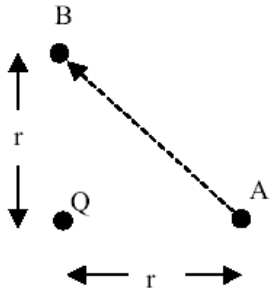
1. A point charge ***q*** is located at position A, a distance ***r*** away from a point charge ***Q***. The charge ***q*** is moved to position B, which is also located a distance ***r*** away from the charged particle ***Q***. Which of the following statements is **correct**?

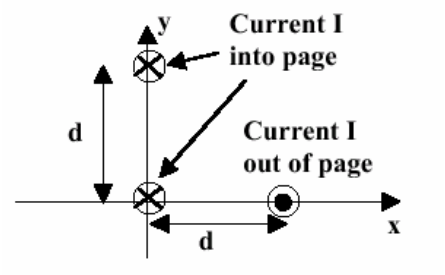


A. The work done by the electric field in moving the charged particle from A to B is
$$W_{AB} = \frac{kQq}{\sqrt{2}r}$$
B. The work done by an outside force in moving the charged particle from A to B is
$$W_{AB} = \frac{kQq}{\sqrt{2}r}$$
C. The work done by the electric field in moving the charged particle from A to B is $W_{AB} = 0$
D. The work done by the electric field in moving the charged particle from A to B is
$$W_{AB} = \frac{kQq}{r}$$
E. The work done by an outside force in moving the charged particle from A to B is
$$W_{AB} = \frac{kQq}{r}$$

2. A very small styrofoam sphere with charge **+2C** is held **1 mm** above the center of a charged **conducting** sheet of size **1 m x 1 m**. The sphere experiences a repulsive force of **2 N**. What can we say about the **local** charge density at the center of the sheet?

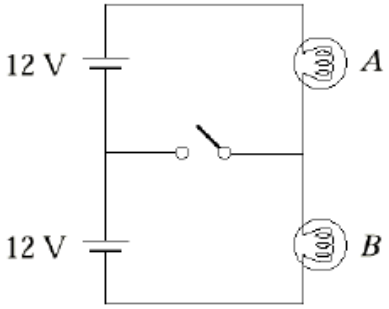
A. The local charge density is **-8.85×10^{-12} C/m^2**.
B. The local charge density is **$+8.85 \times 10^{-12}$ C/m^2**.
C. The local charge density is **$+1.12 \times 10^{-11}$ C/m^2**.
D. The local charge density is **-1.77×10^{-11} C/m^2**.
E. We cannot say anything since we don't have enough information about the charge distribution on the sheet.

3. The figure shows 3 extremely long straight, parallel wires carrying currents of equal magnitude in the directions indicated. What is the direction of the net force on the wire located at the origin?



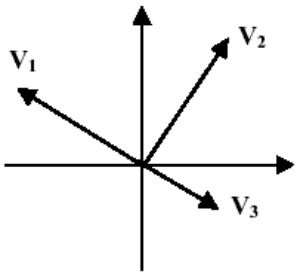
A. Parallel to the vector $+\hat{x}+\hat{y}$
B. Parallel to the vector $+\hat{x}-\hat{y}$
C. Parallel to the vector $-\hat{x}+\hat{y}$
D. Parallel to the vector $-\hat{x}-\hat{y}$
E. The net force is zero.

4. The light bulbs in the circuit are identical. When the switch is closed,



A. both bulbs go out.
B. the intensity of light bulb A increases.
C. the intensity of light bulb A decreases.
D. the intensity of light bulb B increases.
E. nothing changes.

5. The figure shows a phasor diagram for a series *RLC* circuit. Which of the following statements is **correct**? (Note that the figure is drawn to scale.)

