

AAPT/NSTA Introductory Examination Version 1988 R

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Directions:

- 1) **DO NOT OPEN** this examination booklet until you are asked to do so by your teacher.
- 2) **DO NOT WRITE** anything in the examination booklet. Your teacher will provide you with scrap paper and an answer sheet.
- 3) Copy the **VERSION NUMBER** onto your answer sheet. See number at the top right of this page.
- 4) Each question or incomplete statement has a single best answer. When you decide which answer is correct for a question, completely blacken the corresponding space on the answer sheet with a soft pencil. Make a heavy black mark that completely fills the space to record your answer. Mark only one answer for each question. If you wish to change your answer, completely erase the first mark.
- 5) This examination is divided into five sections as follows:

PART I

SECTION A. Mechanics	24 questions	27 minutes	page 3
SECTION B. Waves, Optics, and Sound	16 questions	18 minutes	page 8
TOTAL	40 questions	45 minutes	

PART II

SECTION C. Heat & Kinetic Theory	8 questions	9 minutes	page 12
SECTION D. Electricity & Magnetism	20 questions	23 minutes	page 14
SECTION E. Modern Physics	12 questions	13 minutes	page 20
TOTAL	40 questions	45 minutes	

You should answer only the questions in the section(s) that your teacher instructs you to answer.

6) The score on this examination is equal to the number of correct answers given. Thus it is to your advantage to answer every question in the section(s) assigned by your teacher.

7) The following values are given:

- a) magnitude of acceleration due to gravity at Earth's surface = $10.0 \text{ meters/second}^2$
- b) $4.2 \text{ joules} = 1.0 \text{ caloric}$
- c) speed of light in a vacuum = $3.0 \times 10^8 \text{ meters/second}$
- d) speed of sound in air at room temperature = $330 \text{ meters/second}$

8) When you are instructed to stop working, put down your pencil, close this examination booklet, and wait for directions from your teacher.

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AAPT/NSTA

1988 Introductory Physics Examination

Part I - SECTION A

Mechanics

1. A solid homogeneous object has a mass of 1.0×10^3 kilograms and a volume of 5.0 meters^3 . What is the volume of a 1.0 kilogram piece of this object?

- (A) $5.0 \times 10^{-3} \text{ meter}^3$
- (B) $2.0 \times 10^{-2} \text{ meter}^3$
- (C) $5.0 \times 10^{-1} \text{ meter}^3$
- (D) $2.0 \times 10^{-2} \text{ meters}^3$
- (E) $5.0 \times 10^{-3} \text{ meters}^3$

2. A constant unbalanced force is applied to a 2.0-kilogram object which was initially at rest. If the object moves 4.0 meters in 2.0 seconds, what is the momentum of the object after the 2.0 seconds?

- (A) 1.0 kilogram•meter/second
- (B) 2.0 kilogram•meter/second
- (C) 4.0 kilogram•meter/second
- (D) 8.0 kilogram•meter/second
- (E) 16 kilogram•meter/second

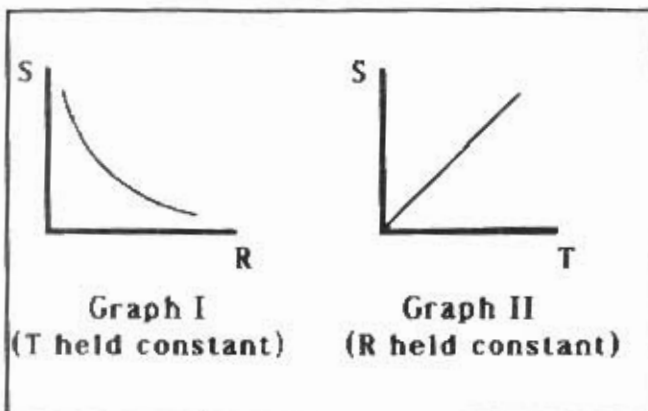


Diagram for Question #3

3. Two experiments were performed to find the relationship between the variables R, S, and T. In the first experiment, T was held constant and graph I above shows the results of the measurements made while varying S and R. In the second experiment, R was held constant and graph II above shows the results of the measurements made while varying S and T.

If K represents a constant, which equation best represents the relationship between R, S, and T?

- (A) $S = K/R + T$
 - (B) $S = K/T + R$
 - (C) $S = KT/R$
 - (D) $S = KR/T$
 - (E) $S = KRT$
4. Which of the following is NOT a vector quantity?
- (A) acceleration
 - (B) displacement
 - (C) energy
 - (D) force
 - (E) velocity

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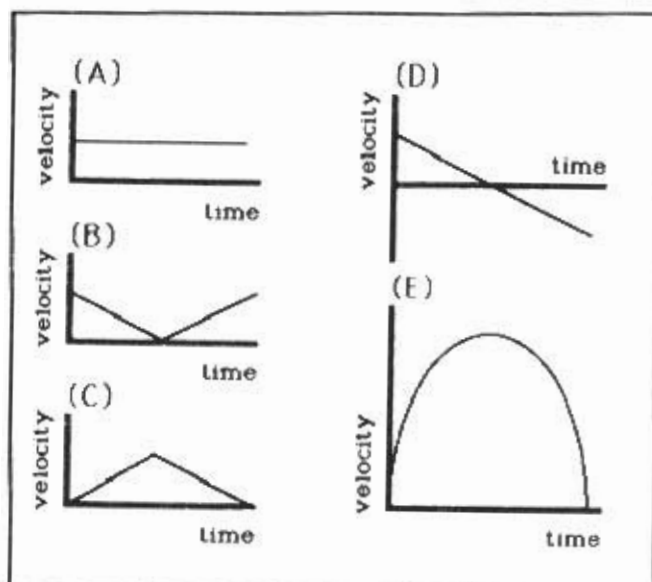


Diagram for Question #5

5. In the diagram above, which graph describes how the velocity of a ball thrown vertically upward changes with time?

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

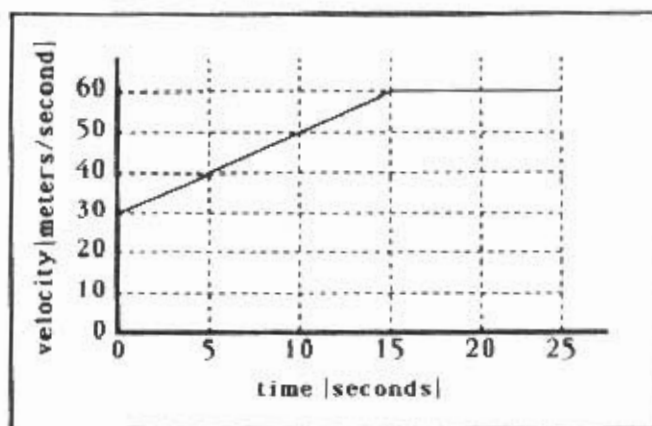


Diagram for Questions #6 and #7.

