




PHYSICS TEST

Note: To simplify calculations, you may use $g = 10 \text{ m/s}^2$ for the acceleration due to gravity at Earth's surface.

Part A

Directions: Each set of lettered choices below refers to the numbered questions immediately following it. Select the one lettered choice that best answers each question, and then fill in the corresponding circle on the answer sheet. A choice may be used once, more than once, or not at all in each set.

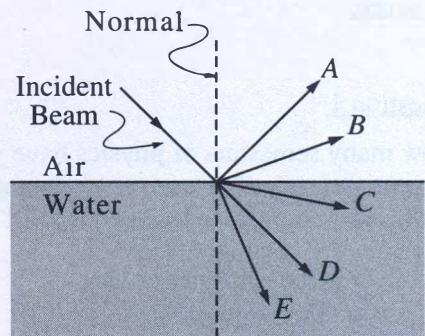
Questions 1-3 refer to the following list of physical quantities.

Questions 4-5

- (A) Kinetic energy
- (B) Momentum
- (C) Velocity
- (D) Acceleration
- (E) Displacement

A narrow beam of light traveling in air is directed toward the surface of water as shown below. The labeled arrows show possible paths of the beam after it reaches the water surface.

1. Which quantity is nearly constant for an object falling freely in a vacuum near Earth's surface?
2. Which quantity has the units kilogram•meter/second?
3. Which quantity is NOT a vector?



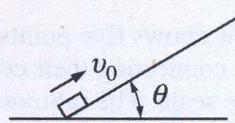
- (A) Path A
 - (B) Path B
 - (C) Path C
 - (D) Path D
 - (E) Path E
4. Which path is followed by the refracted ray?
 5. Which path is followed by the reflected ray?


PHYSICS TEST—Continued
Questions 6-7

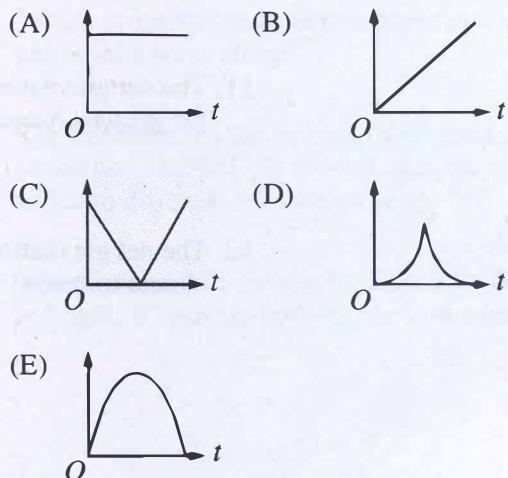
Two very small, identical conducting spheres are used in electrostatics experiments. In each experiment, sphere A initially has a charge Q , and sphere B is initially uncharged. For each of the procedures described, select the choice below that best indicates the final charges on the spheres.

<u>Sphere A</u>	<u>Sphere B</u>
(A) Zero	Zero
(B) $Q/2$	$Q/2$
(C) Q	Q
(D) Q	$-Q$
(E) $2Q$	$-Q$

6. Sphere A is touched to sphere B, which is otherwise isolated, and then removed.
7. Sphere B is grounded, and sphere A is touched to sphere B. Then the ground is removed, and the spheres are separated.

Questions 8-10


A block is projected with initial speed v_0 up a frictionless inclined plane, as shown above. The block slides up the plane and then returns to the bottom. Consider the following graphs showing functions of time t .



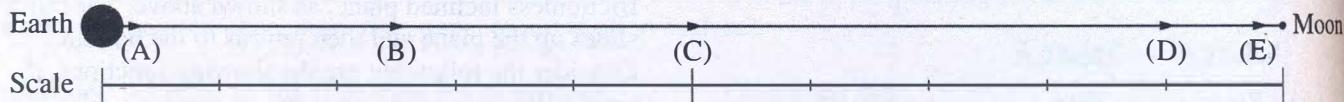
8. Which graph could represent the magnitude of the acceleration of the block as a function of t ?
9. Which graph could represent the displacement from the starting point of the block as a function of t ?
10. Which graph could represent the speed of the block as a function of t ?



PHYSICS TEST—*Continued*

Questions 11-12

The figure below shows five points on the trajectory of a rocket that is assumed to travel from the Earth to the Moon along a line connecting their centers. The sizes of the Earth and Moon and the distance between them are shown on the same scale. The ratio of the mass of the Earth to the mass of the Moon is approximately 81: 1. The rocket burns out just before reaching point (A), and then travels under the influence of gravitational forces alone until hitting the Moon.



11. The net gravitational force on the rocket will have the greatest magnitude at which point?
 12. The net gravitational force on the rocket will be closest to zero at which point?



PHYSICS TEST—Continued

Questions 13-14

Each choice below gives a possible change in a quantity X when another quantity is changed. In each question, assume that all factors not mentioned are constant.

