THE COLLEGE BOARD

Advanced Placement Examination

PHYSICS C

1984

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THE COLLEGE BOARD

Advanced Placement Examination

PHYSICS C

SECTION I

multiple-choice questions

1984

PHYSICS C

You may take the entire C Exam, or Mechanics only, or Electricity and Magnetism only as follows:

	Entire C Exam Both Mech. & Elect. and Mag.	Mechanics only	Electricity and Magnetism only
1st 45 min.	Sec. I, Mech. 35 questions this booklet, pp. 4-13	Sec. I, Mech. 35 questions this booklet, pp. 4-13	Sec. I, Elect. and Mag. 35 questions this booklet, pp. 14-22
2nd 45 min.	Sec. I, Elect. and Mag. 35 questions this booklet, pp. 14-22	Sec. II, Mech. 3 questions pink booklet, pp. 4-15	Sec. II, Elect. and Mag. 3 questions pink booklet, pp. 16-26
3rd 45 min.	Sec. II, Mech. 3 questions pink booklet, pp. 4-15		
4th 45 min.	Sec. II, Elect. and Mag. 3 questions pink booklet, pp. 16-26		

Separate grades are reported for Mechanics and for Electricity and Magnetism. Each section of each examination is 50 percent of the total grade; each question in a section has equal weight. Battery-operated hand-held calculators, slide rules, and rulers or straightedges may be used in all parts of this examination. 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 3 of this booklet and on the front of the green insert.

The Physics C Examination contains a total of 70 multiple-choice questions. If you are taking

—*Mechanics only*, please be careful to use the answer sheet spaces numbered 1-35,
—*Electricity and Magnetism only*, please be careful to use the answer sheet spaces numbered 36-70,
—*the entire examination* (Mechanics *and* Electricity and Magnetism), use only the spaces numbered 1-70 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 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.

PHYSICS C

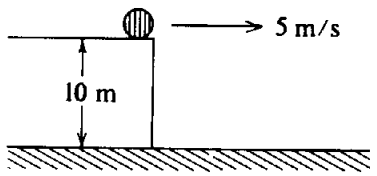
SECTION I, MECHANICS

Time—45 minutes

35 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.

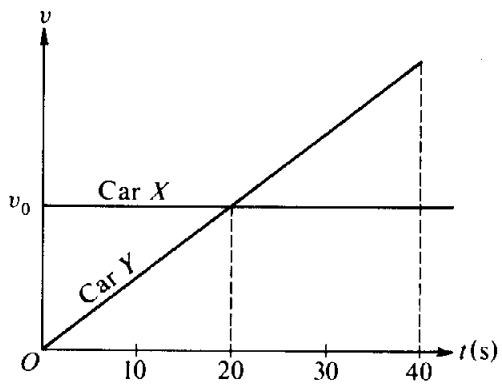
1. Torque is the rotational analogue of
   (A) kinetic energy
   (B) linear momentum
   (C) acceleration
   (D) force
   (E) mass



2. An object slides off a roof 10 meters above the ground with an initial horizontal speed of 5 meters per second as shown above. The time between the object's leaving the roof and hitting the ground is most nearly
   (A) $\frac{1}{2}$ s (B) $\frac{1}{\sqrt{2}}$ s (C) $\sqrt{2}$ s
   (D) 2 s (E) $5\sqrt{2}$ s

3. A simple pendulum of length ℓ, whose bob has mass m, oscillates with a period T. If the bob is replaced by one of mass $4m$, the period of oscillation is
   (A) $\frac{1}{4}T$ (B) $\frac{1}{2}T$ (C) T
   (D) $2T$ (E) $4T$

Questions 4-5



At time $t = 0$, car X traveling with speed v_0 passes car Y, which is just starting to move. Both cars then travel on two parallel lanes of the same straight road. The graphs of speed v *versus* time t for both cars are shown above.

4. Which of the following is true at time $t = 20$ seconds?
   (A) Car Y is behind car X.
   (B) Car Y is passing car X.
   (C) Car Y is in front of car X.
   (D) Both cars have the same acceleration.
   (E) Car X is accelerating faster than car Y.

5. From time $t = 0$ to time $t = 40$ seconds, the areas under both curves are equal. Therefore, which of the following is true at time $t = 40$ seconds?
   (A) Car Y is behind car X.
   (B) Car Y is passing car X.
   (C) Car Y is in front of car X.
   (D) Both cars have the same acceleration.
   (E) Car X is accelerating faster than car Y.

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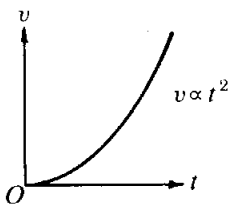
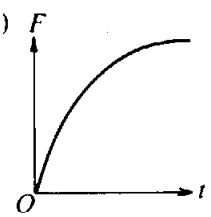
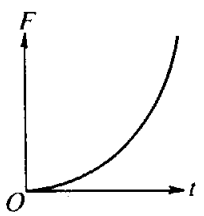
6. An ice skater is spinning about a vertical axis with arms fully extended. If the arms are pulled in closer to the body, in which of the following ways are the angular momentum and kinetic energy of the skater affected?

	Angular Momentum	Kinetic Energy
(A)	Increases	Increases
(B)	Increases	Remains Constant
(C)	Remains Constant	Increases
(D)	Remains Constant	Remains Constant
(E)	Decreases	Remains Constant



7. The parabola above is a graph of speed v as a function of time t for an object. Which of the following graphs best represents the magnitude F of the net force exerted on the object as a function of time t?