In the graph, the velocity of an object moving in a straight line is plotted versus time.

6. What is the acceleration of the object between 5 and 10 seconds?

- (A) zero
- (B) 2 meters/second²
- (C) 4 meters/second²
- (D) 5 meters/second²
- (E) 8 meters/second²

7. How far did the object travel between 5 to 10 seconds?

- (A) less than 200 meters
- (B) between 200 and 250 meters
- (C) between 250 and 300 meters
- (D) between 300 and 350 meters
- (E) more than 350 meters

8. If an object is accelerating, then the velocity of that object must be

- (A) zero.
- (B) constant.
- (C) changing.
- (D) decreasing.
- (E) increasing.

9. An automobile travelling at a constant speed rounds a curve with a constant radius. The acceleration of the car is

- (A) zero.
- (B) tangent to the circle.
- (C) directed toward the center of the circle.
- (D) directed outward from the center of the circle.
- (E) vertically upward.

10. The mass of an object can be reduced by

- (A) moving it to the equator.
- (B) allowing it to fall freely.
- (C) whirling it at the end of a string.
- (D) putting it in an orbiting satellite.
- (E) none of the above.

11. A ball is projected at an angle of 30° above the horizontal with a speed of 10 meters/second. Assume the effects caused by air resistance and the size of the Earth are negligible. Which of the following quantities change as the ball moves through the air?

- I. horizontal component of velocity
- II. vertical component of velocity
- III. acceleration

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

PIVOT

12. A force of one newton is approximately equal to the weight of a(n)

- (A) apple.
- (B) elephant.
- (C) fly.
- (D) human.
- (E) nickel.

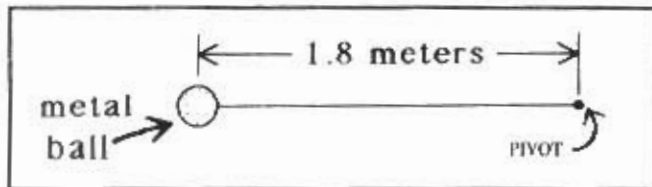


Diagram for Question #13.

13. In the diagram above, a metal ball at the end of a 1.8-meter string is raised so that the string is horizontal and then released. What is the speed of the ball at the lowest point of its path?

- (A) less than 7.0 meters/second
- (B) between 7.0 and 9.0 meters/second
- (C) between 9.0 and 11 meters/second
- (D) between 11 and 13 meters/second
- (E) greater than 13 meters/second

14. If the speed of an object moving around a circle is halved, without changing the radius, the acceleration of the object will

- (A) decrease by a factor of four.
- (B) decrease by a factor of two.
- (C) remain unchanged.
- (D) increase by a factor of two.
- (E) increase by a factor of four.

15. A golf ball was struck by a golf club. Which forces are acting on the ball as it is travelling through the air?

- I. force due to gravity
 - II. force due to golf club
 - III. force due to air resistance
- (A) only force I
 - (B) only forces I and II
 - (C) only forces I and III
 - (D) only forces II and III
 - (E) forces I, II, and III

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16. A net force gives a 10 kilogram object an acceleration of $2.0 \text{ meters/second}^2$. What acceleration will that same net force give a 20 kilogram object?

- (A) $0.50 \text{ meter/second}^2$
- (B) $1.0 \text{ meter/second}^2$
- (C) $2.0 \text{ meters/second}^2$
- (D) $4.0 \text{ meters/second}^2$
- (E) $5.0 \text{ meters/second}^2$

17. The sum of all the forces acting on an object is zero. Which statements could describe the object's motion?

- I. at rest
- II. moving in a straight line with constant speed
- III. moving in a circle with constant speed

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

18. A ball is thrown straight upward. Which statement describes the energy transformation of the ball as it rises?

- (A) Both kinetic energy and potential energy increase.
- (B) Both kinetic energy and potential energy decrease.
- (C) Both kinetic energy and potential energy remain constant.
- (D) Kinetic energy increases and potential energy decreases.
- (E) Kinetic energy decreases and potential energy increases.

19. Which quantity is measured in the same unit as work?

- (A) acceleration
- (B) energy
- (C) force
- (D) impulse
- (E) weight

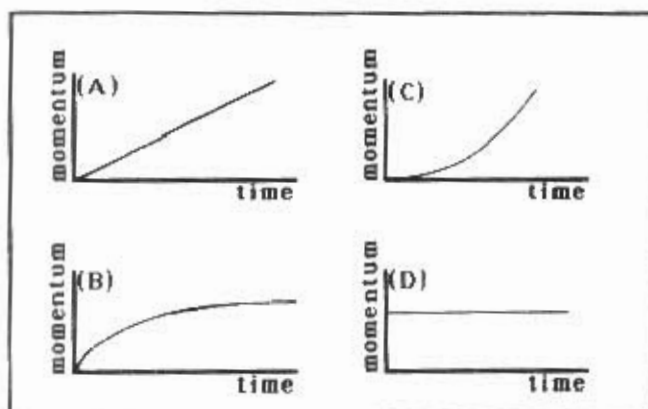
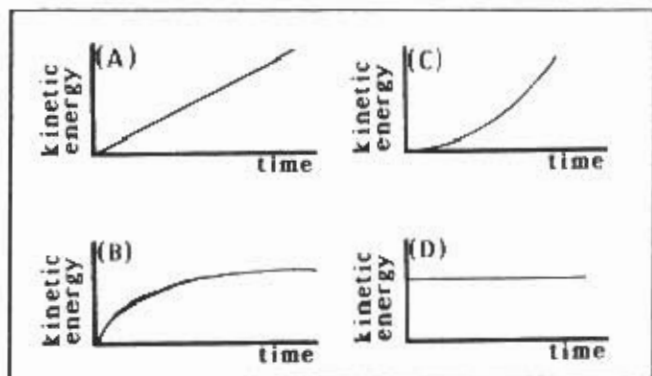


Diagram for Question #20.

