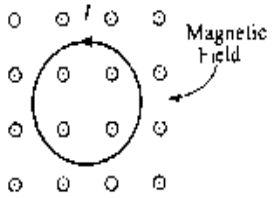
18. Which two arrangements of resistors shown above have the same resistance between the terminals?
    (A) I and II
    (B) I and IV
    (C) II and III
    (D) II and IV
    (E) III and IV



Questions 19-20. A point *P* is 0.50 meter from a point charge of 5.0 x 10^{-8} coulomb.

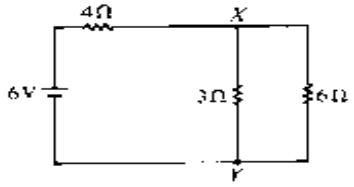
19. The intensity of the electric field at point *P* is most nearly
    (A) 2.5 x 10^{-8} N/C
    (B) 2.5 x 10^{1} N/C
    (C) 9.0 x 10^{2} N/C
    (D) 1.8 x 10^{3} N/C
    (E) 7.5 x 10^{8} N/C

20. The electric potential at point *P* is most nearly
    (A) 2.5 x 10^{-8} *V*
    (B) 2.5 x 10^{1} *V*
    (C) 9.0 x 10^{2} *V*
    (D) 1.8 x 10^{3} *V*
    (E) 7.5 x 10^{8} *V*



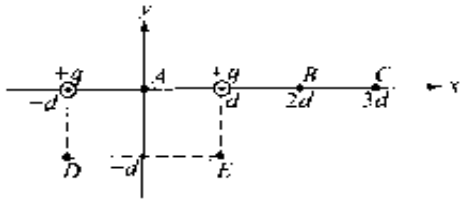
21. There is a counterclockwise current *I* in a circular loop of wire situated in an external magnetic field directed out of the page as shown above. The effect of the forces that act on this current is to make the loop
    (A) expand in size
    (B) contract in size
    (C) rotate about an axis perpendicular to the page
    (D) rotate about an axis in the plane of the page
    (E) accelerate into the page

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



22. In the circuit shown above, what is the value of the potential difference between points *X* and *Y* if the 6-volt battery has no internal resistance?
    (A) 1 V
    (B) 2 V
    (C) 3 V
    (D) 4 V
    (E) 6 V
23. One joule of work is needed to move one coulomb of charge from one point to another with no change in velocity. Which of the following is true between the two points?
    (A) The resistance is one ohm.
    (B) The current is one ampere.
    (C) The potential difference is one volt.
    (D) The electric field strength is one newton per coulomb.
    (E) The electric field strength is one joule per electron.

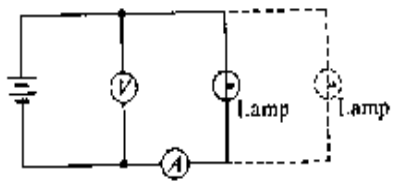
Questions 24-25



Two positive charges of magnitude q are each a distance *d* from the origin *A* of a coordinate system as shown above.

24. At which of the following points is the electric field least in magnitude?
    (A) *A*
    (B) *B*
    (C) *C*
    (D) *D*
    (E) *E*

25. At which of the following points is the electric potential greatest in magnitude?
    (A) *A*
    (B) *B*
    (C) *C*
    (D) *D*
    (E) *E*

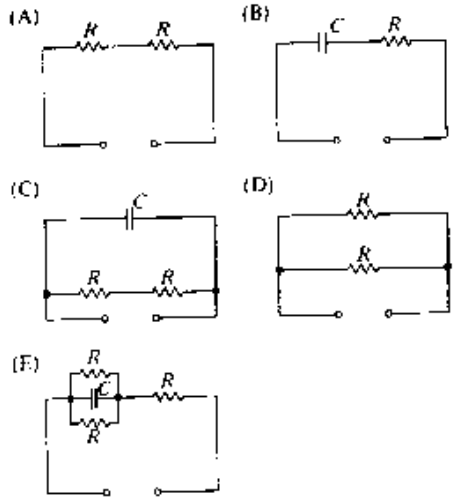


26. A lamp, a voltmeter *V*, an ammeter *A*, and a battery with zero internal resistance are connected as shown above. Connecting another lamp in parallel with the first lamp as shown by the dashed lines would

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

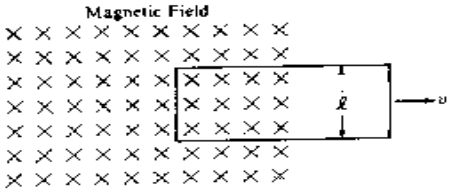
(A) increase the ammeter reading
(B) decrease the ammeter reading
(C) increase the voltmeter reading
(D) decrease the voltmeter reading
(E) produce no change in either meter reading

Questions 27-28 relate to the five incomplete circuits below composed of resistors R, all of equal resistance, and capacitors *C*, all of equal capacitance. A battery that can be used to complete any of the circuits is available.



27. Into which circuit should the battery be connected to obtain the greatest steady power dissipation?

28. Which circuit will retain stored energy if the battery is connected to it and then disconnected?



29. The figure above shows a rectangular loop of wire of width ℓ and resistance R. One end of the loop is in a uniform magnetic field of strength B at right angles to the plane of the loop. The loop is pulled to the right at a constant speed v. What are the magnitude and direction of the induced current in the loop?

	Magnitude	Direction
(A)	$B\ell vR$	Clockwise
(B)	$B\ell vR$	Counterclockwise
(C)	$B\ell v/R$	Clockwise
(D)	$B\ell v/R$	Counterclockwise
(E)	0	Undefined

30. A 2-kilogram block of metal with a specific heat of 100 joules per kilogram • Kelvin falls from rest through a distance of 100 meters to the Earth's surface. If half of the potential energy lost by the fallen block is converted to internal energy of the block, the temperature change of the block is most nearly
(A) 1 K
(B) 5 K
(C) 10 K
(D) 25 K
(E) 45 K

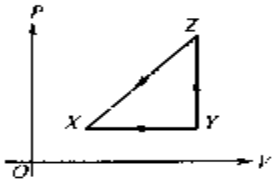
31. The maximum efficiency of a heat engine that operates between temperatures of 1500 K in the firing chamber and 600 K in the exhaust chamber is most nearly

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(A) 33%
(B) 40%
(C) 60%
(D) 67%
(E) 100%

32. An ideal gas is made up of *N* diatomic molecules, each of mass *M*. All of the following statements about this gas are true EXCEPT:
(A) The temperature of the gas is proportional to the average translational kinetic energy of the molecules.
(B) All of the molecules have the same speed.
(C) The molecules make elastic collisions with the walls of the container.
(D) The molecules make elastic collisions with each other.
(E) The average number of collisions per unit time that the molecules make with the walls of the container depends on the temperature
of the gas.

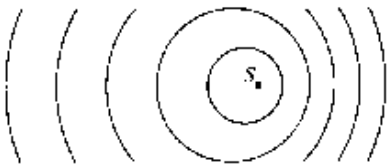
Questions 33-34



A thermodynamic system is taken form an initial state *X* along the path *XYZX* as shown in the *PV*-diagram above.

33. For the process $X \rightarrow Y$, ΔU is greater than zero and
(A) Q<0 and W=0
(B) Q<0 and W>0
(C) Q>0 and W<0
(D) Q>0 and W=0
(E) Q>0 and W>0

34. For the process Y→Z, Q is greater than zero and
(A) W<0 and ΔU=0
(B) W=0 and ΔU<0
(C) W=0 and ΔU>0
(D) W>0 and ΔU=0
(E) W>0 and ΔU>0



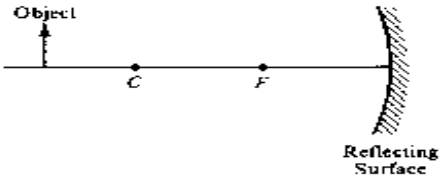
35. A small vibrating object *S* moves across the surface of a ripple tank producing the wave fronts shown above. The wave fronts move with speed *v*. The object is traveling in what direction and with what speed relative to the speed of the wave fronts produced?

	Direction	Speed
(A)	To the right	Equal to *v*
(B)	To the right	Less than *v*
(C)	To the right	Greater than *v*
(D)	To the left	Less than *v*

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(E) To the left Greater than v

36. The critical angle for a transparent material in air is 30°. The index of refraction of the material is most nearly
(A) 0.33
(B) 0.50
(C) 1.0
(D) 1.5
(E) 2.0



37. An object is placed as shown in the figure above. The center of curvature C and the focal point F of the reflecting surface are marked. As compared with the object, the image formed by the reflecting surface is
(A) erect and larger
(B) erect and the same size
(C) erect and smaller
(D) inverted and larger
(E) inverted and smaller

38. When one uses a magnifying glass to read fine print, one uses a
(A) converging lens to produce a virtual image of the print
(B) converging lens to produce a real image of the print
(C) mirror to produce a virtual image of the print
(D) diverging lens to produce a real image of the print
(E) diverging lens to produce a virtual image of the print

39. Two point sources in a ripple tank radiate waves in phase with a constant wavelength of 0.02 meter. The first-order interference maximum appears at 6° (use sin 6° = 0.1). The separation of the sources is most nearly
(A) 0.001 m
(B) 0.002 m
(C) 0.06 m
(D) 0.1 m
(E) 0.2 m

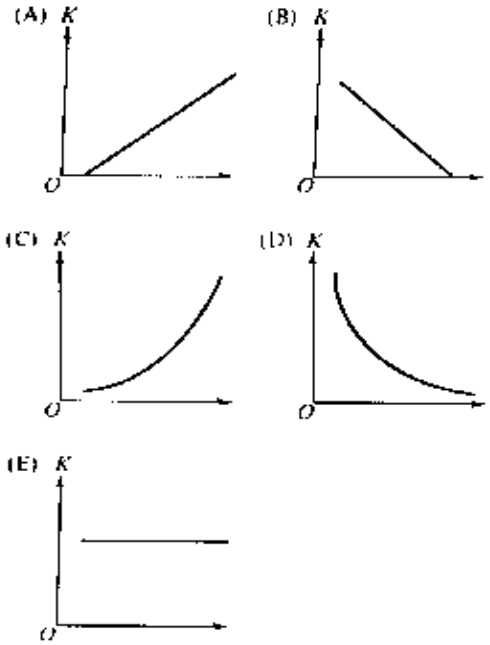
40. A cord of fixed length and uniform density, when held between two fixed points under tension T, vibrates with a fundamental frequency f. If the tension is doubled, the fundamental frequency is
(A) $2f$
(B) $\sqrt{2f}$
(C) f
(D) $\frac{f}{\sqrt{2}}$
(E) $\frac{f}{2}$

41. Which color of light emitted from an atom would be associated with the greatest change in energy of the atom?
(A) Blue
(B) Green
(C) Red

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(D) Violet
(E) Yellow

Questions 42-43 relate to photoelectric effect and the five graphs below.



42. Which graph best shows the maximum kinetic energy K of the photoelectrons as a function of the frequency of incident light?

43. Which graph best shows the maximum kinetic energy K of the photoelectrons as a function of the intensity of incident light?

44. $${}^{235}_{92}U + {}^{1}_{0}n \rightarrow 3\ {}^{1}_{0}n + {}^{142}_{56}Ba + _____$$
The additional product of the nuclear fission reaction shown above is
(A) ${}^{91}_{36}Kr$
(B) ${}^{92}_{35}Br$
(C) ${}^{93}_{36}Kr$
(D) ${}^{93}_{37}Rb$
(E) ${}^{94}_{37}Rb$

45. The deuteron mass m_d is related to the neutron mass m_n and the proton mass m_p by which of the following expressions?
(A) $m_d = m_n - m_p$
(B) $m_d = m_n + m_p$
(C) $m_d = 2(m_n + m_p)$
(D) $m_d = m_n + m_p$ – (mass equivalent to deuteron binding energy)
(E) $m_d = m_n + m_p$ + (mass equivalent to deuteron binding energy)

46. Electrons that have been accelerated from rest through a potential difference of 150 volts have a de Broglie wavelength of approximately 1 Ångstrom (10^{-10} meter). In order to obtain electrons whose de Broglie wavelength is 0.5 Ångstrom (5 X 10^{-11}~ meter), what accelerating potential is required?
(A) 37.5 V
(B) 75 V

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(C) 300 V
(D) 600 V
(E) 22,590 V

Questions 47-49

A 1.0-meter stick and a clock move with speed 0.8 c relative to an observer.