(A)


(B)


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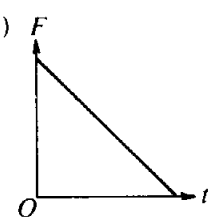
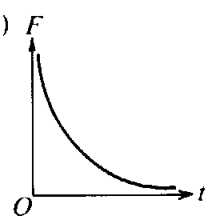
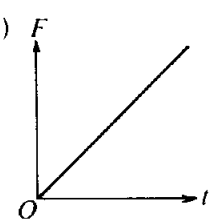


(D)


(E)


8. An object of mass m is lifted at constant velocity a vertical distance H in time T. The power supplied by the lifting force is

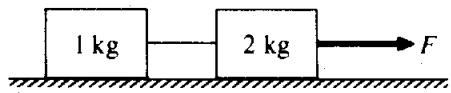
(A) $mgHT$

(B) mgH/T

(C) mg/HT

(D) mgT/H

(E) zero



9. 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) $\frac{1}{3}F$

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Questions 10-12

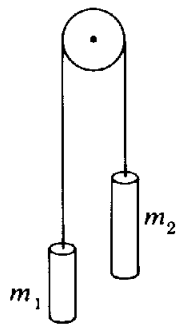
A cylinder rotates with constant angular acceleration about a fixed axis. The cylinder's moment of inertia about the axis is 4 kg m^2. At time $t = 0$ the cylinder is at rest. At time $t = 2$ seconds its angular velocity is 1 radian per second.

10. What is the angular acceleration of the cylinder between $t = 0$ and $t = 2$ seconds?
    (A) 0.5 radian $\cdot$ s^{-2}
    (B) 1 radian $\cdot$ s^{-2}
    (C) 2 radians $\cdot$ s^{-2}
    (D) 4 radians $\cdot$ s^{-2}
    (E) 5 radians $\cdot$ s^{-2}

11. What is the angular momentum of the cylinder at time $t = 2$ seconds?
    (A) 1 kg $\cdot$ m^2 $\cdot$ s^{-1}
    (B) 2 kg $\cdot$ m^2 $\cdot$ s^{-1}
    (C) 3 kg $\cdot$ m^2 $\cdot$ s^{-1}
    (D) 4 kg $\cdot$ m^2 $\cdot$ s^{-1}
    (E) It cannot be determined without knowing the radius of the cylinder.

12. What is the kinetic energy of the cylinder at time $t = 2$ seconds?
    (A) 1 J
    (B) 2 J
    (C) 3 J
    (D) 4 J
    (E) It cannot be determined without knowing the radius of the cylinder.

Questions 13-14



A system consists of two objects having masses m_1 and m_2 ($m_1 < m_2$). The objects are connected by a massless string, hung over a pulley as shown above, and then released.

13. When the speed of each object is v, the magnitude of the total linear momentum of the system is
    (A) $(m_1 + m_2)\, v$
    (B) $(m_2 - m_1)\, v$
    (C) $\frac{(m_1 + m_2)}{2}\, v$
    (D) $\frac{(m_2 - m_1)}{2}\, v^2$
    (E) $m_2 v$

14. When the object of mass m_2 has descended a distance h, the potential energy of the system has decreased by
    (A) $(m_2 - m_1)\, gh$
    (B) $m_2 gh$
    (C) $(m_1 + m_2)\, gh$
    (D) $\frac{1}{2}(m_1 + m_2)\, gh$
    (E) 0

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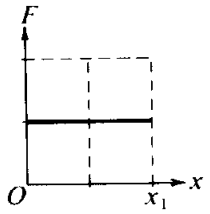
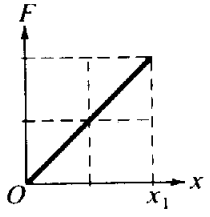
15. The following graphs, all drawn to the same scale, represent the net force F as a function of displacement x for an object that moves along a straight line. Which graph represents the force that will cause the greatest change in the kinetic energy of the object from $x = 0$ to $x = x_1$?

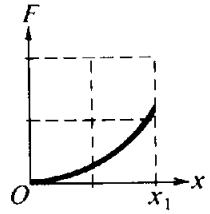
(A)



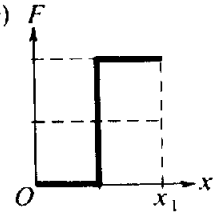
(B)



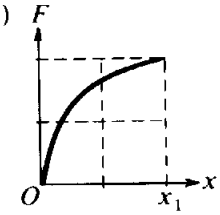
(C)

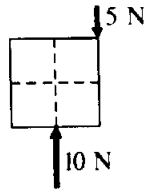


(D)



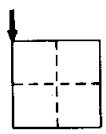
(E)





16. A square piece of plywood on a horizontal tabletop is subjected to the two horizontal forces shown above. Where should a third force of magnitude 5 newtons be applied to put the piece of plywood into equilibrium?

(A)



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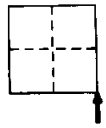

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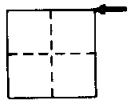
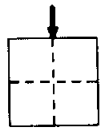


(D)



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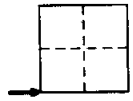

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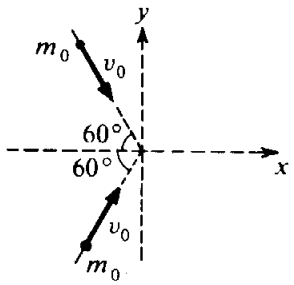

17. Two particles of equal mass m_0, moving with equal speeds v_0 along paths inclined at 60° to the x-axis as shown above, collide and stick together. Their velocity after the collision has magnitude

(A) $\frac{v_0}{4}$ (B) $\frac{v_0}{2}$ (C) $\frac{\sqrt{2}v_0}{2}$

(D) $\frac{\sqrt{3}v_0}{2}$ (E) v_0

18. 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.

19. A particle is moving in a circle of radius 2 meters according to the relation $\theta = 3t^2 + 2t$, where θ is measured in radians and t in seconds. The speed of the particle at $t = 4$ seconds is

(A) 13 m/s (B) 16 m/s (C) 26 m/s
(D) 52 m/s (E) 338 m/s

20. The mass of Planet X is one-tenth that of the Earth, and its diameter is one-half that of the Earth. The acceleration due to gravity at the surface of Planet X is most nearly

(A) 2 m/s^2 (B) 4 m/s^2 (C) 5 m/s^2
(D) 7 m/s^2 (E) 10 m/s^2

21. 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

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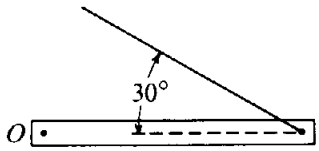


22. A uniform rigid bar of weight W is supported in a horizontal orientation as shown above by a rope that makes a 30° angle with the horizontal. The force exerted on the bar at point O, where it is pivoted, is best represented by a vector whose direction is which of the following?

