AP Physics C: Electricity and Magnetism

From the 2016 Administration

HumbleAcademy
航铂教育

HumbleAcademy
航铂教育

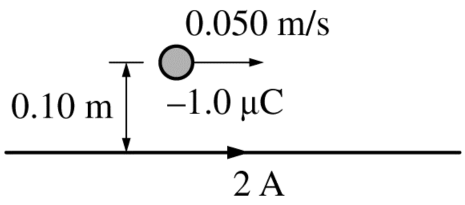
专业国际课程辅导
AP、IB、A Level、OSSD、国际学科竞赛、学术拓展训练

南京校区 秦淮区中山南路 1 号南京中心 47 楼

I Multiple Choice Questions

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 fill in the corresponding circle on the answer sheet.



1. A small object of charge $-1.0\,\mu$C that is 0.10 m above a long, straight wire moves at a speed of 0.050 m/s parallel to the wire, as shown in the figure above. The current in the wire is 2 A. What is the magnitude and direction of the magnetic force on the object?

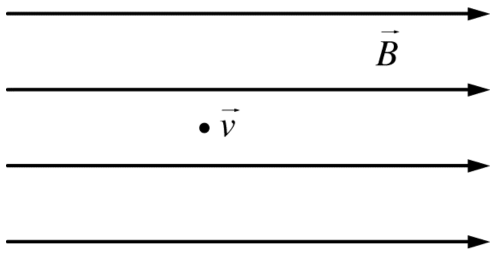
   (A) 2×10^{-13} N, toward the wire

   (B) 2×10^{-13} N, away from the wire

   (C) $4\pi \times 10^{-13}$ N, toward the wire

   (D) $4\pi \times 10^{-13}$ N, away from the wire

   (E) Zero, direction is undefined



2. An electron travels through a uniform magnetic field $\vec{B}$ directed to the right. The electron's velocity $\vec{v}$ is directed out of the page, as shown in the figure above. The direction of the force on the electron due to the magnetic field at the instant shown is

(A) toward the top of the page

(B) toward the bottom of the page

(C) to the left

(D) to the right

(E) into the page

3. Two long parallel wires have currents of I_1 and I_2 and are a distance d apart. The force per unit length exerted by one wire on the other is F/L. The current in each wire is doubled, and the distance between the wires is reduced to $d/2$. The new force per unit length is

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

See the instruction for questions 4 to 5.

A capacitor is constructed of two large, identical, parallel metal plates separated by a small distance d. A battery fully charges the capacitor and is then disconnected.

4. The plate separation is now increased to a distance $2d$. Which of the following correctly describes the change, if any, of the voltage across the capacitor, the electric field between the plates, and the energy stored in the capacitor?

	Voltage	Electric Field	Energy
(A)	Does not change	Does not change	Does not change
(B)	Does not change	Doubles	Does not change
(C)	Doubles	Doubles	Does not change
(D)	Doubles	Does not change	Doubles
(E)	Doubles	Doubles	Doubles

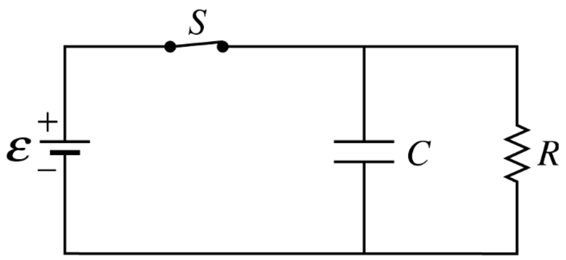
5. If, instead of separating the plates, the empty space between the plates is filled with a slab of insulating material that has a dielectric constant $K = 2$, which of the following correctly describes the change, if any, of the voltage across the capacitor, the electric field between the plates, and the energy stored in the capacitor?

	Voltage	Electric Field	Energy
(A)	Halves	Halves	Halves
(B)	Halves	Halves	Does not change
(C)	Does not change	Does not change	Halves
(D)	Does not change	Halves	Halves
(E)	Does not change	Does not change	Does not change

6. A capacitor stores energy U_1 when it holds charge Q. The same capacitor stores energy U_2 when it holds charge $16Q$. What is the ratio U_2/U_1 ?