- (A) X decreases to one-ninth its original value.
 - (B) X decreases to one-third its original value.
 - (C) X stays at the same value.
 - (D) X increases to three times its original value.
 - (E) X increases to nine times its original value.
13. X is the displacement of a ball after the ball falls freely from rest for a certain time. If the ball falls freely from rest for three times as long and air resistance is negligible, what happens to X ?
14. X is the period of a pendulum. If the mass of the pendulum is tripled, what happens to X ?

Questions 15-18 refer to the following properties of waves.

- (A) Frequency
- (B) Amplitude
- (C) Speed
- (D) Phase
- (E) Wavelength

15. Which property is greater for a note played loudly on a piano than for the same note played softly?
16. Which property can be determined from the period of a wave alone?
17. The difference in the amount of diffraction of sound and visible light around open doorways is due to differences in which property?
18. Which property is greater for blue light than for red light, if both are traveling in a vacuum?

PHYSICS TEST—Continued**Part B**

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 circle on the answer sheet.

19. The speed of sound in air is about 330 meters per second. A girl sees a flash of lightning and 10 seconds later hears the thunder from that flash. The distance between the girl and the location of the lightning is most nearly

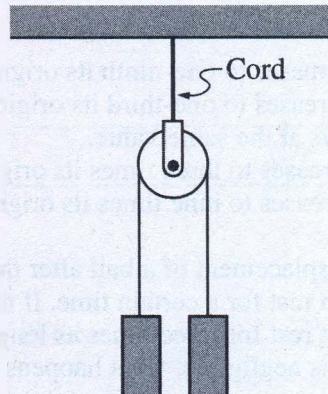
- (A) 33 m
- (B) 100 m
- (C) 330 m
- (D) 1,000 m
- (E) 3,300 m

20. A small ball is dropped from rest at a point 45.0 meters above the ground. Air resistance is negligible. The time it will take the ball to hit the ground is most nearly

- (A) 1.50 s
- (B) 2.12 s
- (C) 3.00 s
- (D) 4.50 s
- (E) 9.00 s

21. If the net force acting on an object is multiplied by 6 and the mass of the object is doubled, the acceleration of the object will be multiplied by

- (A) 12
- (B) 6
- (C) 3
- (D) $\frac{1}{3}$
- (E) $\frac{1}{12}$

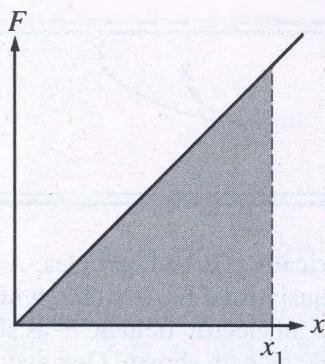


22. Two blocks of equal weight W are suspended over a massless pulley that is hung from the ceiling by a cord, as shown above. When the blocks are at rest, the tension in the cord connecting the pulley to the ceiling is

- (A) Zero
- (B) $W/2$
- (C) W
- (D) $2W$
- (E) $3W$



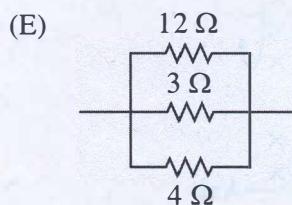
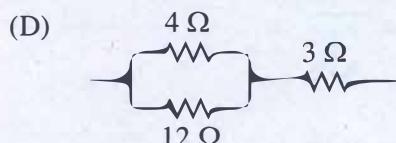
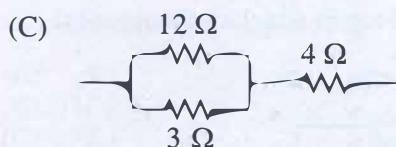
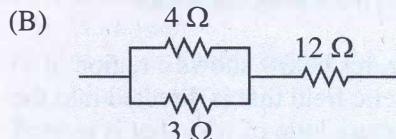
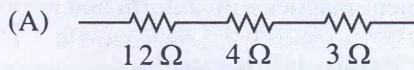
PHYSICS TEST—Continued



23. The graph above shows the magnitude of the force F exerted by a spring on a block attached to it as a function of the distance x that the spring is compressed. When the spring is compressed a distance x_1 , which of the following quantities is represented by the shaded area?

- (A) The value of the spring constant of the spring
- (B) The potential energy stored in the spring
- (C) The acceleration of the block
- (D) The maximum velocity of the block
- (E) The change in momentum of the block

24. A resistance of 6 ohms is required in a certain circuit. Only three resistors are available, and they have resistances of 12, 4, and 3 ohms, respectively. Which of the following arrangements would give the required resistance?





