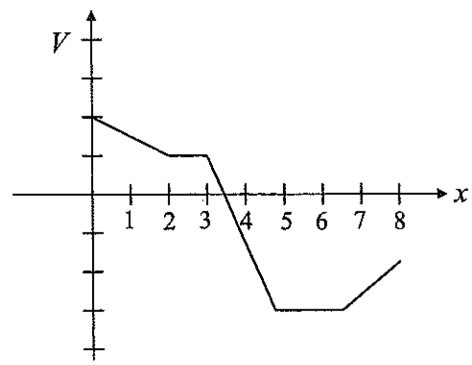
AP PHYSICS C TEST

SECTION I–Electricity and Magnetism

Time: 45 minutes
35 Questions

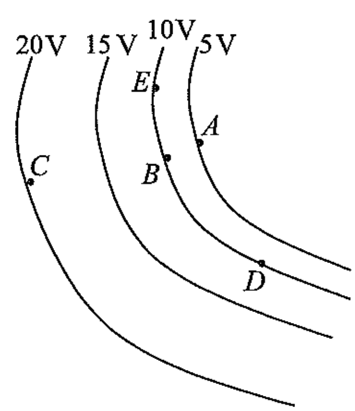
Directions: Each of the questions or incomplete statements below is followed by 5 suggested answers or completions. Select the one that is best in each case.



1. The graph shows the electric potential as a function of position along the x-axis. At which position would a charged particle experience the greatest magnitude of force?

(A) $x = 1$ m (B) $x = 2.5$ m (C) $x = 3.5$ m (D) $x = 5$ m (E) $x = 7$ m

Questions 2 and 3



The figure shows some equipotential surfaces in a region of space.

2. An electron placed at B would be most likely to approach which point after being released from rest?

(A) A (B) B (stay there) (C) C (D) D (E) E

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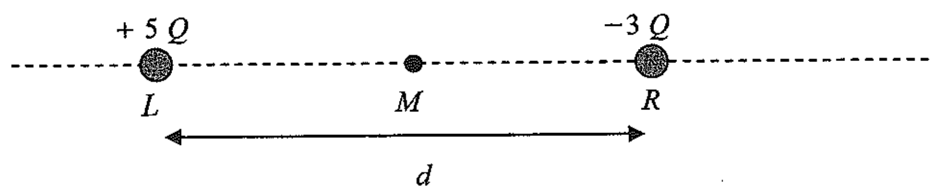
3. A +2C charge is placed at B and then moved slowly to C, and then slowly to D. The total work that this takes is closest to

(A) 20 J (B) −20 J (C) 0 (D) 40 J (E) −40 J

4. If you know the value of the electric field $\vec{E}$ at every point in a region of space, which of the following Gaussian surfaces could be used to determine the charge contained within the surface?
I. sphere
II. cylinder
III. cube

(A) I and II only (B) I and III only (C) II and III only (D) I only (E) I, II, and III

Questions 5 and 6 refer to the two charges shown in the figure below.



5. The electric field along the line is 0 at a point in which region?
(A) to the left of L
(B) between L and M
(C) between M and R
(D) to the right of R
(E) The field is 0 only at infinity.

6. The value of the electric potential at M is equal to

(A) $\frac{1}{4\pi\varepsilon_0}\frac{2Q}{d}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{4Q}{d}$ (C) $\frac{1}{4\pi\varepsilon_0}\frac{8Q}{d}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{16Q}{d}$ (E) $\frac{1}{4\pi\varepsilon_0}\frac{5Q}{3d}$

7. A spherical conductor of radius R carries a charge $+Q$. A neutral conductor of radius $\frac{1}{3}R$ is brought into contact with the first sphere and then separated from it. The charge on the smaller sphere after separation is closest to

