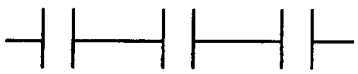
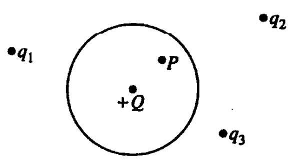


36. Three 1/2 μF capacitors are connected in series as shown in the diagram above. The capacitance of the combination is (A) 0.1 μF (B) 1 μF (C) 2/3 μF (D) ½ μF (E) 1/6 μF

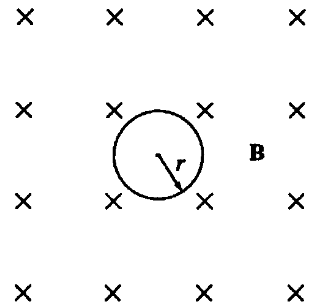
37. A hair dryer is rated as 1200 W, 120 V. Its effective internal resistance is
(A) 0.1 Ω (B) 10 Ω (C) 12Ω
(D) 120 Ω (E) 1440 Ω



38. A point charge +Q is inside an uncharged conducting spherical shell that in turn is near several isolated point charges, as shown above. The electric field at point P inside the shell depends on the magnitude of
(A) Q only
(B) the charge distribution on the sphere only
(C) Q and the charge distribution on the sphere
(D) all of the point charges
(E) all of the point charges and the charge distribution on the sphere

39. In a certain region, the electric field along the x-axis is given by
$E = ax + b$, where $a = 40\ \text{V/m}^2$
and $b = 4$ V/m.
The potential difference between the origin and x = 0.5 m is
(A) -36 V (B) -7 V (C) -3 V (D) 10 V
(E) 16 V

Questions 40-41



A particle of charge +e and mass m moves with speed v perpendicular to a uniform magnetic field **B** directed into the page. The path of the particle is a circle of radius *r*, as shown above.

40. Which of the following correctly gives the direction of motion and the equation relating *v* and *r* ?

Direction	Equation
(A) Clockwise	$eBr = mv$
(B) Clockwise	$eBr = mv^2$
(C) Counterclockwise	$eBr = mv$
(D) Counterclockwise	$eBr = mv^2$
(E) Counterclockwise	$eBr^2 = mv^2$

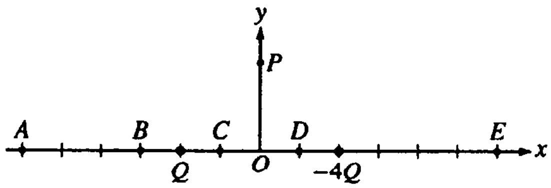
41. The period of revolution of the particle is
(A) mr/eB (B) $\sqrt{m/eB}$
(C) 2πm/eB (D) $2\pi\sqrt{m/eB}$
(E) $2\pi\sqrt{mr/eB}$

42. A *20* μF parallel-plate capacitor is fully charged to 30 V. The energy stored in the capacitor is most nearly
(A) 9×10^{3} J (B) 9×10^{-3} J (C) 6×10^{-4} J
(D) 2×10^{-4} J (E) 2×10^{-7} J

43. A potential difference V is maintained between two large, parallel conducting plates. An electron starts from rest on the surface of one plate and accelerates toward the other. Its speed as it reaches the second plate is proportional to
(A) 1/V
(B) $1/\sqrt{V}$
(C) $\sqrt{V}$
(D) V
(E) V^2

44. A wire of radius R has a current I uniformly distributed across its cross-sectional area. Ampere's law is used with a concentric circular path of radius r, with $r < R$, to calculate the magnitude of the magnetic field B at a distance r from the center of the wire. Which of the following equations results from a correct application of Ampere's law to this situation?
(A) $B(2\pi r) = \mu_0 I$ (B) $B(2\pi r) = \mu_0 I(r^2/R^2)$ (C) $B(2\pi r) = 0$ (D) $B(2\pi R) = \mu_0 I$ (E) $B(2\pi R) = \mu_0 I(r^2/R^2)$