47. If the stick is aligned parallel to the direction of motion, its observed length is most nearly
(A) 0.6*m*
(B) 0.8*m*
(C) 1.0*m*
(D) $\frac{1}{0.8}m$
(E) $\frac{1}{0.6}m$

48. If the stick is aligned perpendicularly to the direction of motion, its observed length is most nearly
(A) 0.6 *m*
(B) 0.8 *m*
(C) 1.0*m*
(D) $\frac{1}{0.8}m$
(E) $\frac{1}{0.6}m$

49. Compared to clocks at rest relative to the observer, the moving clock will seem to the observer to run
(A) slower, at about 0.6 times the rate of the clocks at rest
(B) slower, at about 0.8 times the rate of the clocks at rest
(C) at the same rate as the clocks at Pest
(D) faster, at about $\frac{1}{0.8}$ times the rate of the clacks at rest
(E) faster, at about $\frac{1}{0.6}$ times the rate of the clocks at rest

50. An ideal gas confined in a box initially has pressure *p*. If the absolute temperature of the gas is doubled and the volume of the box is quadrupled, the pressure is
(A) $\frac{1}{8}p$
(B) $\frac{1}{4}p$
(C) $\frac{1}{2}p$
(D) p
(E) $2p$

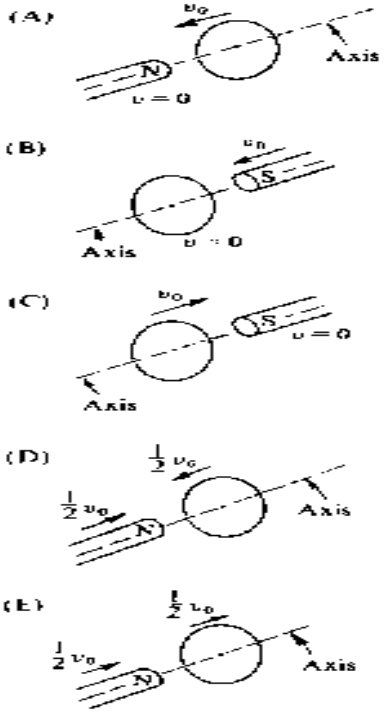
51. A ball attached to a string is whirled around in a horizontal circle having a radius *r*. If the radius of the circle is changed to 4*r* and the same centripetal force is applied by the string, the new speed of the ball is which of the following?
(A) One-quarter the original speed
(B) One-half the original speed
(C) The same as the original speed
(D) Twice the original speed
(E) Four times the original speed

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

52. A person pushes a box across a horizontal surface at a constant speed of 0.5 meter per second. The box has a mass of 40 kilograms, and the coefficient of sliding friction is 0.25. The power supplied to the box by the person is
    (A) 0.2 W
    (B) 5 W
    (C) 50 W
    (D) 100 W
    (E) 200 W

53. In each of the following situations, a bar magnet is aligned along the axis of a conducting loop. The magnet and the loop move with the indicated velocities. In which situation will the bar magnet NOT induce a current in the conducting loop?

54. A parallel-plate capacitor has a capacitance C_0. A second parallel-plate capacitor has plates with twice the area and twice the separation. The capacitance of the second capacitor is most nearly
    (A) $\frac{1}{4}C_0$
    (B) $\frac{1}{2}C_0$
    (C) C_0
    (D) $2C_0$
    (E) $4C_0$

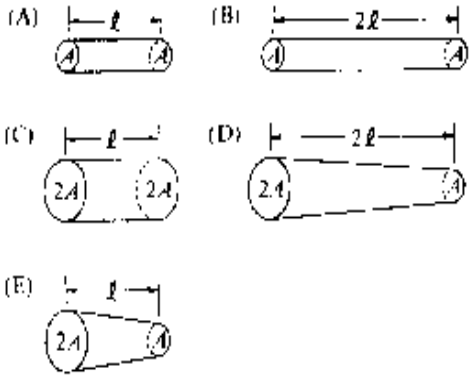


55. A vibrating tuning fork sends sound waves into the air surrounding it. During the time in which the tuning fork makes one complete vibration, the emitted wave travels
    (A) one wavelength
    (B) about 340 meters
    (C) a distance directly proportional to the frequency of the vibration
    (D) a distance directly proportional to the square root of the air density
    (E) a distance inversely proportional to the square root of the pressure

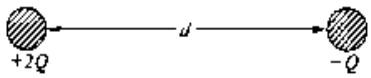
56. Two planets have the same size, but different masses, and no atmospheres. Which of the following would be the same for objects with equal mass on the surfaces of the two planets?
    I. The rate at which each would fall freely
    II. The amount of mass each would balance on an equal-arm balance
    III. The amount of momentum each would acquire when given a certain impulse
    (A) I only
    (B) III only
    (C) I and II only
    (D) II and II1 only
    (E) I, II, and III

57. The five resistors shown below have the lengths and cross-sectional areas indicated and are made of material with the same resistively. Which has the greatest resistance?

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

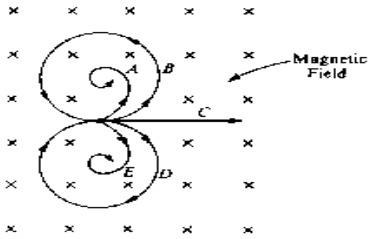


58. According to the Bohr model of the atom, electrons orbit the nucleus in definite orbits. According to the laws of classical physics, this model would be impossible because electrons
(A) the positively charged nucleus attracts the electrons
(B) Coulomb's law applies
(C) accelerating electrons radiate energy
(D) there is a centripetal force on the electrons
(E) angular momentum is conserved

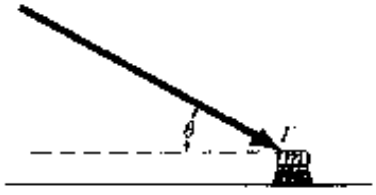


59. Two identical conducting spheres are charged to +2Q and -Q, respectively, and are separated by a distance d (much greater than the radii of the spheres) as shown above. The magnitude of the force of attraction on the left sphere is F_1. After the two spheres are made to touch and then are reseparated by distance d, the magnitude of the force on the left sphere is F_1. Which of the following relationships is correct?
(A) $2F_1 = F_2$
(B) $F_1 = F_2$
(C) $F_1 = 2F_2$
(D) $F_1 = 4F_2$
(E) $F_1 = 8F_2$

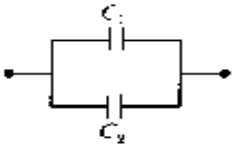
60. Which of the paths above represents the path of an electron traveling without any loss of energy through a uniform magnetic field directed into the page?
(A) A
(B) B
(C) C
(D) D
(E) E



61. A push broom of mass m is pushed across a rough horizontal floor by a force of magnitude T directed at angle θ as shown above. The coefficient of friction between the broom and the floor is It. The frictional force on the broom has magnitude
(A) $\mu(mg + T\sin\theta)$
(B) $\mu(mg + T\sin\theta)$
(C) $\mu(mg + T\cos\theta)$
(D) $\mu(mg - T\cos\theta)$
(E) μmg



Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purpose ıde available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



62. Two capacitors are connected in parallel as shown above. A voltage V is applied to the pair. What is the ratio of charge stored on C_2 to the charge stored on C_1, when $C_1 = 1.5C_2$?

(A) $\frac{4}{9}$

(B) $\frac{2}{3}$

(C) 1

(D) $\frac{3}{2}$

(E) $\frac{9}{4}$

63. Two long, parallel wires, fixed in space, carry currents I, and 12. The force of attraction has magnitude F. What currents will give an attractive force of magnitude 4F?

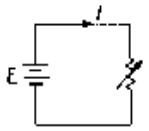
(A) $2I_1$ *and* $\frac{1}{2}I_2$

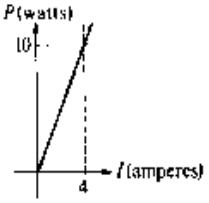
(B) I_1 *and* $\frac{1}{4}I_2$

(C) $\frac{1}{2}I_1$ *and* $\frac{1}{2}I_2$

(D) $2I_1$ *and* $2I_2$

(E) $4I_1$ *and* $4I_2$





64. The circuit shown above left is made up of a variable resistor and a battery with negligible internal resistance. A graph of the power P dissipated in the resistor as a function of the current I supplied by the battery is given above right. What is the emf of the battery?

(A) 0.025 V
(B) 0.67 V
(C) 2.5 V
(D) 6.25 V
(E) 40 V

65. A body moving in the positive x direction passes the origin at time $t = 0$. Between t = 0 and t = 1 second, the body has a constant speed of 24 meters per second. At $t = 1$ second, the body is given a constant acceleration of 6 meters per second squared in the negative x direction. The position x of the body at $t = 11$ seconds is

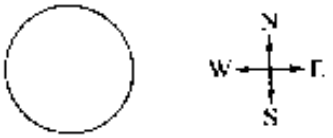
(A) +99 m
(B) +36 m
(C) -36 m
(D) -75 m
(E) -99 m

66. A person weighing 800 newtons on Earth travels to another planet with twice the mass and twice the radius of Earth. The person's weight on this other planet is most nearly

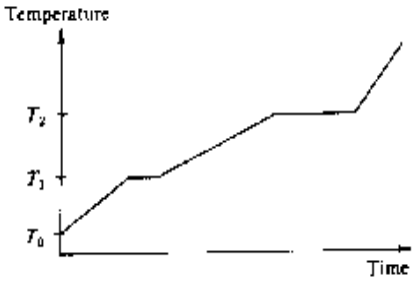
Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(A) 400 N
(B) $\frac{800}{\sqrt{2}}N$
(C) 800 N
(D) $800\sqrt{2}N$
(E) 1,600 N

67. A racing car is moving around the circular track of radius 300 meters shown above. At the instant when the car's velocity is directed due east, its acceleration is directed due south and has a magnitude of 3 meters per second squared. When viewed from above, the car is moving
(A) clockwise at 30 m/s
(B) clockwise at 10 m/s
(C) counterclockwise at 30 m/s
(D) counterclockwise at 10 m/s
(E) with constant velocity



View of Track from Above



68. Heat is added at a constant rate to a sample of pure substance that is initially a solid at temperature To. The temperature of the sample as a function of time is shown in the graph above. From the graph, one can conclude that the
(A) substance sublimes directly from the solid phase to the vapor phase
(B) melting point is T2
(C) specific heat is greater for the liquid phase than for the solid phase
(D) heat of fusion and heat of vaporization are equal
(E) specific heat of the solid increases linearly with temperature

69. An illuminated object is placed 0.30 meter from a lens whose focal length is -0.15. meter. The image is
(A) inverted, real, and 0,30 meter from the lens on the opposite side from the object
(B) upright, virtual, and 0.30 meter from the lens on the opposite side, from the object
(C) upright, real, and 0110 meter from the lens on the same side as the object
(D) upright, virtual, and 0. 10 meter from the lens on the same side as the object
(E) inverted, real, and 0. 10 meter from the lens on the same side as the object

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

1993 PHYSICS B
SECTION I
Time—90 minutes
70 Questions

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding oval on the answer sheet.

1. In which of the following situations would an object be accelerated?

I. It moves in a straight line at constant speed.
II. It moves with uniform circular motion.
III. It travels as a projectile in a gravitational field with negligible air resistance.