20. A car starts from rest and is acted on by a constant force along a straight and level road. The effects of air resistance can be neglected. In the diagram above, which graph best represents the momentum of the car as a function of time?

- (A) A
- (B) B
- (C) C
- (D) D
- (E) none of the above



21. A car starts from rest and is acted on by a constant force along a straight and level road. The effects of air resistance can be neglected. In the diagram above, which graph best represents the kinetic energy of the car as a function of time?

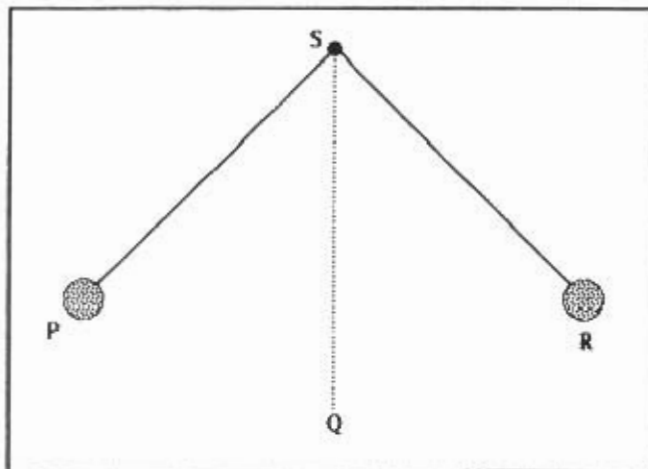
- (A) A
- (B) B
- (C) C
- (D) D
- (E) none of the above

22. What does the area under a graph of net force versus time represent?

- (A) work done
- (B) acceleration
- (C) displacement
- (D) change of momentum
- (E) change of potential energy

23. A bullet with mass m_1 , originally moving with a speed v_1 in a horizontal direction, collides with and becomes imbedded in a block of wood with a mass m_2 . The block of wood was initially at rest on a horizontal frictionless surface. What is an expression for the speed of the block after the collision?

- (A) $m_1 v_1 / m_2$
- (B) $m_1 v_1 / (m_1 + m_2)$
- (C) $m_1 v_1 / (m_1 - m_2)$
- (D) $(m_1 + m_2) v_1 / m_1$
- (E) $m_2 v_1 / m_1$



24. A pendulum bob suspended from point S is released from point P, and swings through point Q toward point R. When the pendulum bob passes through point Q, which statement about the tension in the string is correct?

- (A) The tension is zero.
- (B) The tension is equal to the weight of the pendulum bob.
- (C) The tension is greater than the weight of the pendulum bob.
- (D) The tension is less than the weight of the pendulum bob, but not zero.
- (E) None of the above are correct.

END OF SECTION A

Part I - SECTION B

Waves, Optics, and Sound

25. Which statements are correct?

I. The wavelength of infrared radiation is shorter than the wavelength of green light in the same medium.

II. The speed of light in water is less than the speed of light in vacuum.

III. The frequency of light is directly proportional to its wavelength in the same medium.

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

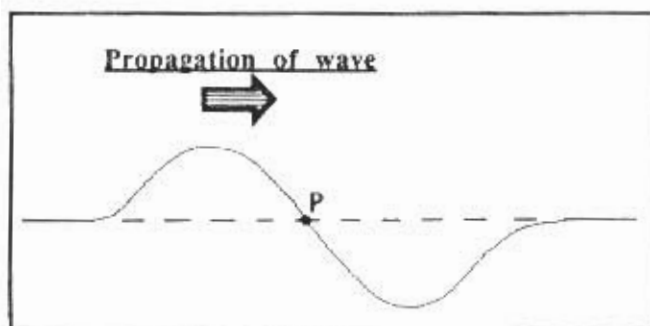


Diagram for Question #26.

26. In the diagram above, a wave pulse is travelling toward the right on a long rope. The diagram above represents a photograph of the wave pulse at a particular instant. Which statement is true about point P on the rope at the instant the photograph was taken?

- (A) The point P is moving up.
- (B) The point P is moving down.
- (C) The point P is stationary, but about to move up.
- (D) The point P is stationary, but about to move down.
- (E) The point P is stationary, and will remain stationary.

27. A source of waves is moving with increasing speed toward a stationary observer. Compared to the frequency of the source, the frequency of the waves measured by the observer is

- (A) smaller and decreasing.
- (B) smaller and increasing.
- (C) the same.
- (D) greater and decreasing.
- (E) greater and increasing.

28. A standing wave pattern is established on a long spring. If the distance between adjacent nodes is 0.40 meter and the frequency of the waves is 5.0 hertz, what is the speed of the waves in the spring?

- (A) zero
- (B) 0.08 meter/second
- (C) 0.16 meter/second
- (D) 2.0 meters/second
- (E) 4.0 meters/second

29. When waves travel from one medium into another (e.g., when water waves travel from deep to shallow water), which properties of the waves **MAY** change?