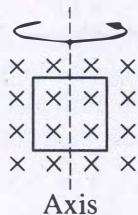
PHYSICS TEST—Continued

25. If each end of a metal bar is attracted to the north pole of a permanent magnet, it can be correctly concluded that the bar is

- (A) a permanent magnet with two south poles
- (B) a permanent magnet with two north poles
- (C) a permanent magnet with a north and a south pole
- (D) made of a substance that can be magnetized
- (E) made of an insulating substance

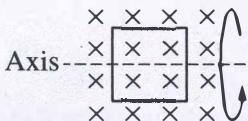
26. Each of the figures below shows a region of uniform magnetic field that is directed into the paper, and a square loop of wire that is rotated around an axis as shown. There is an induced current in the loop in which of these cases?

I.



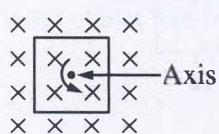
Axis

II.



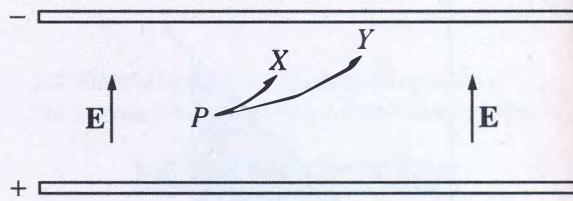
Axis

III.



Axis

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



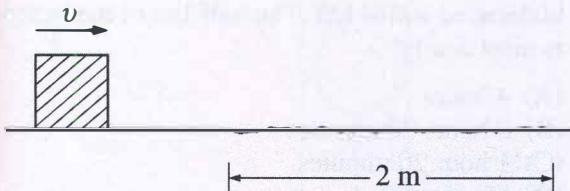
27. Two electrically charged particles, X and Y , are simultaneously fired horizontally with different speeds into an electric field at P as shown above. Each traces the path shown. One may correctly conclude that

- (A) X has a greater mass than Y
- (B) Y has a greater mass than X
- (C) X has a greater charge than Y
- (D) Y has a greater charge than X
- (E) X and Y have charges of the same sign



PHYSICS TEST—Continued

Questions 28-30



An 8-kilogram block with 36 joules of kinetic energy slides with velocity v on a frictionless portion of a horizontal surface, as shown above. The block then enters a rough portion of the surface and slides 2 meters before coming to rest.

28. The momentum of the block before it encounters the rough surface is

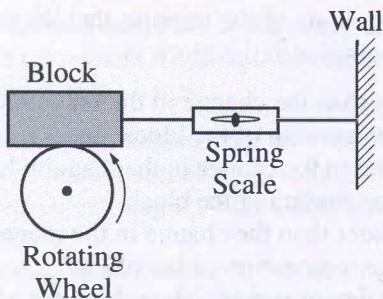
- (A) 12 kg•m/s
- (B) 24 kg•m/s
- (C) 36 kg•m/s
- (D) 72 kg•m/s
- (E) 144 kg•m/s

29. The magnitude of the impulse that the rough surface applies to the block is

- (A) less than the change in the magnitude of the momentum of the block
- (B) equal to the change in the magnitude of the momentum of the block
- (C) greater than the change in the magnitude of the momentum of the block
- (D) not determinable unless the force of friction is known
- (E) not determinable unless the density of the block is known

30. If the initial velocity of the block were only $v/2$, its initial kinetic energy would be

- (A) 9 J
- (B) 18 J
- (C) 36 J
- (D) 144 J
- (E) 288 J


PHYSICS TEST—Continued


31. In the apparatus shown above, the block rests on the wheel as the wheel rotates at constant speed. Which of the following quantities can the apparatus measure directly?

- (A) The weight of the block
- (B) The force of static friction between the block and the wheel
- (C) The force of kinetic friction between the block and the wheel
- (D) The normal force of the wheel on the block
- (E) The speed of the wheel

32. Low-energy neutrons can closely approach a nucleus because neutrons

- (A) have a spin of $1/2$
- (B) have no charge
- (C) can be easily stored
- (D) can be easily accelerated
- (E) can be easily focused

33. At 12 noon, 96 atoms of a particular radioactive isotope existed. At 4 P.M. there were only 12 undecayed atoms left. The half-life of the isotope is most nearly

- (A) 4 hours
- (B) 3 hours 20 minutes
- (C) 1 hour 20 minutes
- (D) 45 minutes
- (E) 2 minutes 45 seconds

34. The neutral atoms of two isotopes of chlorine differ in the number of which of the following?

- (A) Electrons only
- (B) Protons only
- (C) Neutrons only
- (D) Protons and electrons
- (E) Protons and neutrons

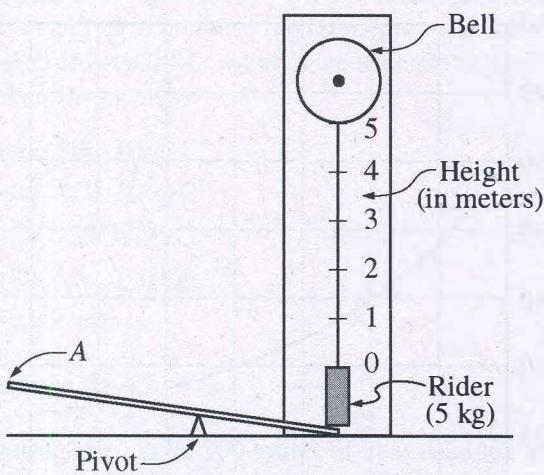
35. Which of the following demonstrates the wave nature of an electron?