(A) ↑

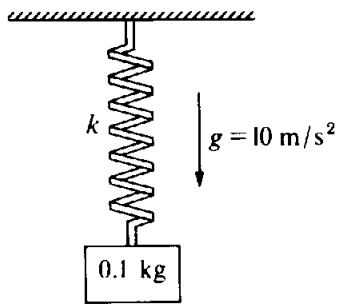
(B) ↗

(C) →

(D) ↘

(E) ↙

Questions 23-24



A 0.1-kilogram block is attached to an initially unstretched spring of force constant $k = 40$ newtons per meter as shown above. The block is released from rest at time $t = 0$.

23. What is the amplitude of the resulting simple harmonic motion of the block?

(A) $\frac{1}{40}$ m (B) $\frac{1}{20}$ m (C) $\frac{1}{4}$ m

(D) $\frac{1}{2}$ m (E) 1 m

24. At what time after release will the block first return to its initial position?

(A) $\frac{\pi}{40}$ s (B) $\frac{\pi}{20}$ s (C) $\frac{\pi}{10}$ s

(D) $\frac{\pi}{5}$ s (E) $\frac{\pi}{4}$ s

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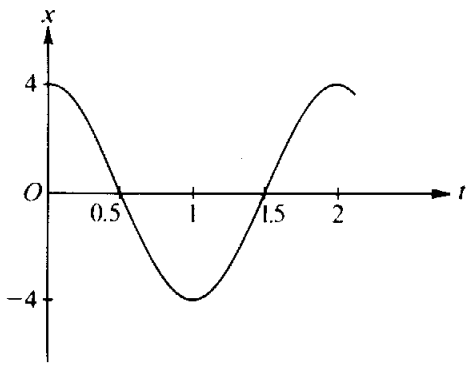


25. A particle moves in simple harmonic motion represented by the graph above. Which of the following represents the velocity of the particle as a function of time?

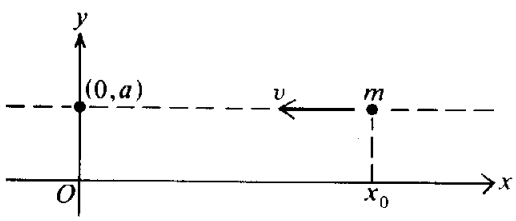
(A) $v(t) = 4 \cos \pi t$

(B) $v(t) = \pi \cos \pi t$

(C) $v(t) = -\pi^2 \cos \pi t$

(D) $v(t) = -4 \sin \pi t$

(E) $v(t) = -4\pi \sin \pi t$



26. A particle of mass m moves with a constant speed v along the dashed line $y = a$. When the x-coordinate of the particle is x_0, the magnitude of the angular momentum of the particle with respect to the origin of the system is

(A) zero

(B) mva

(C) mvx_0

(D) $mv\sqrt{x_0^2 + a^2}$

(E) $\dfrac{mva}{\sqrt{x_0^2 + a^2}}$

27. A uniform stick has length L. The moment of inertia about the center of the stick is I_0. A particle of mass M is attached to one end of the stick. The moment of inertia of the combined system about the center of the stick is

(A) $I_0 + \frac{1}{4} ML^2$

(B) $I_0 + \frac{1}{2} ML^2$

(C) $I_0 + \frac{3}{4} ML^2$

(D) $I_0 + ML^2$

(E) $I_0 + \frac{5}{4} ML^2$

28. 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

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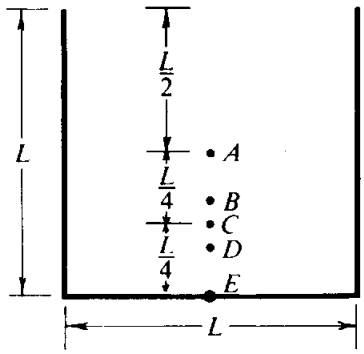
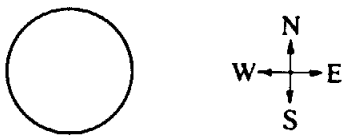


29. The center of mass of a uniform wire, bent in the shape shown above, is located closest to point

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



View of Track from Above

30. 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

31. Mass M_1 is moving with speed v toward stationary mass M_2. The speed of the center of mass of the system is

(A) $\left(\frac{M_1}{M_2}\right)v$

(B) $\left(1+\frac{M_1}{M_2}\right)v$

(C) $\left(1+\frac{M_2}{M_1}\right)v$

(D) $\left(1-\frac{M_1}{M_2}\right)v$

(E) $\left(\frac{M_1}{M_1+M_2}\right)v$

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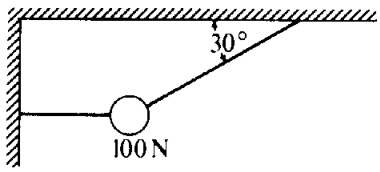

32. A 100-newton weight is suspended by two cords as shown in the figure above. The tension in the slanted cord is

(A) 50 N
(B) 100 N
(C) 150 N
(D) 200 N
(E) 250 N

33. If a particle moves in such a way that its position x is described as a function of time t by $x = t^{\frac{3}{2}}$, then its kinetic energy is proportional to

(A) t^2

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

(C) t

(D) $t^{\frac{1}{2}}$

(E) t^0 (i.e., kinetic energy is constant)

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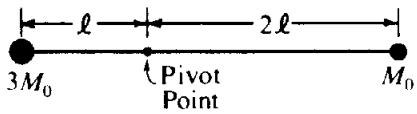
34. From the top of a 70-meter-high building, a 1-kilogram ball is thrown directly downward with an initial speed of 10 meters per second. If the ball reaches the ground with a speed of 30 meters per second, the energy lost to friction is most nearly

(A) 0 J
(B) 100 J
(C) 300 J
(D) 400 J
(E) 700 J



35. A light rigid rod with masses attached to its ends is pivoted about a horizontal axis as shown above. When released from rest in a horizontal orientation, the rod begins to rotate with an angular acceleration of magnitude

(A) $\frac{1}{7}\frac{g}{\ell}$

(B) $\frac{1}{5}\frac{g}{\ell}$

(C) $\frac{1}{4}\frac{g}{\ell}$

(D) $\frac{5}{7}\frac{g}{\ell}$

(E) $\frac{g}{\ell}$

END OF SECTION I, MECHANICS

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON SECTION I, MECHANICS, ONLY.
DO NOT WORK ON ANY OTHER TEST MATERIALS.