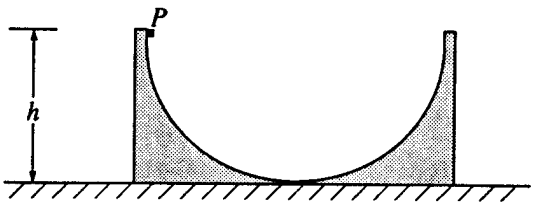
(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III

2. A ball falls straight down through the air under the influence of gravity. There is a retarding force F on the ball with magnitude given by F = bv, where t is the speed of the ball and b is a positive constant. The magnitude of the acceleration a of the ball at any time is equal to which of the following?

(A) $g - b$
(B) $g - \frac{bv}{m}$
(C) $g + \frac{bv}{m}$
(D) $\frac{g}{b}$
(E) $\frac{bv}{m}$

3. An ideal spring obeys Hooke's law, F = - kx. A mass of 0.50 kilogram hung vertically from this spring stretches the spring 0.075 meter. The value or the force constant for the spring is most nearly

(A) 0.33 N/m
(B) 0.66 N/m
(C) 6.6 N/m
(D) 33 N/m
(E) 66 N/m



4. The figure above shows a rough semicircular track whose ends are at a vertical height h. A block placed at point P at one end of the track is released from rest and slides past the bottom of the track. Which of the following is true of the height to which the block rises on the other side of the track?

(A) It is equal to h/2 π .

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(B) It is equal to h/4.
(C) It is equal to h/2.
(D) It is equal to h.
(E) It is between zero and h; the exact height depends on how much energy is lost to friction.

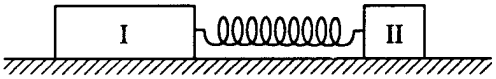
5. An object is released from rest on a planet that has no atmosphere. The object falls freely for 3.0 meters in the first second. What is the magnitude of the acceleration due to gravity on the planet?

(A) l .5 m/s^2
(B) 3.0 m/s^2
(C) 6.0 m/s^2
(D) 10.0 m/s^2
(E) 12.0 m/s^2

6. If Spacecraft X has twice the mass of Spacecraft Y. then true statements about X and Y include which of the following?

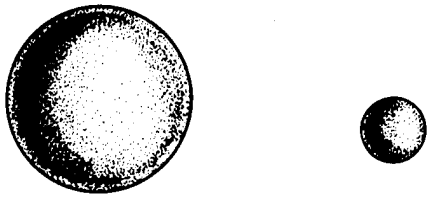
I. On Earth, X experiences twice the gravitational force that Y experiences.
II. On the Moon, X has twice the weight of Y.
III. When both are in the same circular orbit, X has twice the centripetal acceleration of Y.

(A) I only
(B) III only
(C) I and II only
(D) II and III on1y
(E) I, II, and III



7. Two pucks are attached by a stretched spring and are initially held at rest on a friction1ess surface, as shown above. The pucks are then released simultaneously. If puck I has three times the mass of puck II, which of the following quantities is the same for both pucks as the spring pulls the two pucks toward each other?

(A) Speed
(B) Velocity
(C) Acceleration
(D) Kinetic energy
(E) Magnitude of momentum



8. The two spheres pictured above have equal densities and are subject only to their mutual gravitational attraction. Which of the following quantities must have the same magnitude for both spheres?

(A) Acceleration
(B) Velocity
(C) Kinetic energy
(D) Displacement from the center of mass
(E) Gravitational force

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

9. When an object oscillating in simp1e harmonic motion is at its maximum displacement from the equi1ibrium position, which of the following is true of the values of its speed and the magnitude of the restoring force?

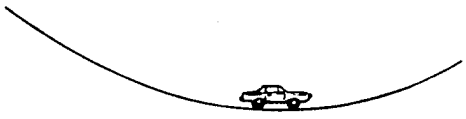
Speed	Restoring Force
(A) Zero	Maximum
(B) Zero	Zero
(C) ½ maximum	½ maximum
(D) Maximum	½ maximum
(E) Maximum	Zero

10. Which of the following is true when an object of mass m moving on a horizontal frictionless surface hits and sticks to an object of mass M > m, which is initially at rest on the surface?

(A) The collision is elastic.
(B) All of the initial kinetic energy of the less-massive object is lost.
(C) The momentum of the objects that are stuck together has a smaller magnitude than the initial momentum of the less-massive object.
(D) The speed of the objects that are stuck together will be less than the initial speed of the less-massive object.
(E) The direction of motion of the objects that are stuck together depends on whether the hit is a head-on collision.

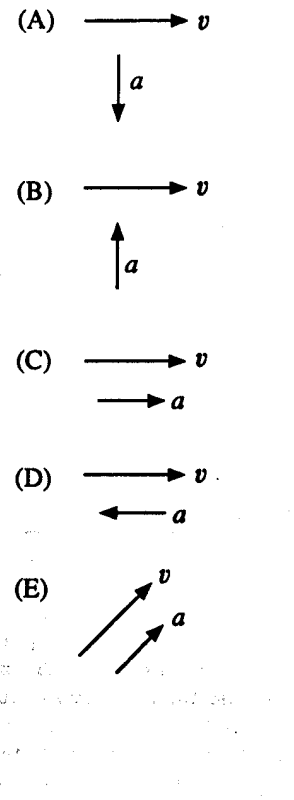
11. Two objects having the same mass travel toward each other on a flat surface, each with a speed of 10 meter per second relative to the surface. The objects collide head-on and are reported to rebound after the collision, each with a speed of 20 meters per second relative to the surface. Which of the following assessments of this report is most accurate?

(A) Momentum was not conserved, therefore the report is false.
(B) If potential energy was released to the objects during the collision, the report could be true.
(C) If the objects had different masses, the report could be true.
(D) If the surface was inclined, the report could be true.
(E) If there was no friction between the objects and the surface, the report could be true.



12. An automobile moves at constant speed down one hill and up another hill along the smoothly curved surface shown above. Which of the following diagrams best represents the directions of the velocity and the acceleration of the automobile at the instant that it is at the lowest position, as shown.

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



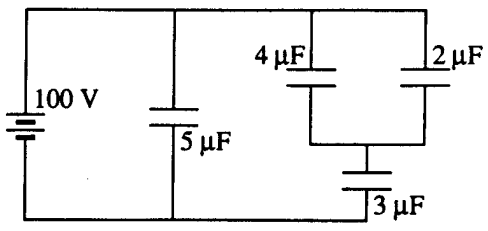
13. Which of the following will cause the electrical resistance of certain materials known as superconductors to suddenly decrease to essentially zero?

(A) Increasing the voltage applied to the material beyond a certain threshold voltage
(B) Increasing the pressure applied to the material beyond a certain threshold pressure
(C) Cooling the material below a certain threshold temperature
(D) Stretching the material to a wire of sufficiently small diameter
(E) Placing the material in a sufficiently large magnetic field

14. Kirchhoff's loop rule for circuit analysis is an expression of which of the following?

(A) Conservation of charge
(B) Conservation of energy
(C) Ampere's law
(D) Faraday's law
(E) Ohm's law

Questions 15-16 refer to the circuit shown below.



15. The equivalent capacitance for this network is most nearly

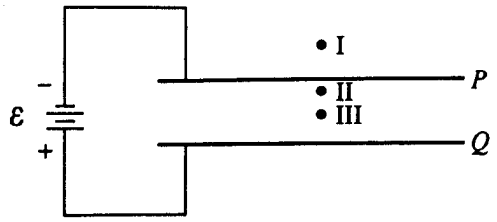
(A) 10/7 *u*F

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(B) 3/2 *u*F
(C) 7/3 *u*F
(D) 7 *u*F
(E) 14 *u*F

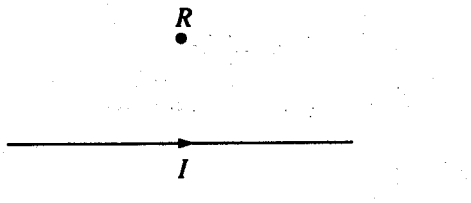
16. The charge stored in the 5-microfarad capacitor is most nearly

(A) 360 *u*C
(B) 500 *u*C
(C) 710 *u*C
(D) 1,100 *u*C
(E) 1,800 *u*C



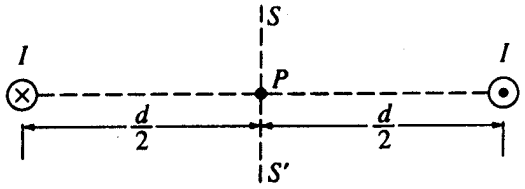
17. Two large parallel conducting plates P and Q are connected to a battery of emf C, as shown above. A test charge is placed successively at points I, II, and III. If edge effects are negligible, the force on the charge when it is at point III is

(A) of equal magnitude and in the same direction as the force on the charge when it is at point I
(B) of equal magnitude and in the same direction as the force on the charge when it is at point II
(C) equal in magnitude to the force on the charge when it is at point I, but in the opposite direction
(D) much greater in magnitude than the force on the charge when it is at point II, but in the same direction
(E) much less in magnitude than the force on the charge when it is at point II, but in the same direction



18. The direction of the magnetic field at point R caused by the current I in the wire shown above is

(A) to the left
(B) to the right
(C) toward the wire
(D) into the page
(E) out of the page

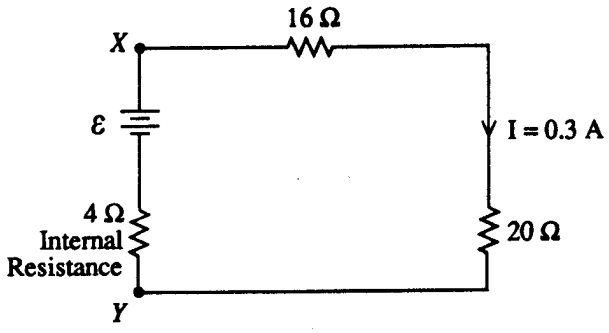


Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

19. Two long, parallel wires are separated by a distance a as shown above. One wire carries a steady current I into the plane of the page while the other wire carries a steady current I out of the page. At what points in the plane of the page and outside the wires, besides points at infinity, is the magnetic field due to the currents zero?

(A) Only at point P
(B) At all points on the line *SS'*
(C) At all points on the line connecting the two wires
(D) At all points on a circle of radius 2d centered on point P
(E) At no points

Questions 20-22 relate to the following circuit diagram, which shows a battery with an internal resistance of 4.0 ohms connected to a 16-ohm and a 20-ohm resistor in series. The current in the 20-ohm resistor is 0.3 amperes.



20. What is the emf of the battery?
(A) 1.2 V
(B) 6.0 V
(C) 10.8 V
(D) 12.0 V
(E) 13.2 V

21. What is the potential difference across the terminals X and Y of the battery?

(A) 1.2 V
(B) 6.0 V
(C) 10.8 V
(D) 12.0 V
(E) 13.2 V

22. What power is dissipated by the 4-ohm internal resistance of the battery?

A) 0.36 W
(B) 1.2 W
(C) 3.2 W
(D) 3.6 W
(E) 4.8 W

23. If the gas in a container absorbs 275 joules of heat has 125 joules of work done on it, and then does 50 joules of work, what is the increase in the internal energy of the gas?

(A) 100 J
(B) 200 J
(C) 350 J
(D) 400 J
(E) 450 J

Questions 24-25

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

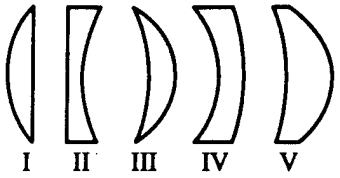
A piece of metal with a mass of 1.50 kilograms, specific heat of 200 J/kg / C°, and initial temperature of 100° C is dropped into an insulated jar that contains liquid with a mass of 3.00 kilograms, specific heat of 1,000 J/kg · C°, and initial temperature of 0° C. The piece of metal is removed after 5 seconds, at which time its temperature is 20° C. Neglect any effects of heat transfer to the air or to the insulated jar.