- (A) The interference pattern formed by electrons in a double-slit experiment
- (B) Use of a magnetic field to measure the ratio of an electron's charge to its mass
- (C) Emission of an electron in the photoelectric effect
- (D) Measurement of the charge on an electron in the Millikan experiment
- (E) Deflection of an electron beam by a magnetic field



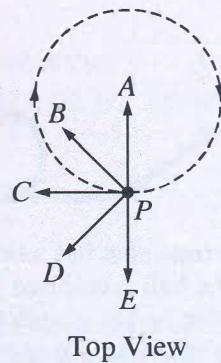
PHYSICS TEST—Continued

Questions 36–37



36. The work that must be done to lift the rider high enough just to touch the bell is most nearly
- 25 J
 - 100 J
 - 250 J
 - 350 J
 - 500 J

37. The rider is driven up the wire, strikes the bell to make a very loud sound, and falls back to its starting position. At which of the following positions is the speed of the rider greatest?
- At the 1-meter mark on the way up
 - At the 3-meter mark on the way up
 - At the 1-meter mark on the way down
 - At the 3-meter mark on the way down
 - The speed is the same at all points.

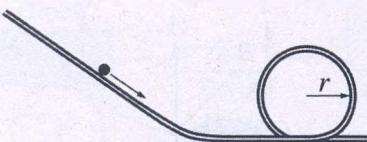


38. A small ball is attached to a string and is swung around in a horizontal circular path with constant speed, as shown in the top view above. If the string were to break when the ball is at point P, which lettered arrow would show the direction of the motion of the ball immediately after the string breaks?
- A
 - B
 - C
 - D
 - E



PHYSICS TEST—Continued

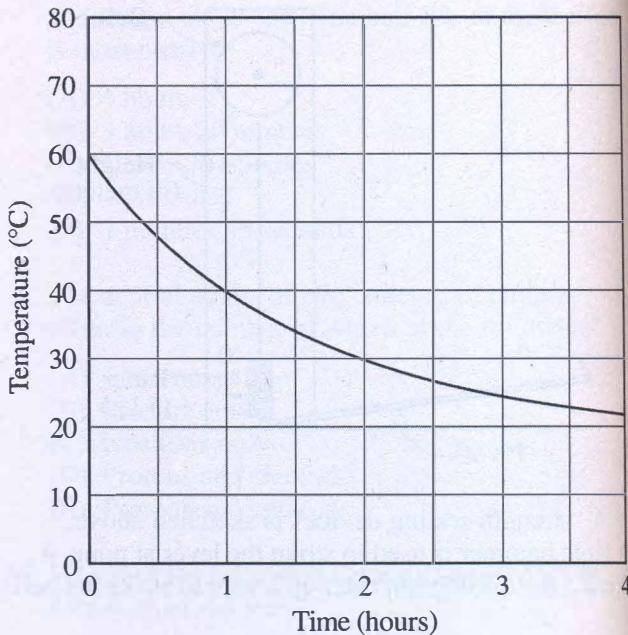
Questions 39–40



A ball rolls on a track that has a loop of radius r , as shown above. The ball is released from rest from a starting point whose height is such that when the ball reaches the top of the loop it is traveling at the minimum speed v required for the ball to remain on the track.

39. If the ball is released from a higher starting point, how will this affect the ball's speed at the top of the loop?
- The speed is less.
 - The speed is the same.
 - The speed is greater.
 - The effect cannot be determined without knowing the exact height of release.
 - The effect cannot be determined without knowing the exact radius of the loop.
40. If the loop is replaced by a new loop of radius $2r$, what is the new minimum speed required for the ball to remain on the track?
- $\frac{1}{2}v$
 - v
 - $\sqrt{2}v$
 - $2v$
 - $4v$

Questions 41–42



The graph above shows the temperature of the water in a tank as a function of time as the water was allowed to cool in a room whose temperature was held constant.