(A) 8 (B) 16 (C) 64 (D) 128 (E) 256

See the instruction for questions 7 to 8.



Switch S in the circuit shown above has been closed for a long time.

7. Which of the following is the correct expression for the current in the resistor?

(A) $\dfrac{\mathcal{E}}{R}$ (B) $\dfrac{C\mathcal{E}}{R}$ (C) $C\mathcal{E}$ (D) $\dfrac{\mathcal{E}}{RC}$ (E) Zero

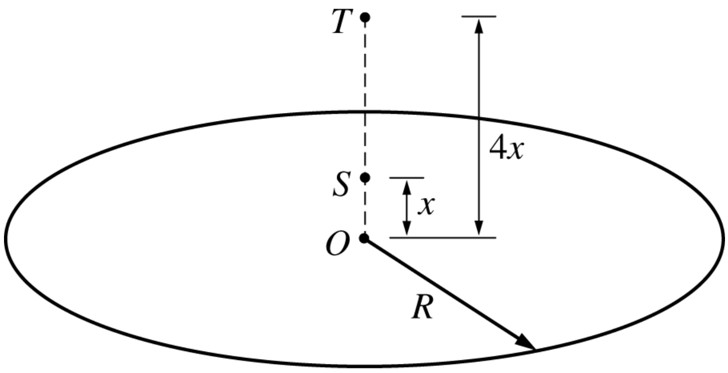
8. Suppose that the switch is opened at time $t = 0$. Which of the following combinations of a differential equation and an initial condition can be used to solve for the charge $Q(t)$ on the upper plate of the capacitor as a function of time t?

	Differential Equation	Initial Condition
(A)	$\dfrac{Q}{C} - R\dfrac{\mathrm{d}Q}{\mathrm{d}t} = 0$	$Q(0) = C\mathcal{E}$
(B)	$\dfrac{Q}{C} - R\dfrac{\mathrm{d}Q}{\mathrm{d}t} = \mathcal{E}$	$Q(0) = 0$
(C)	$\dfrac{Q}{C} + R\dfrac{\mathrm{d}Q}{\mathrm{d}t} = \mathcal{E}$	$Q(0) = C\mathcal{E}$
(D)	$\dfrac{Q}{C} + R\dfrac{\mathrm{d}Q}{\mathrm{d}t} = 0$	$Q(0) = 0$
(E)	$\dfrac{Q}{C} + R\dfrac{\mathrm{d}Q}{\mathrm{d}t} = 0$	$Q(0) = C\mathcal{E}$

9. A nonconducting sphere of radius R has a uniform volume charge density ρ. At the surface of the sphere, the electric field strength is E. If a second sphere of radius $2R$ was created of the same material and with the same charge density, what would be the strength of the electric field at the surface of the second sphere?

   (A) $E/4$ (B) $E/2$ (C) E (D) $2E$ (E) $4E$

See the instruction for questions 10 to 11.



Note: Figure not drawn to scale.

The figure above shows a thin, circular nonconducting sheet of positive charge uniformly distributed over its area. The radius of the sheet is R. Point O is at the center of the sheet. Point S is a distance x from the center of the sheet, and point T is a distance $4x$ from the center of the sheet. Assume $R \gg x$.

10. If the magnitude of the electric field at point T is E_T, which of the following best represents the magnitude of the electric field at point S ?

    (A) $E_T/16$ (B) $E_T/4$ (C) E_T (D) $4E_T$ (E) $16E_T$

11. A small sphere of mass m and charge $-q$ is released from rest at point T. If the electric potentials at points S and T are V_S and V_T, respectively, what is the speed of the sphere when it reaches point S ? Ignore the effects of gravity.

    (A) $\frac{2q}{m}(V_S + V_T)$

    (B) $\frac{4q}{m}(V_S + V_T)$

    (C) $\sqrt{\frac{q}{2m}(V_S - V_T)}$

    (D) $\sqrt{\frac{q}{2m}(V_S + V_T)}$

    (E) $\sqrt{\frac{2q}{m}(V_S - V_T)}$

See the instruction for questions 12 to 13.