24. The temperature of the liquid after the metal is removed is

(A) 0° C
(B) 4° C
(C) 8° C
(D) 10° C
(E) 20° C

25. The average rate at which heat is transferred while the piece of metal is in the liquid is

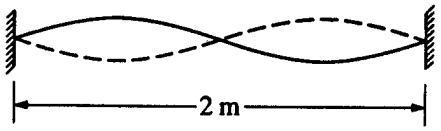
(A) 4,000 J/s
(B) 4,800 J/s
(C) 6,000 J/s
(D) 9,600 J/s
(E) 16,000 J/s



26. Which three of the glass lenses above, when placed in air, will cause parallel rays of light to converge?

(A) I, II, and III
(B) I, III, and V
(C) l, IV, and V
(D) II, III, and IV
(E) II, IV, and V

Questions 27-28



A standing wave of frequency 5 hertz is set up on a string 2 meters long with nodes at both ends and in the center, as shown above.

27. The speed at which waves propagate on the string is

(A) 0.4 m/s
(B) 2.5 m/s
(C) 5 m/s
(D) 10 m/s
(E) 20 m/s

28. The fundamental frequency of vibration of the string is

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(A) I Hz
(B) 2.5 Hz
(C) 5 Hz
(D) 7.5 Hz
(E) 10 Hz

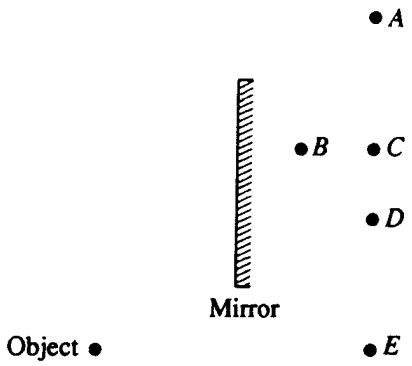
Radio waves
Infrared radiation
Visible light
Ultraviolet radiation
Gamma radiation

29. For the five types of electromagnetic radiation listed above, which of the following correctly describes the way in which wavelength, frequency, and photon energy change as one goes from the top of the list to the bottom?

	Wavelength	Frequency	Photon Energy
(A)	Decreases	Decreases	Increases
(B)	Decreases	Increases	Increases
(C)	Increases	Decreases	Decreases
(D)	Increases	Decreases	Increases
(E)	Increases	Increases	Increases

30. Sound in air can best be described as which of the following types of waves?

(A) Longitudinal
(B) Transverse
(C) Torsional
(D) Electromagnetic
(E) Polarized



31. An object is placed near a plane mirror, as shown above. Which of the labeled points is the position of the image?

(A) A
(B) B
(C) C
(D) D

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(E) E

Questions 32-33 deal with nuclear fission for which the following reaction is a good example.

$$\frac{235}{92}\text{U} + \frac{1}{0}\text{n} \rightarrow \frac{138}{56}\text{Ba} + \frac{95}{36}\text{Kr} + \text{neutrons} + \text{released energy}$$

32. The total number of free neutrons in the products of this reaction is

(A) 2
(B) 3
(C) 4
(D) 5
(E) 6

33. Which of the following statements is always true for neutron-induced fission reactions involving $\frac{235}{92}\text{U}$?

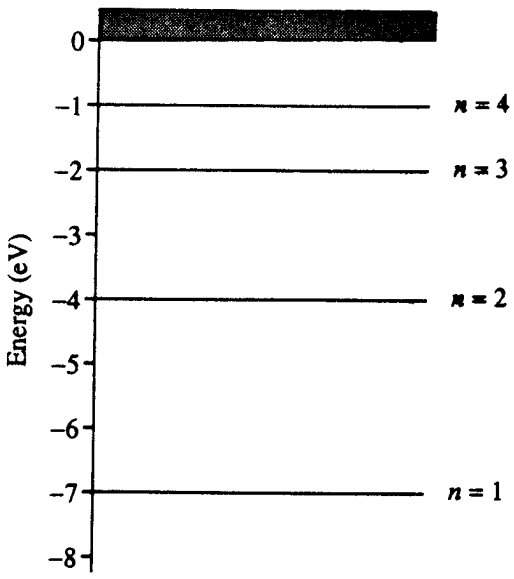
I. The end products always include Ba and Kr.

II. The rest mass of the end products is less than that of $\frac{235}{92}\text{U} + \frac{1}{0}\text{n}$.

III The total number of nucleons (protons plus neutrons) in the end products is less than that in $\frac{235}{92}\text{U} + \frac{1}{0}\text{n}$.

(A) lI only
(B) Ill only
(C) I and ll only
(D) I and lll only
(E) l,ll, and lll

Questions 34-35



A hypothetical atom has four energy states as shown above.

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

34. Which of the following photon energies could NOT be found in the emission spectra of this atom after it has been excited to the $n = 4$ state?

(A) l eV
(B) 2 eV
(C) 3 eV
(D) 4 eV
(E) 5 eV

35. Which of the following transitions will produce the photon with the longest wavelength?

(A) $n = 2$ to $n = l$
(B) $n = 3$ to $n = l$
(C) $n = 3$ to $n = 2$
(D) $n = 4$ to $n = l$
(E) $n = 4$ to $n = 3$

36. Cobalt 60 is a radioactive source with a half-life of about 5 years. After how many years will the activity of a new sample of cobalt 60 be decreased to 1/8 its original value?

(A) 2.5 years
(B) 5 years
(C) 10 years
(D) 15 years
(E) It depends on the original amount of cobalt 60.

37. Of the following phenomena, which provides the best evidence that light can have particle properties?

(A) Interference of light in thin films
(B) Electromagnetic radiation
(C) Photoelectric effect
(D) Electron diffraction
(E) X-ray diffraction

38. Of the following phenomena, which provides the best evidence that particles can have wave properties?

(A) The absorption of photons by electrons in an atom
(B) The a-decay of radioactive nuclei
(C) The interference pattern produced by neutrons incident on a crystal
(D) The production of x-rays by electrons striking a metal target
(E) The scattering of photons by electrons at rest

39. A muon, with a lifetime of 2×10^{-6} second in its frame of reference, is created in the upper atmosphere with a velocity of 0.998c toward the Earth. The lifetime of the muon, as measured by an observer on the Earth, is most nearly

(A) 3 x l0-2s
(B) 3 x 10-3 S
(C) 3 x l0-4s
(D) 3 x 10-5 S
(E) 3 x l0-h S

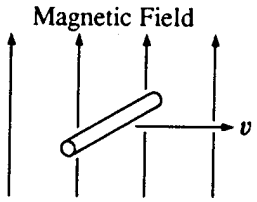
40. The operator of a space station observes a space vehicle approaching at a constant speed v. The operator sends a light signal at speed c toward the space vehicle. The speed of the light signal relative to the space vehicle is

(A) c + v
(B) c - v
(C) c

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

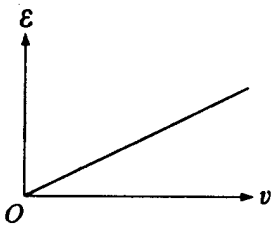
(D) $v / \sqrt{1 - v^2 / c^2}$

(E) c $\sqrt{1 - v^2 / c^2}$

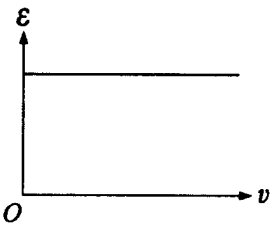


4l. A wire of constant length is moving in a constant magnetic field, as shown above. The wire and the velocity vector are perpendicular to each other and are both perpendicular to the field. Which of the following graphs best represents the potential difference ε between the ends of the wire as a function of the speed *v* of the wire?

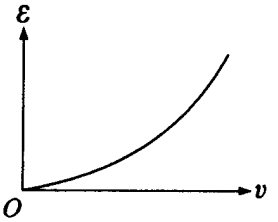
(A)



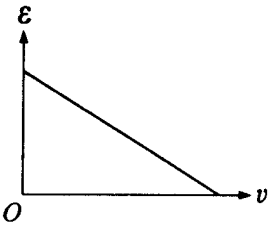
(B)



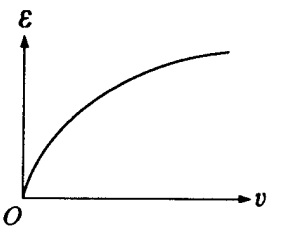
(C)



(D)



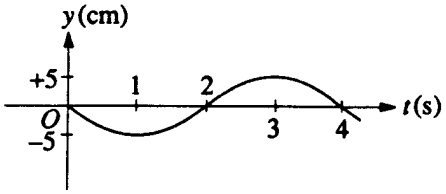
(E)



Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

42. Forces between two objects which are inversely proportional to the square of the distance between the objects include which of the following?
I. Gravitational force between two celestial bodies
II. Electrostatic force between two electrons
III. Nuclear force between two neutrons

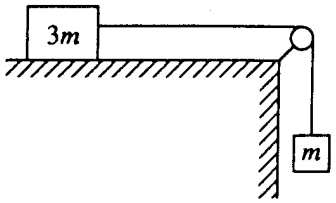
(A) I only
(B) III only
(C) I and II only
(D) lI and III only
(E) I, II, and III



43. A particle oscillates up and down in simple harmonic motion. Its height y as a function of time t is shown in the diagram above. At what time t does the particle achieve its maximum positive acceleration?
(A) 1s
(B) 2s
(C) 3s
(D) 4s
(E) None of the above, because the acceleration is constant

44. A weight lifter lifts a mass m at constant speed to a height *h* in time *t*. What is the average power output of the weight lifter?

(A) *mg*
(B) *mh*
(C) *mgh*
(D) *mght*
(E) *mgh/t*



45. A block of mass 3m can move without friction on a horizontal table. This block is attached to another block of mass m by a cord that passes over a frictionless pulley, as shown above. If the masses of the cord and the pulley are negligible, what is the magnitude of the acceleration of the descending block?

(A) Zero
(B) g/4
(C) g/3
(D) 2g/3
(E) g

46. A car initially travels north and then turns to the left along a circular curve. This causes a package on the seat of the car to slide toward the right side of the car. Which of the following is true of the net force on the package while it is sliding?

(A) The force is directed away from the center of the circle.

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

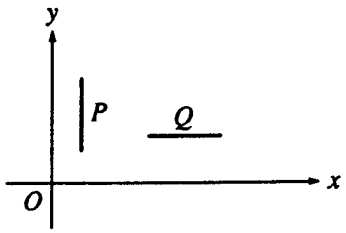
(B) The force is directed north.
(C) There is not enough force directed north to keep the package from sliding.
(D) There is not enough force tangential to the car's path to keep the package from sliding.
(E) There is not enough force directed toward the center of the circle to keep the package from sliding.

47. A block of mass m slides on a horizontal frictionless table with an initial speed v_0. It then compresses a spring of force constant k and is brought to rest. How much is the spring compressed from its natural length?

(A) $\frac{v_0^2}{2g}$
(B) $\frac{mg}{k}$
(C) $\frac{m}{k}v_0$
(D) $\sqrt{\frac{m}{k}}v_0$
(E) $\sqrt{\frac{k}{m}}v_0$

48. The planet Mars has mass 6.4×10^{23} kilograms and radius 3.4×10^{6} meters. The acceleration of an object in free-fall near the surface of Mars is most nearly

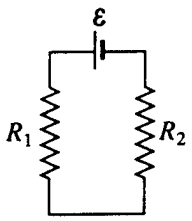
(A) zero
(B) l.0 m/s2
(C) 1.9 m/s2
(D) 3.7 m/s2
(E) 9.8 m/s2



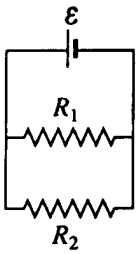
49. Rods P and Q are at rest in an inertial reference frame and oriented as shown above. Both rods have length L in this reference frame. A person moves at a relativistic speed in the y direction. Which of the following would be the lengths, as compared to L, observed for these rods by the person?