PHYSICS C

SECTION I, ELECTRICITY AND MAGNETISM

Time—45 minutes

35 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.

36. 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) $2\,C_0$

(E) $4\,C_0$

37. When lighted, a 100-watt light bulb operating on a 110-volt household circuit has a resistance closest to

(A) 10^{-2} ohm
(B) 10^{-1} ohm
(C) 1 ohm
(D) 10 ohms
(E) 100 ohms

38. If i is current, t is time, E is electric field intensity, and x is distance, the ratio of $\int i dt$ to $\int E dx$ may be expressed in

(A) coulombs (B) joules (C) newtons (D) farads (E) henrys

39. The electric field **E** just outside the surface of a charged conductor is

(A) directed perpendicular to the surface
(B) directed parallel to the surface
(C) independent of the surface charge density
(D) zero
(E) infinite

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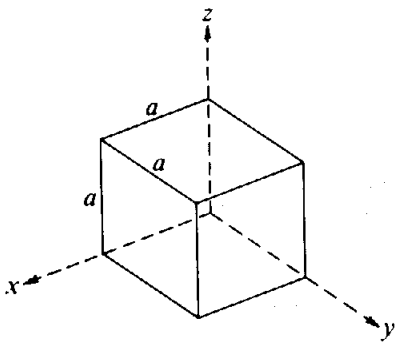
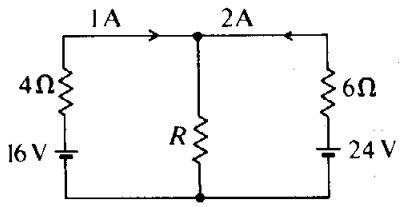


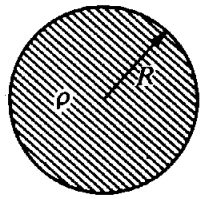
40. A closed surface, in the shape of a cube of side a, is oriented as shown above in a region where there is a constant electric field of magnitude E parallel to the x-axis. The total electric flux through the cubical surface is

(A) $-Ea^2$
(B) zero
(C) Ea^2
(D) $2\,Ea^2$
(E) $6\,Ea^2$

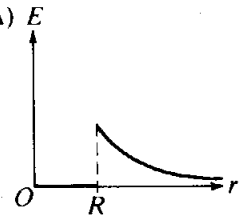


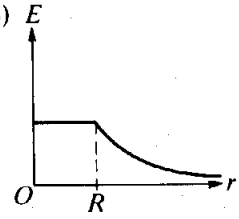
41. In the circuit shown above, what is the resistance R?

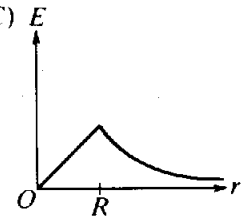
(A) 3 Ω (B) 4 Ω (C) 6 Ω
(D) 12 Ω (E) 18 Ω

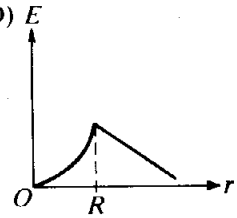


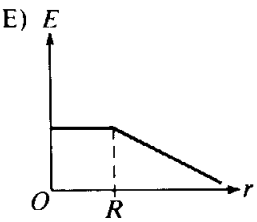
42. The figure above shows a spherical distribution of charge of radius R and constant charge density ρ. Which of the following graphs best represents the electric field strength E as a function of the distance r from the center of the sphere?

(A) 

(B) 

(C) 

(D) 

(E) 

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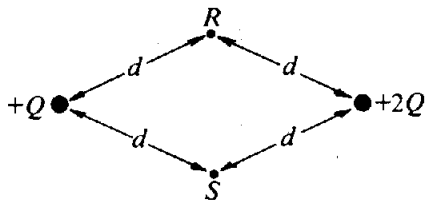
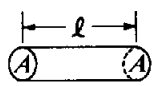
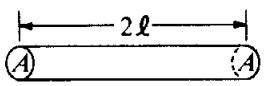


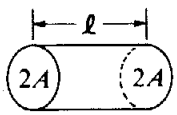
43. Points R and S are each the same distance d from two unequal charges, $+Q$ and $+2Q$, as shown above. The work required to move a charge $-Q$ from point R to point S is

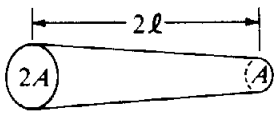
(A) dependent on the path taken from R to S
(B) directly proportional to the distance between R and S
(C) positive
(D) zero
(E) negative

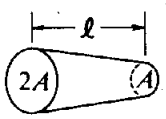
44. The five resistors shown below have the lengths and cross-sectional areas indicated and are made of material with the same resistivity. Which has the greatest resistance?

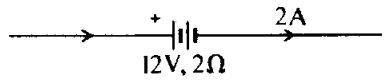
(A) 

(B) 

(C) 

(D) 

(E) 



45. A 12-volt storage battery, with an internal resistance of 2Ω, is being charged by a current of 2 amperes as shown in the diagram above. Under these circumstances, a voltmeter connected across the terminals of the battery will read

(A) 4 V (B) 8 V (C) 10 V
(D) 12 V (E) 16 V

46. A galvanometer has a resistance of 99 ohms and deflects full scale when a current of 10^{-3} ampere passes through it. In order to convert this galvanometer into an ammeter with a full-scale deflection of 0.1 ampere, one should connect a resistance of

(A) 1 Ω in series with it
(B) 901 Ω in series with it
(C) 9,900 Ω in series with it
(D) 1 Ω in parallel with it
(E) 9,900 Ω in parallel with it

47. 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 $4I_2$

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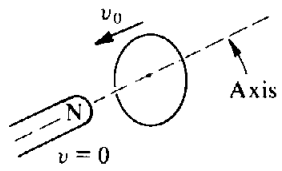
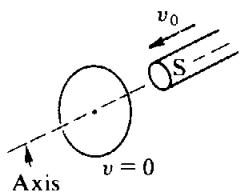
48. In each of the following situations, a bar magnet is aligned along the axis of a conducting loop. The magnet and the loop move with the indicated velocities. In which situation will the bar magnet NOT induce a current in the conducting loop?