Capacitor	K	L	M	N
Plate area	A	A	$2A$	$2A$
Plate separation	d	$2d$	d	$2d$

The chart above shows the plate area and separation for four different air-filled parallel-plate capacitors: K, L, M, and N.

12. Each capacitor is charged such that the same electric field is created between the plates. Which of the following correctly ranks the charge stored on each capacitor?

    (A) $(Q_M = Q_N) > (Q_K = Q_L)$

    (B) $Q_M > Q_K > Q_N > Q_L$

    (C) $(Q_K = Q_M) > (Q_L = Q_N)$

    (D) $Q_K = Q_L = Q_M = Q_N$

    (E) $Q_M > (Q_K = Q_N) > Q_L$

13. Each capacitor is charged such that the same potential difference exists across the plates. Which of the following correctly ranks the magnitude of electric field between the plates of each capacitor?

    (A) $(E_M = E_N) > (E_K = E_L)$

    (B) $E_M > E_K > E_N > E_L$

    (C) $(E_K = E_M) > (E_L = E_N)$

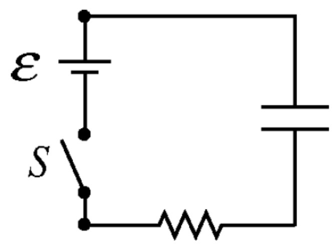
    (D) $E_K = E_L = E_M = E_N$

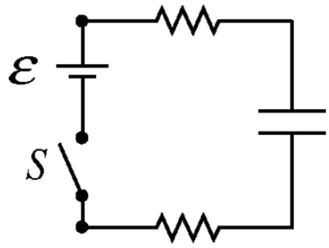
    (E) $E_L > (E_K = E_N) > E_M$

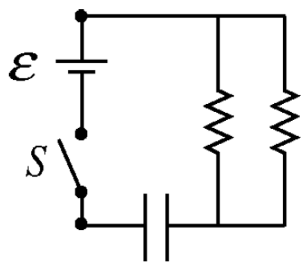
14. A parallel-plate capacitor stores 240 nC when fully charged by the application of a 12 V potential difference across its plates. What is its capacitance?

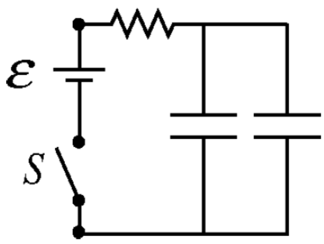
(A) 5.0×10^{-11} F (B) 1.7×10^{-9} F (C) 2.0×10^{-8} F (D) 2.9×10^{-6} F (E) 4.8×10^{-6} F

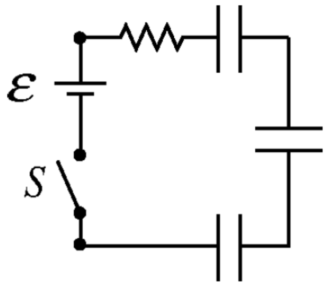
15. Identical resistors and identical uncharged capacitors are connected to identical ideal batteries of emf $\mathcal{E}$ in the circuits shown below. Each circuit has a switch S in the open position. In which circuit will the capacitors reach half their maximum charge in the least amount of time when switch S is closed?

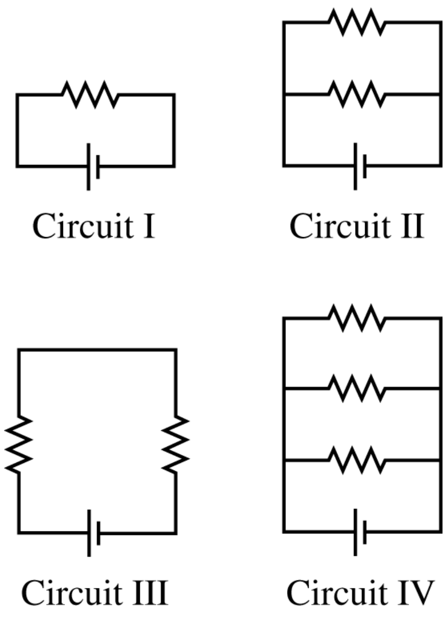
(A)