41. After 8 hours of cooling, the temperature of the water would be expected to be closest to
- 0°C
 - 5°C
 - 10°C
 - 20°C
 - 30°C
42. The tank of water loses 8×10^5 joules of heat energy for every degree Celsius that it cools. When it was losing heat energy at the rate of 16×10^6 joules per hour, its temperature was falling at the rate of
- $5 \times 10^{10}^{\circ}\text{C}/\text{hr}$
 - $8 \times 10^5^{\circ}\text{C}/\text{hr}$
 - $2 \times 10^5^{\circ}\text{C}/\text{hr}$
 - $20^{\circ}\text{C}/\text{hr}$
 - $2^{\circ}\text{C}/\text{hr}$


PHYSICS TEST—Continued

43. A sample of a particular substance has a mass of 0.500 kilogram. If 1,000 joules of heat energy is required to increase the temperature of the sample by 4.00°C , what is the specific heat of the substance?
- (A) $500 \text{ J/kg}\cdot\text{C}^{\circ}$
 (B) $250 \text{ J/kg}\cdot\text{C}^{\circ}$
 (C) $125 \text{ J/kg}\cdot\text{C}^{\circ}$
 (D) $62.5 \text{ J/kg}\cdot\text{C}^{\circ}$
 (E) Zero

Questions 44-45

During one cycle, 500 joules of heat is added to a heat engine and 300 joules of work is done by the engine.

44. What is the efficiency of this engine?

- (A) 0.17
 (B) 0.25
 (C) 0.40
 (D) 0.60
 (E) 0.67

45. How much heat is expelled by this engine in one cycle?

- (A) 200 J
 (B) 300 J
 (C) 400 J
 (D) 500 J
 (E) 800 J

Building	Room Temperature in Degrees Celsius	Outside Wall	
		Area in Square Meters	Thickness in Meters
A	20°	9	0.18
B	19°	9	0.20
C	18°	10	0.18
D	17°	10	0.18
E	17°	9	0.20

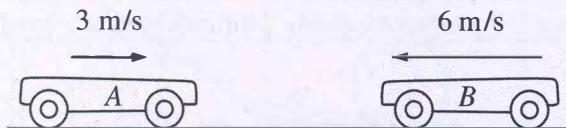
46. Each of five buildings with walls made of the same material has a room with one outside windowless wall. The areas and thicknesses of the outside walls and temperatures inside the rooms are given in the table above. On a winter day when the outside temperature is 5°C , in which of the buildings does the room lose the least amount of heat per unit time through its outside wall?

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



PHYSICS TEST—Continued

Questions 47-49



Two identical carts, each with a mass of 2 kilograms, travel toward each other, as shown above. The initial speed of cart *A* is 3 meters per second, and the initial speed of cart *B* is 6 meters per second. The carts have a head-on elastic collision, and cart *A* bounces back with a speed of 6 meters per second afterward.

47. What is the speed of cart *B* after the collision?

- (A) 1.5 m/s
- (B) 2 m/s
- (C) 3 m/s
- (D) 6 m/s
- (E) 12 m/s

48. The sum of the kinetic energies of the carts after the collision is

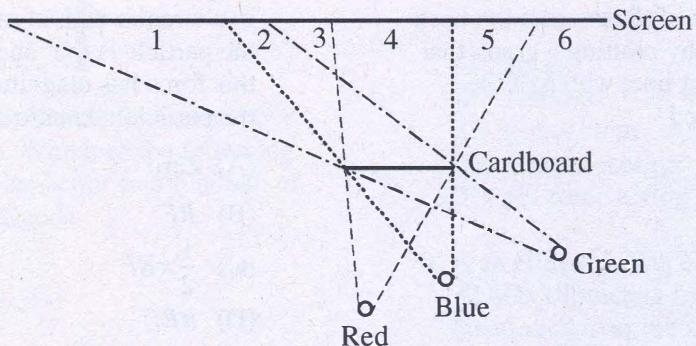
- (A) 4.5 J
- (B) 9 J
- (C) 15 J
- (D) 30 J
- (E) 45 J

49. If instead the collision was inelastic and the carts stuck together, the speed of the carts after the collision would be

- (A) 1.5 m/s
- (B) 2 m/s
- (C) 3 m/s
- (D) 6 m/s
- (E) 12 m/s

50. If a wave has a wavelength of 0.02 meter, an amplitude of 0.005 meter, and a frequency of 4,000 hertz, its speed is

- (A) 80 m/s
- (B) 20 m/s
- (C) 5×10^{-6} m/s
- (D) 80 m
- (E) 20 s

PHYSICS TEST—Continued**Questions 51-52**

Three very small, intense lightbulbs of different colors are placed in front of a screen, and a rectangular piece of cardboard is placed between them and the screen, as shown in the figure above.

51. In which of the labeled regions of the screen could an observer stand and not be able to see any of the bulbs?

- (A) 3 only
- (B) 4 only
- (C) 2 and 3
- (D) 4 and 5
- (E) At least one of the bulbs is visible in each region.

