# AP® Physics C
# 1993 Multiple Choice Questions
# Electricity and Magnetism

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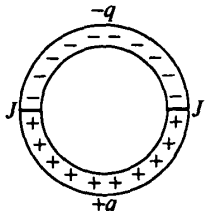
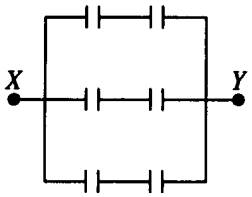
36. From the electric field vector at a point, one can determine which of the following?
    I. The direction of the electrostatic force on a test charge of known sign at that point
    II. The magnitude of the electrostatic force exerted per unit charge on a test charge at that point
    III. The electrostatic charge at that point
    A) I only  B) III only  C) I and II only  D) II and III only  E) I, II, and III




37. A circular ring made of an insulating material is cut in half. One half is given a charge -q uniformly distributed along its arc. The other half is given a charge + q also uniformly distributed along its arc. The two halves are then rejoined with insulation at the junctions J, as shown above. If there is no change in the charge distributions, what is the direction of the net electrostatic force on an electron located at the center of the circle?
    A) Toward the top of the page  B) Toward the bottom of the page  C) To the right
    D) To the left  E) Into the page.

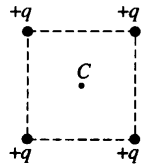
38. The net electric flux through a closed surface is
    A) infinite only if there are no charges enclosed by the surface
    B) infinite only if the net charge enclosed by the surface is zero
    C) zero if only negative charges are enclosed by the surface
    D) zero if only positive charges are enclosed by the surface
    E) zero if the net charge enclosed by the surface is zero

Questions 39-40 refer to the system of six 2-microfarad capacitors shown below.




39. The equivalent capacitance of the system of capacitors is
    A) 2/3μF  B) 4/3 μF  C) 3 μF  D) 6 μF  E) 12 μF

40. What potential difference must be applied between points X and Y so that the charge on each plate of each capacitor will have magnitude 6 microcoulombs?
    A) 1.5 V  B) 3V  C) 6 V  D) 9 V  E) 18 V

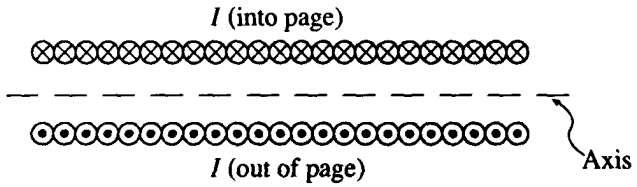



41. Four positive charges of magnitude q are arranged at the corners of a square, as shown above. At the center C of the square, the potential due to one charge alone is $V_o$ and the electric field due to one charge alone has magnitude $E_o$. Which of the following correctly gives the electric potential and the magnitude of the electric field at the center of the square due to all four charges?

| | Electric Potential | Electric Field |
|---|---|---|
| A) | Zero | Zero |

| | | |
|---|---|---|
| B) | Zero | $2E_o$ |
| C) | $2\ V_o$ | $4E_o$ |
| D) | $4\ V_o$ | Zero |
| E) | $4\ V_o$ | $2E_o$ |

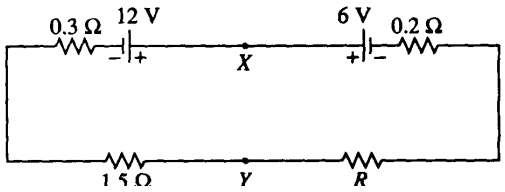
42. A large parallel-plate capacitor is being charged and the magnitude of the electric field between the plates of the capacitor is increasing at the rate dE/dt. Which of the following statements is correct about the magnetic field in the region between the plates of the charging capacitor?
    A) It is parallel to the electric field.
    B) Its magnitude is directly proportional to dE/dt.
    C) Its magnitude is inversely proportional to dE/dt.
    D) Nothing about the field can be determined unless the charging current is known.
    E) Nothing about the field can be determined unless the instantaneous electric field is known.




43. A cross section of a long solenoid that carries current I is shown above. All of the following statements about the magnetic field B inside the solenoid are correct EXCEPT:
    A) B is directed to the left.
    B) An approximate value for the magnitude of B may be determined by using Ampere's law.
    C) The magnitude of B is proportional to the current I.
    D) The magnitude of B is proportional to the number of turns of wire per unit length.
    E) The magnitude of B is proportional to the distance from the axis of the solenoid.

