Advanced Placement Examination

PHYSICS B
SECTION I
multiple-choice questions

1984

PHYSICS B

You must take the entire B Exam as follows:

1st 90 minutes	Section I—Multiple Choice 70 Questions This booklet, pp. 3-16 Percent of Total Grade—50
2nd 90 minutes	Section II—Free Response 6 Questions Pink Booklet, pp. 4-26 Percent of Total Grade—50

Each question in a section has equal weight. Battery-operated hand-held calculators, slide rules, and rulers or straightedges may be used in both sections. However, all calculator memories must be cleared of both programs and data and no peripheral devices such as magnetic cards or tapes will be permitted. Calculators may not be shared. A table of information that may be helpful is found on page 2 of this book and on the front of the green insert.

This examination contains 70 multiple-choice questions. Therefore, please be careful to blacken only the spaces numbered from 1 to 70 on your answer sheet.

General Instructions

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE INSTRUCTED TO DO SO.

INDICATE ALL YOUR ANSWERS TO QUESTIONS IN SECTION I ON THE SEPARATE ANSWER SHEET. No credit will be given for anything written in this examination booklet, but you may use the booklet for notes or scratchwork. After you have decided which of the suggested answers is best, blacken the corresponding space on the answer sheet. BE SURE THAT EACH MARK IS BLACK AND COMPLETELY FILLS THE ANSWER SPACE. Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely.

Example:

Chicago is a

(A) state
(B) city
(C) country
(D) continent
(E) village

Sample Answer

ⒶⒷⒸⒹⒺ

Many candidates wonder whether or not to guess the answers to questions about which they are not certain. In this section of the examination, as a correction for haphazard guessing, one-fourth of the number of questions you answer incorrectly will be subtracted from the number of questions you answer correctly. It is improbable, therefore, that mere guessing will improve your score significantly; it may even lower your score, and it does take time. If, however, you are not sure of the correct answer but have some knowledge of the question and are able to eliminate one or more of the answer choices as wrong, your chance of getting the right answer is improved, and it may be to your advantage to answer such a question.

Use your time effectively, working as rapidly as you can without losing accuracy. It is not expected that everyone will be able to answer all the multiple-choice questions.

TABLE OF INFORMATION

1 atomic mass unit,	$1 \text{ amu} = 1.66 \times 10^{-27}$ kilogram
Rest mass of the proton,	$m_p = 1.67 \times 10^{-27}$ kilogram
Rest mass of the neutron,	$m_n = 1.67 \times 10^{-27}$ kilogram
Rest mass of the electron,	$m_e = 9.11 \times 10^{-31}$ kilogram
Magnitude of the electron charge,	$e = 1.60 \times 10^{-19}$ coulomb
Avogadro's number,	$N_0 = 6.02 \times 10^{23}$ per mole
Universal gas constant,	$R = 8.32$ joules/(mole·K)
Boltzmann's constant,	$k_B = 1.38 \times 10^{-23}$ joule/K
Speed of light,	$c = 3.00 \times 10^8$ m/s
Planck's constant,	$h = 6.63 \times 10^{-34}$ joule·second $= 4.14 \times 10^{-15}$ eV·second
	$hc = 1.99 \times 10^{-25}$ joule·meter $= 1.24 \times 10^4$ eV·Ångstrom
1 electron volt,	$1 \text{ eV} = 1.60 \times 10^{-19}$ joule
Vacuum permittivity,	$\epsilon_0 = 8.85 \times 10^{-12}$ coulomb^2/(newton·meter^2)
Coulomb's law constant,	$k = 1/4\pi\epsilon_0 = 9.0 \times 10^9$ newtons·meter^2/coulomb^2
Vacuum permeability,	$\mu_0 = 4\pi \times 10^{-7}$ weber/(ampere·meter)
Magnetic constant, $k' = k/c^2 = \mu_0/4\pi = 10^{-7}$ weber/(ampere·meter)	
Acceleration due to gravity,	$g = 9.8$ m/s^2
1 atmosphere pressure,	$1 \text{ atm} = 1.0 \times 10^5$ newtons/meter$^2 = 1.0 \times 10^5$ pascals (Pa)
1 Ångstrom,	$1 \text{ Å} = 1 \times 10^{-10}$ meter

$$1 \text{ weber/m}^2 = 1 \text{ tesla}$$

$$1 \text{ calorie} = 4.19 \text{ joules} = 2.61 \times 10^{19} \text{ eV}$$

$$1 \text{ kilocalorie (1 Calorie)} = 4.19 \times 10^3 \text{ joules}$$

The following conventions are used in this examination.

I. Unless otherwise stated, the frame of reference of any problem is assumed to be inertial.

II. The direction of any electric current is the direction of flow of positive charge (conventional current).

III. For any isolated electric charge, the electric potential is defined as zero at an infinite distance from the charge.