(A) Q (B) $\frac{1}{3}Q$ (C) $\frac{1}{4}Q$ (D) $\frac{1}{9}Q$ (E) $3Q$

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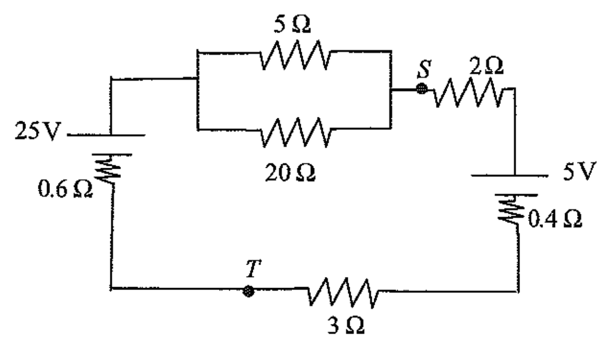
Questions 8–10



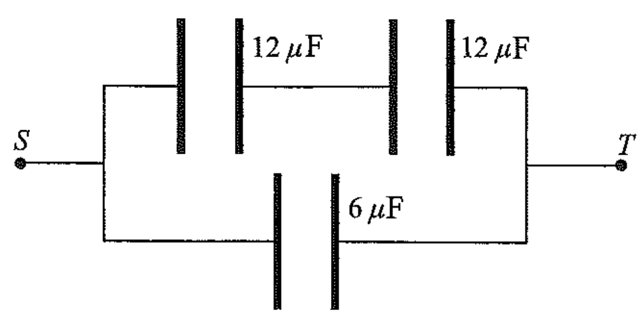
In the circuit above, the battery voltages and resistances are as indicated, with the internal resistances of each battery 0.6 Ω and 0.4 Ω, respectively.

8. The energy consumed by the 2 Ω resistor in 1 minute is
(A) 18 J (B) 8 J (C) 1,080 J (D) 480 J (E) 240 J

9. The terminal voltage of the 5 V battery is
(A) 5.4 V (B) 5.8 V (C) 5 V (D) 4.6 V (E) 4.2 V

10. A voltmeter connected between *T* and *S* would have what magnitude reading?
(A) 15.8 V (B) 5.8 V (C) 11.2 V (D) 21.2 V (E) 12.8 V

Questions 11 and 12 refer to the combination of capacitors shown below.



11. What is the equivalent capacitance of this combination of capacitors?
(A) 30 μF (B) 18 μF (C) 12 μF (D) 6 μF (E) 9 μF

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12. What voltage would have to be applied to produce equal magnitude charges on the plates of all three capacitors?
I. 20 V
II. 30 V
III. 40 V

(A) I only (B) II only (C) I and II only (D) II and III only (E) I, II, and III

13. A resistor R, a capacitor C, and an inductor L are connected in series to a battery of terminal voltage V_B. If i is the current in the circuit and Q is the charge on the capacitor, which of the following equations best describes this circuit?

(A) $iR + \frac{Q}{C} + L\frac{di}{dt} = 0$

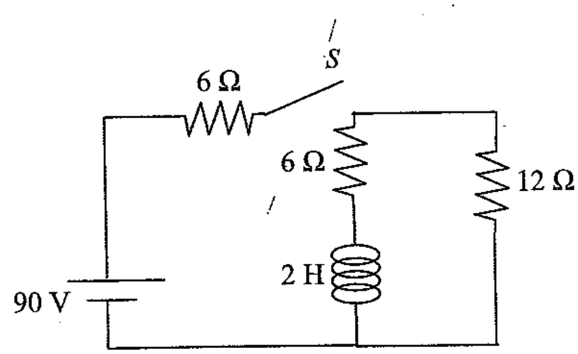
(B) $V_B - iR - \frac{Q}{C} + L\frac{di}{dt} = 0$

(C) $V_B - i^2R - \frac{Q}{C} - L\frac{di}{dt} = 0$

(D) $V_B - iR - \frac{Q}{C} - L\frac{di}{dt} = 0$

(E) $-i^2R + \frac{1}{2}\frac{Q^2}{C} + \frac{1}{2}Li^2 = 0$

Questions 14 and 15 refer to the circuit below containing a combination of a battery, switch, inductor, and 3 resistors.