(B)


(C)


(D)


(E)


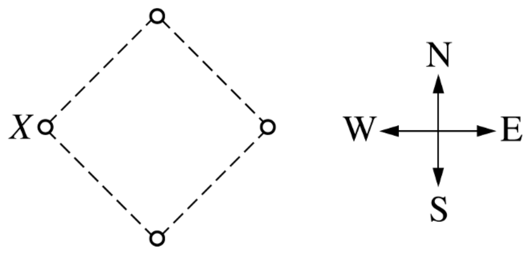


16. All four circuits shown above contain identical ideal batteries and identical resistors. Which circuits draw the most and least power from the battery?

	Most Power	Least Power
(A)	I	II
(B)	I	V
(C)	II	III
(D)	IV	I
(E)	IV	III

17. The current in a $10\,\Omega$ resistor is given as a function of time t by the equation $I = I_0 e^{-\alpha t}$, where $I_0 = 4\,\mathrm{A}$ and $\alpha = 2\,\mathrm{s}^{-1}$. What is the total energy dissipated in the resistor from time $t = 0$ until the current becomes zero?

(A) 20 J (B) 40 J (C) 80 J (D) 160 J (E) 320 J



18. Four conducting wires perpendicular to the plane of the page are at the corners of a square, as shown in cross section in the figure above. The wires carry equal currents in the same direction. What is the direction of the total magnetic force on wire X caused by the other three wires?

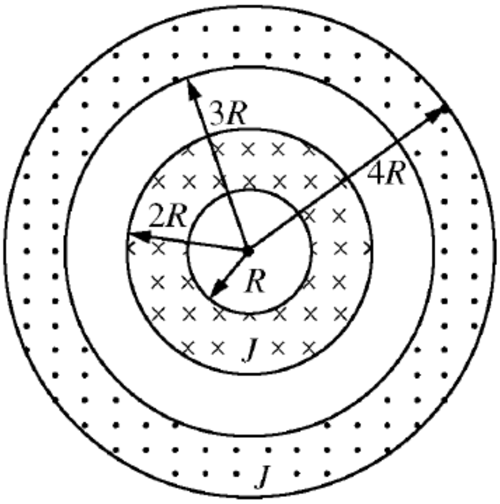
(A) To the north

(B) To the south

(C) To the east

(D) To the west

(E) In none of the directions above, since the magnitude of the force is zero



19. Two long, hollow, concentric conducting cylinders carry currents in opposite directions into and out of the plane of the page, as shown in the cross section above. The currents are unequal, but the current density J is the same for both cylinders. In which of the following regions can the net magnetic field be zero at some nonzero finite distance r from the central axis?

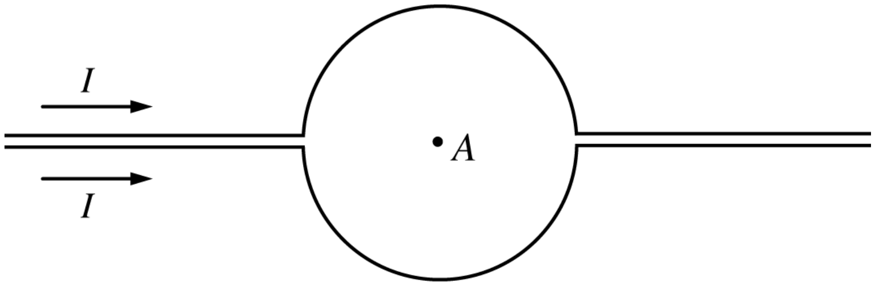
    (A) $r < R$ only

    (B) Both $r < R$ and $R < r < 2R$

    (C) Both $r < R$ and $2R < r < 3R$

    (D) Both $r < R$ and $3R < r < 4R$

    (E) $r > 4R$ only



20. The middle sections of two long, straight wires are each bent into semicircular shapes. The two wires are placed close to each other in a plane as shown above. Point A is the center of the circle formed by the two wires. There is a current I in each wire. Which of the following best represents the direction of the magnetic field, if any, at point A due to the currents?