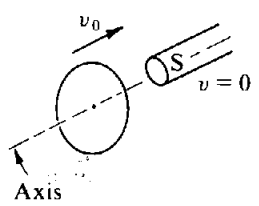
(A)



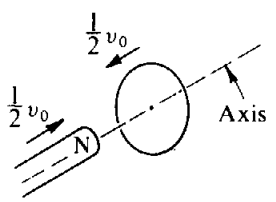
(B)



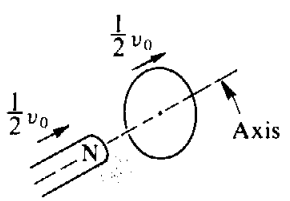
(C)



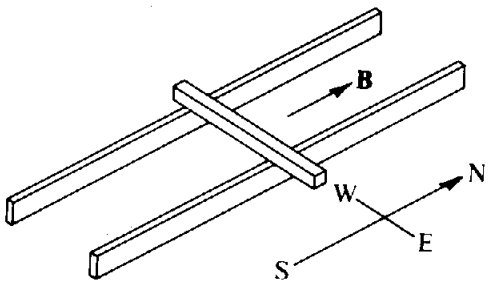
(D)



(E)



Questions 49-50



The ends of a metal bar rest on two horizontal north-south rails as shown above. The bar may slide without friction freely with its length horizontal and lying east and west as shown above. There is a magnetic field parallel to the rails and directed north.

49. If the bar is pushed northward on the rails, the electromotive force induced in the bar as a result of the magnetic field will

(A) be directed upward
(B) be zero
(C) produce a westward current
(D) produce an eastward current
(E) stop the motion of the bar

50. A battery is connected between the rails and causes the electrons in the bar to drift to the east. The resulting magnetic force on the bar is directed

(A) north
(B) south
(C) east
(D) west
(E) vertically

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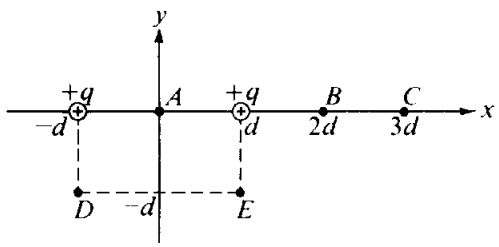
51. A charged particle is projected with its initial velocity parallel to a uniform magnetic field. The resulting path is a

(A) spiral
(B) parabolic arc
(C) circular arc
(D) straight line parallel to the field
(E) straight line perpendicular to the field

Questions 52-53



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

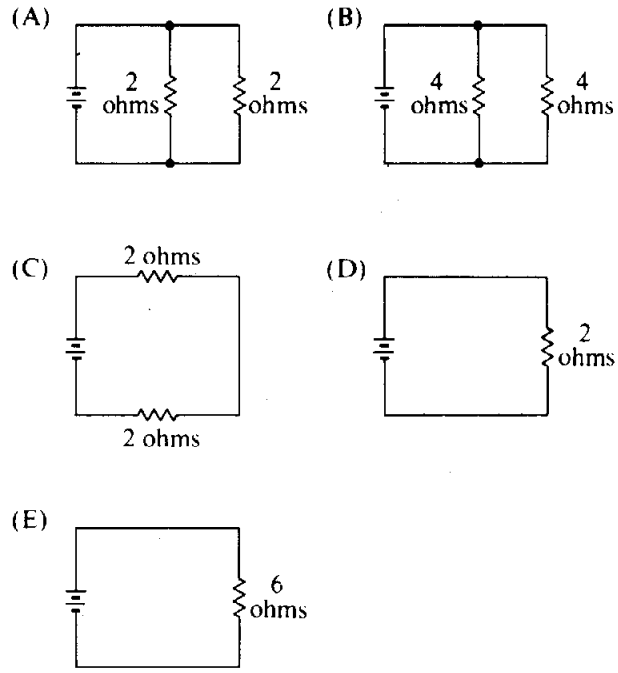
52. At which of the following points is the electric field least in magnitude?

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

53. At which of the following points is the electric potential greatest in magnitude?

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

Questions 54-56



The batteries in each of the circuits shown above are identical and the wires have negligible resistance.

54. In which circuit is the current furnished by the battery the greatest?

55. In which circuit is the equivalent resistance connected to the battery the greatest?

56. Which circuit dissipates the least power?

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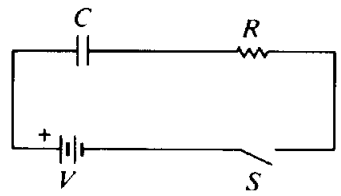
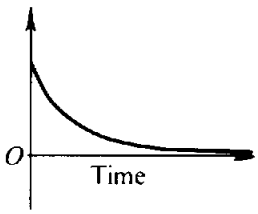
Questions 57-59 refer to the circuit shown below.

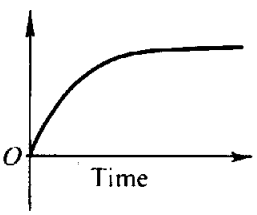


Assume the capacitor C is initially uncharged. The following graphs may represent different quantities related to the circuit as functions of time t after the switch S is closed.

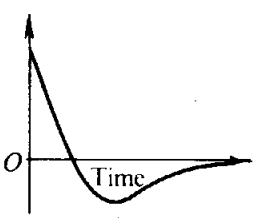
(A)



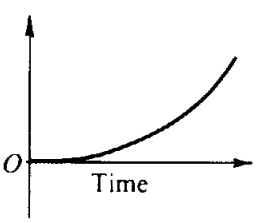
(B)



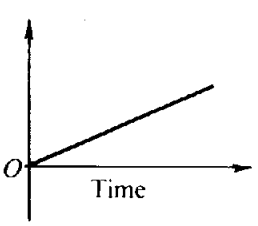
(C)



(D)



(E)



57. Which graph best represents the voltage *versus* time across the resistor R?

58. Which graph best represents the current *versus* time in the circuit?

59. Which graph best represents the voltage across the capacitor *versus* time?

Questions 60-61

Three 6-microfarad capacitors are connected in series with a 6-volt battery.