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 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) 1 m/s
(B) 2.5 m/s
(C) 5 m/s
(D) 7 m/s
(E) 7.5 m/s
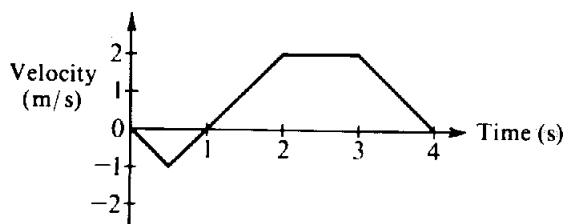
3. The graph above shows the velocity *versus* time for an object moving in a straight line. At what time after time = 0 does the object again pass through its initial position?

(A) Between 0 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.
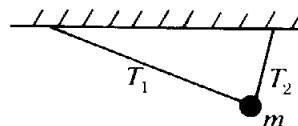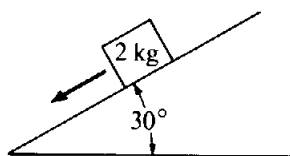

5. A ball of mass m is suspended from two strings of unequal length as shown above. The tensions T_1 and T_2 in the strings must satisfy which of the following relations?

(A) $T_1 = T_2$
(B) $T_1 > T_2$
(C) $T_1 < T_2$
(D) $T_1 + T_2 = mg$
(E) $T_1 - T_2 = mg$

GO ON TO THE NEXT PAGE

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?

(A)

(B)

(C)

(D)

(E)

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?
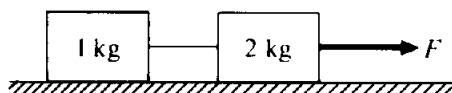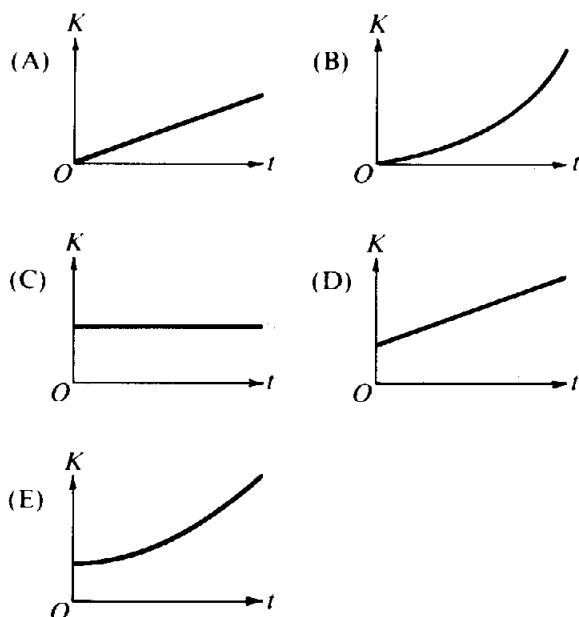
11. When the frictionless system shown above is accelerated by an applied force of magnitude F, the tension in the string between the blocks is

(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
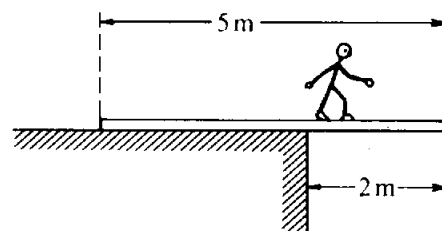
13. A 5-meter uniform plank of mass 100 kilograms rests on the top of a building with 2 meters extended over the edge as shown above. How far can a 50-kilogram person venture past the edge of the building on the plank before the plank just begins to tip?

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

(B) 1 m

(C) $\frac{3}{2}$ m

(D) 2 m

(E) It is impossible to make the plank tip since the person would have to be more than 2 meters from the edge of the building.
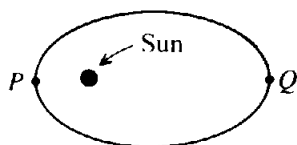
14. An asteroid moves in an elliptic orbit with the Sun at one focus as shown above. Which of the following quantities increases as the asteroid moves from point P in its orbit to point Q?

(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

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.
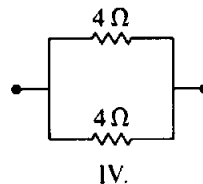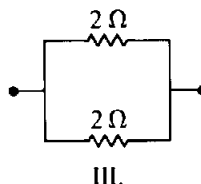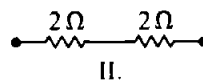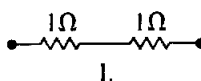
18. Which two arrangements of resistors shown above have the same resistance between the terminals?