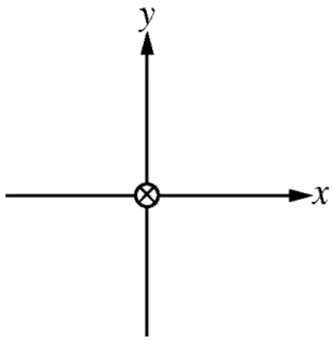
(A) 

(B) 

(C)  (Out of the page)

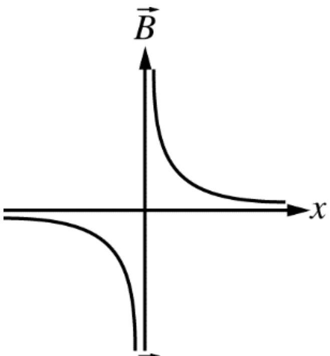
(D)  (Into the page)

(E) There is no direction, because the magnetic field is zero.

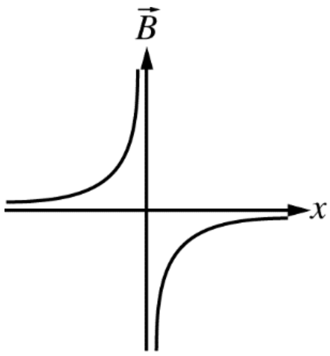


21. A long straight wire is located at the origin of an xy-coordinate system and is perpendicular to the xy-plane. The wire has a current that is directed into the page, as shown in the figure above. Which of the following graphs best represents the magnetic field $\vec{B}$ due to the current as a function of the position x along the x-axis? Assume a positive magnetic field to be directed in the $+y$ direction.

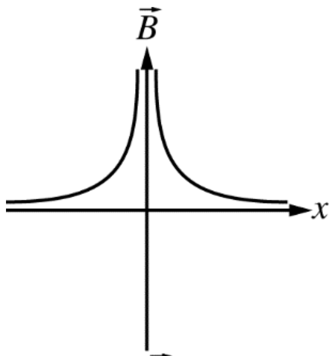
(A)



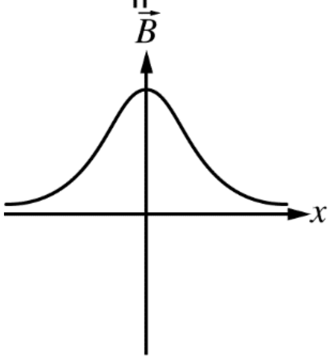
(B)



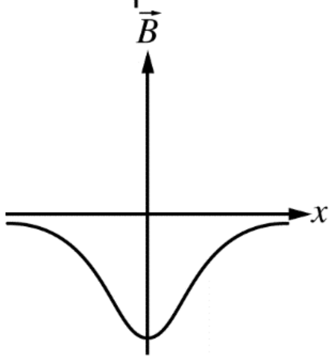
(C)

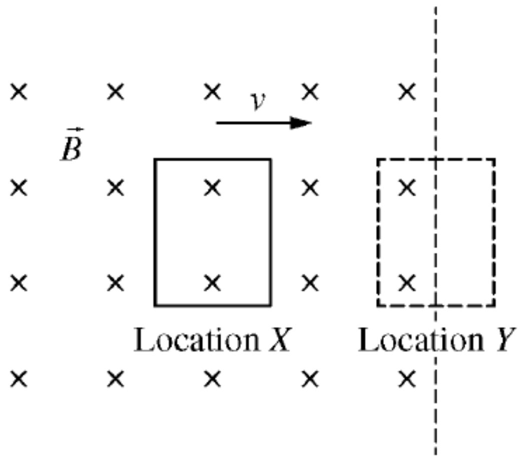


(D)



(E)