- I. direction of propagation
- II. frequency
- III. wavelength

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

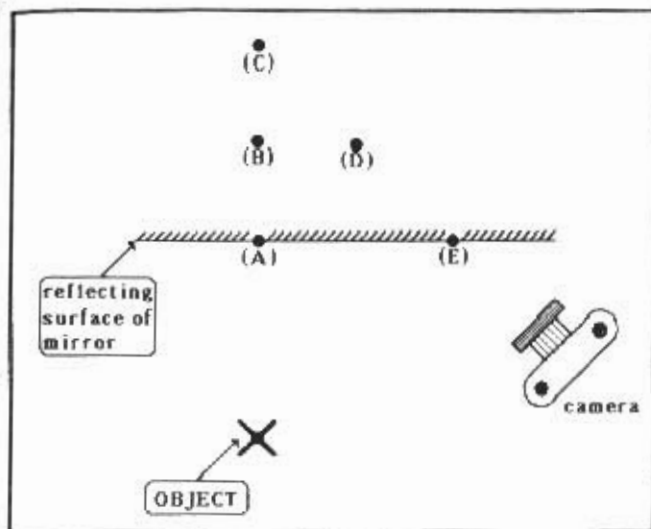


Diagram for Question #30.

30. A camera is used to take a photograph of the flat mirror image of an object placed at position X in the diagram above. On which point should the camera be focused?

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

31. Which phenomenon can be used to distinguish between longitudinal waves and transverse waves?

- (A) diffraction
- (B) polarization
- (C) reflection
- (D) refraction
- (E) speed

32. An object is placed 15 centimeters in front of a converging mirror which has a focal length of 10 centimeters. Which describes the properties of the image?

DISTANCE OF IMAGE FROM MIRROR	SIZE OF IMAGE	ORIENTATION OF IMAGE
(A) less than 10 cm	smaller	erect
(B) less than 10 cm	larger	erect
(C) between 10 cm and 20 cm	smaller	inverted
(D) between 10 cm and 20 cm	larger	inverted
(E) greater than 20 cm	larger	inverted

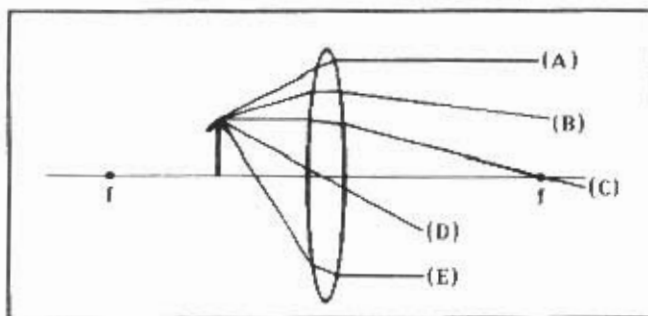


Diagram for Question #33.

33. In the diagram above, which ray is NOT drawn correctly?

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

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34. An object is placed 20 centimeters from a thin converging lens which has a focal length of 30 centimeters. Compared to the object, the image formed will be

- (A) erect, real, and enlarged.
- (B) erect, real, and diminished.
- (C) inverted, real, and enlarged.
- (D) erect, virtual, and enlarged.
- (E) inverted, virtual, and diminished.

35. An object placed 20 centimeters from a thin converging lens forms an image at 10 centimeters on the opposite side of the lens. What is the focal length of the lens?

- (A) 3.3 centimeters
- (B) 6.7 centimeters
- (C) 10 centimeters
- (D) 14 centimeters
- (E) 15 centimeters

36. When light from a point source passes through a small circular opening onto a screen, it forms a spot of light surrounded by concentric light and dark rings. What is the name of this phenomena?

- (A) diffraction
- (B) dispersion
- (C) inverse square law
- (D) reflection
- (E) refraction

37. An interference pattern is produced when red light passes through a pair of slits cut in an opaque surface. If the red light is replaced with blue light the separation of the

bands of light in the interference pattern decreases because the

- (A) speed of red light is greater than speed of blue light.
- (B) frequency of red light is greater than frequency of blue light.
- (C) index of refraction of glass depends on the color of the light.
- (D) wavelength of red light is greater than wavelength of blue light.
- (E) energy of a photon of red light is greater than energy of a photon of blue light.

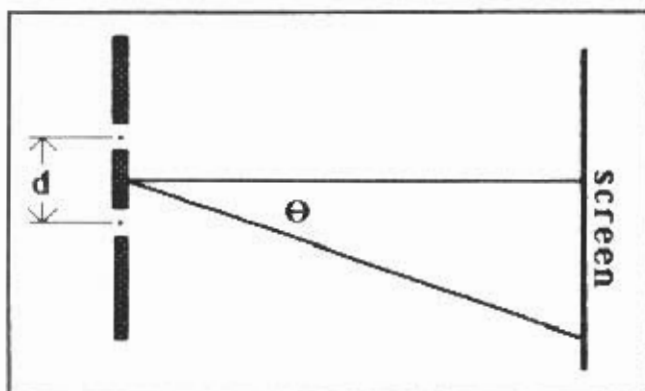


Diagram for Question #38.

38. As shown in the diagram above, monochromatic light of wavelength λ is incident perpendicular to the plane containing a pair of narrow slits d centimeters apart producing an interference pattern. For what values of X in the equation $d \sin \theta = X \lambda$ will the light intensity be a maximum?

- (A) 0, 1, 2, 3, 4, ...
- (B) $1/2, 3/2, 5/2, \dots$
- (C) $1/2, 1, 3/2, 2, \dots$
- (D) 0, $1/2, 1, 3/2, 2, \dots$
- (E) none of the above

39. Which observation provides the **BEST** evidence that sound is a wave phenomenon? Sound can

- (A) reflect.
- (B) refract.
- (C) shatter a glass.
- (D) travel through air.
- (E) produce an interference phenomena.

40. "Sound is not a form of electromagnetic radiation." Which observation provides the **BEST** evidence for this statement?

- (A) Sound can be reflected.
- (B) Sound can be refracted.
- (C) Sound can be diffracted.
- (D) Interference effects can be produced with sound
- (E) Sound travels through air at about 330 meters/second.

END OF SECTION B

END OF PART I

Part II - SECTION C

Heat and Kinetic Theory

41. Which statement about evaporation and boiling at atmospheric pressure is correct?

- (A) Bubbles form during evaporation, but not during boiling.
- (B) Evaporation and boiling are different words for the same thing.
- (C) The heat of vaporization has a larger value for boiling than for evaporation.
- (D) Boiling occurs at a definite temperature, but evaporation can occur over a range of temperatures.
- (E) None of these statements is correct.