14. What is the current in the 12 Ω resistor immediately after the switch S is thrown?

(A) 0 (B) 3 A (C) 5 A (D) 6 A (E) 9 A

15. After S has been closed for a long time, it is opened again. How much energy will be consumed in the circuit resistors after S is opened?

(A) 0 (B) 9 J (C) 25 J (D) 36 J (E) 81 J

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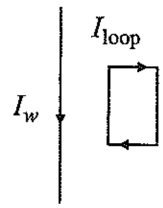
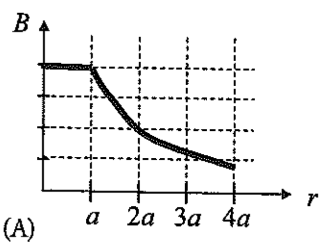


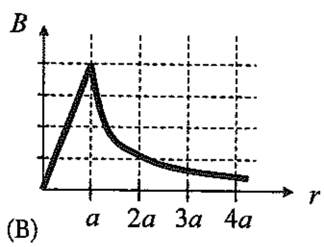
16. A long wire carries a current I_w as shown in the figure. Next to the wire lies a rectangular loop that carries a current I_{loop}. The net force on the loop is

(A) to the left (B) to the right (C) toward the top of page
(D) toward the bottom of page (E) 0

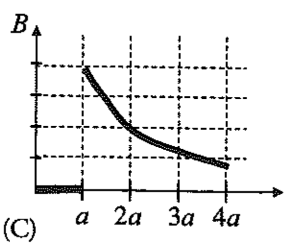
17. A long wire of radius a carries a current I. Which graph best describes the magnitude of the magnetic field created by the wire as a function of r, the distance from the center of the wire?



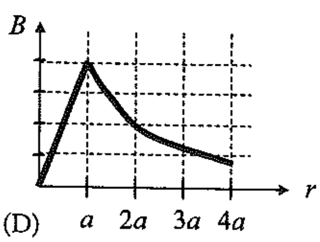
(A)



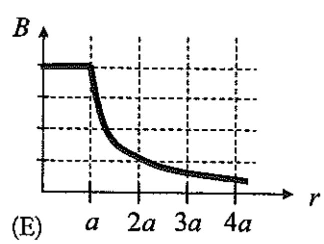
(B)



(C)



(D)



(E)

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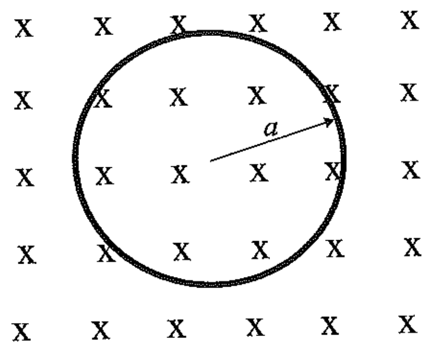

18. A circular loop of radius a and resistance R is stationary in a spatially uniform magnetic field. From the time $t = 0$ to $t = T$, the field increases into the paper according to $B = bt^2$. At $t = \frac{1}{2}T$, the current in the loop is

(A) $\pi a^2 \frac{bT^2}{R}$ (B) $\pi a^2 \frac{bT^2}{4R}$ (C) $\pi a^2 \frac{bT}{R}$ (D) $\pi a^2 \frac{bT}{2R}$ (E) $\pi a^2 \frac{bT}{4R}$

Questions 19 and 20

In a region of space the electric potential is cylindrically symmetric and described by the formula $V(r) = -Cr^{\frac{3}{2}}$, where r is the distance to the symmetry axis and C is a constant.