52. In which of the labeled regions of the screen will the illumination of the screen be most nearly white?

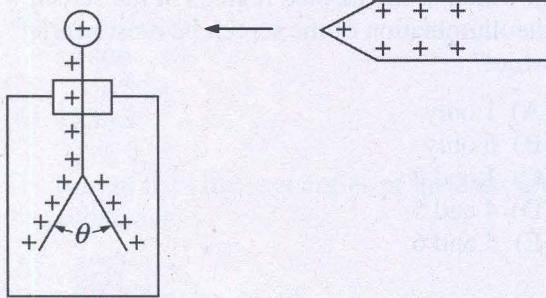
- (A) 1 only
- (B) 6 only
- (C) 1 and 2
- (D) 4 and 5
- (E) 5 and 6



PHYSICS TEST—Continued

53. Quantity A is measured for several different values of quantity B , and it appears that A is proportional to the square of B . In order to check the apparent relationship by plotting a graph that is expected to be a straight line, which of the following should be plotted?

- (A) A vs. B
- (B) A vs. B^2
- (C) A vs. \sqrt{B}
- (D) A vs. $1/B$
- (E) A vs. $1/B^2$

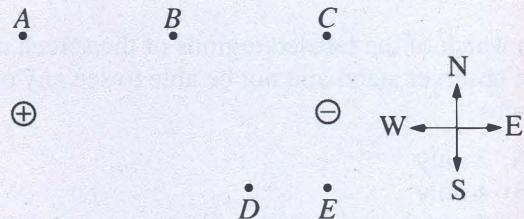


54. A positively charged electroscope contains two movable leaves that make an angle θ between them, as shown above. Assume that no charge leaks from the electroscope. As a positively charged rod is brought near but does not touch the electroscope, the angle θ will

- (A) decrease only
- (B) decrease at first and then increase
- (C) not change
- (D) increase only
- (E) increase at first and then decrease

55. A charged particle in a region of uniform magnetic field moves perpendicular to the field in a circular path of radius R . The only force on the particle is that due to the magnetic field, and this force has magnitude F . What is the change in the particle's kinetic energy for each revolution?

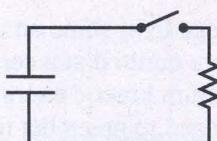
- (A) Zero
- (B) RF
- (C) $\frac{1}{2}\pi RF$
- (D) πRF
- (E) $2\pi RF$



56. Two spheres with equal and opposite charges are shown in the figure above. At which of the locations shown would the electrical force on a small negative charge be directly west?

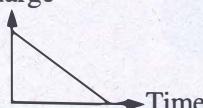
- (A) A
- (B) B
- (C) C
- (D) D
- (E) E

PHYSICS TEST—Continued

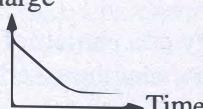


57. A charged capacitor is connected as shown above to a resistor and a switch. Which of the following shows the charge on the capacitor as a function of time after the switch is closed?

(A) Charge



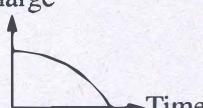
(B) Charge



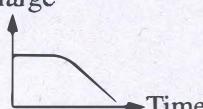
(C) Charge



(D) Charge



(E) Charge



58. At some instant, an object that has constant nonzero acceleration may have all of the following quantities equal to zero EXCEPT

- (A) speed
- (B) velocity
- (C) momentum
- (D) kinetic energy
- (E) net force acting on it

59. A satellite orbiting Earth at a distance of 42,000 kilometers from its center is always positioned over the same location on Earth's equator. Which of the following gives the numerical value for the speed of the satellite, in meters per second?

(A) $\frac{2\pi(4.2 \times 10^7)}{24(60)(60)}$

(B) $\frac{2\pi(4.2 \times 10^{10})}{24(60)(60)}$

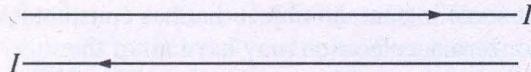
(C) $\frac{2\pi(4.2 \times 10^4)}{24(60)}$

(D) $\frac{2\pi(4.2 \times 10^7)}{24(60)}$

(E) $\frac{2\pi(4.2 \times 10^7)}{(60)(60)}$



PHYSICS TEST—Continued



60. Two long wires each carry a current I in opposite directions, as shown above. At a point halfway between the wires, these currents cause

(A) a magnetic field parallel to the wires
 (B) an electric field parallel to the wires
 (C) a magnetic field perpendicular to the page
 (D) an electric field perpendicular to the page
 (E) no field of any kind

61. According to present theory, possible states in the evolution of stars include all of the following EXCEPT

(A) red giant
 (B) white dwarf
 (C) black hole
 (D) quasar
 (E) supernova

62. Rutherford proposed the nuclear model for the atom on the basis of experiments in which a beam of alpha particles was fired through a thin gold foil. The important observation in this experiment was that

(A) some gold nuclei were knocked out of the foil
 (B) no alpha particles were deflected
 (C) most alpha particles were absorbed
 (D) some alpha particles were deflected slightly
 (E) a few alpha particles were deflected backward

63. Photons of orange light shine on a metallic surface and electrons are emitted at a certain rate and with a certain maximum kinetic energy. If the color of the light is changed to green but the rate of photons striking the metal is not changed, which of the following changes?