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

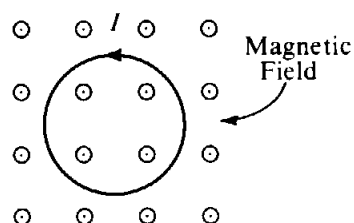Questions 19-20. A point P is 0.50 meter from a point charge of 5.0×10^{-8} coulomb.

19. The intensity of the electric field at point P is most nearly

(A) 2.5×10^{-8} N/C
(B) 2.5×10^{1} N/C
(C) 9.0×10^{2} N/C
(D) 1.8×10^{3} N/C
(E) 7.5×10^{8} N/C

20. The electric potential at point P is most nearly

(A) 2.5×10^{-8} V
(B) 2.5×10^{1} V
(C) 9.0×10^{2} V
(D) 1.8×10^{3} V
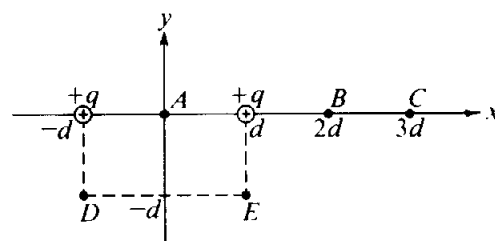(E) 7.5×10^{8} V

Magnetic Field

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
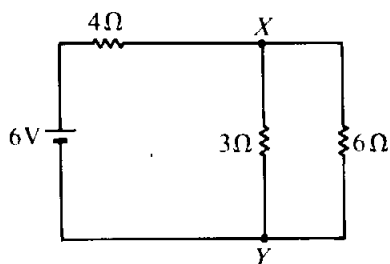
22. In the circuit shown above, what is the value of the potential difference between points X and Y if the 6-volt battery has no internal resistance?

(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.
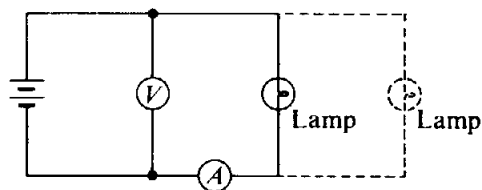
Questions 24-25

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

GO ON TO THE NEXT PAGE

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

   (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.

(A)

(B)

(C)

(D)

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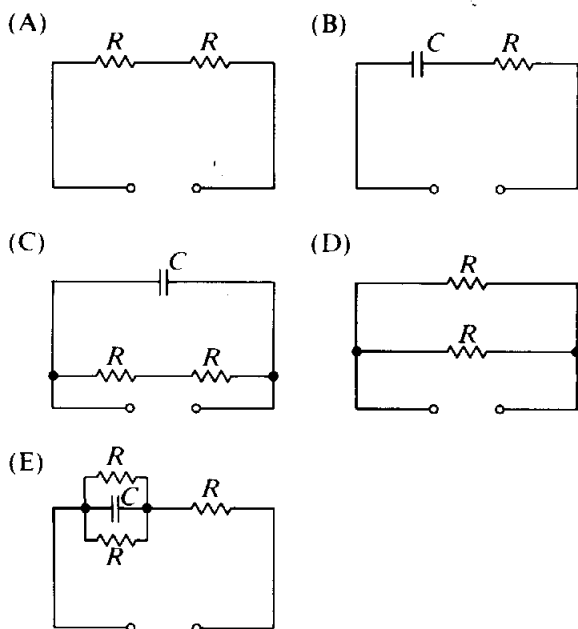
27. Into which circuit should the battery be connected to obtain the greatest steady power dissipation?

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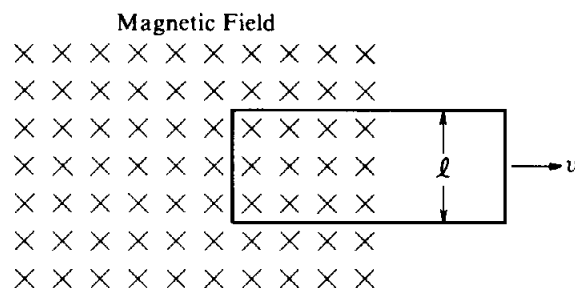
Magnetic Field

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

GO ON TO THE NEXT PAGE

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

(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.
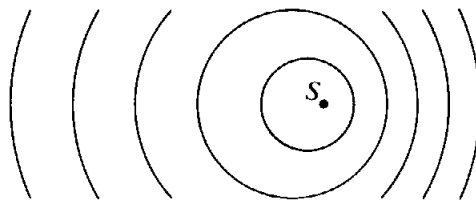
Questions 33-34
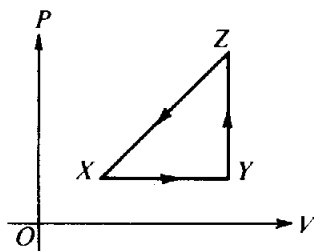
A thermodynamic system is taken from an initial state X along the path $XYZX$ as shown in the PV-diagram above.

