AP® Physics C
1998 Multiple Choice Questions
Electricity and Magnetism

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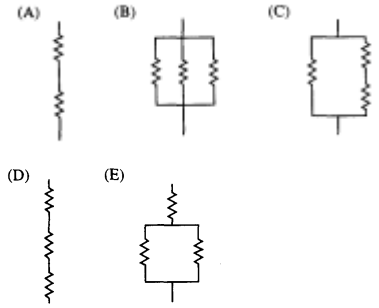
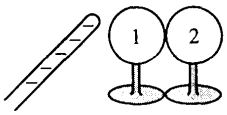
36. A resistor R and a capacitor C are connected in series to a battery of terminal voltage V_0. Which of the following equations relating the current I in the circuit and the charge Q on the capacitor describes this circuit?
(A) $V_0 + QC - I^2R = 0$ (B) $V_0 - Q/C - IR = 0$ (C) $V_0^2 - Q^2/2C - I^2R = 0$
(D) $V_0 - C(dQ/dt) - I^2R = 0$ (E) $Q/C - IR = 0$

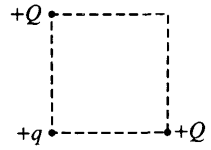
37. Which of the following combinations of 4Ω resistors would dissipate 24 W when connected to a 12 Volt battery?





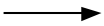
38. Two initially uncharged conductors, 1 and 2, are mounted on insulating stands and are in contact, as shown above. A negatively charged rod is brought near but does not touch them. With the rod held in place, conductor 2 is moved to the right by pushing its stand, so that the conductors are separated. Which of the following is now true of conductor 2 ?
(A) It is uncharged. (B) It is positively charged. (C) It is negatively charged.
(D) It is charged, but its sign cannot be predicted.
(E) It is at the same potential that it was before the charged rod was brought near.

Questions 39-40



As shown above, two particles, each of charge +Q, are fixed at opposite corners of a square that lies in the plane of the page. A positive test charge +q is placed at a third corner.

39. What is the direction of the force on the test charge due to the two other charges?

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

40. If F is the magnitude of the force on the test charge due to only one of the other charges, what is the magnitude of the net force acting on the test charge due to both of these charges?
(A) Zero (B) $\frac{F}{\sqrt{2}}$ (C) F (D) $\sqrt{2}F$ (E) 2

41. Gauss's law provides a convenient way to calculate the electric field outside and near each of the following isolated charged conductors EXCEPT a
(A) large plate (B) sphere (C) cube (D) long, solid rod (E) long, hollow cylinder

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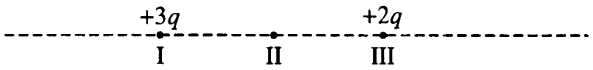
42. A wire of resistance *R* dissipates power *P* when a current *I* passes through it. The wire is replaced by another wire with resistance *3R*. The power dissipated by the new wire when the same current passes through it is
(A) P/9 (B) P/3 (C) P (D) 3P (E) 6P

Questions 43-44
A narrow beam of protons produces a current of 1.6×10^{-3} A. There are 10^{9} protons in each meter along the beam.

43. Of the following, which is the best estimate of the average speed of the protons in the beam?
(A) 10^{-15} m/s (B) 10^{-12} m/s (C) 10^{-7} m/s (D) 10^{7} m/s (E) 10^{12} m/s

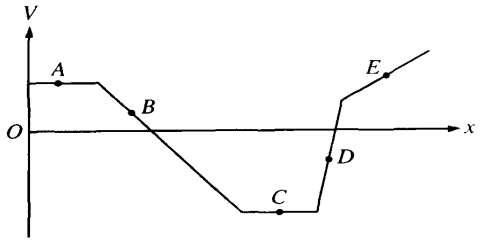
44. Which of the following describes the lines of magnetic field in the vicinity of the beam due to the beam's current?
(A) Concentric circles around the beam (B) Parallel to the beam (C) Radial and toward the beam
(D) Radial and away from the beam (E) There is no magnetic field.