44. The power dissipated in a wire carrying a constant electric current I may be written as a function of I, the length *l* of the wire, the diameter d of the wire, and the resistivity ρ of the material in the wire. In this expression, the power dissipated is directly proportional to which of the following?
    A) *l* only  B) d only  C) *l* and ρ only  D) d and ρ only  E) *l*, d, and ρ

Questions 45-47



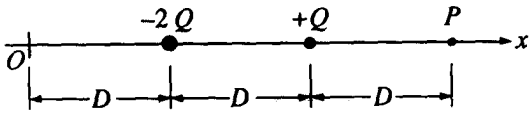

In the circuit above, the emf's and the resistances have the values shown. The current I in the circuit is 2 amperes.

45. The resistance R is
    A) 1 Ω  B) 2Ω  C) 3 Ω  D) 4 Ω  E) 6 Ω

46. The potential difference between points X and Y is
    A) 1.2 V  B) 6.0 V  C) 8.4 V  D) 10.8 V  E) 12.2 V

47. How much energy is dissipated by the 1.5-ohm resistor in 60 seconds?
    A) 6 J  B) 180 J  C) 360 J  D) 720 J  E) 1,440 J

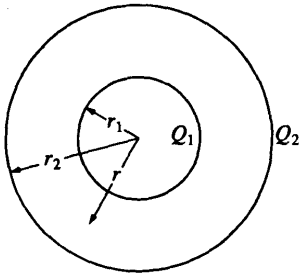
48. A conducting sphere of radius R carries a charge Q. Another conducting sphere has a radius R/2, but carries the same charge. The spheres are far apart. The ratio of the electric field near the surface of the smaller sphere to the field near the surface of the larger sphere is most nearly
A) 1/4 B) 1/2 C) 1 D) 2 E) 4




49. Two charges, -2Q and +Q, are located on the x-axis, as shown abovE) Point P, at a distance of 3D from the origin O, is one of two points on the positive x-axis at which the electric potential is zero. How far from the origin O is the other point?
A) (2/3) D B) D C) 3/2 D D) 5/3 D E) 2D

50. What is the radial component of the electric field associated with the potential $V = ar^{-2}$ where a is a constant?
A) $-2ar^{-3}$ B) $-2ar^{-1}$ C) $ar^{-1}$ D) $2ar^{-1}$ E) $2ar^{-3}$

Questions 51-52

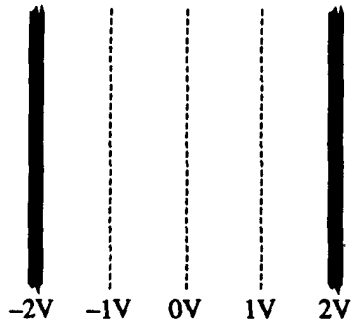



Two concentric, spherical conducting shells have radii $r_1$ and $r_2$ and charges $Q_1$ and $Q_2$, as shown above. Let r be the distance from the center of the spheres and consider the region $r_1 < r < r_2$.

51. In this region the electric field is proportional to
A) $Q_1/r^2$ B) $(Q_1 + Q_2)/r^2$ C) $(Q_1 + Q_2)/r$ D) $Q_1/r_1 + Q_2/r$ E) $Q_1/r + Q_2/r_2$

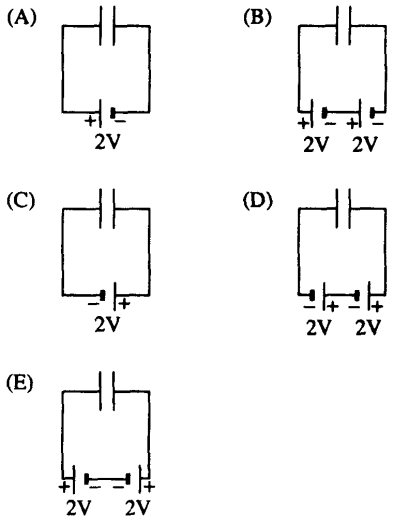
52. In this region the electric potential relative to infinity is proportional to
A) $Q_1/r^2$ B) $(Q_1 + Q_2)/r^2$ C) $(Q_1 + Q_2)/r$ D) $Q_1/r_1 + Q_2/r$ E) $Q_1/r + Q_2/r_2$

Questions 52-53




A battery or batteries connected to two parallel plates produce the equipotential lines between the plates shown above.