33. For the process $X \rightarrow Y$, $\triangle U$ 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 $Y \rightarrow Z$, Q is greater than zero and

(A) $W < 0$ and $\triangle U = 0$
(B) $W = 0$ and $\triangle U < 0$
(C) $W = 0$ and $\triangle U > 0$
(D) $W > 0$ and $\triangle U = 0$
(E) $W > 0$ and $\triangle U > 0$

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
(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

Reflecting Surface
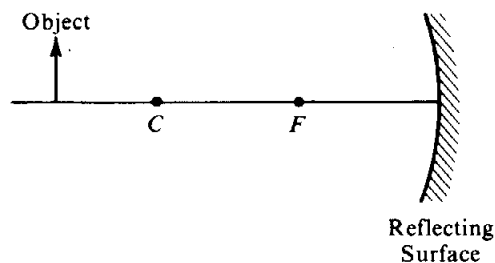
37. An object is placed as shown in the figure above. The center of curvature C and the focal point F of the reflecting surface are marked. As compared with the object, the image formed by the reflecting surface is

(A) erect and larger
(B) erect and the same size
(C) erect and smaller
(D) inverted and larger
(E) inverted and smaller

GO ON TO THE NEXT PAGE

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) $\sqrt{2}f$
(C) f
(D) $\dfrac{f}{\sqrt{2}}$
(E) $\dfrac{f}{2}$

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
(D) Violet
(E) Yellow

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

(A) K (B) K (C) K (D) K (E) K
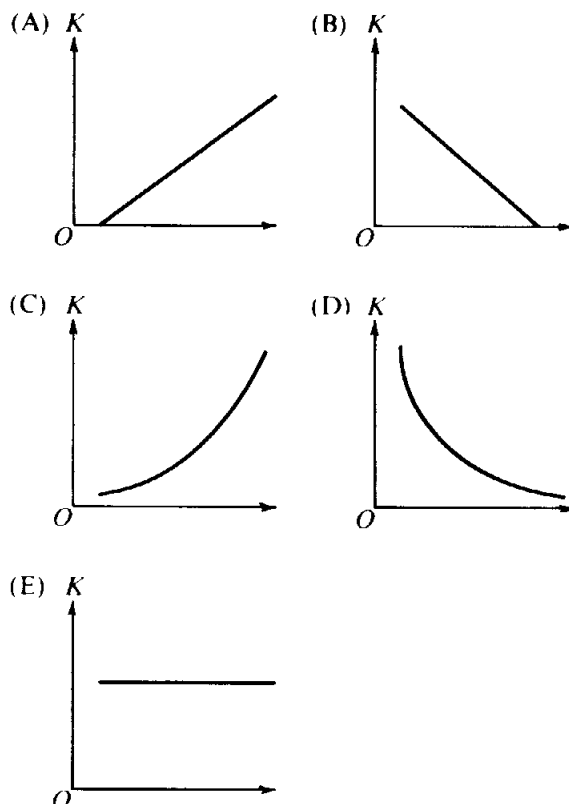
42. Which graph best shows the maximum kinetic energy K of the photoelectrons as a function of the frequency of incident light?

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

GO ON TO THE NEXT PAGE

44. $^{235}_{92}U + ^{1}_{0}n \rightarrow 3\left(^{1}_{0}n\right) + ^{142}_{56}Ba + \underline{\hspace{2cm}}$
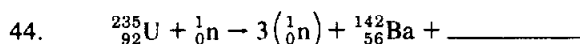
The additional product of the nuclear fission reaction shown above is

(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 (5×10^{-11} meter), what accelerating potential is required?

(A) 37.5 V
(B) 75 V
(C) 300 V
(D) 600 V
(E) 22,500 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 rest

(D) faster, at about $\frac{1}{0.8}$ times the rate of the clocks 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 $4r$ 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

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?

(A)

(B)

(C)

(D)
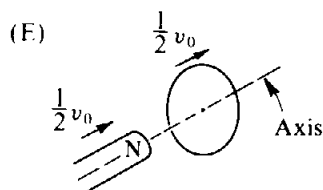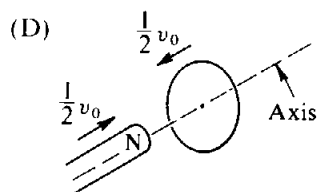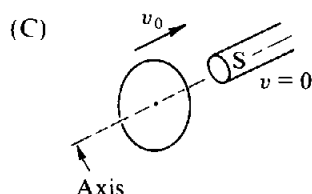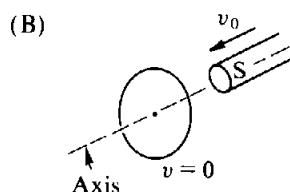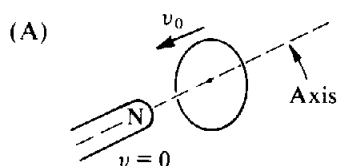
(E)