Questions 45-46 refer to two charges located on the line shown in the figure below, in which the charge at point I is +3q and the charge at point III is +2q. Point II is halfway between points I and III.



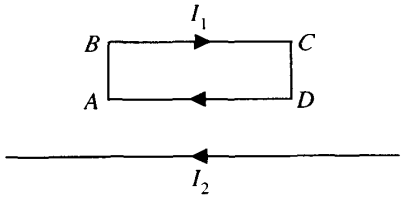
45. Other than at infinity, the electric field strength is zero at a point on the line in which of the following ranges?
(A) To the left of I (B) Between I and II (C) Between II and III (D) To the right of III
(E) None; the field is zero only at infinity.

46. The electric potential is negative at some points on the line in which of the following ranges?
(A) To the left of I (B) Between I and II (C) Between II and III (D) To the right of III
(E) None; this potential is never negative.



47. The graph above shows the electric potential V in a region of space as a function of position along the x-axis. At which point would a charged particle experience the force of greatest magnitude?
(A) A (B) B (C) C (D) D (E) E:

48. The work that must be done by an external agent to move a point charge of 2 mC from the origin to a point 3 m away is 5 J. What is the potential difference between the two points?
(A) 4×10^{-4} V (B) 10^{-2} V (C) 2.5×10^{3} V (D) 2×10^{6} V (E) 6×10^{6} V



49. A rigid, rectangular wire loop ABCD carrying current I_1 lies in the plane of the page above a very long wire carrying current I_2 as shown above. The net force on the loop is
(A) toward the wire (B) away from the wire (C) toward the left (D) toward the right (E) zero

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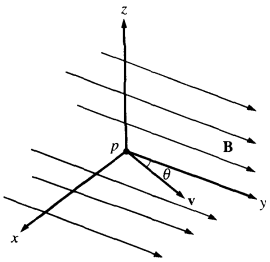
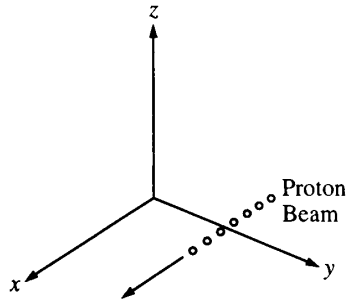


50. A uniform magnetic field **B** is parallel to the xy-plane and in the +y-direction, as shown above. A proton *p* initially moves with velocity **v** in the xy-plane at an angle θ to the magnetic field and the y-axis. The proton will subsequently follow what kind of path?
(A) A straight-line path in the direction of **v** (B) A circular path in the xy-plane
(C) A circular path in the yz-plane (D) A helical path with its axis parallel to the y-axis
(E) A helical path with its axis parallel to the z-axis

51. A parallel-plate capacitor has charge $+Q$ on one plate and charge $-Q$ on the other. The plates, each of area A, are a distance d apart and are separated by a vacuum. A single proton of charge $+e$, released from rest at the surface of the positively charged plate, will arrive at the other plate with kinetic energy proportional to
(A) $\frac{edQ}{A}$ (B) $\frac{Q^2}{eAd}$ (C) $\frac{AeQ}{d}$ (D) $\frac{Q}{ed}$ (E) $\frac{eQ^2}{Ad}$

52. In which of the following cases does there exist a nonzero magnetic field that can be conveniently determined by using Ampere's law?
(A) Outside a point charge that is at rest
(B) Inside a stationary cylinder carrying a uniformly distributed charge
(C) Inside a very long current-carrying solenoid
(D) At the center of a current-carrying loop of wire
(E) Outside a square current-carrying loop of wire



53. A beam of protons moves parallel to the x-axis in the positive x-direction, as shown above, through a region of crossed electric and magnetic fields balanced for zero deflection of the beam. If the magnetic field is pointed in the positive y-direction, in what direction must the electric field be pointed?
(A) Positive y-direction (B) Positive z-direction (C) Negative x-direction (D) Negative y-direction
(E) Negative z-direction