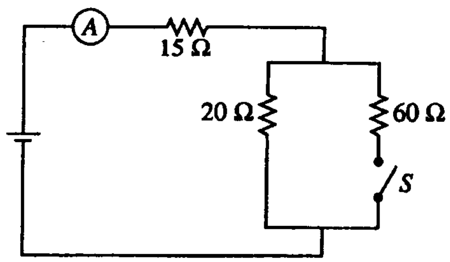
Questions 45-46



Particles of charge Q and -4Q are located on the x-axis as shown in the figure above. Assume the particles are isolated from all other charges.

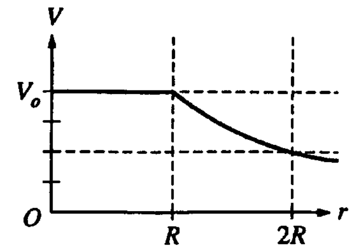
45. Which of the following describes the direction of the electric field at point P ?
(A) +x (B) +y (C)-y
(D) Components in both the -x- and +y-directions
(E) Components in both the +x- and -y-directions

46. At which of the labeled points on the x-axis is the electric field zero?
(A) A (B) B (C) C (D) D (E) E

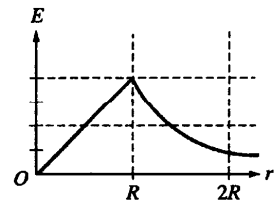


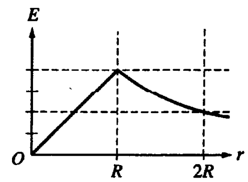
47. When the switch S is open in the circuit shown above, the reading on the ammeter A is 2.0 A. When the switch is closed, the reading on the ammeter is
(A) doubled
(B) increased slightly but not doubled
(C) the same
(D) decreased slightly but not halved
(E) halved

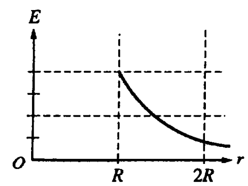
48. Two conducting cylindrical wires are made out of the same material. Wire X has twice the length and twice the diameter of wire Y. What is the ratio R_x/R_y of their resistances?
(A) 1/4 (B) ½ (C) 1 (D) 2 (E) 4

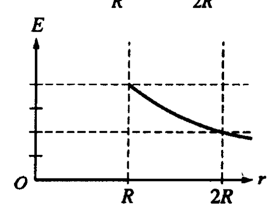


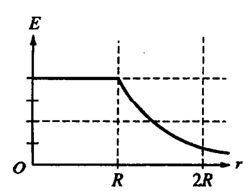
49. A solid metallic sphere of radius R has charge Q uniformly distributed on its outer surface. A graph of electric potential V as a function of position r is shown above. Which of the following graphs best represents the magnitude of the electric field E as a function of position r for this sphere?

(A)


(B)


(C)


(D)


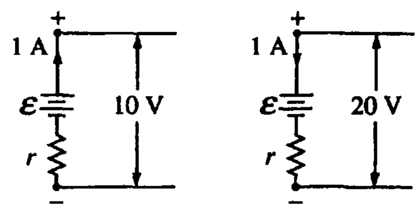
(E)


50. Two parallel wires, each carrying a current I, repel each other with a force *F*. If both currents are doubled, the force of repulsion is

(A) 2F (B) $2\sqrt{2}$ F (C) 4F
(D) $4\sqrt{2}$ F (E) 8F

51. A circular current-carrying loop lies so that the plane of the loop is perpendicular to a constant magnetic field *of* strength *B*. Suppose that the radius *R* of the loop could be made to increase with time *t* so that $R = at$, where *a is* a constant. What is the magnitude of the emf that would be generated around the loop as a function of *t* ?