P	Q
(A) Less than L	Less than L
(B) Less than L	L
(C) Less than L	Greater than L
(D) L	Less than L
(E) L	L

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



Series Connection



Parallel Connection

50. In the diagrams above, resistors R_1. and R_2 are shown in two different connections to the same source of emf **ε** that has no internal resistance. How does the power dissipated by the resistors in these two cases compare?

(A) It is greater for the series connection.
(B) It is greater for the parallel connection.
(C) It is the same for both connections.
(D) It is different for each connection, but one must know the values of . R_1 and R_2 to know which is greater.
(E) It is different for each connection, but one must know the value of **ε** to know which is greater.

5l. The product

2 amperes x 2 volts x 2 seconds

is equal to

(A) 8 coulombs
(B) 8 newtons
(C) 8 joules
(D) 8 calories
(E) 8 newton-amperes

52. A radar operates at a wavelength of 3 centimeters. The frequency of these waves is

(A) 10^{-10} Hz
(B) 10^{6} Hz
(C) 10^{8} Hz
(D) 3×10^{8} Hz
(E) 10^{10} Hz

53. In the photoelectric effect, the maximum speed of the electrons emitted by a metal surface when it is illuminated by light depends on which of the following?

I. Intensity of the light
II. Frequency of the light
III. Nature of the photoelectric surface

(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III only

54. Atoms of isotopes of the same element contain the same number of

(A) protons but a different number of neutrons

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

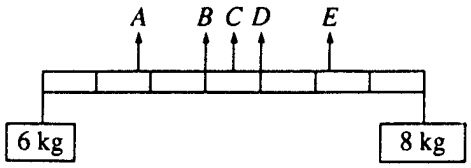
(B) electrons but a different number of protons
(C) neutrons but a different number of protons
(D) neutrons as electrons
(E) protons as neutrons

55. In each cycle of a Carnot engine, 100 joules of heat is absorbed from the high-temperature reservoir and 60 joules is exhausted to the low-temperature reservoir. What is the efficiency of the engine?

(A) 40%
(B) 60%
(C) 67%
(D) l50%
(E) l67%

56. In the Bohr model of the atom, the postulate stating that the orbital angular momentum of the electron is quantized can be interpreted in which of the following ways?

(A) An integral number of electron wavelengths must fit into the electron's circular orbit.
(B) Only one electron can exist in each possible electron state.
(C) An electron has a spin of l/2.
(D) The atom is composed of a small, positively charged nucleus orbited by electrons.
(E) An incident photon is completely absorbed when it causes an electron to move to a higher energy state.



57. Two objects, of masses 6 and 8 kilograms, are hung from the ends of a stick that is 70 centimeters long and has marks every l0 centimeters, as shown above. If the mass of the stick is negligible, at which of the points indicated should a cord be attached if the stick is to remain horizontal when suspended from the cord?

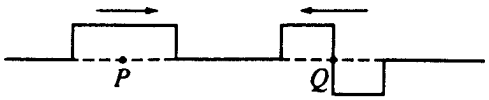
(A) A
(B) B
(C) C
(D) D
(E) E

58. In the Doppler effect for sound waves, factors that affect the frequency that the observer hears include which of the following?

I. The speed of the source
II. The speed of the observer
III. The loudness of the sound

(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

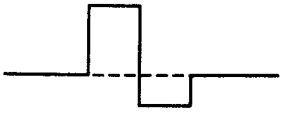


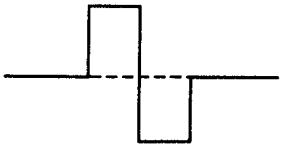
59. The figure above shows two wave pulses that are approaching each other. Which of the following best shows the shape of the resultant pulse when the centers of the pulses, points P and Q. coincide?

(A)


(B)


(C)

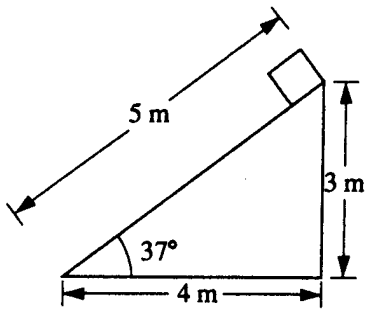

(D)


(E)


60. Observations that indicate that visible light has a wavelength much shorter than a centimeter include which of the following?

I. The colored pattern seen in a soap bubble
II. The colored pattern seen when light passes through a diffraction grating
III. The bending of light when it passes from one medium to another medium

(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III



Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

A plane 5 meters in length is inclined at an angle of 37°, as shown above. A block of weight 20 newtons is placed at the top of the plane and allowed to slide down.

61. The mass of the block is most nearly

(A) 1.0 kg
(B) 1.2 kg
(C) 1.6 kg
(D) 2.0 kg
(E) 2.5 kg

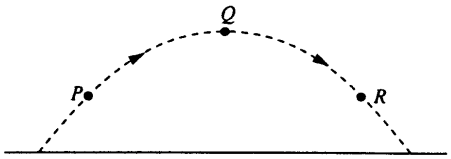
62. The magnitude of the normal force exerted on the block by the plane is most nearly

(A) l0 N
(B) 12N
(C) l6 N
(D) 20 N
(E) 33 N

63. The work done on the block by the gravitational force during the 5-meter slide down the plane is most nearly

(A) 20 J
(B) 60 J
(C) 80
(D) 100
(E) l30 J

Questions 64-66



A ball is thrown and follows the parabolic path shown above. Air friction is negligible. Point Q is the highest point on the path. Points P and R are the same height above the ground.

64. How do the speeds of the ball at the three points compare?

(A) $v_P < v_Q < v_R$
(B) $v_R < v_Q < v_P$
(C) $v_Q < v_R < v_P$
(D) $v_Q < v_P = v_R$
(E) $v_P = v_R < v_Q$

65. Which of the following diagrams best shows the direction of the acceleration of the ball at point P ?

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(A) 

(B) 

(C)

(D) 

(E)

66. Which of the following best indicates the direction of the net force, if any, on the ball at point Q ?

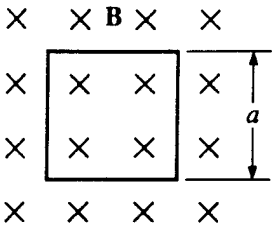
(A)

(B)

(C)

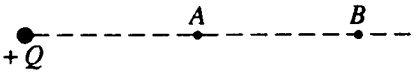
(D) 

(E) There is no net force on the ball at point Q.



67. A square loop of wire of resistance R and side a is oriented with its plane perpendicular to a magnetic field B. as shown above. What must be the rate of change of the magnetic field in order to produce a current I in the loop?

(A) IR/a^2
(B) la^2/R
(C) la /R
(D) Ra/l
(E) IRa



68. The diagram above shows an iso*l*ated, positive charge Q. Point B is twice as far away from Q as point A. The ratio of the electric field strength at point A to the electric field strength at point B is

(A) 8 to 1
(B) 4 to 1

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

(C) 2 to 1
(D) 1 to 1
(E) 1 to 2

69. If the object distance for a converging thin lens is more than twice the focal length of the lens, the image is

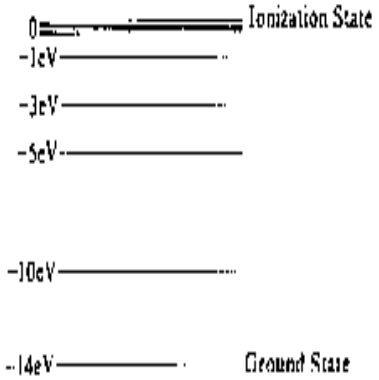
(A) virtual and erect
(B) larger than the object
(C) located inside the focal point
(D) located at a distance between f and 2f from the lens
(E) located at a distance more than by from the lens



70. Two conducting spheres of different radii, as shown above, each have charge - Q. Which of the following occurs when the two spheres are connected with a conducting wire?

(A) No charge flows.
(B) Negative charge flows from the larger sphere to the smaller sphere until the electric field at the surface of each sphere is the same.
(C) Negative charge flows from the larger sphere to the smaller sphere until the electric potential of each sphere is the same.
(D) Negative charge flows from the smaller sphere to the larger sphere until the electric field at the surface of each sphere is the same.
(E) Negative charge flows from the smaller sphere to the larger sphere until the electric potential of each sphere is the same.

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



70. The energy level diagram above is for a hypothetical atom. A gas of these atoms initially in the ground state is irradiated with photons having a continuous range of energies between 7 and 10 electron volts, One would expect photons of which of the following energies to he emitted from the gas?
    (A) 1, 2, and 3 eV only
    (B) 4, 5, and 9 eV only
    (C) 1, 3, 5, and 10 eV only
    (D) 1, 5, 3, and 10 eV only
    (E) Since the original photons have a range of energies, one would expect a range of emitted photons with no particular energies

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

1998 PHYSICS B
SECTION I
Time--90 minutes
70 Questions

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding oval on the answer sheet.

Note: To simplify calculations, you may use $g = 10\ m/s^2$ in all problems.

1. A solid metal ball and a hollow plastic ball of the same external radius are released from rest in a large vacuum chamber. When each has fallen I m, they both have the same

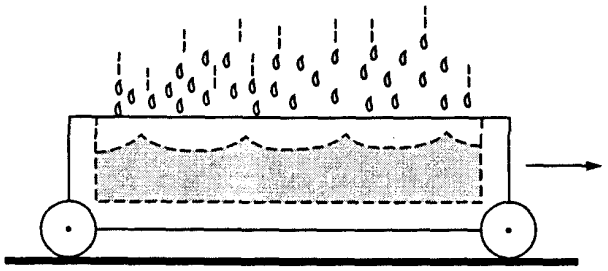
   (A) inertia
   (B) speed
   (C) momentum
   (D) kinetic energy
   (E) change in potential energy

2. A student weighing 700 N climbs at constant speed to the top of an 8 in vertical rope in 10 s. The average power expended by the student to overcome gravity is most nearly

   (A) 1.1 W
   (B) 87.5 W
   (C) 560 W
   (D) 875 W
   (E) 5,600 W

3. A railroad car of mass *m* is moving at speed υ when it collides with a second railroad car of mass *M* which is at rest. The two cars lock together instantaneously and move along the track. What is the speed of the cars immediately after the collision?

   (A) $\frac{\upsilon}{2}$
   (B) $\frac{m\upsilon}{M}$
   (C) $\frac{M\upsilon}{m}$
   (D) $\frac{(m + M)\,\upsilon}{m}$
   (E) $\frac{mv}{m+M}$



4. An open cart on a level surface is rolling without frictional loss through a vertical downpour of rain, as shown above. As the cart rolls, an appreciable amount of rainwater accumulates in the cart. The speed of the cart will

   (A) increase because of conservation of momentum
   (B) increase because of conservation of mechanical energy
   (C) decrease because of conservation of momentum
   (D) decrease because of conservation of mechanical energy
   (E) remain the same because the raindrops are falling perpendicular to the direction of the cart's motion

5. Units of power include which of the following?

   I. Watt
   II. Joule per second
   III. Kilowatt-hour

   (A) I only
   (B) III only
   (C) I and II only
   (D) II and III only
   (E) I, II, and III

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

6. A 2 kg object moves in a circle of radius 4 m at a constant speed of 3 m/s. A net force of 4.5 N acts on the object. What is the angular momentum of the object with respect to an axis perpendicular to the circle and through its center?