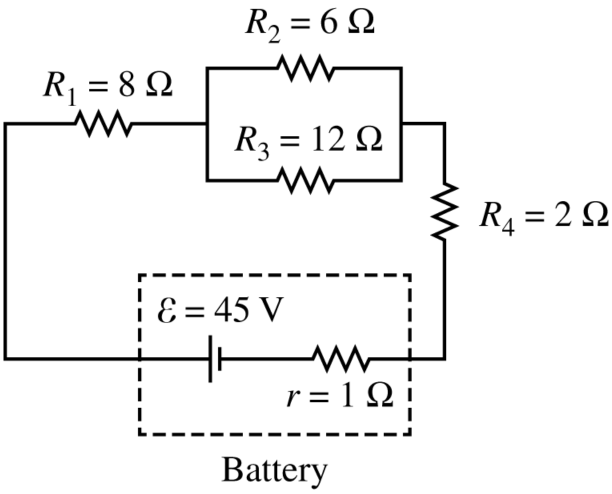
22. A loop of wire at location X is moving toward the right with constant speed v in a region of uniform magnetic field $\vec{B}$, which is perpendicular to the plane of the loop. The magnetic field region ends at the dashed line, as shown in the figure above. Later, the loop is at location Y and exiting the magnetic field with the same constant speed v. The process is then repeated with the loop moving at a speed of $2v$. Which of the following best describes the emf in the loop at the two positions shown when the process is repeated at a speed of $2v$?

	Emf at Location X	Emf at Location Y
(A)	Nonzero and halved	Nonzero and halved
(B)	Nonzero and doubled	Nonzero and doubled
(C)	Nonzero and doubled	Zero at both speeds
(D)	Zero at both speeds	Zero at both speeds
(E)	Zero at both speeds	Nonzero and doubled

23. A long solenoid has 300 loops. The region inside the solenoid has a uniform magnetic field that is directed parallel to the axis of the solenoid. Each loop has an area $2 \times 10^{-4}\,\mathrm{m}^2$. The magnetic field decreases at a constant rate from $0.5\,\mathrm{T}$ to zero. What is the time duration for the change in magnetic field if a potential difference of $10\,\mathrm{V}$ is induced between the ends of the solenoid while the field is decreasing?

    (A) $1 \times 10^{-5}\,\mathrm{s}$ (B) $3 \times 10^{-5}\,\mathrm{s}$ (C) $3 \times 10^{-3}\,\mathrm{s}$ (D) $1 \times 10^{-2}\,\mathrm{s}$ (E) $3 \times 10^{-2}\,\mathrm{s}$

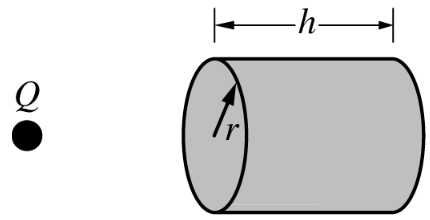
See the instruction for questions 24 to 25.



The circuit represented in the figure above contains four resistors and a battery. The 45 V battery has a 1 Ω internal resistance.

24. Which of the following ranks the absolute values of the potential differences ΔV across the resistors from highest to lowest?
    (A) $\Delta V_3 > \Delta V_1 > \Delta V_2 > \Delta V_4$
    (B) $\Delta V_4 > \Delta V_2 > \Delta V_1 > \Delta V_3$
    (C) $\Delta V_1 > \Delta V_4 > \Delta V_2 > \Delta V_3$
    (D) $\Delta V_1 > (\Delta V_2 = \Delta V_3) > \Delta V_4$
    (E) $\Delta V_4 > (\Delta V_2 = \Delta V_3) > \Delta V_1$

25. How much energy is dissipated by the battery's internal resistance in 60 s ?
    (A) 9 J (B) 180 J (C) 540 J (D) 900 J (E) 8100 J



26. A closed cylindrical shell of volume $\pi r^2 h$ is placed close to an object with a charge of Q, as shown in the figure above. There are no other charged objects nearby. The electric flux through the closed cylindrical shell is

(A) zero (B) Q/ε_0 (C) $\pi r^2 Q$ (D) $2\pi r h Q$ (E) $2\pi r^2 Q + 2\pi r h Q$

27. The electric field is zero everywhere within a certain region of space. The electric potential everywhere within the region