(A) $2\pi Ba^2t$ (B) $2\pi Bat$ (C) $2\pi Bt$
(D) πBa^2t (E) $(\pi/3)Ba^2t^3$

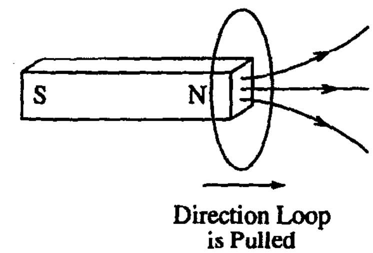


52. The figures above show parts of two circuits, each containing a battery of emf ε and internal resistance r. The current in each battery is 1 A, but the direction of the current in one battery is opposite to that in the other. If the potential differences across the batteries' terminals are 10 V and 20 V as shown, what are the values of ε and *r* ?

(A) ε = 5 V, r = 15 Ω
(B) ε =IOV, r=100 Ω
(C) ε = 15 V, r = 5 Ω
(D) ε = 20 V, r = 10 Ω
(E) The values cannot be computed unless the complete circuits are shown.

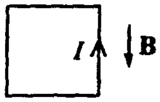
53. A charged particle can move with constant velocity through a region containing both an electric field and a magnetic field only if the

(A) electric field is parallel to the magnetic field
(B) electric field is perpendicular to the magnetic field
(C) electric field is parallel to the velocity vector
(D) magnetic field is parallel to the velocity vector
(E) magnetic field is perpendicular to the velocity vector

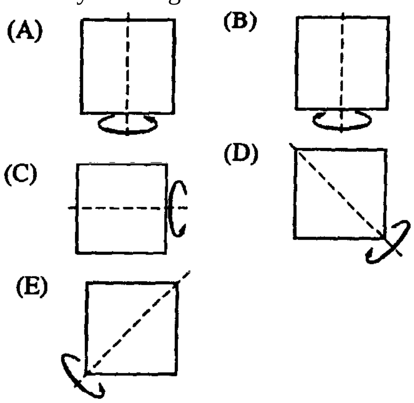


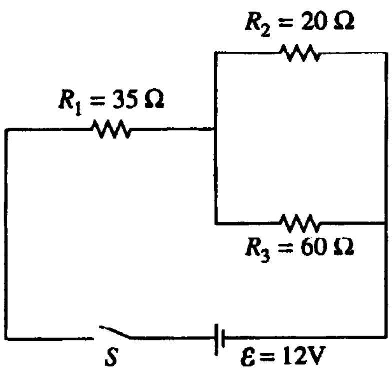
54. A conducting loop of wire that is initially around a magnet is pulled away from the magnet to the right, as indicated in the figure above, inducing a current in the loop. What is the direction of the force on the magnet and the direction of the magnetic field at the center of the loop due to the induced current?

	Direction of Force on the Magnet	Direction of Magnetic Field at Center of Loop due to Induced Current
(A)	To the right	To the right
(B)	To the right	To the left
(C)	To the left	To the right
(D)	To the left	To the left
(E)	No direction; the force is zero.	To the left



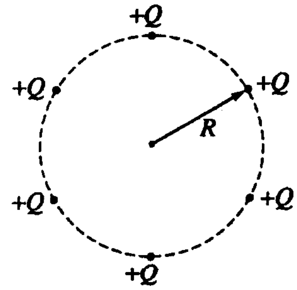
55. A square loop of wire carrying a current I is initially in the plane of the page and is located in a uniform magnetic field B that points toward the bottom of the page, as shown above. Which of the following shows the correct initial rotation of the loop due to the force exerted on it by the magnetic field?





56. In the circuit shown above, the equivalent resistance of the three resistors is
(A) 10.5 Ω (B) 15Ω (C) 20 Ω
(D) 50 Ω (E) 115 Ω

Questions 57-58



As shown in the figure above, six particles, each with charge $+Q$, are held fixed and ate equally spaced around the circumference of a circle of radius R.