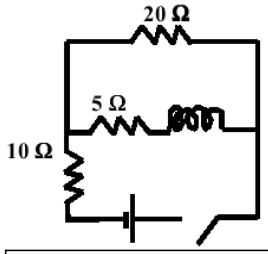


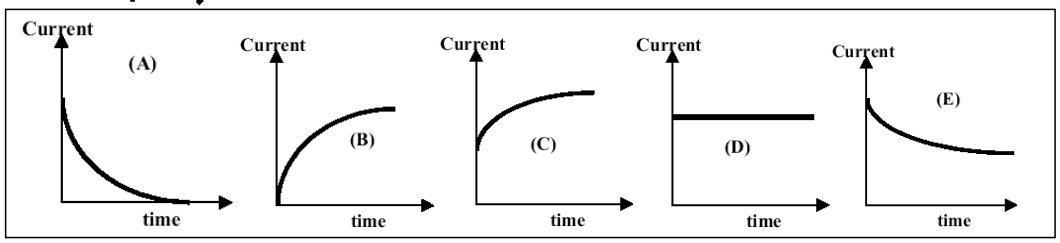
A. The drive frequency is **below** the resonance frequency, V_1 is the voltage drop across the resistor, V_2 is the voltage drop across the inductor, and V_3 is the voltage drop across the capacitor.
B. The drive frequency is **below** the resonance frequency, V_1 is the voltage drop across the inductor, V_2 is the voltage drop across the resistor, and V_3 is the voltage drop across the capacitor.
C. The drive frequency is **above** the resonance frequency, V_1 is the voltage drop across the resistor, V_2 is the voltage drop across the inductor, and V_3 is the voltage drop across the capacitor.
D. The drive frequency is **above** the resonance frequency, V_1 is the voltage drop across the inductor, V_2 is the voltage drop across the resistor, and V_3 is the voltage drop across the capacitor.
E. The drive frequency is **above** the resonance frequency, V_1 is the voltage drop across the capacitor, V_2 is the voltage drop across the resistor, and V_3 is the voltage drop across the inductor .

6. A capacitor is fully charged using a battery of EMF **E**. It is then disconnected from the battery and connected across an inductor in an ideal LC circuit. Which of the following statements is **correct**?

A. The capacitor and the inductor will dissipate the same (non-zero) amount of energy in each cycle of oscillation.
B. The value of the inductor determines the value of the maximum charge stored on the capacitor.
C. The value of the maximum charge stored on the capacitor determines the value of the maximum current through the inductor.
D. When the current in the LC circuit is zero, there is no charge on the capacitor.
E. The EMF of the battery determines the amount of energy dissipated in each cycle of oscillation.

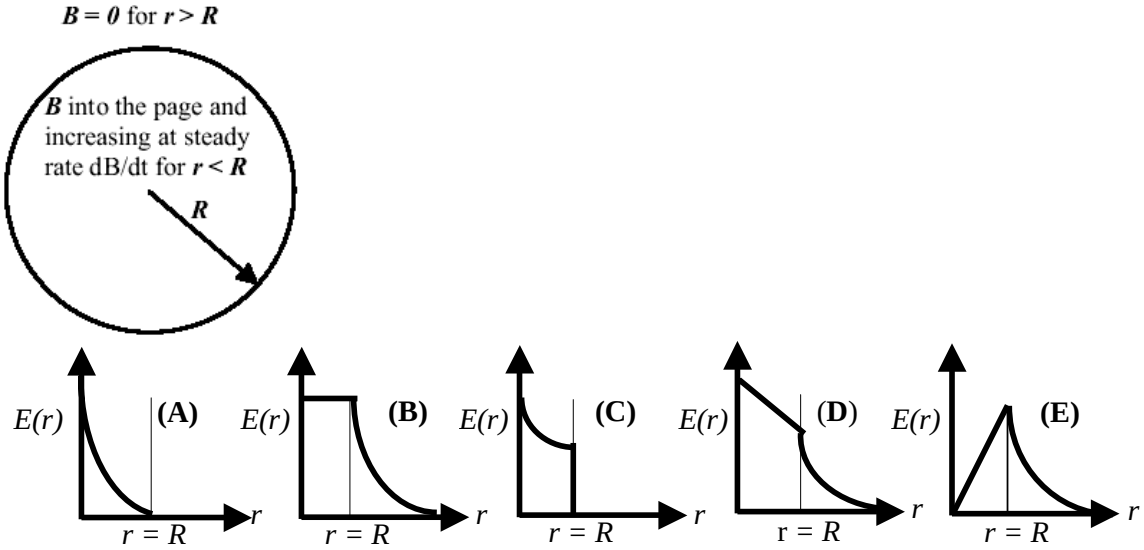
7. In the circuit shown, the switch is closed at t = 0. Which of the graphs below correctly represents the current in the **20 Ω resistor** as a function of time? (The origin of the each graph is (0,0).)