I. The energy of the incident photons
 II. The electrons' maximum kinetic energy
 III. The work function of the material

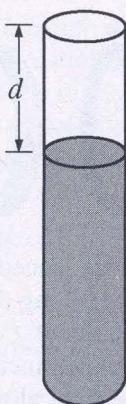
(A) II only
 (B) III only
 (C) I and II only
 (D) I and III only
 (E) I, II, and III

64. What is the total energy of a particle of mass m moving at a velocity v near the speed of light?

(A) $\frac{1}{2}mv^2$
 (B) mc^2
 (C) $mc^2 - \frac{1}{2}mv^2$
 (D) $\frac{1}{2}mv^2 - mc^2$
 (E) $\frac{mc^2}{\sqrt{1-v^2/c^2}}$



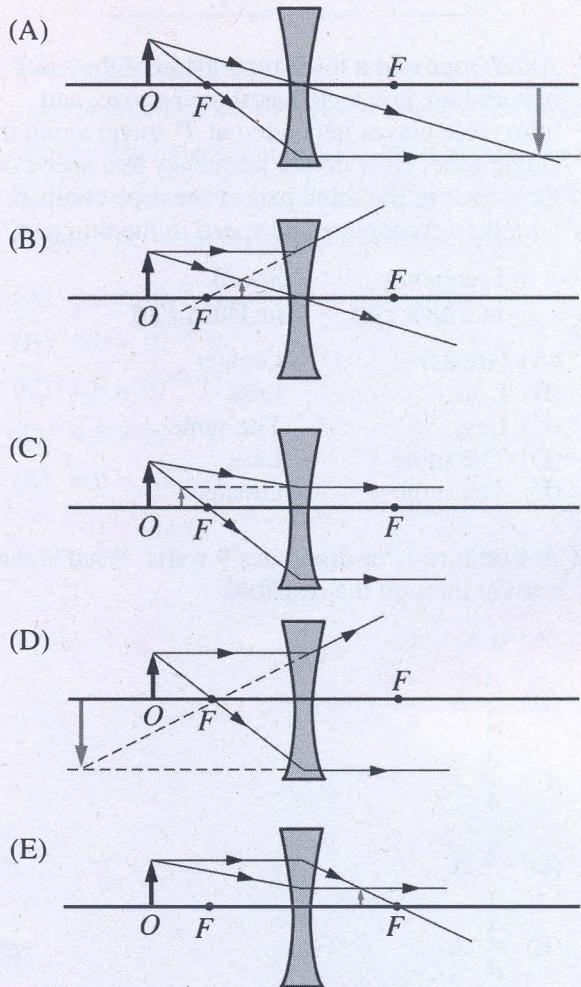
PHYSICS TEST—Continued



65. A vibrating tuning fork is held above the glass tube shown above. As the water level in the glass tube is raised, a resonance is observed when the level is a distance $d = 63$ centimeters from the top of the tube, and again when $d = 49$ centimeters. At which of the following values of d would one expect to find another resonance?

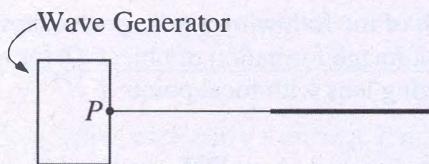
- (A) 56 cm
- (B) 42 cm
- (C) 28 cm
- (D) 14 cm
- (E) 7 cm

66. Which of the following ray diagrams shows the correct image formation of object O for a diverging lens with focal points F ?





PHYSICS TEST—Continued



67. A thin rope and a thick rope made of the same material are connected as shown above, and transverse waves generated at P travel along this single rope. How do the frequency and speed of the waves in the thick part of the rope compare with their frequency and speed in the thin part?

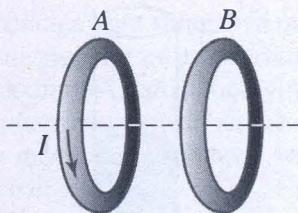
<u>Frequency in Thick Part</u>	<u>Speed in Thick Part</u>
------------------------------------	--------------------------------

- (A) Greater
- (B) Less
- (C) Less
- (D) The same
- (E) The same

<u>Frequency in Thick Part</u>	<u>Speed in Thick Part</u>
------------------------------------	--------------------------------

68. A 4-ohm resistor dissipates 9 watts. What is the current through the resistor?

- (A) 6 A
- (B) $\frac{9}{2}$ A
- (C) $\frac{9}{4}$ A
- (D) $\frac{3}{2}$ A
- (E) $\frac{3}{4}$ A



69. Two loops of wire are placed parallel to each other, with their axes along the dashed line as shown above. The current I in loop A is increasing, producing an increasing magnetic field directed to the right along the dashed line. What is the direction of the current induced in loop B relative to the current in loop A , and the direction of the magnetic field at the center of loop B created by this induced current?