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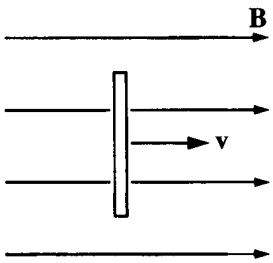
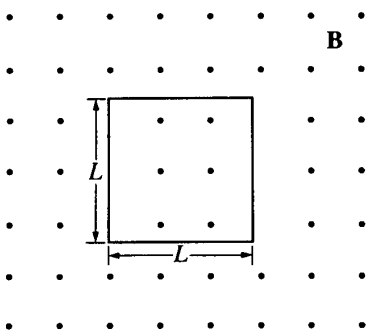


54. A vertical length of copper wire moves to the right with a steady velocity v in the direction of a constant horizontal magnetic field B as shown above. Which of the following describes the induced charges on the ends of the wire?

Top End	Bottom End
(A) Positive	Negative
(B) Negative	Positive
(C) Negative	Zero
(D) Zero	Negative
(E) Zero	Zero

55. Suppose that an electron (charge -e) could orbit a proton (charge +e) in a circular orbit of constant radius R. Assuming that the proton is stationary and only electrostatic forces act on the particles, which of the following represents the kinetic energy of the two-particle system?

(A) $\frac{1}{4\pi\varepsilon_0}\frac{e}{R}$ (B) $\frac{1}{8\pi\varepsilon_0}\frac{e^2}{R}$ (C) $-\frac{1}{8\pi\varepsilon_0}\frac{e^2}{R}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{e^2}{R^2}$ (E) $-\frac{1}{4\pi\varepsilon_0}\frac{e^2}{R^2}$



56. A square wire loop with side *L* and resistance *R* is held at rest in a uniform magnetic field of magnitude *B* directed out of the page, as shown above. The field decreases with time *t* according to the equation $B = a - bt$, where a and b are positive constants. The current I induced in the loop is
(A) zero (B) aL^2/R, clockwise (C) aL^2/R, counterclockwise
(D) bL^2/R, clockwise (E) bL^2/R, counterclockwise

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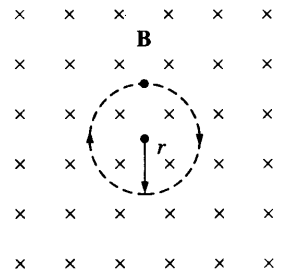
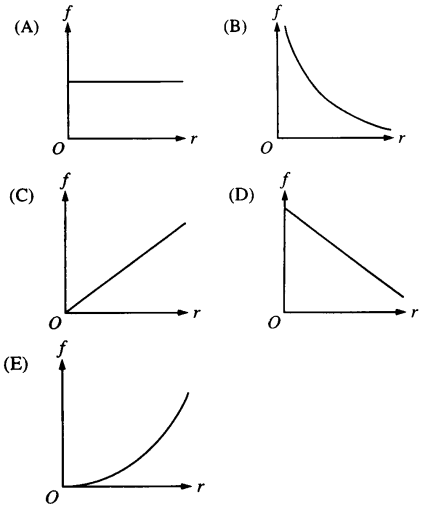


57. A negatively charged particle in a uniform magnetic field B moves in a circular path of radius r, as shown above. Which of the following graphs best depicts how the frequency of revolution f of the particle depends on the radius r ?



58. If the only force acting on an electron is due to a uniform electric field, the electron moves with constant
    (A) acceleration in a direction opposite to that of the field
    (B) acceleration in the direction of the field
    (C) acceleration in a direction perpendicular to that of the field
    (D) speed in a direction opposite to that of the field
    (E) speed in the direction of the field

Questions 59-60

In a region of space, a spherically symmetric electric potential is given as a function of *r*, the distance from the origin, by the equation $V(r) = kr^2$, where *k* is a positive constant.