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 III 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 resistivity. Which has the greatest resistance?
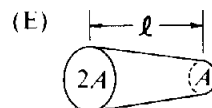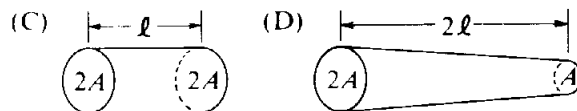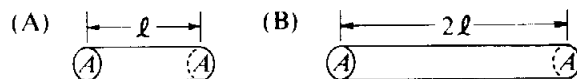
58. According to the Bohr model of the atom, electrons orbit the nucleus in definite orbits. According to the laws of classical physics, this model would be impossible because

(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

+2Q   d   −Q
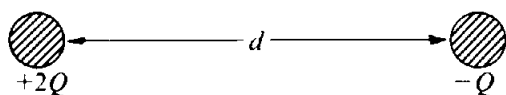
59. Two identical conducting spheres are charged to $+2Q$ and $-Q$, respectively, and are separated by a distance d (much greater than the radii of the spheres) as shown above. The magnitude of the force of attraction on the left sphere is F_1. After the two spheres are made to touch and then are reseparated by distance d, the magnitude of the force on the left sphere is F_2. 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) $F_1 = 8F_2$
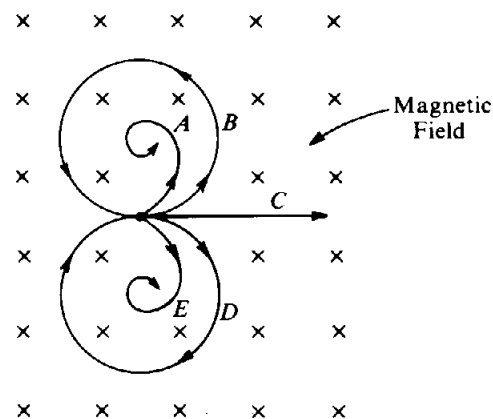
60. Which of the paths above represents the path of an electron traveling without any loss of energy through a uniform magnetic field directed into the page?

(A) A
(B) B
(C) C
(D) D
(E) E
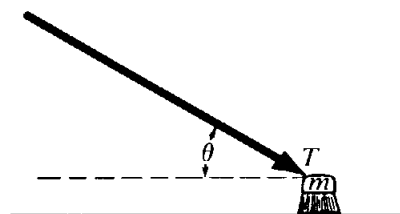
61. A push broom of mass m is pushed across a rough horizontal floor by a force of magnitude T directed at angle θ as shown above. The coefficient of friction between the broom and the floor is μ. The frictional force on the broom has magnitude

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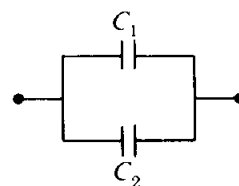
62. Two capacitors are connected in parallel as shown above. A voltage V is applied to the pair. What is the ratio of charge stored on C_1 to the charge stored on C_2, when $C_1 = 1.5 \, C_2$?

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

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

(C) 1

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

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

GO ON TO THE NEXT PAGE

63. Two long, parallel wires, fixed in space, carry currents I_1 and I_2. 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 $4I_2$
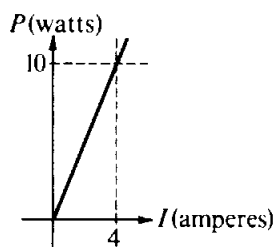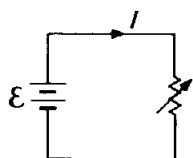
64. The circuit shown above left is made up of a variable resistor and a battery with negligible internal resistance. A graph of the power P dissipated in the resistor as a function of the current I supplied by the battery is given above right. What is the emf of the battery?

(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

(A) 400 N

(B) $\frac{800}{\sqrt{2}}$ N

(C) 800 N

(D) $800\sqrt{2}$ N

(E) 1,600 N
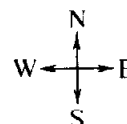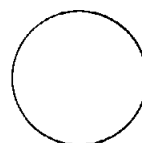
View of Track from Above