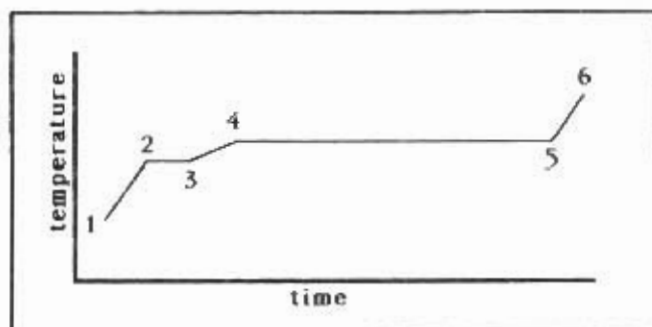


Diagram for Question #42.

42. The graph above shows the temperature of a mass of water versus time as heat is added at a steady rate to the water. Which statement is true?

- (A) The plateau in region 4-5 should be the same length as the plateau in region 2-3.
- (B) In region 3-4 there is a change in the average kinetic energy of the water molecules.
- (C) In region 1-2 the molecules have a greater average separation than molecules in region 5-6.
- (D) In region 1-2 the molecules have the same average potential energy as molecules in region 5-6.
- (E) In region 2-3 the molecules have larger average kinetic energy than molecules in region 4-5.

43. The walls of a vacuum thermos bottle are coated with silver in order to reduce heat transfer by

- (A) conduction.
- (B) convection.
- (C) evaporation.
- (D) radiation.
- (E) sublimation.

44. If the number of molecules of an ideal gas in a container is doubled and the volume is halved while the temperature is held constant, the pressure will be

- (A) decreased by a factor of four.
- (B) decreased by a factor of two.
- (C) unchanged.
- (D) increased by a factor of two.
- (E) increased by a factor of four.

45. Which describes the change in the boiling and freezing points of water when the pressure is increased?

boiling point	freezing point
(A) lowered	lowered
(B) lowered	raised
(C) raised	lowered
(D) raised	raised
(E) not changed	not changed

46. The absolute (Kelvin) temperature of an ideal gas is doubled. The average kinetic energy of the molecules of the gas will

- (A) decrease by a factor of four.
- (B) decrease by a factor of two.
- (C) not change.
- (D) increase by a factor of two.
- (E) increase by a factor of four.

47. Which are examples of heat transfer?

- I. conduction of heat by a metal rod
- II. radiation from an incandescent light bulb
- III. rising hot air

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

48. If each system has the same mass, which system has the greatest entropy?

- (A) ice at zero degrees Celsius
- (B) water at zero degrees Celsius
- (C) water at 50 degrees Celsius
- (D) water at 100 degrees Celsius
- (E) steam at 100 degrees Celsius

END OF SECTION C

Part II - SECTION D

Electricity and Magnetism

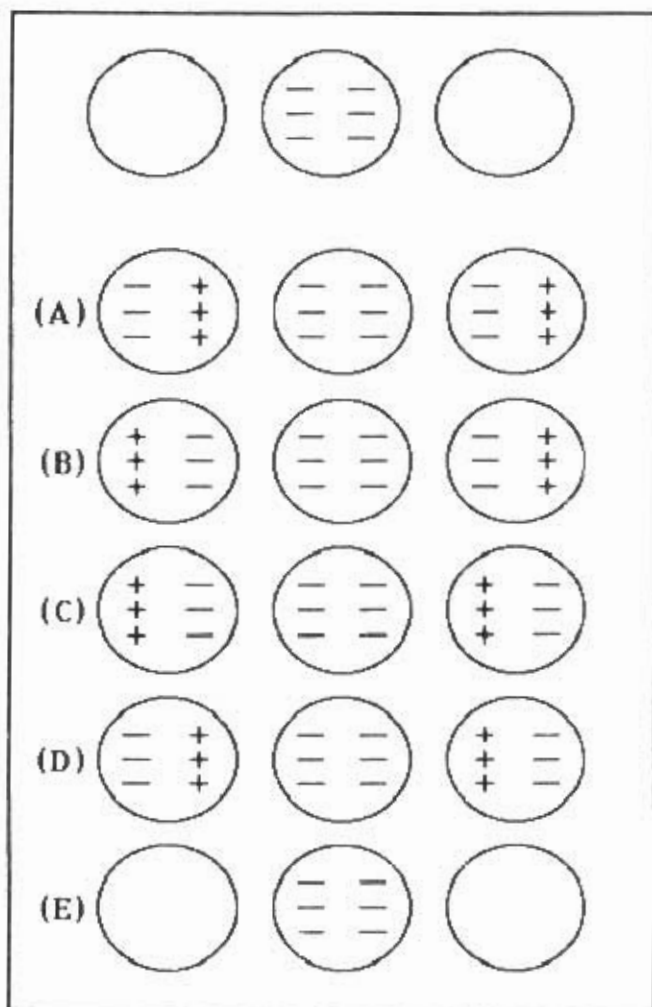


Diagram for Question #49.

49. As shown in the diagram above, a negatively charged conducting sphere is placed between (but does not touch) two fixed neutral conducting spheres. Which diagram below best represents the distribution of charge on the spheres after equilibrium has been established?

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

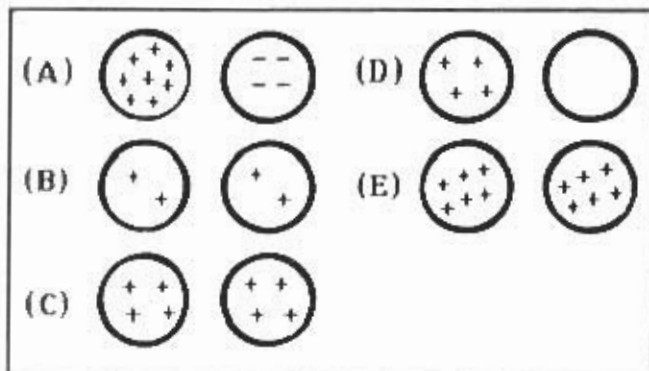


Diagram for Question #50.