53. Which of the following configurations is most likely to produce these equipotential lines?

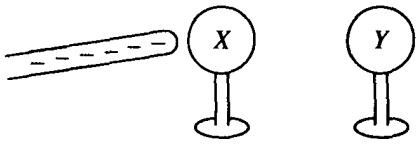



54. The force on an electron located on the 0-volt potential line is

A) 0 N B) I N, directed to the right C) I N, directed to the left

D) directed to the right, but its magnitude cannot be determined without knowing the distance between the lines

E) directed to the left, but its magnitude cannot be determined without knowing the distance between the lines




55. Two metal spheres that are initially uncharged are mounted on insulating stands, as shown above. A negatively charged rubber rod is brought close to, but does not make contact with, sphere X. Sphere Y is then brought close to X on the side opposite to the rubber rod. Y is allowed to touch X and then is removed some distance away. The rubber rod is then moved far away from X and Y. What are the final charges on the spheres?

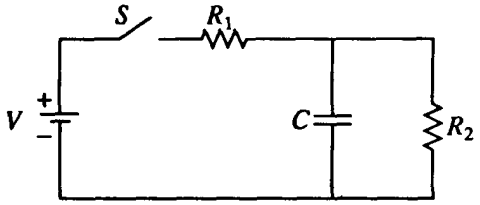
| Sphere X | Sphere Y |
|---|---|
| A) Zero | Zero |
| B) Negative | Negative |
| C) Negative | Positive |
| D) Positive | Negative |
| E) Positive | Positive |

56. The potential of an isolated conducting sphere of radius R is given as a function of the charge q on the sphere by the equation V = kq/R. If the sphere is initially uncharged, the work W required to gradually increase the total charge on the sphere from zero to Q is given by which of the following expressions?

A) W = kQ/R B) W = $kQ^2/R$ C) W = $\int_0^Q (kq / R)dq$ D) W = $\int_0^Q (kq^2 / R)dq$

E) W = $\int_0^Q (kq / R^2)dq$

Questions 57-58




In the circuit shown above, the battery supplies a constant voltage V when the switch S is closed. The value of the capacitance is C, and the value of the resistances are $R_1$ and $R_2$.

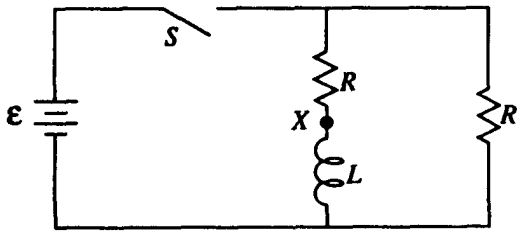
57. Immediately after the switch is closed, the current supplied by the battery is

A) $V/(R_1 + R_2)$ B) $V/R_1$ C) $V/R_2$ D) $V(R_1 + R_2)/R_1R_2$ E) zero

58. A long time after the switch has been closed, the current supplied by the battery is

A) $V/(R_1 + R_2)$ B) $V/R_1$ C) $V/R_2$ D) $V(R_1 + R_2)/R_1R_2$ E) zero

Questions 59-61 relate to the following circuit in which the switch S has been open for a long time.



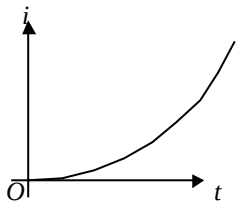

59. What is the instantaneous current at point X immediately after the switch is closed?

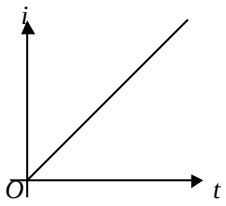
A) 0 B) $\mathcal{E}/R$ C) $\mathcal{E}/2R$ D) $\mathcal{E}/RL$ E) $\mathcal{E}L/2R$

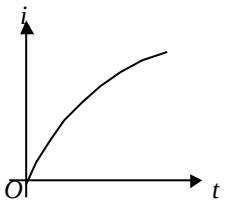
60. When the switch has been closed for a long time what is the energy stored in the inductor?