57. What is the magnitude of the resultant electric field at the center of the circle?

(A) 0 (B) $\frac{\sqrt{6}}{4\pi\varepsilon_0}\frac{Q}{R^2}$ (C) $\frac{2\sqrt{3}}{4\pi\varepsilon_0}\frac{Q}{R^2}$ (D) $\frac{3\sqrt{2}}{4\pi\varepsilon_0}\frac{Q}{R^2}$

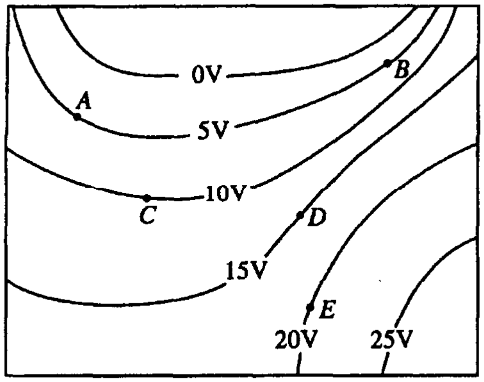
(E) $\frac{3}{2\pi\varepsilon_0}\frac{Q}{R^2}$

58. With the six particles held fixed, how much work would be required to bring a seventh particle of charge + Q from very far away and place it at the center of the circle?

(A) 0 (B) $\frac{\sqrt{6}}{4\pi\varepsilon_0}\frac{Q}{R}$ (C) $\frac{3}{2\pi\varepsilon_0}\frac{Q^2}{R^2}$

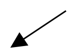
(D) $\frac{3}{2\pi\varepsilon_0}\frac{Q^2}{R}$ (E) $\frac{9}{\pi\varepsilon_0}\frac{Q^2}{R}$

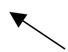
Questions 59-61



The diagram above shows equipotential lines produced by an unknown charge distribution. A, B, C, D, and E are points in the plane.

59. Which vector below best describes the direction of the electric field at point A ?

(A)  (B) 

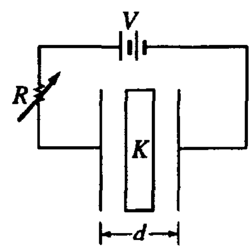
(C)  (D) 

(E) None of these; the field is zero.

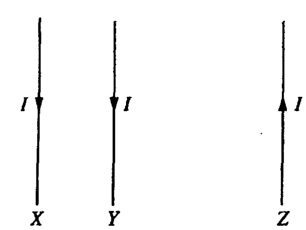
60. At which point does the electric field have the greatest magnitude?
(A) A
(B) B
(C) C
(D) D
(E) E

61. How much net work must be done by an external force to move a -1 μC point charge from rest at point C to rest at point E ?
(A) -20 μJ
(B) -10 μJ
(C) 10 μJ
(D) 20 μJ
(E) 30 μJ

62. One of Maxwell's equations can be written as $\oint E \bullet ds = -\frac{d\phi}{dt}$. This equation expresses the fact that
(A) a changing magnetic field produces an electric field
(B) a changing electric field produces a magnetic field
(C) the net magnetic flux through a closed surface depends on the current inside
(D) the net electric flux through a closed surface depends on the charge inside
(E) electric charge is conserved



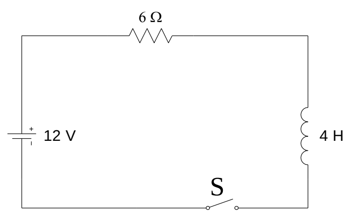
63. The plates of a parallel-plate capacitor of cross sectional area *A* are separated by a distance *d*, as shown above. Between the plates is a dielectric material of constant *K*. The plates are connected in series with a variable resistance *R* and a power supply of potential difference *V*. The capacitance *C* of this capacitor will increase if which of the following is decreased?
(A) *A* (B) *R* (C) *K*
(D) *d* (E) *V*