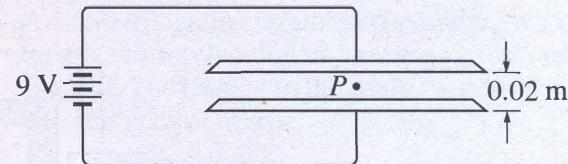
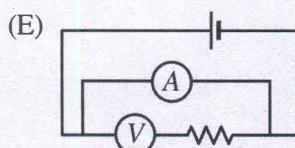
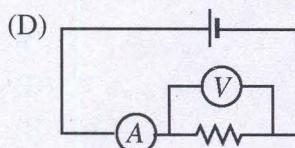
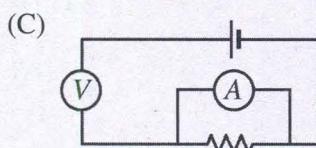
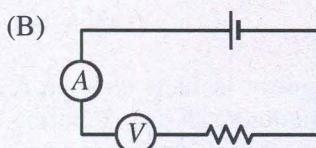
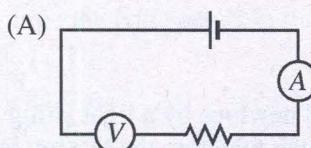
<u>Current Direction</u>	<u>Field Direction</u>
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- | | |
|--------------------------|-------------------------------|
| (A) Opposite that in A | To the right |
| (B) Opposite that in A | To the left |
| (C) Same as that in A | To the right |
| (D) Same as that in A | To the left |
| (E) Same as that in A | Toward the top
of the page |



PHYSICS TEST—Continued

70. The resistance of a length of heater wire is to be determined from measurements of current and voltage. Which of the diagrams below, in which the heater wire is represented as a resistor, shows a correct placement of an ammeter *A* and a voltmeter *V* to provide these measurements?

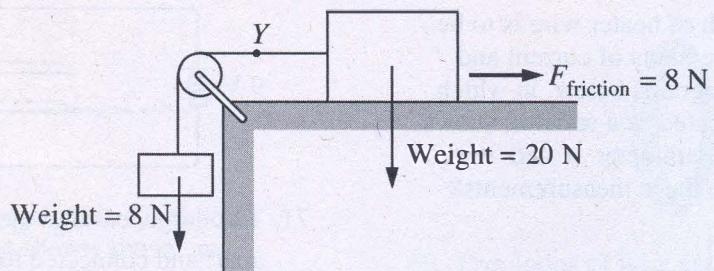


71. Two large, parallel metal plates are 0.02 meter apart and connected to a 9-volt battery, as shown above. What electrical force is exerted on a charge of 1×10^{-6} coulombs placed at point *P*, which is halfway between the plates near their center?

- (A) 2.2×10^{-9} N
- (B) 9.0×10^{-8} N
- (C) 1.8×10^{-7} N
- (D) 4.5×10^{-4} N
- (E) 9.0×10^{-4} N



PHYSICS TEST—Continued



72. The box weighing 20 newtons shown above is connected to another box weighing 8 newtons by a light string that passes over a frictionless pulley. If the 20 newton box remains at rest on the rough tabletop, the tension in the string at point Y is
- (A) 0 N (B) 8 N (C) 16 N (D) 20 N (E) 28 N



PHYSICS TEST—Continued

73. One person throws a ball that is caught by another person who is 60 meters away. The ball leaves the thrower's hand with an initial velocity of 25 meters per second directed at 37° above the horizontal ($\sin 37^\circ = 3/5$, $\cos 37^\circ = 4/5$). The time the ball spends in the air is most nearly
- (A) 1.5 s
 (B) 2.0 s
 (C) 2.4 s
 (D) 3.0 s
 (E) 4.0 s

74. A mass on an ideal spring oscillates with a period T , and its amplitude of oscillation is A . If the amplitude is increased to $4A$, the period will be

- (A) $\frac{T}{16}$
 (B) $\frac{T}{2}$
 (C) T
 (D) $2T$
 (E) $16T$

75. A 1,000-kilogram elevator is descending with a downward acceleration of 2 meters per second squared. The tension in the cable supporting the elevator is most nearly
- (A) 2,000 N
 (B) 6,000 N
 (C) 8,000 N
 (D) 10,000 N
 (E) 12,000 N

S T O P

**IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS TEST ONLY.
DO NOT TURN TO ANY OTHER TEST IN THIS BOOK.**