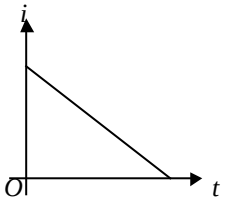
A) $L\mathcal{E}/2R$ B) $L\mathcal{E}^2/2R^2$ C) $L\mathcal{E}^2/4R^2$ D) $LR^2/2\mathcal{E}^2$ E) $\mathcal{E}^2R^2/4L$

61. After the switch has been closed for a long time, it is opened at time t = 0. Which of the following graphs best represents the subsequent current i at point X as a function of time t ?

(A)



(B)



(C)



(D)
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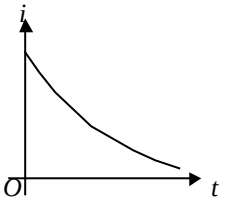
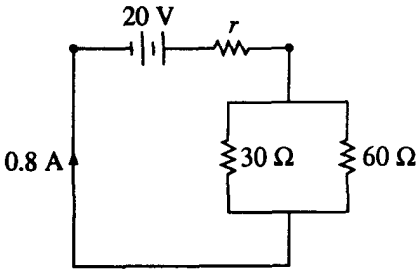
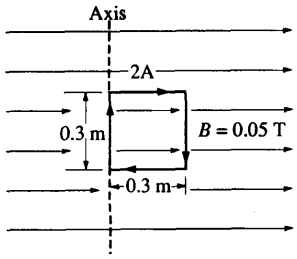


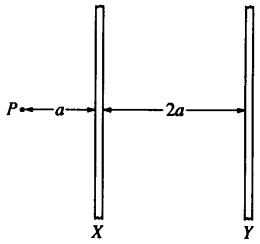

62. A 30-ohm resistor and a 60-ohm resistor are connected as shown above to a battery of emf 20 volts and internal resistance r. The current in the circuit is 0.8 ampere. What is the value of r ?

A) 0.22 Ω B) 4.5 Ω C) 5 Ω D) 16Ω E) 70 Ω

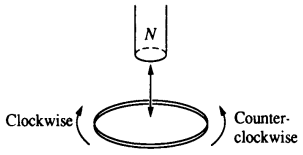



63. A square loop of wire 0.3 meter on a side carries a current of 2 amperes and is located in a uniform 0.05-tesla magnetic field. The left side of the loop is aligned along and attached to a fixed axis. When the plane of the loop is parallel to the magnetic field in the position shown above, what is the magnitude of the torque exerted on the loop about the axis?
A) 0.00225 Nm B) 0.0090 Nm C) 0.278 Nm D) 1.11 Nm E) 111 Nm

64. A solid nonconducting sphere of radius R has a charge Q uniformly distributed throughout its volume. A Gaussian surface of radius r with r < R is used to calculate the magnitude of the electric field E at a distance r from the center of the sphere. Which of the following equations results from a correct application of Gauss's law for this situation?
A) $E(4\pi R^2) = Q/\varepsilon_o$ B) $E(4\pi r^2) = Q/\varepsilon_o$ C) $E(4\pi r^2) = (Q3r^3)/(\varepsilon_o 4\pi R)$
D) $E(4\pi r^2) = (Qr^3)/(\varepsilon_o R^3)$ E) $E(4\pi r^2) = 0$

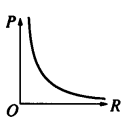


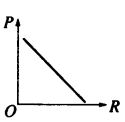

65. Two long parallel wires are a distance 2a apart, as shown above. Point P is in the plane of the wires and a distance a from wire X. When there is a current I in wire X and no current in wire Y, the magnitude of the magnetic field at P is $B_o$. When there are equal currents I in the same direction in both wires, the magnitude of the magnetic field at P is
A) $2B_o/3$ B) $B_o$ C) $10B_o/9$ D) $4B_o/3$ E) $2\,B_o$

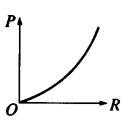


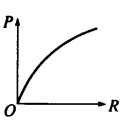

66. In the figure above, the north pole of the magnet is first moved down toward the loop of wire, then withdrawn upward. As viewed from above, the induced current in the loop is
A) always clockwise with increasing magnitude
B) always clockwise with decreasing magnitude
C) always counterclockwise with increasing magnitude
D) always counterclockwise with decreasing magnitude
E) first counterclockwise, then clockwise

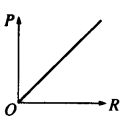
67. A variable resistor is connected across a constant voltage source. Which of the following graphs represents the power P dissipated by the resistor as a function of its resistance R ?