60. The equivalent capacitance of the set of capacitors is
    (A) 0.5 μF
    (B) 2 μF
    (C) 3 μF
    (D) 9 μF
    (E) 18 μF

61. The energy stored in each capacitor is
    (A) 4 μJ
    (B) 6 μJ
    (C) 12 μJ
    (D) 18 μJ
    (E) 36 μJ

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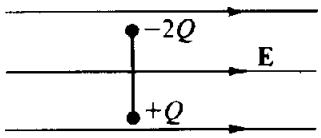
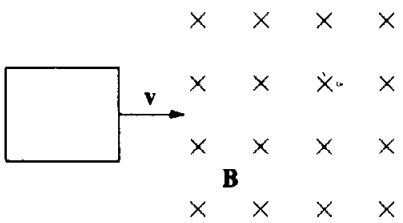


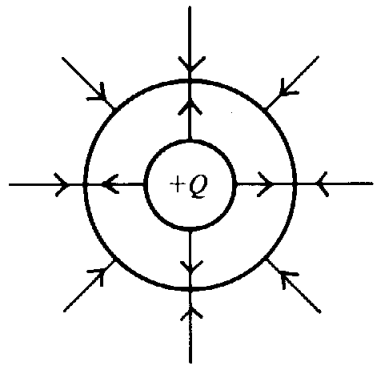
62. A rigid insulated rod, with two unequal charges attached to its ends, is placed in a uniform electric field **E** as shown above. The rod experiences a

(A) net force to the left and a clockwise rotation
(B) net force to the left and a counterclockwise rotation
(C) net force to the right and a clockwise rotation
(D) net force to the right and a counterclockwise rotation
(E) rotation, but no net force



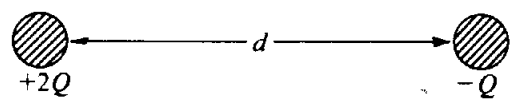
63. A loop of wire is pulled with constant velocity **v** to the right through a region of space where there is a uniform magnetic field **B** directed into the page, as shown above. The magnetic force on the loop is

(A) directed to the left both as it enters and as it leaves the region
(B) directed to the right both as it enters and as it leaves the region
(C) directed to the left as it enters the region and to the right as it leaves
(D) directed to the right as it enters the region and to the left as it leaves
(E) zero at all times



64. The electric field of two long coaxial cylinders is represented by lines of force as shown above. The charge on the inner cylinder is $+Q$. The charge on the outer cylinder is

(A) $+3Q$ (B) $+Q$ (C) 0
(D) $-Q$ (E) $-3Q$



65. 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) $F_1 = 8F_2$

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66. An isolated capacitor with air between its plates has a potential difference V_0 and a charge Q_0. After the space between the plates is filled with oil, the difference in potential is V and the charge is Q. Which of the following pairs of relationships is correct?

(A) $Q = Q_0$ and $V > V_0$

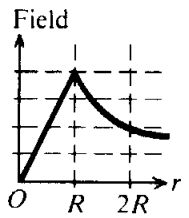
(B) $Q = Q_0$ and $V < V_0$

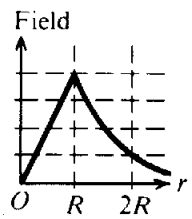
(C) $Q > Q_0$ and $V = V_0$

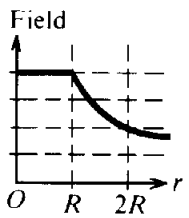
(D) $Q < Q_0$ and $V < V_0$

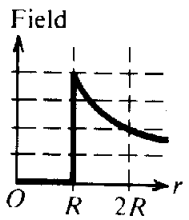
(E) $Q > Q_0$ and $V > V_0$

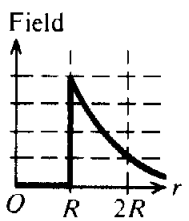
67. A solid cylindrical conductor of radius R carries a current I uniformly distributed throughout its interior. Which of the following graphs best represents the magnetic field intensity as a function of r, the radial distance from the axis of the cylinder?

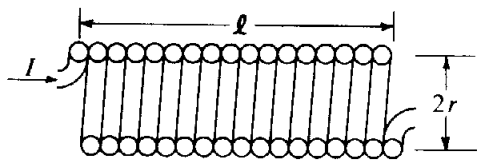
(A)


(B)


(C)


(D)


(E)




68. The cross section above shows a long solenoid of length ℓ and radius r consisting of N closely wound turns of wire. When the current in the wire is I, the magnetic field within this solenoid has magnitude B_0. A solenoid with the same number of turns N, length ℓ, and current I, but with radius $2r$, would have a magnetic field of magnitude most nearly equal to

(A) $B_0/4$

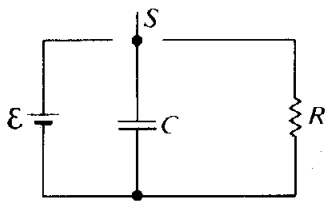
(B) $B_0/2$

(C) B_0

(D) $2\,B_0$

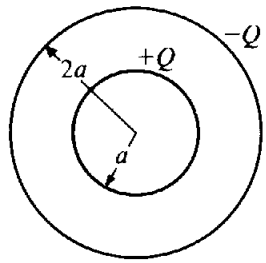
(E) $4\,B_0$

GO ON TO THE NEXT PAGE

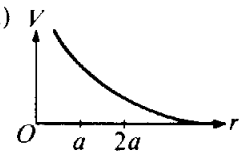


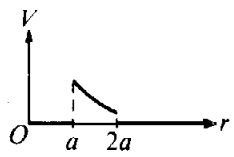
69. In the circuit shown above, the capacitor C is first charged by throwing switch S to the left, then discharged by throwing S to the right. The time constant for discharge could be increased by which of the following?