59. What is the magnitude of the electric field at a point a distance r_0 from the origin?
    (A) Zero (B) kr_0 (C) $2kr_0$ (D) kr_0^2 (E) $2kr_0^3/3$

60. What is the direction of the electric field at a point a distance r_0 from the origin and the direction of the force on an electron placed at this point?

Electric Field	Force on Electron
(A) Toward origin	Toward origin
(B) Toward origin	Away from origin
(C) Away from origin	Toward origin
(D) Away from origin	Away from origin
(E) Undefined, since the field is zero	Undefined, since the force is zero

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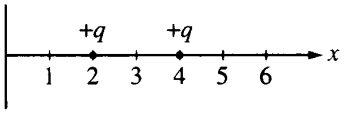
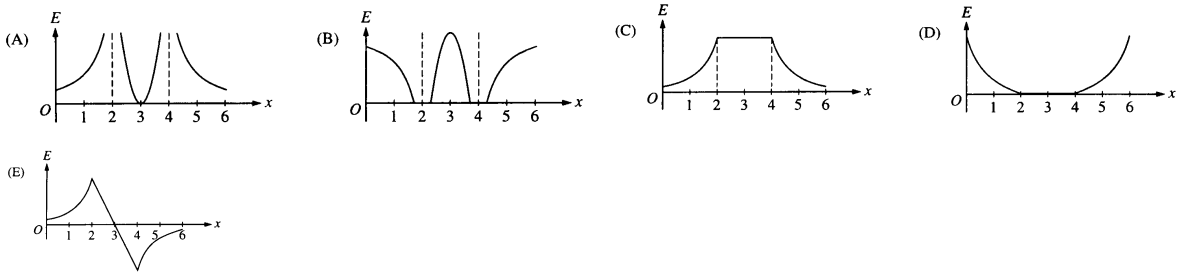
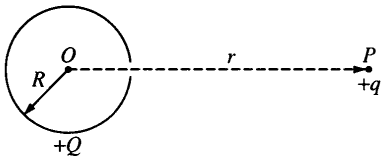


61. Two charged particles, each with a charge of +q, are located along the x-axis at x = 2 and x = 4, as shown above. Which of the following shows the graph of the magnitude of the electric field along the x-axis from the origin to x = 6 ?

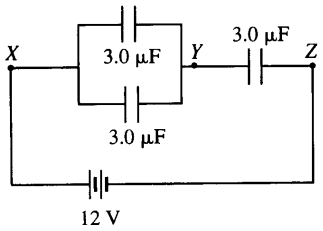


62. A positive electric charge is moved at a constant speed between two locations in an electric field, with no work done by or against the field at any time during the motion. This situation can occur only if the
(A) charge is moved in the direction of the field
(B) charge is moved opposite to the direction of the field
(C) charge is moved perpendicular to an equipotential line
(D) charge is moved along an equipotential line
(E) electric field is uniform



63. The nonconducting hollow sphere of radius R shown above carries a large charge +Q, which is uniformly distributed on its surface. There is a small hole in the sphere. A small charge +q is initially located at point P. a distance r from the center of the sphere. If k = I/4~0, what is the work that must be done by an external agent in moving the charge +q from P through the hole to the center O of the sphere?
(A) Zero (B) kqQ/r (C) kqQ/R (D) kq(Q-q)/r (E) kqQ(1/R - 1/r)

Questions 64-65



Three identical capacitors, each of capacitance 3.0 μF, are connected in a circuit with a 12 V battery as shown above.

64. The equivalent capacitance between points X and Z is
(A) 1.0 μF (B) 2.0 μF (C) 4.5 μF (D) 6.0 μF (E) 9.0 μF

65. The potential difference between points Y and Z is
(A) zero (B) 3 V (C) 4 V (D) 8 V (E) 9 V

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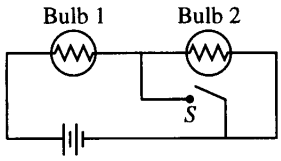
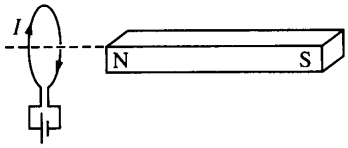
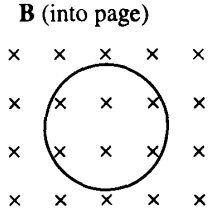


6. The circuit in the figure above contains two identical lightbulbs in series with a battery. At first both bulbs glow with equal brightness. When switch S is closed, which of the following occurs to the bulbs?