64. The currents in three parallel wires, *X*, *Y*, and <u>*Z*</u>, each have magnitude l and are in the directions shown above. Wire *Y* is closer to wire *X* than to wire *Z*. The magnetic force on wire *Y* is
(A) zero (B) into the page (C) out of the page
(D) toward the bottom of the page
(E) toward the left

65. A physics problem starts: "A solid sphere has charge distributed uniformly throughout. . . " It may be correctly concluded that the
(A) electric field is zero everywhere inside the sphere
(B) electric field inside the sphere is the same as the electric field outside
(C) electric potential on the surface of the sphere is not constant
(D) electric potential in the center of the sphere is zero
(E) sphere is not made of metal

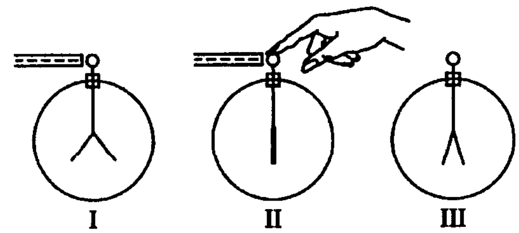
Questions 66-67 relate to the circuit represented below. The switch S, after being open for a long time, is then closed.



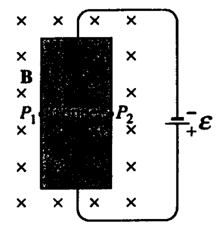
66. What is the current in the circuit after the switch has been closed a long time?
(A) 0 A
(B) 1.2 A
(C) 2 A
(D) 3 A
(E) 12 A

67. What is the potential difference across the resistor immediately after the switch is closed?
(A) 0 V
(B) 2 V
(C) 7.2 V
(D) 8 V
(E) 12 V

68. A uniform spherical charge distribution has radius *R*.. Which of the following is true of the electric field strength due to this charge distribution at a distance r from the center of the charge?
(A) It is greatest when $r = 0$.
(B) It is greatest when $r = R/2$.
(C) It is directly proportional to *r* when $r > R$.
(D) It is directly proportional to *r* when $r < R$.
(E) It is directly proportional to r^2.



69. When a negatively charged rod is brought near, but does not touch, the initially uncharged electroscope shown above, the leaves spring apart (I). When the electroscope is then touched with a finger, the leaves collapse (II). When next the finger and finally the rod are removed, the leaves spring apart a second time (III). The charge on the leaves is
(A) positive in both I and III
(B) negative in both I and III
(C) positive in I, negative in III
(D) negative in I, positive in III
(E) impossible to determine in either I or III



70. A sheet of copper in the plane of the page is connected to a battery as shown above, causing electrons to drift through the copper toward the bottom of the page. The copper sheet is in a magnetic field **B** directed into the page. P_1 and P_2 are points at the edges of the strip. Which of the following statements is true?
(A) P_1 is at a higher potential than P_2.
(B) P_2 is at a higher potential than P_1.
(C) P_1 and P_2 are at equal positive potential.
(D) P_1 and P_2 are at equal negative potential.
(E) Current will cease to flow in the copper sheet.

AP Physics | Physics C Exam - **<u>Electricity & Magnetism</u> 2004** | Solutions to Multiple Choice