19. What is the magnitude of the electric field at a distance R from the axis?

(A) $CR^{\frac{1}{2}}$ (B) $\frac{3}{2}CR^{\frac{1}{2}}$ (C) 0 (D) $CR^{\frac{3}{2}}$ (E) $\frac{2}{5}CR^{\frac{5}{2}}$

20. An electron is placed at a point a distance R from the axis. Which of the following is true?

(A) The electron will remain stationary.
(B) The electron will move away from the axis with a constant acceleration.
(C) The electron will move away from the axis with an acceleration that decreases.
(D) The electron will move toward the axis with a constant acceleration.
(E) The electron will oscillate about the axis.

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21. Electrons with a range of speeds move in a region of uniform magnetic field, perpendicular to the field. Which of the following is true?

(A) All the electrons will move in circles of the same radius.
(B) The magnetic field will cause the faster electrons to slow down more quickly than the slower electrons.
(C) The magnetic field will cause the slower electrons to speed up more quickly than the faster electrons.
(D) All the electrons will take the same time to execute 1 revolution.
(E) All the electrons experience the same centripetal force.

22. Two large isolated conducting plates of area A are separated by a distance d. The two plates carry charges $+Q$ and $-Q$, respectively. Which of the following best describes the behavior of the electric field in the region between the plates and the potential difference between the two plates when d is increased to $2d$, keeping the charge on each plate fixed?

	Electric Field	Potential Difference
(A)	decreases by $\frac{1}{2}$	stays the same
(B)	decreases by $\frac{1}{2}$	doubles
(C)	stays the same	doubles
(D)	decreases by $\frac{1}{4}$	stays the same
(E)	decreases by $\frac{1}{4}$	doubles

23. An electron with mass m_e and charge $-e$ is released from rest a distance d from a stationary proton with mass m_p and charge $+e$. When the electron is a distance $\frac{1}{2}d$ from the proton, its speed is closest to

(A) $\sqrt{\dfrac{e^2}{4\pi\varepsilon_0 m_e d}}$ (B) $\sqrt{\dfrac{e^2}{2\pi\varepsilon_0 m_e d}}$ (C) $\sqrt{\dfrac{e^2}{4\pi\varepsilon_0 m_p d}}$ (D) $\sqrt{\dfrac{e^2}{2\pi\varepsilon_0 m_p d}}$ (E) $\sqrt{\dfrac{e^2}{8\pi\varepsilon_0 m_e d}}$

24. A neutral conductor has a spherical cavity within it. A point charge Q is placed at the center of the cavity. Which of the following is true when equilibrium is established?

I. The flux through any closed surface surrounding the charge will equal $\frac{Q}{\varepsilon_0}$.
II. The electric field will be 0 within the conductor, but non-zero outside of the cavity.
III. Within the cavity, the electric potential is constant.

(A) I only (B) II only (C) III only (D) I and II only (E) I and III only

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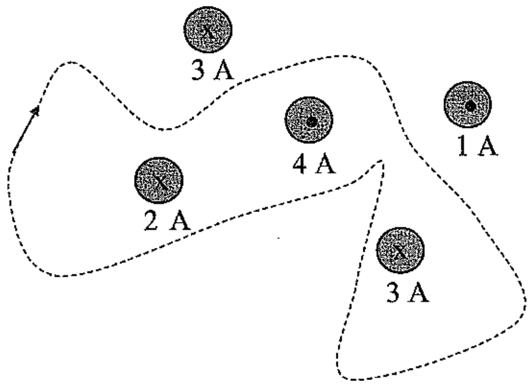
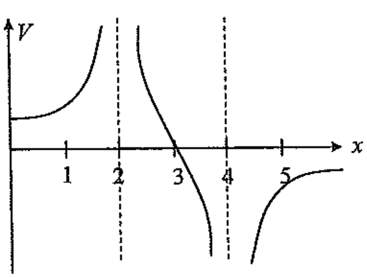
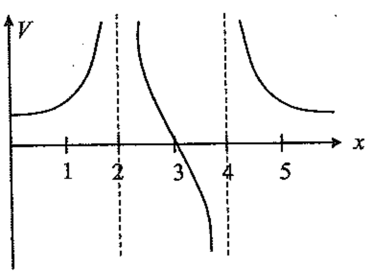