50. A positively charged conducting sphere (net charge = +8 units) is touched to a negatively charged conducting sphere (net charge = -4 units). The spheres are otherwise identical. In the diagram the + represents one unit of positive charge, and the - represents one unit of negative charge. Which diagram represents the amount of charge on the spheres after they are separated?

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

51. When separated by a center-to-center distance of 0.20 meters, each of two small electrically charged spheres exert electrical forces of magnitude F on each other. If this distance is increased to 0.60 meters, the electrical force acting on each sphere will be

- (A) $F/3$.
- (B) $2F/3$.
- (C) F .
- (D) $3F$.
- (E) none of the above.

52. A charged particle moves in a vacuum from a region of high electric potential to a region of low electric potential. Which of the properties of the charged particle will change as it moves?

- I. charge
- II. electrical potential energy
- III. speed

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

53. The electric potential at a distance of one meter from a point charge is V . What is the electric potential at a distance of two meters from that point?

- (A) 0.25 V
- (B) 0.5 V
- (C) V
- (D) 2 V
- (E) 4 V

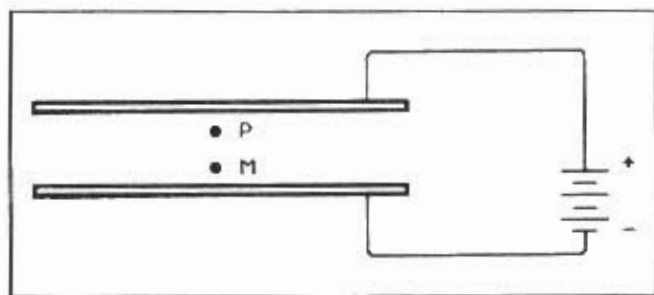


Diagram for Question #54.

54. In the diagram above, two large parallel conducting plates are connected to a battery so that the top plate is positive. Which statements are true?

- I. The direction of the electric field between the plates is from the top plate to bottom plate.
- II. The electric field at point P is larger than that at point M.

III. The magnitude of the positive charge on top plate is equal to the magnitude of the negative charge on bottom plate.

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

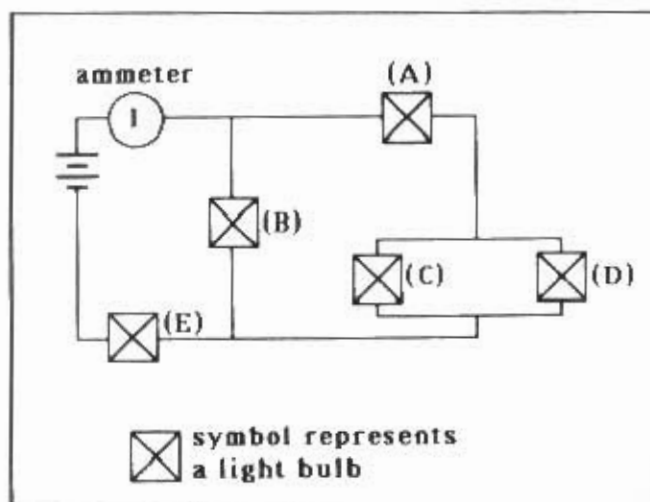


Diagram for Question #55.

55. In the circuit shown above, which single light bulb of the five shown in the circuit should be removed from its socket so that the ammeter will read zero?

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

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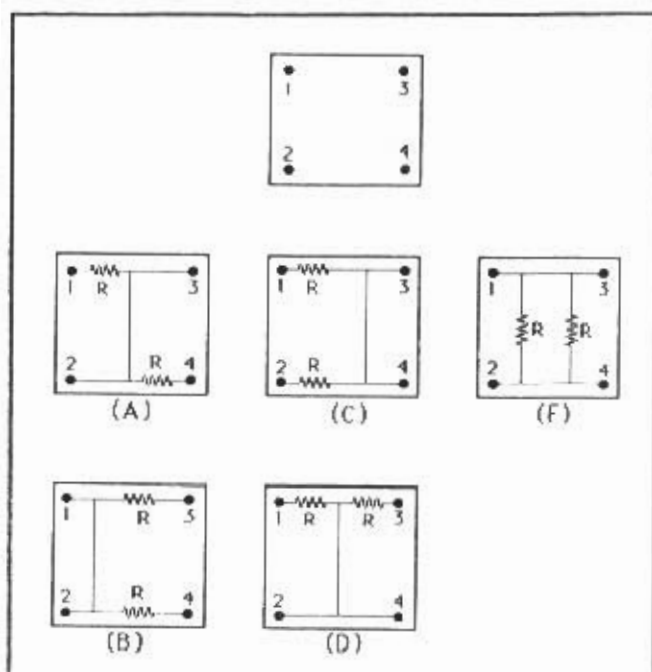


Diagram for Question #56.

56. The diagram above shows a box with four terminals labeled 1, 2, 3, and 4. The following observations are made:

- I. The resistance between terminals 1 and 2 is R .
- II. The resistance between terminals 1 and 3 is $2R$.

Which circuit could account for these observations?

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

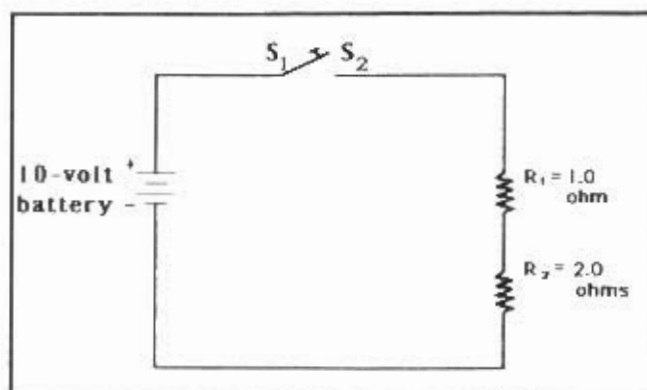


Diagram for Questions #57 and #58.