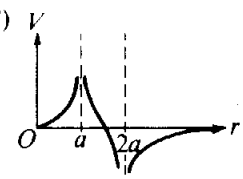
(A) Placing another capacitor in parallel with C
(B) Placing another capacitor in series with C
(C) Placing another resistor in parallel with the resistor R
(D) Increasing battery emf $\mathcal{E}$
(E) Decreasing battery emf $\mathcal{E}$

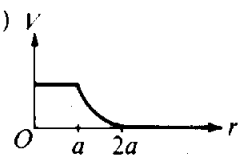


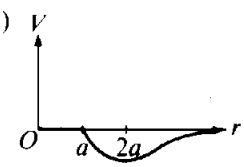
70. Concentric conducting spheres of radii a and $2a$ bear equal but opposite charges $+Q$ and $-Q$, respectively. Which of the following graphs best represents the electric potential V as a function of r?

(A)


(B)


(C)


(D)


(E)


END OF SECTION I, ELECTRICITY AND MAGNETISM

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON SECTION I, ELECTRICITY AND MAGNETISM, ONLY.
DO NOT WORK ON ANY OTHER TEST MATERIALS.

THE COLLEGE BOARD

Advanced Placement Examination

PHYSICS C

SECTION II

free-response questions

1984

PHYSICS C

SECTION II

Free-Response Questions

Mechanics	45 minutes	3 required questions of equal weight on pages 4-15
Electricity and Magnetism	45 minutes	3 required questions of equal weight on pages 16-26

Section II is 50 percent of the total grade for each of the two examinations.

Mark one of the three boxes below to indicate which questions you are answering.

- ☐ Mechanics only
- ☐ Electricity and Magnetism only
- ☐ Both Mechanics and Electricity and Magnetism

General Instructions

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 write your answer to each question in the pink booklet. 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.

The College Board

Advanced Placement Examination

PHYSICS C

SECTION II

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 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.

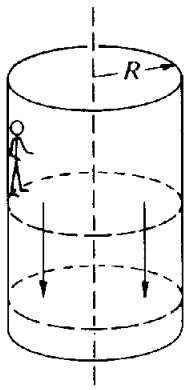
PHYSICS C

SECTION II, MECHANICS

Time—45 minutes

3 Questions

ANSWER ALL OF THE QUESTIONS. EACH OF THE THREE 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.



Mech. 1. An amusement park ride consists of a rotating vertical cylinder with rough canvas walls. The floor is initially about halfway up the cylinder wall as shown above. After the rider has entered and the cylinder is rotating sufficiently fast, the floor is dropped down, yet the rider does not slide down. The rider has a mass of 50 kilograms, the radius R of the cylinder is 5 meters, the angular velocity of the cylinder when rotating is 2 radians per second, and the coefficient of static friction between the rider and the wall of the cylinder is 0.6.

(a) On the diagram below, draw and identify the forces on the rider when the system is rotating and the floor has dropped down.

(b) Calculate the centripetal force on the rider when the cylinder is rotating and state what provides that force.

(c) Calculate the upward force that keeps the rider from falling when the floor is dropped down and state what provides that force.

(d) At the same rotational speed would a rider of twice the mass slide down the wall? Explain your answer.

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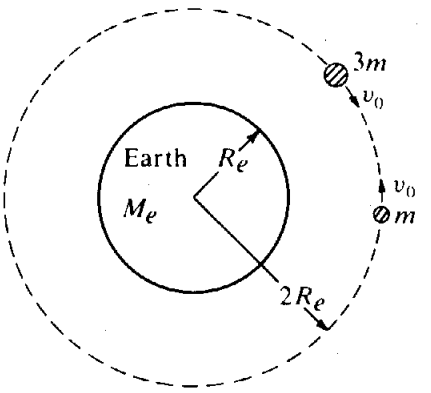


Mech. 2. Two satellites, of masses m and $3m$, respectively, are in the same circular orbit about the Earth's center, as shown in the diagram above. The Earth has mass M_e and radius R_e. In this orbit, which has a radius of $2R_e$, the satellites initially move with the same orbital speed v_0, but in opposite directions.

(a) Calculate the orbital speed v_0 of the satellites in terms of G, M_e, and R_e.

(b) Assume that the satellites collide head-on and stick together. In terms of v_0, find the speed v of the combination immediately after the collision.

(c) Calculate the total mechanical energy of the system immediately after the collision in terms of G, m, M_e, and R_e. Assume that the gravitational potential energy of an object is defined to be zero at an infinite distance from the Earth.

GO ON TO THE NEXT PAGE

Mech. 3. A small body of mass m located near the Earth's surface falls from rest in the Earth's gravitational field. Acting on the body is a resistive force of magnitude kmv, where k is a constant and v is the speed of the body.

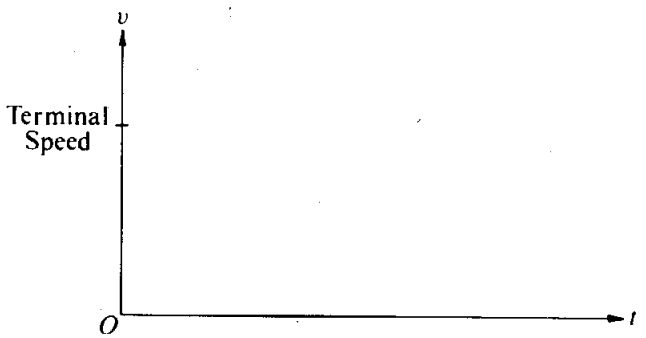
(a) On the diagram below, draw and identify all of the forces acting on the body as it falls.

(b) Write the differential equation that represents Newton's second law for this situation.

(c) Determine the terminal speed v_T of the body.

(d) Integrate the differential equation once to obtain an expression for the speed v as a function of time t. Use the condition that $v = 0$ when $t = 0$.

(e) On the axes provided below, draw a graph of the speed v as a function of time t.



END OF SECTION II, MECHANICS

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON SECTION II, MECHANICS, ONLY. DO NOT WORK ON ANY OTHER TEST MATERIALS.