Stieve '05

	BASIC IDEA	SOLUTION	ANSWER
36.	$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + ... + \frac{1}{C_n}$	capacitors in series.	E
37.	$P = IV = \frac{V^2}{R}$	$1200 = \frac{(120)^2}{R}$	C
38.	Gauss' Law	No field within the walls of the conducting shell.	A
39.	$\int_{V_a}^{V_b} dV = -\int_a^b \vec{E} \cdot d\vec{s}$	$\Delta V = -\int_0^5 (ax+b)dx = -\left[a\frac{x^2}{2} + bx\right]_0^5 = -[(40)(0.125) + 4(0.5) - (0)] = -7 Volts$	B
40.	$\vec{F} = q\vec{v} \times \vec{B}$ $F = ma = m\frac{v^2}{r}$	In order for the positive q to experience a centripetal force the rhr indicates counterclockwise for its motion. $+evB = m\frac{v^2}{r}$ so we have $eBr = mv$	C
41.	vt=distance	$v = \frac{eBr}{m}$ and the distance during one period is $2\pi r$ so we have $\frac{eBr}{m} T = 2\pi r$ and then $T = \frac{2\pi m}{eB}$	C
42.	$W = \frac{1}{2}CV^2$	$W = \frac{1}{2}(20\mu)(30)^2 = 9 \times 10^{-3} J$	B
43.	Cons. Of Energy $K = \frac{1}{2}mv^2$ $\Delta U = q\Delta V$	$\Delta U + \Delta K = -qV + \frac{1}{2}mv^2 = 0$; $-eV + \frac{1}{2}m_e v^2 = 0$ $v = \sqrt{\frac{2eV}{m_e}}$	C
44.	$\oint \vec{B} \cdot d\vec{s} = \mu_o i$	$\oint \vec{B} \cdot d\vec{s} = B2\pi r = \mu_o \frac{\pi r^2}{\pi R^2} I$	B
45.	vector addition of E's	The field caused by the Q is $\nearrow$. That of the -4Q is $\searrow$. The vector sum is clearly to the right and downward.	E
46.	vector addition of E's $E = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}$	To yield zero they must be in the opposite direction. That rules out the region between the two charges where both fields are to the right. To the right of the -4Q all places are closer to this larger charge so the field is non-zero and to the left. This brings us to A or B. Since one charge is four times as great as the other and the field is a function of the inverse square of the distance, the larger charge must be twice as far away. This gives us A.	A
47.	V=IR $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + ...$ $R_{eq} = R_1 + R_2 + ...$	Since adding a parallel resistor always reduces the equivalent resistance of the parallel resistors below the smallest of them, the total resistance of the circuit is less so the current will increase. In order to double the current the total resistance would have to be half of the original 35Ω or 17.5Ω meaning that the pair would have to be the equivalent of 2.5Ω, where as, from $\frac{1}{R_{eq}} = \frac{1}{20} + \frac{1}{60}$ it is 15Ω.	B
48.	$R = \rho\frac{L}{A}$	$\frac{R_x}{R_y} = \frac{\rho\frac{2L_y}{\pi\left(\frac{2d_y}{2}\right)^2}}{\rho\frac{L_y}{\pi\left(\frac{d_y}{2}\right)^2}} = 0.5$	B