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

Temperature

T_2

T_1

T_0

Time

0 ═══════════ Ionization State
−1eV ─────────────
−3eV ─ ─────────
−5eV ··· ··· ─────
−10eV ─────────
−14eV ───────────── Ground State
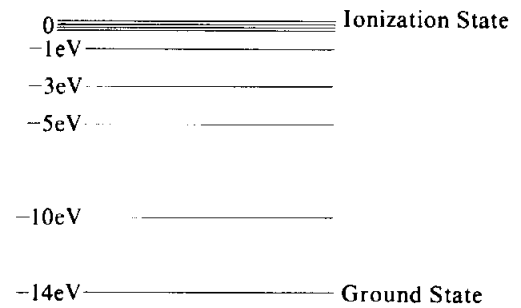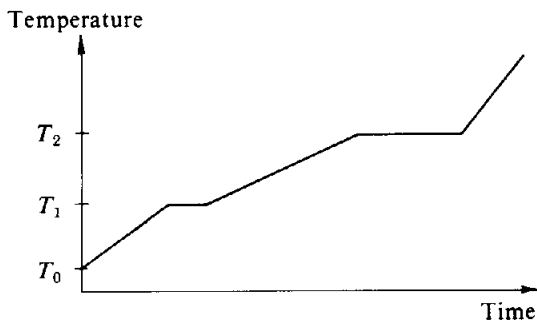
68. Heat is added at a constant rate to a sample of pure substance that is initially a solid at temperature T_0. The temperature of the sample as a function of time is shown in the graph above. From the graph, one can conclude that the

(A) substance sublimes directly from the solid phase to the vapor phase
(B) melting point is T_2
(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 0.10 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

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 be 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, 7, 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.

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.

THE COLLEGE BOARD

Advanced Placement Examination

PHYSICS B
SECTION II
free-response questions

1984

Free-Response Questions

Time—90 minutes

6 required questions of equal weight on pages 4-26

Percent of total grade—50

<u>General Instructions</u>

When you are told to begin, carefully tear out the green insert, and start work. The questions in the green insert are duplicates of those in this booklet. A table of information that may be helpful is on page 3 of this booklet and on the front of the green insert.

Show your work. You are to <u>write your answer to each question in the pink booklet</u>. Several additional answer pages follow each question. Be sure to write CLEARLY and LEGIBLY. If you make an error, you may save time by crossing it out rather than trying to erase it.

TABLE OF INFORMATION

1 atomic mass unit,	1 amu $= 1.66 \times 10^{-27}$ kilogram
Rest mass of the proton,	$m_p = 1.67 \times 10^{-27}$ kilogram
Rest mass of the neutron,	$m_n = 1.67 \times 10^{-27}$ kilogram
Rest mass of the electron,	$m_e = 9.11 \times 10^{-31}$ kilogram
Magnitude of the electron charge,	$e = 1.60 \times 10^{-19}$ coulomb
Avogadro's number,	$N_0 = 6.02 \times 10^{23}$ per mole
Universal gas constant,	$R = 8.32$ joules/(mole·K)
Boltzmann's constant,	$k_B = 1.38 \times 10^{-23}$ joule/K
Speed of light,	$c = 3.00 \times 10^8$ m/s
Planck's constant,	$h = 6.63 \times 10^{-34}$ joule·second $= 4.14 \times 10^{-15}$ eV·second
	$hc = 1.99 \times 10^{-25}$ joule·meter $= 1.24 \times 10^4$ eV·Ångstrom
1 electron volt,	1 eV $= 1.60 \times 10^{-19}$ joule
Vacuum permittivity,	$\epsilon_0 = 8.85 \times 10^{-12}$ coulomb^2/(newton·meter^2)
Coulomb's law constant,	$k = 1/4\pi\epsilon_0 = 9.0 \times 10^9$ newtons·meter^2/coulomb^2
Vacuum permeability,	$\mu_0 = 4\pi \times 10^{-7}$ weber/(ampere·meter)
Magnetic constant, $k' = k/c^2 = \mu_0/4\pi = 10^{-7}$ weber/(ampere·meter)	
Acceleration due to gravity,	$g = 9.8$ m/s^2
1 atmosphere pressure,	1 atm $= 1.0 \times 10^5$ newtons/meter$^2 = 1.0 \times 10^5$ pascals (Pa)
1 Ångstrom,	1 Å $= 1 \times 10^{-10}$ meter

1 weber/m^2 = 1 tesla

1 calorie $= 4.19$ joules $= 2.61 \times 10^{19}$ eV

1 kilocalorie (1 Calorie) $= 4.19 \times 10^3$ joules

The following conventions are used in this examination.

  I.   Unless otherwise stated, the frame of reference of any problem is assumed to be inertial.

 II.   The direction of any electric current is the direction of flow of positive charge (conventional current).

III.   For any isolated electric charge, the electric potential is defined as zero at an infinite distance from the charge.