(A) must be zero

(B) must be uniform

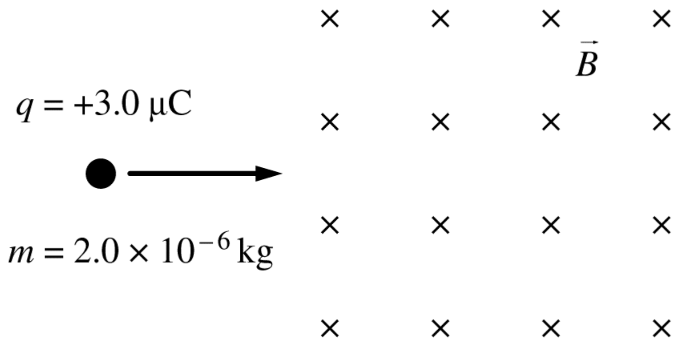
(C) must be positive

(D) must be negative

(E) can be both positive and negative in different parts of the region

28. Two particles with positive charges q_1 and q_2 are both at rest and are very far apart. How much work would be done by external forces to bring the particles to rest at a distance d apart?

(A) Zero (B) $\frac{kq_1q_2}{d}$ (C) $-\frac{kq_1q_2}{d}$ (D) $\frac{2kq_1q_2}{d}$ (E) $-\frac{2kq_1q_2}{d}$



29. A small object with a charge of $q = +3.0\,\mu\text{C}$ and a mass $m = 2.0 \times 10^{-6}\,\text{kg}$ enters a magnetic field of magnitude $B = 0.20\,\text{T}$ directed into the page, as shown in the figure above. If the speed of the object is $1000\,\text{m/s}$, the object's acceleration at the moment it enters the field is most nearly

(A) zero because the velocity is perpendicular to the magnetic field

(B) $300\,\text{m/s}^2$ toward the bottom of the page

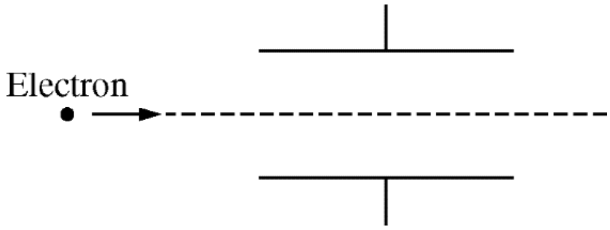
(C) $300\,\text{m/s}^2$ toward the top of the page

(D) $600\,\text{m/s}^2$ toward the bottom of the page

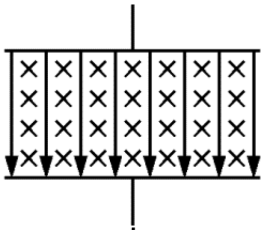
(E) $600\,\text{m/s}^2$ toward the top of the page

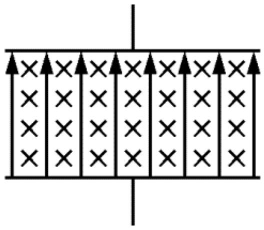
30. A 0.20 m long wire carries a current of 15 A and lies perpendicular to a magnetic field. The magnetic force on the wire is measured to be 0.060 N. What is the magnitude of the magnetic field?

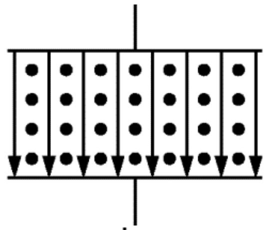
(A) 0.010 T (B) 0.020 T (C) 0.040 T (D) 0.060 T (E) 0.080 T

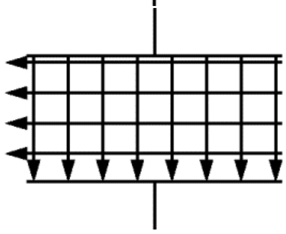


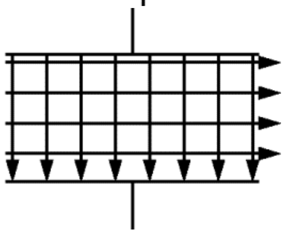
31. Uniform magnetic and electric fields exist between the two oppositely charged parallel plates shown in the figure above. An electron travels horizontally between the plates. Assuming gravitational effects to be negligible, which of the following diagrams shows a combination of electric and magnetic field directions that will allow the electron to travel undeflected?