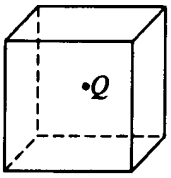
(A) 


(B) 


(C) 

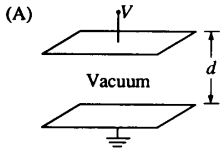

(D) 

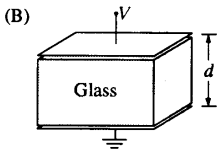

(E) 

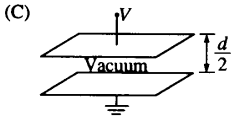



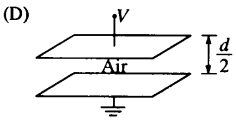

68. The point charge Q shown above is at the center of a metal box that is isolated, ungrounded, and uncharged. Which of the following is true?
A) The net charge on the outside surface of the box is Q.
B) The potential inside the box is zero.
C) The electric field inside the box is constant.
D) The electric field outside the box is zero everywhere.
E) The electric field outside the box is the same as if only the point charge (and not the box) were there.

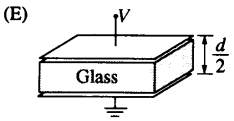
69. Which of the following capacitors, each of which has plates of area A, would store the most charge on the top plate for a given potential difference V ?

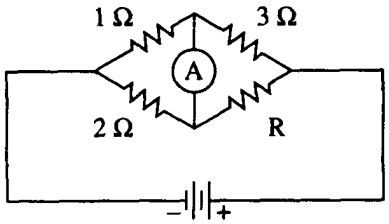
(A) 


(B) 


(C) 


(D) 


(E) 




70. If the ammeter in the circuit above reads zero, what is the resistance R ?

A) 1.5 Ω B) 2Ω C) 4 Ω D) 5 Ω E) 6Ω

# Chapter III

# Answers to the 1993 AP Physics C Examination

## ■ SECTION I: MULTIPLE CHOICE

Listed below are the correct answers to the multiple-choice questions and the percentage of AP candidates who attempted each question and answered it correctly. As a general rule, candidates who correctly answered an individual question in this section also achieved a higher mean score on the exam as a whole than candidates who did not answer that question correctly. An answer sheet gridded with the correct responses appears on the next page.

**Answer Key and Percent Answering Correctly**

| Mechanics | | | Electricity & Magnetism | | |
|---|---|---|---|---|---|
| Item No. | Correct Answer | Percent Correct | Item No. | Correct Answer | Percent Correct |
| 1 | A | 85 | 36 | C | 50 |
| 2 | D | 80 | 37 | B | 69 |
| 3 | D | 52 | 38 | E | 82 |
| 4 | B | 63 | 39 | C | 77 |
| 5 | C | 72 | 40 | C | 38 |
| 6 | B | 77 | 41 | D | 62 |
| 7 | C | 77 | 42 | B | 33 |
| 8 | A | 75 | 43 | E | 61 |
| 9 | D | 37 | 44 | C | 55 |
| 10 | E | 71 | 45 | A | 72 |
| 11 | D | 57 | 46 | C | 52 |
| 12 | C | 65 | 47 | C | 47 |
| 13 | E | 51 | 48 | E | 60 |
| 14 | C | 80 | 49 | D | 55 |
| 15 | E | 17 | 50 | E | 12 |
| 16 | D | 49 | 51 | A | 59 |
| 17 | A | 57 | 52 | E | 22 |
| 18 | A | 60 | 53 | D | 30 |
| 19 | D | 80 | 54 | D | 37 |
| 20 | C | 49 | 55 | D | 64 |
| 21 | E | 49 | 56 | C | 44 |
| 22 | C | 61 | 57 | B | 40 |
| 23 | A | 63 | 58 | A | 60 |
| 24 | A | 45 | 59 | A | 45 |
| 25 | C | 28 | 60 | B | 36 |
| 26 | E | 44 | 61 | E | 63 |
| 27 | C | 80 | 62 | C | 83 |
| 28 | D | 55 | 63 | B | 55 |
| 29 | B | 92 | 64 | D | 48 |
| 30 | E | 56 | 65 | D | 50 |
| 31 | D | 32 | 66 | E | 59 |
| 32 | A | 40 | 67 | A | 38 |
| 33 | A | 68 | 68 | A | 26 |
| 34 | B | 53 | 69 | E | 47 |
| 35 | E | 51 | 70 | E | 25 |