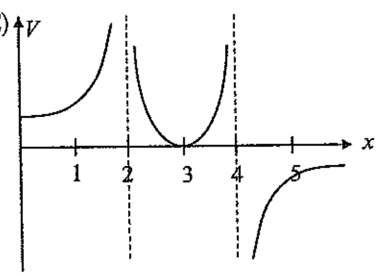
25. Five current segments carry the indicated currents shown in the figure, with x and • indicating the current going into or out of the paper, respectively. The value of $\oint_{\text{path}} \vec{B} \cdot \vec{dl}$ around the dotted path is

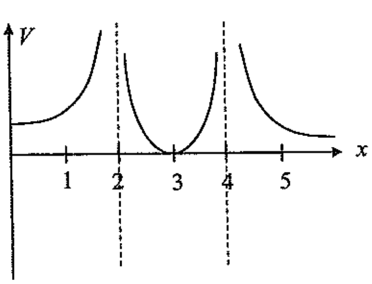
(A) μ_0 (B) $-\mu_0$ (C) $2\mu_0$ (D) $-2\mu_0$ (E) $9\mu_0$

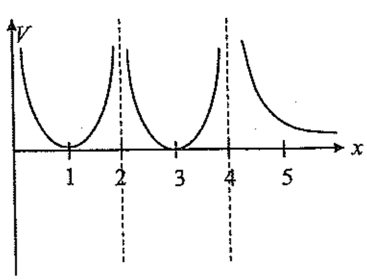
26. Two equal and opposite charges lie along the x-axis as shown in the figure. The graph of the electric potential as a function of x is closest to which of the following?

(A) 

(B) 

(C) 

(D) 

(E) 

27. A parallel plate capacitor with plate area A and plate separation d has a dielectric of thickness $\frac{1}{2}d$, area A, and dielectric constant κ inserted between the plates. If the capacitance before the dielectric was inserted was C, the capacitance after insertion is

(A) κC (B) $\frac{\kappa}{2}C$ (C) $2\kappa C$ (D) $\frac{2\kappa}{\kappa + 1}C$ (E) $\frac{\kappa}{\kappa + 1}C$

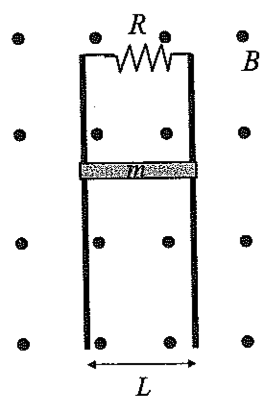
28. If you know the value of the electric potential at a point, which of the following can you determine from this value? Assume the zero of electric potential is at infinity.
I. the electric field at the point
II. the work it would take to slowly move a given charge from the point to infinity
III. the work it would take to slowly move a given charge from the point to another point not at infinity

(A) I only (B) II only (C) III only (E) I and II only (C) II and III only

29. A long, nonconducting cylinder of radius R carries a uniform charge density ρ. To determine the electric field within the cylinder, you use a cylindrical Gaussian surface of radius $r < R$ and length L. Properly applying Gauss's law to this surface would yield which of the following equations?

(A) $E(\pi R^2 L) = \frac{\rho(\pi R^2 L)}{\varepsilon_0}$ (B) $E(4\pi R^2) = \frac{\rho(\frac{4}{3}\pi R^2)}{\varepsilon_0}$ (C) $E(2\pi RL) = \frac{\rho(\pi R^2 L)}{\varepsilon_0}$

(D) $E(2\pi rL) = \frac{\rho(\pi r^2 L)}{\varepsilon_0}$ (E) $E(2\pi RL) = \frac{\rho(\pi r^2 L)}{\varepsilon_0}$



30. A conducting rail of length L and mass m is connected to slide without friction on two vertical rails connected by a resistance R. A uniform magnetic field is directed out of the page. The terminal speed of the rail is