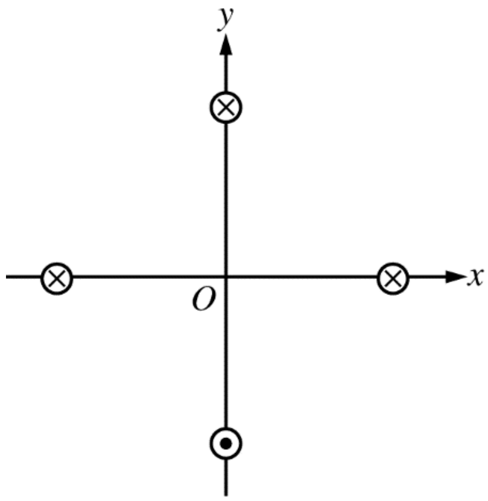
(A)


(B)


(C)


(D)


(E)




32. Four long, straight wires are perpendicular to the xy-plane. Each wire is the same distance from the origin O, as shown in the figure above. The wires have equal currents that are in the directions shown. Which of the following best represents the direction of the net magnetic field, if any, at the origin due to the four currents?

(A) $\uparrow$

(B) $\rightarrow$

(C) $\downarrow$

(D) $\leftarrow$

(E) Undefined because the net field is zero.

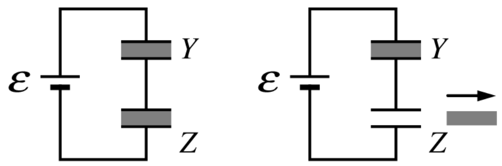
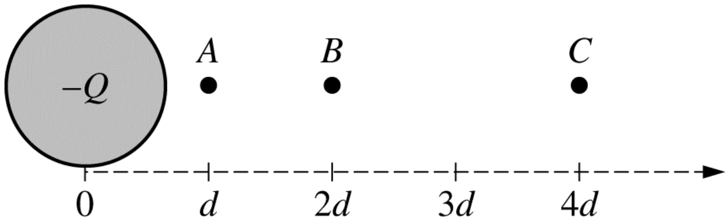


Figure 1 Figure 2

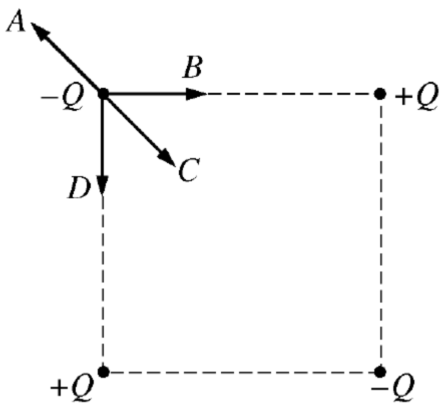
33. Two identical capacitors, Y and Z, are connected in series with an ideal battery, as shown in figure 1 above, and fully charged. Each capacitor has a dielectric slab of dielectric constant $\kappa > 1$ between its plates. If the dielectric slab is removed from capacitor Z, which of the following describes what happens to the voltage across each capacitor?

	Voltage across Capacitor Y	Voltage across Capacitor Z
(A)	Increases	Decreases
(B)	Increases	Increases
(C)	Remains the same	Remains the same
(D)	Decreases	Decreases
(E)	Decreases	Increases



34. A particle of charge $+q$ is released from rest at position B, which is a distance $2d$ from the center of a fixed nonconducting sphere that has a charge of $-Q$ distributed uniformly throughout its volume, as shown in the figure above. When the particle reaches position A, which is a distance d from the center of the charged sphere, its kinetic energy is K_0. The same particle is now released from rest at position C, which is a distance $4d$ from the center of the nonconducting sphere. The kinetic energy of the particle when it again reaches position A is

(A) K_0 (B) $3K_0/2$ (C) $2K_0$ (D) $5K_0/2$ (E) $3K_0$



35. Four point charges of equal magnitude but different signs are arranged on the corners of a square as shown above. Which of the vectors shown represents the direction of the net force acting on the charge at the upper left-hand corner of the square due to the other charges?

    (A) A

    (B) B

    (C) C

    (D) D

    (E) It has no direction because the force is zero.