ANSWER ALL OF THE QUESTIONS. EACH OF THE SIX QUESTIONS HAS EQUAL WEIGHT, BUT THE PARTS WITHIN A QUESTION MAY NOT HAVE EQUAL WEIGHT. SHOW YOUR WORK. CREDIT FOR YOUR ANSWERS DEPENDS ON THE QUALITY OF YOUR EXPLANATIONS.
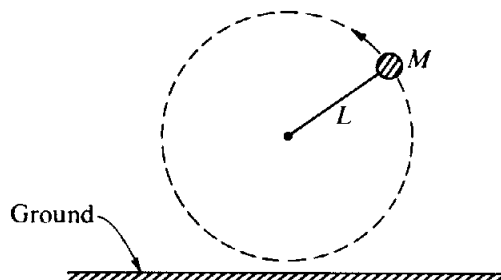

1. A ball of mass M attached to a string of length L moves in a circle in a vertical plane as shown above. At the top of the circular path, the tension in the string is twice the weight of the ball. At the bottom, the ball just clears the ground. Air resistance is negligible. Express all answers in terms of M, L, and g.

   (a) Determine the magnitude and direction of the net force on the ball when it is at the top.

   (b) Determine the speed v_0 of the ball at the top.

   The string is then cut when the ball is at the top.

   (c) Determine the time it takes the ball to reach the ground.

   (d) Determine the horizontal distance the ball travels before hitting the ground.

Before Collision   After Collision

View From Above
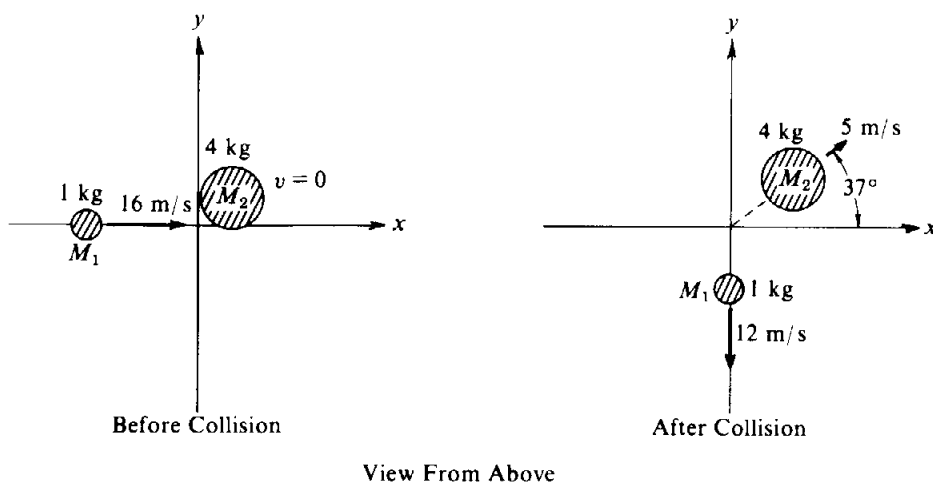
2. Two objects of masses $M_1 = 1$ kilogram and $M_2 = 4$ kilograms are free to slide on a horizontal frictionless surface. The objects collide and the magnitudes and directions of the velocities of the two objects before and after the collision are shown on the diagram above. (sin 37° = 0.6, cos 37° = 0.8, tan 37° = 0.75)

(a) Calculate the x and y components (p_x and p_y, respectively) of the momenta of the two objects before and after the collision, and write your results in the proper places in the following table.

	$M_1 = 1$ kg		$M_2 = 4$ kg	
	$p_x \left(\dfrac{\text{kg} \cdot \text{m}}{\text{s}} \right)$	$p_y \left(\dfrac{\text{kg} \cdot \text{m}}{\text{s}} \right)$	$p_x \left(\dfrac{\text{kg} \cdot \text{m}}{\text{s}} \right)$	$p_y \left(\dfrac{\text{kg} \cdot \text{m}}{\text{s}} \right)$
Before Collision				
After Collision				

(b) Show, using the data that you listed in the table, that linear momentum is conserved in this collision.

(c) Calculate the kinetic energy of the two-object system before and after the collision.

(d) Is kinetic energy conserved in the collision?

3. A heating coil is placed in a thermally insulated tank of negligible heat capacity. The tank contains 0.1 kilogram of water and 0.01 kilogram of ice, both initially at a temperature of 0° C. The resistance of the coil is 25 ohms, independent of temperature, and there is a current of 2 amperes in the coil. Calculate each of the following quantities.

(a) The heat transferred to the water and ice by the heating coil in time t

(b) The time t_1 necessary to melt all the ice (The latent heat of fusion of ice is 3.34×10^5 joules per kilogram.)