49.	$V = \frac{1}{4\pi\varepsilon_o}\frac{q}{r}$ $E = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}$ $\varepsilon_o \oint \vec{E}\cdot d\vec{A} = q_{inside}$	Field within the shell is zero (Gauss's Law). Outside the shell not the field weakens with the inverse square so at 2R the field is one fourth as great as it is at R.	C
50.	$\frac{F}{L} = \frac{\mu_o}{2\pi}\frac{I_1 I_2}{d}$	doubling both currents adds a factor of 4 to the right side.	C
51.	$\Phi_B = \vec{B}\cdot\vec{A}$ $\mathcal{E} = -\frac{d\Phi}{dt}$	$A = \pi r^2 = \pi(at)^2 = \pi a^2 t^2$ therefore $\Phi_B = B\pi a^2 t^2$. $\mathcal{E} = -\frac{d\Phi}{dt} = -2B\pi a^2 t$	A
52.	V=IR	Add the change in potential from bottom to top for each circuit. Left circuit: -Ir + $\mathcal{E}$ = 10volts. Right circuit: +Ir + + $\mathcal{E}$ = 20volts Adding the two equations gives 2e = 30volts so e = 15volts	C
53.	$\vec{F} = q\vec{v}\times\vec{B}$ $\vec{F} = q\vec{E}$	Because the forces caused by the two fields must be in opposite directions in order to add to zero, and since the force of the magnetic field is perpendicular to the magnetic field and the force of the electric field is in the same line as that of the field, the two fields must be perpendicular.	B
54.	Lenz's Law right hand rule	Induced current opposes the change that caused it. The force on the magnet opposes the withdrawal, that is, the force is to the right. The flux to the right through the loop is decreasing so the induced current will try to maintain it so the magnetic field due to the induced current is to the right as well.	A
55.	$\vec{\tau} = \vec{p}\times\vec{B}$ **or** $\vec{F} = I\vec{\ell}\times\vec{B}$ right hand rule	The torque tends to align the dipole moment with the magnetic field. The force on the top wire is out of the page and on the bottom wire is into the page.	C
56.	if necessary $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$ $R_{eq} = R_1 + R_2 + \ldots$	The quickest solution is to note that because the 35Ω resistor is in series with the parallel branch the equivalent resistance must be > 35Ω. Because the 60Ω and 20Ω resistors are in parallel their combination must Be < 20Ω. This gives us that the answer is between 35Ω and 55Ω.	D
57.	Symmetry	The field vectors will negate each other for the diametrically opposed pairs.	A
58.	$V = \frac{1}{4\pi\varepsilon_o}\frac{q}{r}$ ΔU=qΔV	The potential at the center of the circle is $V = \frac{1}{4\pi\varepsilon_o}\frac{6Q}{R}$ so the potential energy of a sixth charge will be $U = \frac{1}{4\pi\varepsilon_o}\frac{6Q^2}{R} = \frac{3}{2\pi\varepsilon_o}\frac{Q^2}{R}$ so this equals the work required to bring it from "infinity" where the U = 0.	D
59.	$E = -\frac{dV}{dr}$	The field points down slope.	A
60.	$E = -\frac{dV}{dr}$	Where the slope is the greatest, that is, where the equipotential lines are closest together.	B
61.	W=ΔU=qΔV	W= $q(V_E - V_C)$ = -1μC(20V-10V) = -10μJ	B

62.	alternate statement Faraday's Law of Induction.	$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi}{dt}$ ⇦ Rate of change of magnetic flux ⮤ Line integral of non-electrostatic field	A
63.	$C = \frac{\kappa \varepsilon_o A}{d}$	The equation for the capacitance of a parallel plate capacitor indicates that C will increase if d is decreased.	D
64.	$\frac{F}{L} = \frac{\mu_o}{2\pi} \frac{I_1 I_2}{d}$	The force decreases with distance. Parallel wires with currents in the same direction appear to attract, and those with currents in the opposite direction seem to repel. (See $\vec{F} = I\vec{\ell} \times \vec{B}$ to explain the direction.)	E
65.	free electrons in a metal	In a static situation the charges will move about until the net field in the conductor is zero.	E
66.	$i = \frac{\varepsilon}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$	As t → ∞ I approaches 12/6 = 2A	C
67.	V=iR	Since $i = 0$ (see equation in #66) $V_R = 0$ at t = 0.	A
68.	$\varepsilon_o \oint \vec{E} \cdot d\vec{A} = q_{inside}$	Inside the sphere: $\varepsilon_o E 4\pi r^2 = \frac{\frac{4}{3}\pi r^3}{\frac{4}{3}\pi R^3}$ yielding E proportional to r. This fact alone eliminates the other choices.	D
69.	charging by induction	In I the electrons are driven onto the leaves. In II the electrons are allowed to go to ground, so in III the leaves have a net positive charge.	D
70.	The Hall Effect $\vec{F} = q\vec{v} \times \vec{B}$	Negative charge will shift to the left causing the right side to be at a higher potential, since potential is defined in terms of the positive charge.	B