Bulb I	Bulb 2
(A) Goes out	Gets brighter
(B) Gets brighter	Goes out
(C) Gets brighter	Gets slightly dimmer
(D) Gets slightly dimmer	Gets brighter
(E) Nothing	Goes out



67. A bar magnet and a wire loop carrying current I are arranged as shown above. In which direction, if any, is the force on the current loop due to the magnet?
(A) Toward the magnet (B) Away from the magnet (C) Toward the top of the page
(D) Toward the bottom of the page (E) There is no force on the current loop.



68. A wire loop of area *A* is placed in a time-varying but spatially uniform magnetic field that is perpendicular to the plane of the loop, as shown above. The induced emf in the loop is given by $\mathcal{E} = bAt^{1/2}$, where b is a constant. The time varying magnetic field could be given by

(A) $\frac{1}{2}bAt^{-1/2}$ (B) $\frac{1}{2}bt^{-1/2}$ (C) $\frac{1}{2}bt^{1/2}$ (D) $\frac{2}{3}bAt^{3/2}$ (E) $\frac{2}{3}bt^{3/2}$

Questions 69-70

A capacitor is constructed of two identical conducting plates parallel to each other and separated by a distance d. The capacitor is charged to a potential difference of V_o by a battery, which is then disconnected.

69. If any edge effects are negligible, what is the magnitude of the electric field between the plates?
(A) $V_o d$ (B) V_o/d (C) d/V_o (D) V_o/d^2 (E) V_o^2/d

70. A sheet of insulating plastic material is inserted between the plates without otherwise disturbing the system. What effect does this have on the capacitance?
(A) It causes the capacitance to increase.
(B) It causes the capacitance to decrease.
(C) None; the capacitance does not change.
(D) Nothing can be said about the effect without knowing the dielectric constant of the plastic.
(E) Nothing can be said about the effect without knowing the thickness of the sheet.

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Chapter V Answers to the 1998 AP Physics C Examination

- Section I: Multiple Choice
  - Blank Answer Sheet
- Section II: Free Response

Section I: Multiple Choice

Listed below are the correct answers to the multiple-choice questions and the percentage of AP candidates who answered each question correctly.

Answer Key and Percent Answering Correctly

Mechanics			Electricity & Magnetism		
Item No.	Correct Answer	Percent Correct	Item No.	Correct Answer	Percent Correct
1	B	82%	36	B	74%
2	E	82%	37	E	65%
3	D	78%	38	C	77%
4	B	67%	39	E	93%
5	C	69%	40	D	79%
6	A	56%	41	C	56%
7	A	56%	42	D	75%
8	D	45%	43	D	29%
9	D	18%	44	A	75%
10	A	53%	45	C	80%
11	E	45%	46	E	61%
12	C	68%	47	D	34%
13	C	81%	48	C	45%
14	B	61%	49	A	49%
15	A	42%	50	D	33%
16	C	54%	51	A	28%
17	A	50%	52	C	45%
18	B	82%	53	E	50%
19	A	35%	54	E	63%
20	B	18%	55	B	26%
21	D	89%	56	E	50%
22	E	42%	57	A	19%
*23	—	—	58	A	53%
24	A	67%	59	C	50%
25	B	56%	60	B	24%
26	C	63%	61	A	74%
27	D	46%	62	D	64%
28	C	59%	63	E	39%
29	E	29%	64	B	71%
30	B	71%	65	D	27%
31	E	48%	66	B	46%
32	E	65%	67	A	24%
33	B	36%	68	E	30%
34	A	37%	69	B	62%
35	D	58%	70	A	61%

*This question was not counted when the exam was scored.