(c) The additional time t_2 necessary to bring the water to a boil (The specific heat of water is 4.19×10^3 joules per kilogram·Kelvin.)
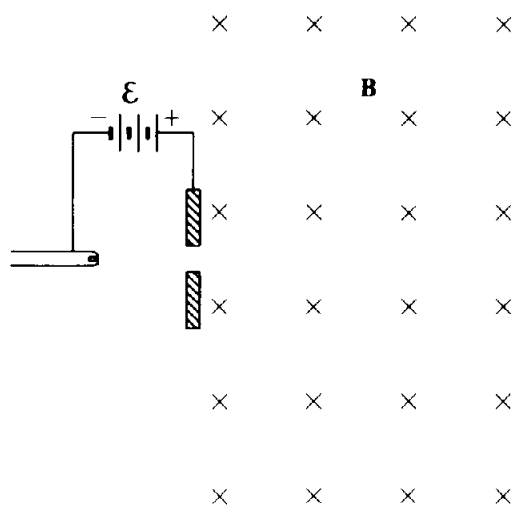
4. An electron from a hot filament in a cathode ray tube is accelerated through a potential difference $\mathcal{E}$. It then passes into a region of uniform magnetic field **B**, directed into the page as shown above. The mass of the electron is m and the charge has magnitude e.

(a) Find the potential difference $\mathcal{E}$ necessary to give the electron a speed v as it enters the magnetic field.

(b) On the diagram above, sketch the path of the electron in the magnetic field.

(c) In terms of mass m, speed v, charge e, and field strength B, develop an expression for r, the radius of the circular path of the electron.

(d) An electric field **E** is now established in the same region as the magnetic field, so that the electron passes through the region undeflected.

 i. Determine the magnitude of **E**.

 ii. Indicate the direction of **E** on the diagram above.

Light

Air $n_1 = 1.00$

Thin Film $n_2 = 1.25$ — S_1

d

— S_2

Glass $n_3 = 1.50$
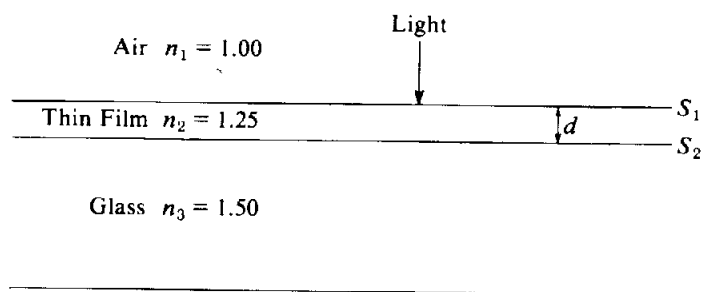
5. The surface of a glass plate (index of refraction $n_3 = 1.50$) is coated with a transparent thin film (index of refraction $n_2 = 1.25$). A beam of monochromatic light of wavelength 6.0×10^{-7} meter traveling in air (index of refraction $n_1 = 1.00$) is incident normally on surface S_1 as shown above. The beam is partially transmitted and partially reflected.

(a) Calculate the frequency of the light.

(b) Calculate the wavelength of the light in the thin film.

The beam of light in the film is then partially reflected and partially transmitted at surface S_2 .

(c) Calculate the minimum thickness d_1 of the film such that the resultant intensity of the light reflected back into the air is a minimum.

(d) Calculate the minimum nonzero thickness d_2 of the film such that the resultant intensity of the light reflected back into the air is a maximum.

Number

Time t (years)
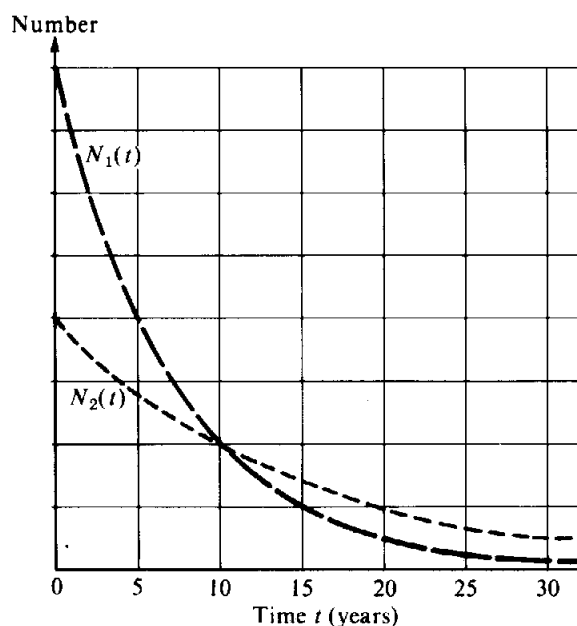
6. Two radioactive isotopes are extracted from spent nuclear fuel and placed in a metal container, which is then sealed and deposited in a nuclear waste disposal facility. The graph above shows how many nuclei of isotopes 1 and 2 remain as a function of time.

(a) From the graph, determine the half-life of isotope 1 and the half-life of isotope 2.

(b) At time $t = 10$ years, which isotope is decaying at the greater rate? Explain your reasoning.

(c) What type of radiation (alpha, beta, or gamma) would be most likely to escape through the container walls?

(d) What characteristics of the type of radiation named in part (c) distinguish it from the other two?

(e) After many years, when the container is removed, it is found to contain helium gas, and the total mass of the contents is found to have decreased. Account for each of these two observations.

END OF EXAMINATION

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