(A) $\frac{BL}{mgR}$ (B) $\frac{B^2L^2}{mgR}$ (C) $\frac{mg}{BLR}$ (D) $\frac{mgR}{B^2L^2}$ (E) $\frac{mgR}{BL}$

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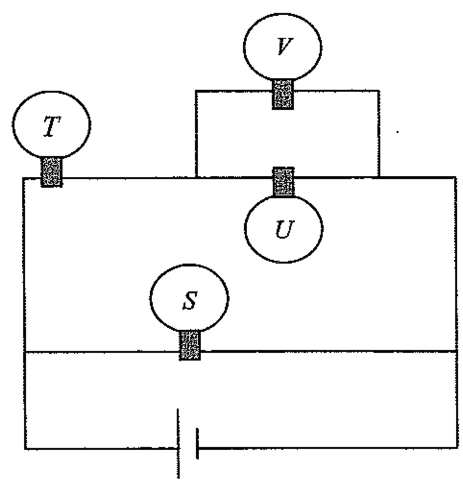
31. A wire of length L, uniform cross-sectional area A, and resistivity ρ is connected across a battery and found to consume energy at the rate P. The wire is then stretched to twice its original length. When connected across the same battery, it will consume energy at the rate

(A) P (B) $\frac{1}{2}P$ (C) $\frac{1}{4}P$ (D) $\frac{1}{8}P$ (E) $\frac{1}{16}P$

32. An isolated parallel plate capacitor has a potential difference V between the plates. Which of the following best describes what happens when a nonconducting material is introduced to fill the region between the plates?

(A) Since the material is a nonconductor, nothing happens.
(B) The nonconducting material will develop a uniform charge density throughout its volume, causing the potential drop across the capacitor to decrease.
(C) The nonconducting material will develop a uniform charge density throughout its volume, causing the potential drop across the capacitor to increase.
(D) The nonconducting material will polarize, inducing a surface charge density near the conducting plates, causing the potential drop to decrease.
(E) The nonconducting material will polarize, inducing a surface charge density near the conducting plates, causing the potential drop to increase.



33. Bulbs S, T, U, and V all behave as identical ideal resistors in the circuit shown above. If bulb V is unscrewed, which of the following is true?

	Bulb S	Bulb T	Bulb U
(A)	stays the same	gets brighter	gets brighter
(B)	stays the same	gets brighter	gets dimmer
(C)	stays the same	gets dimmer	gets brighter
(D)	stays the same	gets dimmer	gets dimmer
(E)	gets brighter	gets dimmer	gets dimmer

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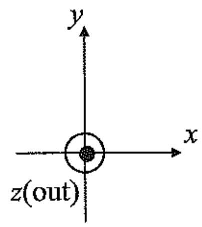
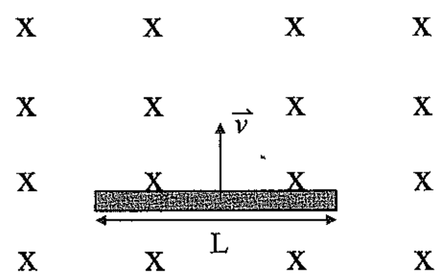


34. An electron is moving along the x-axis in the positive x direction. An electric field is directed in the $+y$ direction. Which direction must the minimum strength magnetic field be pointed to allow the electron to move undeflected?

(A) $+y$ (B) $-y$ (C) $+z$ (D) $-z$ (E) $-x$



35. A conducting rail of length L is pulled at constant velocity $\vec{v}$ through a uniform magnetic field B directed into the page. The magnitude and direction of the electric field induced in the rail is

	Magnitude	Direction
(A)	BLv	points to the left
(B)	BLv	points to the right
(C)	Bv	points to the left
(D)	Bv	points to the right
(E)	Bv	points out of page

STOP
END OF SECTION I, ELECTRICITY AND MAGNETISM
IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON SECTION 1, ELECTRICITY AND MAGNETISM ONLY.
DO NOT TURN TO ANY OTHER TEST MATERIALS.

STOP