In the circuit diagram above, the battery has a constant EMF of 10 volts and negligible internal resistance. Two resistors ($R_1 = 1.0$ ohm and $R_2 = 2.0$ ohms) and a switch are connected to the battery.

The diagram and information above are for questions #57 and #58.

57. When the switch is open as shown, what is the potential difference between points S_1 and S_2 ?

- (A) 0 volts
- (B) 3.3 volts
- (C) 5.0 volts
- (D) 6.7 volts
- (E) 10 volts

58. After the switch is closed, what is the potential difference across the resistor R_2 ?

- (A) 0 volts
- (B) 3.3 volts
- (C) 5.0 volts
- (D) 6.7 volts
- (E) 10 volts.

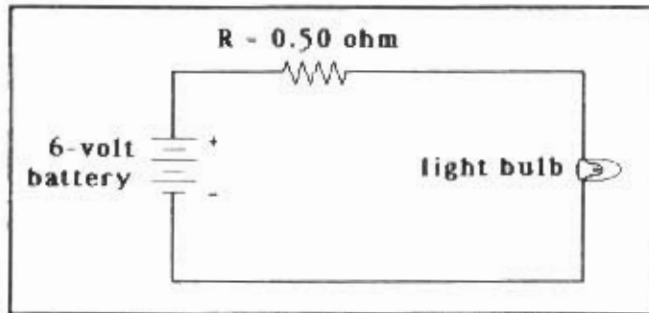


Diagram for Questions #59 and #60.

In the diagram above, a 0.50-ohm resistor and a light bulb are connected in series to a battery with a terminal voltage of 6.0 volts. The current through the resistor is 4.0 amperes.

The diagram and information above are for questions #59 and #60.

59. The current through the light bulb is

- (A) less than 1.5 amperes.
- (B) between 1.5 and 2.5 amperes.
- (C) between 2.5 and 3.5 amperes.
- (D) between 3.5 and 4.5 amperes.
- (E) greater than 4.5 amperes.

60. If the internal resistance of the battery is negligible, how much energy does the battery convert to electrical energy in 10 seconds?

- (A) less than 100 joules
- (B) between 100 and 200 joules
- (C) between 200 and 300 joules
- (D) between 300 and 400 joules
- (E) greater than 400 joules

61. What is the current through a 1.20-kilowatt toaster when operating on 120 volts?

- (A) 0.0100 ampere
- (B) 0.0144 ampere
- (C) 1.00 ampere
- (D) 1.44 amperes
- (E) 10.0 amperes

62. A long, straight wire carrying an electric current is perpendicular to a uniform magnetic field. What is the relationship between the magnitude of the magnetic force (F) acting on the wire, and the current (I) in the wire?

Note: k is a constant.

- (A) $F = kI$
- (B) $F = kI^2$
- (C) $F = k/I$
- (D) $F = k/I^2$
- (E) $F = k/I^3$

63. What is the relationship between the magnetic induction (B) and the distance (r) from a long, straight wire carrying a constant electric current?

Note: k is a constant.

- (A) $B = kr$
- (B) $B = kr^2$
- (C) $B = k/r$
- (D) $B = k/r^2$
- (E) $B = k/r^3$

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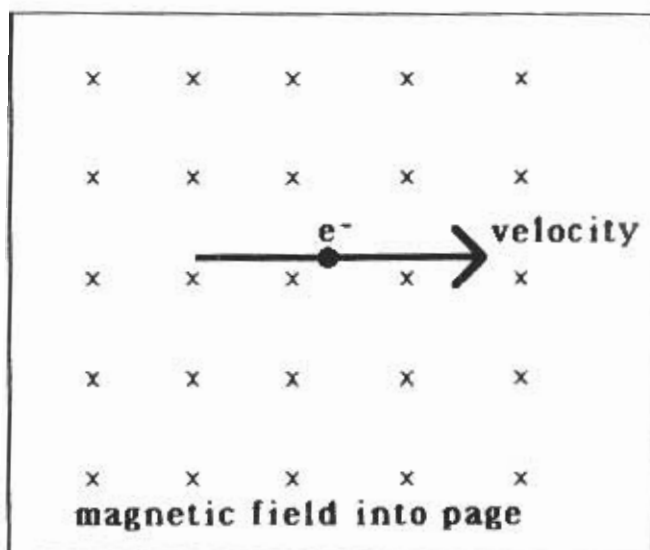


Diagram for Questions #64.

64. In the diagram above, an electron is shown passing through a region in space where a magnetic field and an electric field are present. The magnetic field, as shown in the diagram, is directed into the plane of this page. If the electron passes through this region without being deflected, what is the direction of the electric field?

- (A) into the plane of this page
- (B) out of the plane of this page
- (C) from the bottom to the top of this page
- (D) from the top to the bottom of this page
- (E) from the left to the right of this page

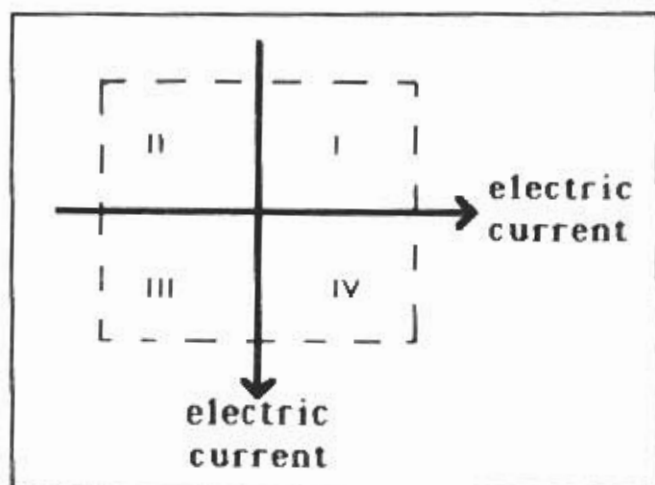


Diagram for Question #65.