(A) $9\,\frac{\mathrm{N}\cdot\mathrm{m}}{\mathrm{kg}}$

(B) $12\,\frac{\mathrm{m}^2}{\mathrm{s}}$

(C) $13.5\,\frac{\mathrm{kg}\cdot\mathrm{m}^2}{\mathrm{s}^2}$

(D) $18\,\frac{\mathrm{N}\cdot\mathrm{m}}{\mathrm{kg}}$

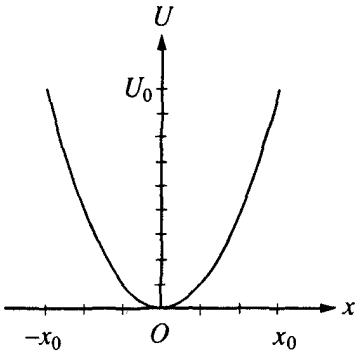
(E) $24\,\frac{\mathrm{kg}\cdot\mathrm{m}^2}{\mathrm{s}}$

7. Three forces act on an object. If the object is in translational equilibrium, which of the following must be true?

I. The vector sum of the three forces must equal zero.
II. The magnitudes of the three forces must be equal
III. All three forces must be parallel

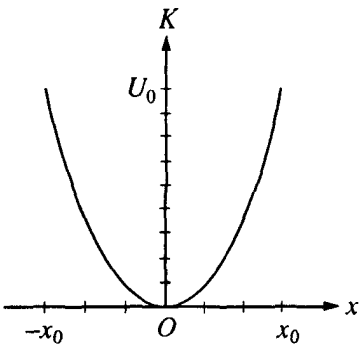
(A) I only
(B) II only
(C) I and III only
(D) II and III only
(E) I, II, and III

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

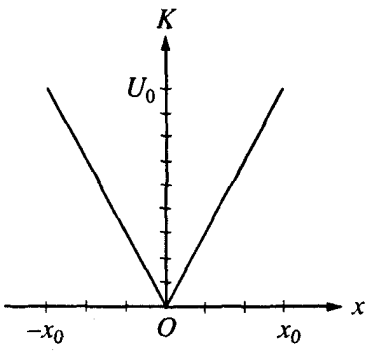


8. The graph above represents the potential energy U as a function of displacement x for an object on the end of a spring oscillating in simple harmonic motion with amplitude x_0. Which of the following graphs represents the kinetic energy **K** of the object as a function of displacement x?

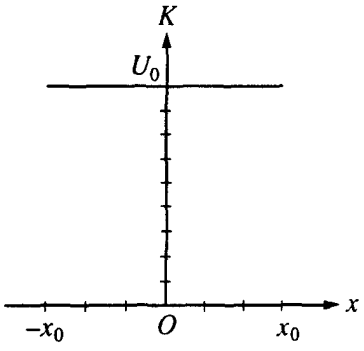
(A)



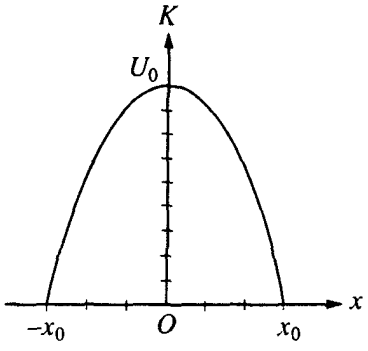
(B)



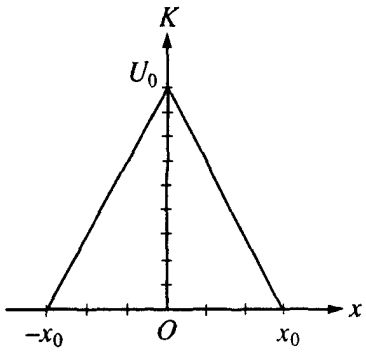
(C)



(D)



(E)



Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

9. A child pushes horizontally on a box of mass m which moves with constant speed υ across a horizontal floor. The coefficient of friction between the box and the floor is μ. At what rate does the child do work on the box?

   (A) $\mu mg\upsilon$
   (B) $mg\upsilon$
   (C) $\upsilon/\mu mg$
   (D) $\mu mg/\upsilon$
   (E) $\mu m\upsilon^2$

10. Quantum transitions that result in the characteristic sharp lines of the X-ray spectrum always involve

    (A) the inner electron shells
    (B) electron energy levels that have the same principal quantum number
    (C) emission of beta particles from the nucleus
    (D) neutrons within the nucleus
    (E) protons within the nucleus

11. Which of the following experiments provided evidence that electrons exhibit wave properties?

    I. Millikan oil-drop experiment
    II. Davisson-Germer electron-diffraction experiment
    III. J. J. Thomson's measurement of the charge-to-mass ratio of electrons

    (A) I only
    (B) II only
    (C) I and III only
    (D) II and III only
    (E) I, II, and III

12. Quantities that are conserved in all nuclear reactions include which of the following?

    I. Electric charge
    II. Number of nuclei
    III. Number of protons

    (A) I only
    (B) II only
    (C) I and III only
    (D) II and III only
    (E) I, II, and III

13. Which of the following is true about the net force on an uncharged conducting sphere in a uniform electric field?

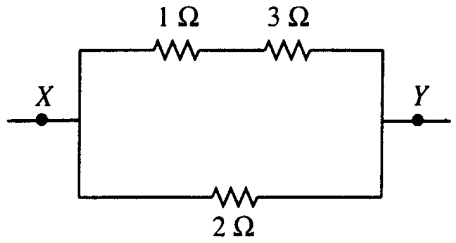
    (A) It is zero.
    (B) It is in the direction of the field.
    (C) It is in the direction opposite to the field.
    (D) It produces a torque on the sphere about the direction of the field.
    (E) It causes the sphere to oscillate about an equilibrium position.

14. Two parallel conducting plates are connected to a constant voltage source. The magnitude of the electric field between the plates is 2,000 N/C. If the voltage is doubled and the distance between the plates is reduced to 1/5 the original distance, the magnitude of the new electric field is

    (A) 800 N/C
    (B) 1,600 N/C
    (C) 2,400 N/C
    (D) 5,000 N/C
    (E) 20,000 N/C

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

Questions 15-16 refer to the following diagram that shows part of a closed electrical circuit.



15. The electrical resistance of the part of the circuit shown between point X and point Y is

(A) $1\frac{1}{3}\Omega$

(B) 2Ω

(C) $2\frac{3}{4}\Omega$

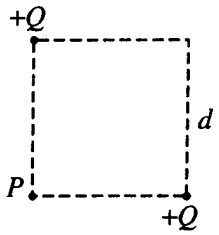
(D) 4Ω

(E) 6Ω

16. When there is a steady current in the circuit, the amount of charge passing a point per unit of time is

(A) the same everywhere in the circuit
(B) greater at point X than at point Y
(C) greater in the 1Ω resistor than in the 2Ω resistor
(D) greater in the 1Ω resistor than in the 3Ω resistor
(E) greater in the 2Ω resistor than in the 3Ω resistor

Questions 17-18



The figure above shows two particles, each with a charge of +Q, that are located at the opposite corners of a square of side *d*.

17. What is the direction of the net electric field at point P ?

(A) 

(B) 

(C) 

(D) 

(E) 

18. What is the potential energy of a particle of charge $+q$ that is held at point P ?

(A) Zero

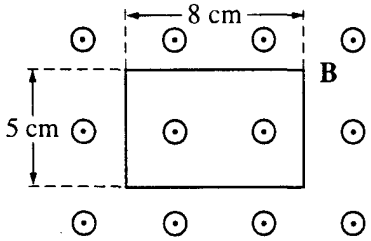
(B) $\frac{\sqrt{2}}{4\pi\epsilon_0}\frac{qQ}{d}$

(C) $\frac{1}{4\pi\epsilon_0}\frac{qQ}{d}$

(D) $\frac{2}{4\pi\epsilon_0}\frac{qQ}{d}$

(E) $\frac{2\sqrt{2}}{4\pi\epsilon_0}\frac{qQ}{d}$

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

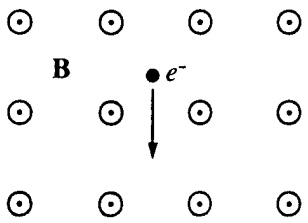


19. A rectangular wire loop is at rest in a uniform magnetic field **B** of magnitude 2 T that is directed out of the page. The loop measures 5 cm by 8 cm, and the plane of the loop is perpendicular to the field, as shown above. The total magnetic flux through the loop is

(A) zero
(B) 2×10^{-3} T•m^2
(C) 8×10^{-3} T•m^2
(D) 2×10^{-1} T•m^2
(E) 8×10^{-1} T•m^2

20. A certain coffeepot draws 4.0 A of current when it is operated on 120 V household lines. If electrical energy costs 10 cents per kilowatt-hour, how much does it cost to operate the coffeepot for 2 hours?

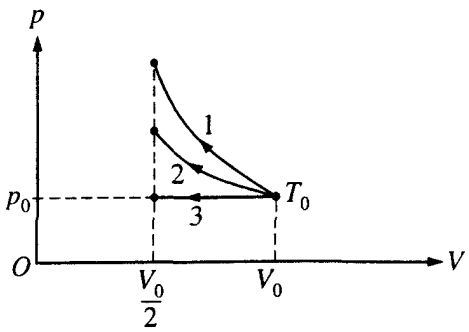
(A) 2.4 cents
(B) 4.8 cents
(C) 8.0 cents
(D) 9.6 cents
(E) 16 cents



22. An electron is in a uniform magnetic field **B** that is directed out of the plane of the page, as shown above. When the electron is moving in the plane of the page in the direction indicated by the arrow, the force on the electron is directed

(A) toward the right
(B) out of the page
(C) into the page
(D) toward the top of the page
(E) toward the bottom of the page

Questions 22-23



A certain quantity of an ideal gas initially at temperature T_0, pressure p_0, and volume V_0 is compressed to one-half its initial volume. As shown above, the process may be adiabatic (process 1), isothermal (process 2), or isobaric (process 3).

21. Which of the following is true of the mechanical work done on the gas?

(A) It is greatest for process 1.
(B) It is greatest for process 3.
(C) It is the same for processes I and 2 and less for process 3.
(D) It is the same for processes 2 and 3 and less for process 1.
(E) It is the same for all three processes.

23. Which of the following is true of the final temperature of this gas?

(A) It is greatest for process 1.
(B) It is greatest for process 2.
(C) It is greatest for process 3.
(D) It is the same for processes 1 and 2.
(E) It is the same for processes 1 and 3.

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

24. In a certain process, 400 J of heat is added to a system and the system simultaneously does 100 J of work. The change in internal energy of the system is

(A) 500 J
(B) 400 J
(C) 300 J
(D) -100 J
(E) -300 J

25. An ice cube of mass *m* and specific heat c_i is initially at temperature T_1, where $T_1 < 273$ K. If *L is* the latent heat of fusion of water, and the specific heat of water is c_w how much energy is required to convert the ice cube to water at temperature T_2, where $273 \text{ K} < T_2 < 373 \text{ K}$?

(A) $m[c_i(273 - T_1) + L + c_w (373 - T_2)]$

(B) $m[c_i(273 - T_1) + L + c_w (T_2 - 273)]$

(C) $c_i (273 - T_1) + c_w (T_2 - 273)$

(D) $mL + c_w (T_2 - T_1)$

(E) $mL + \left(\frac{c_w + c_i}{2}\right)(T_2 - T_1)$

26. A concave mirror with a radius of curvature of 1.0 m is used to collect light from a distant star. The distance between the mirror and the image of the star is most nearly

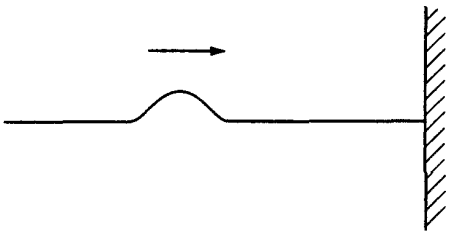
(A) 0.25m
(B) 0.50 m
(C) 0.75 m
(D) 1.0 m
(E) 2.0 m

27. When light passes from air into water, the frequency of the light remains the same. What happens to the speed and the wavelength of light as it crosses the boundary in going from air into water?

	Speed	Wavelength
(A)	Increases	Remains the same
(B)	Remains the same	Decreases
(C)	Remains the same	Remains the same
(D)	Decreases	Increases
(E)	Decreases	Decreases

28. A physics student places an object 6.0 cm from a converging tens of focal length 9.0 cm. What is the magnitude of the magnification of the image produced?