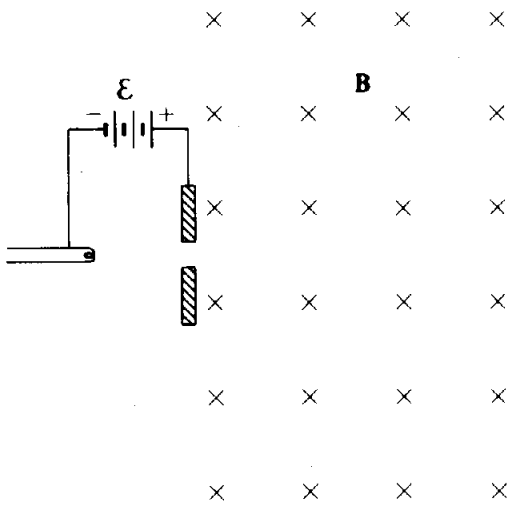
PHYSICS C

SECTION II, ELECTRICITY AND MAGNETISM

Time—45 minutes

3 Questions

ANSWER ALL OF THE QUESTIONS. EACH OF THE THREE 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.



E & M 1. 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.

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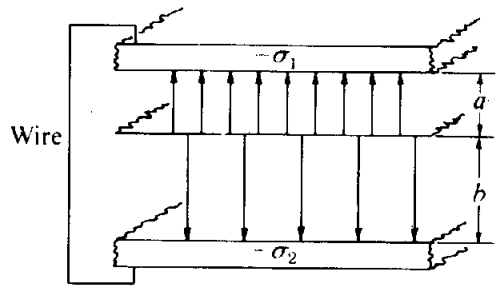
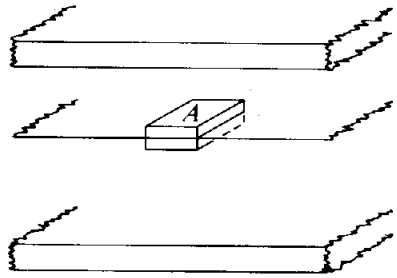


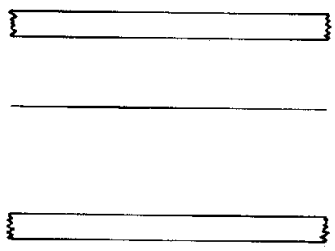
E & M 2. Two large, parallel conducting plates are joined by a wire, as shown above, so that they are at the same potential. Between the plates, at a distance a from the upper plate and a distance b from the lower plate, is a thin, uniformly charged sheet whose charge per unit area is σ. The electric fields between the plates above and below the sheet have magnitudes E_1 and E_2, respectively.

(a) Determine the ratio $\frac{E_1}{E_2}$ so that the potential difference between the outer plates is zero.

(b) The Gaussian surface in the diagram immediately below has faces of area A parallel to the charged sheet. By applying Gauss's law to this surface, develop a relationship among E_1, E_2, σ, and any appropriate fundamental constants.



(c) By applying Gauss's law to an appropriately chosen Gaussian surface, show that the sum of the induced charge densities, σ_1 and σ_2, on the inner surfaces of the conducting plates equals $-\sigma$. Indicate clearly on the diagram below the Gaussian surface you used.



(d) Develop an expression for the potential difference V between the charged sheet and the conducting plates in terms of σ, a, b, and any appropriate fundamental constants.

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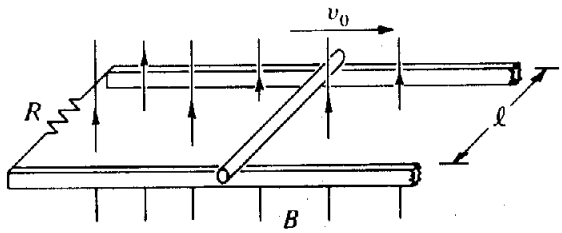

E & M 3. Two horizontal conducting rails are separated by a distance ℓ as shown above. The rails are connected at one end by a resistor of resistance R. A conducting rod of mass m can slide without friction along the rails. The rails and the rod have negligible resistance. A uniform magnetic field of magnitude B is perpendicular to the plane of the rails as shown. The rod is given a push to the right and then allowed to coast. At time $t = 0$ (immediately after it is pushed) the rod has a speed v_0 to the right.

(a) Indicate on the diagram above the direction of the induced current in the resistor.

(b) In terms of the quantities given, determine the magnitude of the induced current in the resistor at time $t = 0$.

(c) Indicate on the diagram above the direction of the force on the rod.

(d) In terms of the quantities given, determine the magnitude of the force acting on the rod at time $t = 0$.

If the rod is allowed to continue to coast, its speed as a function of time will be as follows.

$$v = v_0 e^{-\left(\frac{B^2 \ell^2 t}{Rm}\right)}$$

(e) In terms of the quantities given, determine the power developed in the resistor as a function of time t.

(f) Show that the total energy produced in the resistor is equal to the initial kinetic energy of the bar.

END OF SECTION II, ELECTRICITY AND MAGNETISM

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON SECTION II, ELECTRICITY AND MAGNETISM, ONLY. DO NOT WORK ON ANY OTHER TEST MATERIALS.

KEY Multiple Choice
1984 AP Physics C
Mechanics

1. D
2. C
3. C
4. A
5. B
6. C
7. E
8. B
9. D
10. A
11. D
12. B
13. A
14. A
15. E
16. A
17. B
18. D
19. D
20. B
21. C
22. C
23. A
24. B
25. E
26. D
27. A
28. C
29. B
30. A
31. B
32. D
33. A
34. C
35. A

36. C 72
37. E 60
38. D 43
39. A 82
40. B 37
41. B 51
42. C 42
43. D 52
44. B 62
45. E 22
46. D 36
47. D 68
48. E 87
49. B 62
50. E 73
51. D 69
52. A 70
53. A 48
54. A 75
55. E 90
56. E 59
57. A 54
58. A 58
59. B 58
60. B 76
61. C 36
62. B 66
63. A 31
64. E 58
65. E 35
66. B 43
67. A 22
68. C 32
69. A 50
70. D 39