65. In the diagram, two insulated wires cross each other perpendicularly forming four (I, II, III, and IV) regions in space. Equal electrical currents flow in each wire in the direction shown by the arrows. In which regions will there be points where the net magnetic field is zero?

- (A) regions I and II
- (B) regions I and III
- (C) regions II and III
- (D) regions II and IV
- (E) regions III and IV

66. An electron is moving parallel to the direction of a magnetic field. The magnetic force acting on the electron is

- (A) zero.
- (B) in the direction of the electron's motion.
- (C) opposite the direction of the electron's motion.
- (D) perpendicular to the direction of the electron's motion.
- (E) at an angle of 45 degrees from direction of electron's motion.

67. One metric unit for measuring a magnetic induction is the tesla. Which combination of units is equivalent to a tesla?

- (A) joule/second
- (B) joule/coulomb
- (C) newton/(ampere * meter)
- (D) newton * second/coulomb
- (E) joule/(coulomb * second)

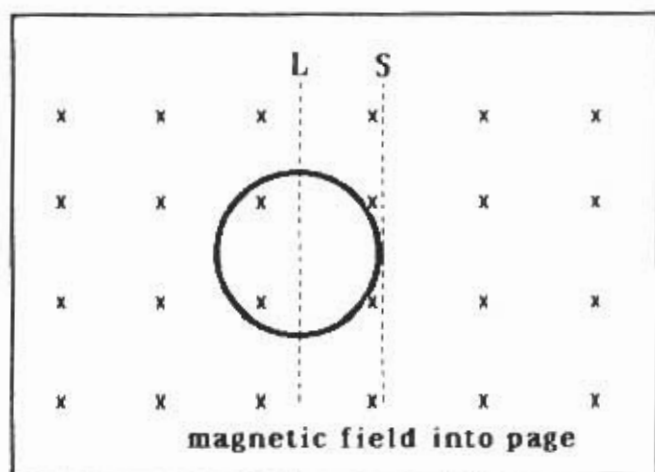


Diagram for Question #68.

68. In the diagram above, a circular loop of wire is placed in a large uniform magnetic field. Lines L and S are perpendicular to the field, and act as possible axes of rotation. Which action will **NOT** induce an electric current in the loop?

- (A) The loop is rotated about the line L.
- (B) The loop is rotated about the line S.
- (C) The loop shrinks to half its present diameter.
- (D) The strength of the magnetic field is decreased.
- (E) The loop is moved a distance equal to one diameter to the left.

END OF SECTION D

Part II - SECTION E

Modern Physics

69. In the Rutherford experiment, a beam of alpha particles was directed at a thin gold foil. The observation that a few alpha particles were deflected through large angles led Rutherford to conclude that

- (A) gold atoms have a net positive electrical charge.
- (B) gold atoms are less massive than alpha particles.
- (C) the electrons of gold atoms move in specific orbits.
- (D) there are small, massive, charged particles in the gold foil.
- (E) the mass of an alpha particle is greater than the mass of a proton.

70. A metal surface emits photoelectrons when exposed to blue light. If the intensity of the blue light is increased, which of the following will also increase?

- I. number of photoelectrons emitted per second
- II. maximum kinetic energy of photoelectrons
- III. energy required to free an electron from the metal

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

71. Excited atoms in a gas discharge tube return to their ground state by emitting

- (A) electrons.
- (B) neutrons.
- (C) photons.
- (D) protons.
- (E) quarks.

72. Which has the greatest rest mass?

- (A) alpha particle
- (B) electron
- (C) gamma ray
- (D) neutron
- (E) proton

73. Compared to a 5.0 electron-volt photon, a 10 electron-volt photon has greater

- (A) frequency.
- (B) rest mass.
- (C) speed.
- (D) wavelength.
- (E) none of the above.

74. De Broglie postulated the idea of wave-particle duality for all matter. According to this idea, the wavelength of an object with a mass m and a speed v is proportional to

- (A) mv .
- (B) mv^2 .
- (C) v/m .
- (D) $1/mv$.
- (E) $1/mv^2$.

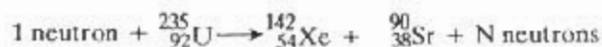
75. In a nuclear reaction, alpha decay refers to

- (A) any process that has a half-life.
- (B) disintegration of an alpha particle.
- (C) a decrease in an alpha particle's energy.
- (D) emission of a helium nucleus from a nucleus.
- (E) radiation damage to material inside a nuclear reactor.

76. A particle is emitted when radon-222 ($^{222}_{86}\text{Rn}$) decays into polonium-218 ($^{218}_{84}\text{Po}$). What is the particle?

- (A) a proton
- (B) a neutron
- (C) a gamma ray
- (D) a beta particle
- (E) an alpha particle

77. In the equation for the nuclear reaction shown below what is the value of N?



- (A) zero
- (B) 1
- (C) 2
- (D) 3
- (E) 4

78. Strontium-90 ($^{90}_{38}\text{Sr}$) is unstable and decays by emitting a beta particle. What nuclide is formed as a result of this process?

- (A) $^{91}_{38}\text{Sr}$
- (B) $^{90}_{39}\text{Y}$
- (C) $^{90}_{38}\text{Sr}$
- (D) $^{89}_{39}\text{Y}$
- (E) $^{89}_{38}\text{Sr}$

79. In a nuclear fission reactor, the main function of the moderator is to

- (A) reduce speed of neutrons in the reactor.
- (B) increase the temperature of the reactor.
- (C) reduce the number of free neutrons in the reactor.
- (D) increase the number of free neutrons in the reactor.
- (E) prevent reactions which release more than one neutron.

80. The annihilation of a proton and an antiproton produces much more energy than the annihilation of an electron and a positron because

- (A) protons spin much faster than electrons.
- (B) a proton is much more massive than an electron.
- (C) the positron is not the antiparticle of the electron.
- (D) at the same temperature, protons move much faster than electrons.
- (E) at the same temperature, electrons move much faster than protons.

END OF SECTION E

END OF EXAMINATION