(A) 0.6
(B) 1.5
(C) 2.0
(D) 3.0
(E) 3.6

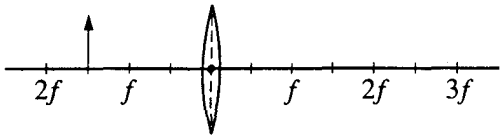


29. One end of a horizontal string is fixed to a wall. A transverse wave pulse is generated at the other end, moves toward the wall as shown above, and is reflected at the wall. Properties of the reflected pulse include which of the following?

I. It has a greater speed than that of the incident pulse.
II. It has a greater amplitude than that of the incident pulse.
III. It is on the opposite side of the string from the incident pulse.

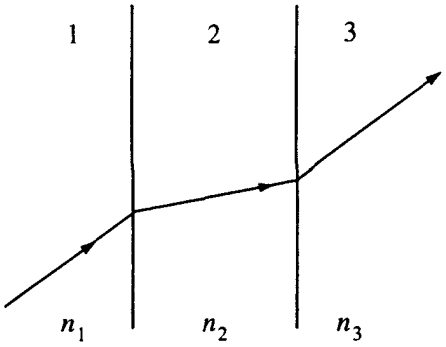
(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



30. An object is placed at a distance of $1.5f$ from a converging lens of focal length f, as shown above. What type of image is formed and what is its size relative to the object?

Type	Size
(A) Virtual	Larger
(B) Virtual	Same size
(C) Virtual	Smaller
(D) Real	Larger
(E) Real	Smaller



31. A light ray passes through substances 1, 2, and 3, as shown above. The indices of refraction for these three substances are n_1, n_2, and n_3, respectively. Ray segments in 1 and in 3 are parallel. From the directions of the ray, one can conclude that

(A) n_3 must be the same as n_1
(B) n_2 must be less than n_1
(C) n_2 must be less than n_3
(D) n_1 must be equal to 1.00
(E) all three indices must be the same

32. At noon a radioactive sample decays at a rate of 4,000 counts per minute. At 12:30 P.m. the decay rate has decreased to 2,000 counts per minute. The predicted decay rate at 1:30 P m. is

(A) 0 counts per minute
(B) 500 counts per minute
(C) 667 counts per minute
(D) 1,000 counts per minute
(E) 1,333 counts per minute

33. A negative beta particle and a gamma ray are emitted during the radioactive decay of a nucleus of $^{214}_{82}\mathrm{Pb}$. Which of the following is the resulting nucleus?

(A) $^{214}_{80}\mathrm{Hg}$
(B) $^{214}_{81}\mathrm{Tl}$
(C) $^{213}_{83}\mathrm{Bi}$
(D) $^{214}_{83}\mathrm{Bi}$
(E) $^{218}_{84}\mathrm{Po}$

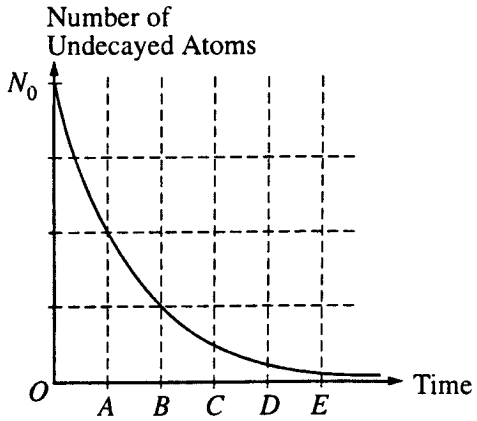
34. If the momentum of an electron doubles, its de Broglie wavelength is multiplied by a factor of

(A) $\frac{1}{4}$
(B) $\frac{1}{2}$
(C) 1
(D) 2
(E) 4

35. Quantum concepts are critical in explaining all of the following EXCEPT

(A) Rutherford's scattering experiments
(B) Bohr's theory of the hydrogen atom
(C) Compton scattering
(D) the blackbody spectrum
(E) the photoelectric effect

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



36. The graph above shows the decay of a sample of carbon 14 that initially contained N_0 atoms. Which of the lettered points on the time axis could represent the half-life of carbon 14 ?

(A) A
(B) B
(C) C
(D) D
(E) E

37. If photons of light of frequency f have momentum p, photons of light of frequency $2f$ will have a momentum of

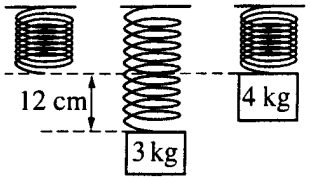
(A) $2p$

(B) $\sqrt{2}p$

(C) p

(D) $\frac{p}{\sqrt{2}}$

(E) $\frac{1}{2}p$



38. A block of mass 3.0 kg is hung from a spring, causing it to stretch 12 cm at equilibrium, as shown above. The 3.0 kg block is then replaced by a 4.0 kg block, and the new block is released from the position shown above, at which the spring is unstretched. How far will the 4.0 kg block fall before its direction is reversed?

(A) 9 cm
(B) 18 cm
(C) 24 cm
(D) 32 cm
(E) 48 cm

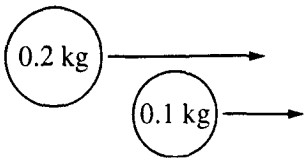
39. An object has a weight W when it is on the surface of a planet of radius *R*. What will be the gravitational force on the object after it has been moved to a distance of *4R* from the center of the planet?

(A) $16W$
(B) $4W$
(C) W
(D) $\frac{1}{4}W$
(E) $\frac{1}{16}W$

40. What is the kinetic energy of a satellite of mass *m* that orbits the Earth, of mass M, in a circular orbit of radius R ?

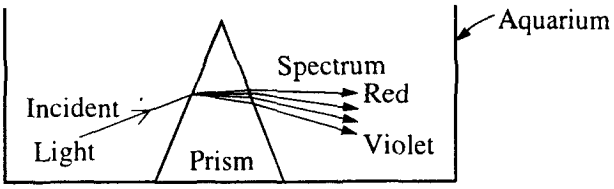
(A) Zero
(B) $\frac{1}{2}\frac{GMm}{R}$
(C) $\frac{1}{4}\frac{GMm}{R}$
(D) $\frac{1}{2}\frac{GMm}{R^2}$
(E) $\frac{GMm}{R^2}$

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



41. Two objects of mass 0.2 kg and 0.1 kg, respectively, move parallel to the x-axis, as shown above. The 0.2 kg object overtakes and collides with the 0. 1 kg object. Immediately after the collision, the y-component of the velocity of the 0.2 kg object is 1 m/s upward. What is the y-component of the velocity of the 0.1 kg object immediately after the collision?

(A) 2 m/s downward
(B) 0.5 m/s downward
(C) 0 m/s
(D) 0.5 m/s upward
(E) 2 m/s upward

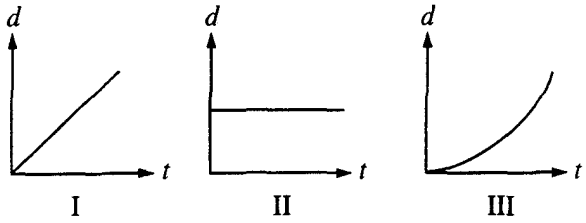


42. A beam of white Bight is incident on a triangular glass prism with an index of refraction of about 1.5 for visible light, producing a spectrum. Initially, the prism is in a glass aquarium filled with air, as shown above. If the aquarium is filled with water with an index of refraction of 1.3, which of the following is true?

(A) No spectrum is produced.
(B) A spectrum is produced, but the deviation of the beam is opposite to that in air.
(C) The positions of red and violet are reversed in the spectrum.
(D) The spectrum produced has greater separation between red and violet than that produced in air.
(E) The spectrum produced has less separation between red and violet than that produced in air.

Questions 43-44

Three objects can only move along a straight, level path. The graphs below show the position d of each of the objects plotted as a function of time t.



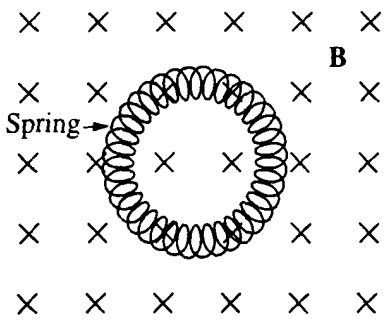
43. The magnitude of the momentum of the object is increasing in which of the cases?

(A) II only
(B) III only
(C) I and II only
(D) I and III only
(E) I, II, and III

44. The sum of the forces on the object is zero in which of the cases?

(A) II only
(B) III only
(C) I and II only
(D) I and III only
(E) I, II, and III

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



45. A metal spring has its ends attached so that it forms a circle. It is placed in a uniform magnetic field, as shown above. Which of the following will NOT cause a current to be induced in the spring?

(A) Changing the magnitude of the magnetic field
(B) Increasing the diameter of the circle by stretching the spring
(C) Rotating the spring about a diameter
(D) Moving the spring parallel to the magnetic field
Moving the spring in and out of the magnetic field

A magnetic field of 0.1 T forces a proton beam of 1.5 mA to move in a circle of radius 0.1 m. The plane of the circle is perpendicular to the magnetic field.

46. Of the following, which is the best estimate of the work done by the magnetic field on the protons during one complete orbit of the circle?

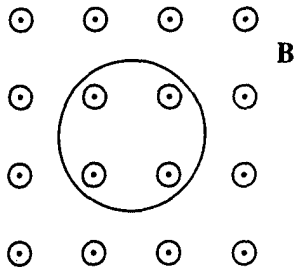
(A) 0 J
(B) 10^{-22} J
(C) 10^{-5} J
(D) 10^{2} J
(E) 10^{20} J

47. Of the following, which is the best estimate of the speed of a proton in the beam as it moves in the circle?

(A) 10^{-2} m/s
(B) 10^{3} m/s
(C) 10^{6} m/s
(D) 10^{8} m/S
(E) 10^{15} m/s

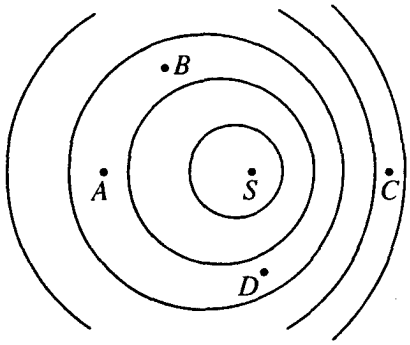
Questions 46-47

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



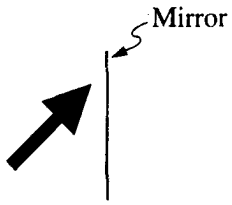
48. A single circular loop of wire in the plane of the page is perpendicular to a uniform magnetic field B directed out of the page, as shown above. If the magnitude of the magnetic field is decreasing, then the induced current in the wire is

(A) directed upward out of the paper
(B) directed downward into the paper
(C) clockwise around the loop
(D) counterclockwise around the loop
(E) zero (no current is induced)

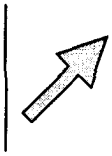


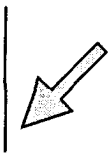
49. A small vibrating object on the surface of a ripple tank is the source of waves of frequency 20 Hz and speed 60 cm/s. If the source S is moving to the right, as shown above, with speed 20 cm/s, at which of the labeled points will the frequency measured by a stationary observer be greatest?

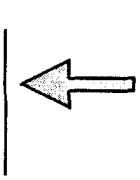
(A) A
(B) B
(C) C
(D) D
(E) It will be the same at all four points.

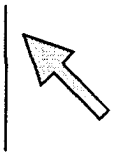


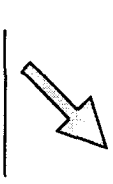
50. An object, slanted at an angle of 45°, is placed in front of a vertical plane mirror, as shown above. Which of the following shows the apparent position and orientation of the object's image?

(A)


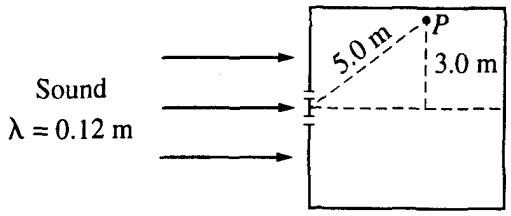
(B)


(C)


(D)


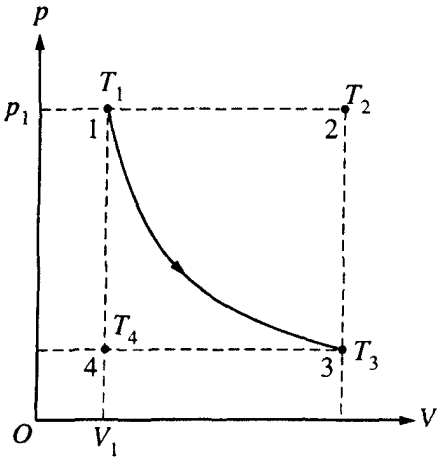
(E)


Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



51. Plane sound waves of wavelength 0.12 m are incident on two narrow slits in a box with nonreflecting walls, as shown above. At a distance of 5.0 m from the center of the slits, a first-order maximum occurs at point P, which is 3.0 m from the central maximum. The distance between the slits is most nearly

(A) 0.07 m
(B) 0.09 m
(C) 0.16 m
(D) 0.20 m
(E) 0.24 m



52. An ideal gas is initially in a state that corresponds to point 1 on the graph above, where it has pressure p_1, volume V_1, and temperature T_1. The gas undergoes an isothermal process represented by the curve shown, which takes it to a final state 3 at temperature T_3. If T_2 and T_4 are the temperatures the gas would have at points 2 and 4, respectively, which of the following relationships is true?

(A) $T_1 < T_3$
(B) $T_1 < T_2$
(C) $T_1 < T_4$
(D) $T_1 = T_2$
(E) $T_1 = T_4$

53. The absolute temperature of a sample of monatomic ideal gas is doubled at constant volume. What effect, if any, does this have on the pressure and density of the sample of gas?

	Pressure	Density
(A)	Remains the same	Remains the same
(B)	Remains the same	Doubles
(C)	Doubles	Remains the same
(D)	Doubles	Is multiplied by a factor of 4
(E)	Is multiplied by a factor of 4	Doubles

54. The disk-shaped head of a pin is 1.0 mm in diameter. Which of the following is the best estimate of the number of atoms in the layer of atoms on the top surface of the pinhead?

(A) 10^4
(B) 10^{14}
(C) 10^{24}
(D) 10^{34}
(E) 10^{50}

55. In an experiment, light of a particular wavelength is incident on a metal surface, and electrons are emitted from the surface as a result, To produce more electrons per unit time but with less kinetic energy per electron, the experimenter should do which of the following?

(A) Increase the intensity and decrease the wavelength of the light.
(B) Increase the intensity and the wavelength of the light.
(C) Decrease the intensity and the wavelength of the light.
(D) Decrease the intensity and increase the wavelength of the light.
(E) None of the above would produce the desired result.

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

56. An object moves up and down the y -axis with an acceleration given as a function of time *t* by the expression $a = A\sin\omega t$, where *A* and ω are constants. What is the period of this motion?

(A) ω

(B) $2\pi\omega$

(C) $\omega^2 A$

(D) $\dfrac{2\pi}{\omega}$

(E) $\dfrac{\omega}{2\pi}$

57. A ball of mass 0.4 kg is initially at rest on the ground. It is kicked and leaves the kicker's foot with a speed of 5.0 m/s in a direction 60° above the horizontal. The magnitude of the impulse imparted by the ball to the foot is most nearly

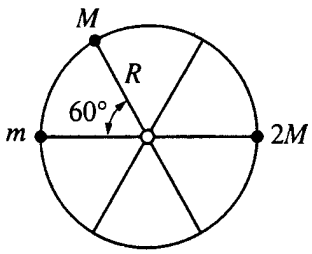
(A) $1\ \mathrm{N\cdot s}$

(B) $\sqrt{3}\ \mathrm{N\cdot s}$

(C) $2\ \mathrm{N\cdot s}$

(D) $\dfrac{2}{\sqrt{3}}\ \mathrm{N\cdot s}$

(E) $4\ \mathrm{N\cdot s}$



58. A wheel of radius *R* and negligible mass is mounted on a horizontal frictionless axle so that the wheel is in a vertical plane. Three small objects having masses *m*, *M*, and 2*M*, respectively, are mounted on the rim of the wheel, as shown above. If the system is in static equilibrium, what is the value of *m* in terms of *M?*

(A) $\dfrac{M}{2}$

(B) M

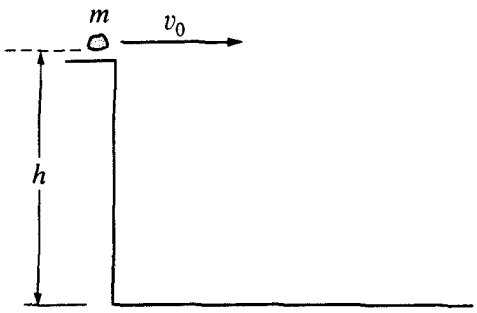
(C) $\dfrac{3M}{2}$

(D) $2M$

(E) $\dfrac{5m}{2}$

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

Questions 59-60



A rock of mass *m* is thrown horizontally off a building from a height *h*, as shown above. The speed of the rock as it leaves the thrower's hand at the edge of the building is υ_0.

59. How much time does it take the rock to travel from the edge of the building to the ground?

(A) $\sqrt{h\upsilon_0}$

(B) h/υ_0

(C) $h\upsilon_0/g$

(D) $2h/g$

(E) $\sqrt{2h/g}$

60. What is the kinetic energy of the rock just before it hits the ground?

(A) mgh

(B) $\frac{1}{2}m\upsilon_0^2$

(C) $\frac{1}{2}m\upsilon_0^2 - mgh$

(D) $\frac{1}{2}m\upsilon_0^2 + mgh$

(E) $mgh - \frac{1}{2}m\upsilon_0^2$

61. Which of the following statements is NOT a correct assumption of the classical model of an ideal gas?

(A) The molecules are in random motion.
(B) The volume of the molecules is negligible compared with the volume occupied by the gas.
(C) The molecules obey Newton's laws of motion.
(D) The collisions between molecules are inelastic.
(E) The only appreciable forces on the molecules are those that occur during collisions.

62. A sample of an ideal gas is in a tank of constant volume. The sample absorbs heat energy so that its temperature changes from 300 K to 600 K. If υ_1 is the average speed of the gas molecules before the absorption of heat and υ_2 is their average speed after the absorption of heat, what is the ratio υ_2/υ_1?

(A) $\frac{1}{2}$

(B) 1

(C) $\sqrt{2}$

(D) 2

(E) 4

63. Two people of unequal mass are initially standing still on ice with negligible friction. They then simultaneously push each other horizontally. Afterward, which of the following is true?

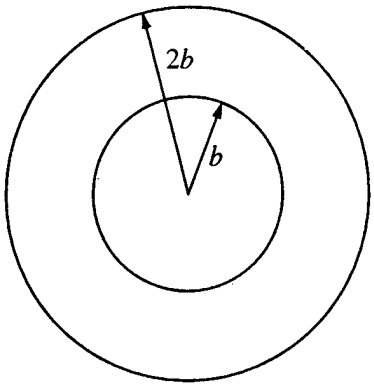
(A) The kinetic energies of the two people are equal.
(B) The speeds of the two people are equal.
(C) The momenta of the two people are of equal magnitude.
(D) The center of mass of the two-person system moves in the direction of the less massive person.
(E) The less massive person has a smaller initial acceleration than the more massive person.

64. Two parallel conducting plates, separated by a distance *d*, are connected to a battery of emf ε. Which of the following is correct if the plate separation is doubled while the battery remains connected?

(A) The electric charge on the plates is doubled.
(B) The electric charge on the plates is halved.
(C) The potential difference between the plates is doubled.
(D) The potential difference between the plates is halved.
(E) The capacitance is unchanged.

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603

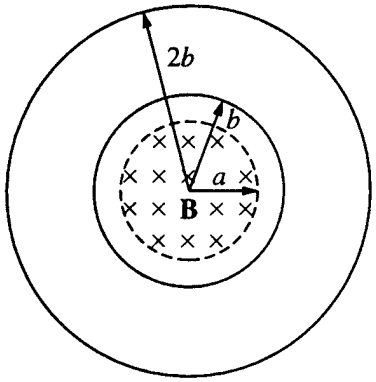
Questions 65-66



Two concentric circular loops of radii *b* and *2b*, made of the same type of wire, lie in the plane of the page, as shown above.

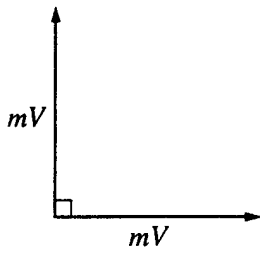
65. The total resistance of the wire loop of radius *b* is R. What is the resistance of the wire loop of radius 2*b* ?

(A) *R*/4
(B) *R*/2
(C) *R*
(D) 2*R*
(E) 4*R*



66. A uniform magnetic field **B** that is perpendicular to the plane of the page now passes through the loops, as shown above. The field is confined to a region of radius a, where a < b, and is changing at a constant rate. The induced emf in the wire loop of radius b is $\mathcal{E}$. What is the induced emf in the wire loop of radius 2b ?

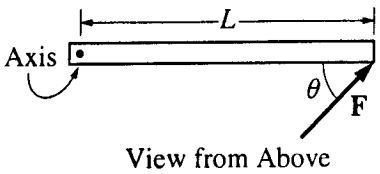
(A) Zero
(B) $\mathcal{E}/2$
(C) $\mathcal{E}$
(D) $2\mathcal{E}$
(E) $4\mathcal{E}$



67. A stationary object explodes, breaking into three pieces of masses *m*, *m*, and 3*m*. The two pieces of mass *m* move off at right angles to each other with the same magnitude of momentum *m*V, as shown in the diagram above. What are the magnitude and direction of the velocity of the piece having mass 3*m* ?

	Magnitude	Direction
(A)	$\frac{V}{\sqrt{3}}$	↗
(B)	$\frac{V}{\sqrt{3}}$	↙
(C)	$\frac{\sqrt{2}\,V}{3}$	↗
(D)	$\frac{\sqrt{2}\,V}{3}$	↙
(E)	$\sqrt{2}\,V$	↙

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603



View from Above

68. A rod on a horizontal tabletop is pivoted at one end and is free to rotate without friction about a vertical axis, as shown above. A force **F** is applied at the other end, at an angle θ to the rod. If **F** were to be applied perpendicular to the rod, at what distance from the axis should it be applied in order to produce the same torque?

(A) $L\sin\theta$
(B) $L\cos\theta$
(C) L
(D) $L\tan\theta$
(E) $\sqrt{2}L$

69. Which of the following imposes a limit on the number of electrons in an energy state of an atom?

(A) The Heisenberg uncertainty principle
(B) The Pauli exclusion principle
(C) The Bohr model of the hydrogen atom
(D) The theory of relativity
(E) The law of conservation of energy

70. A 4 μF capacitor is charged to a potential difference of 100 V. The electrical energy stored in the capacitor is

(A) 2×10^{-10} J
(B) 2×10^{-8} J
(C) 2×10^{-6} J
(D) 2×10^{-4} J
(E) 2×10^{-2} J

S T 0 P

END OF SECTION I

IF YOU FINISH BEFORE TIME IS CALLED,
YOU MAY
CHECK YOUR WORK ON THIS SECTION.

DO NOT GO ON TO SECTION II UNTIL YOU
ARE TOLD TO DO SO.

Copyright © 1976 to 1998 by Educational Testing Service, Princeton, NJ 08541. All rights reserved. For face-to-face teaching purposes. Classroom teachers are permitted to reproduce the questions. Made available for convenience, accessibility and adaptation purposes by Ron Esman, Abilene High School, 2800 N. 6th Street, Abilene, Texas 79603