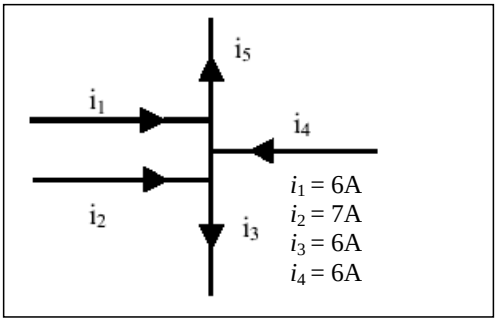
A. A
B. B
C. C
D. D
E. E

8. In the figure, the magnetic field within the circular area is into the page, is **uniform** and is **increasing at a constant rate**. The magnetic field outside the circular area is **zero**. Use Faraday's Law to determine which graph correctly depicts the magnitude of electric field $\boldsymbol{E}(\boldsymbol{r})$, where $\boldsymbol{r}$ is the distance from the center of the circle. The radius of the circular area is $\boldsymbol{R}$.



A. **A**
B. **B**
C. **C**
D. **D**
E. **E**

9. What is the value of the current i_5 in the following configuration:

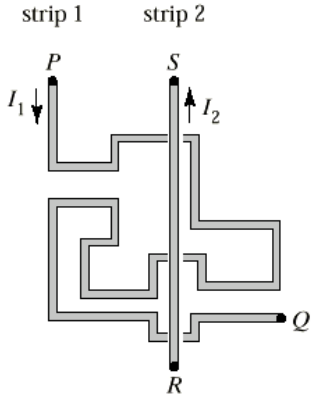


A. -13 A
B. -1 A
C. 1 A
D. 13 A
E. 25 A

10. The Curie temperature of iron is around 800 ºC. Which of the following statements is **correct**?

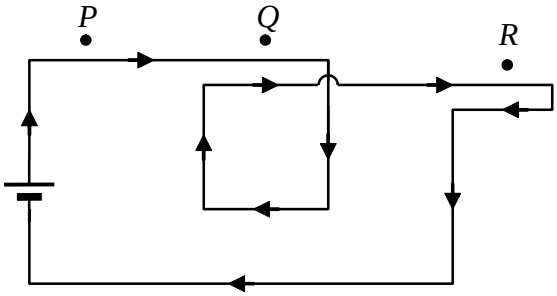
A. Iron is a ferromagnet above 800 ºC.
B. Iron is a paramagnet below 800 ºC.
C. Iron is a superconductor above 800 ºC.
D. Iron is a ferromagnet below 800 ºC.
E. Iron is a ferromagnet at all temperatures.

11. On a computer chip, two conducting interconnects carry charge from *P* to *Q* and from *R* to *S*. If the current direction is reversed in both wires, the net magnetic force of strip 1 on strip 2:



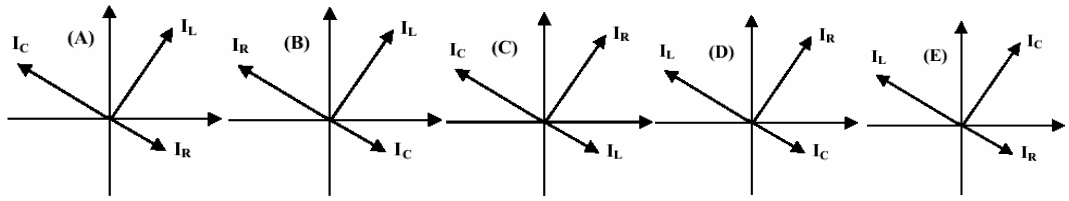
A. remains the same.
B. reverses.
C. changes in magnitude, but not in direction.
D. changes to some other direction.
E. none of the above.

12. A battery establishes a steady current around the circuit below. A compass needle is placed successively at points *P*, *Q*, and *R*. The relative deflection of the needle, in descending order, is:



A. *P*, *Q*, *R*
B. *Q*, *R*, *P*
C. *R*, *Q*, *P*
D. *P*, *R*, *Q*
E. *Q*, *P*, *R*

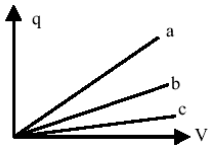
13. A capacitor, resistor and inductor are connected in **parallel** across an ac source of EMF given by $\mathbf{E = E_m \sin(\omega t)}$. A student constructs a phasor diagram representing the currents in the three components (labelled as I_C , I_R and I_L, for the capacitor, resistor and inductor respectively). Which of the figures below could correctly depict a phasor representation of this circuit?



A. A
B. B
C. C
D. D
E. E

14. The figure shows plots of charge versus potential difference for three parallel-plate capacitors, which have the following plate areas and separations:

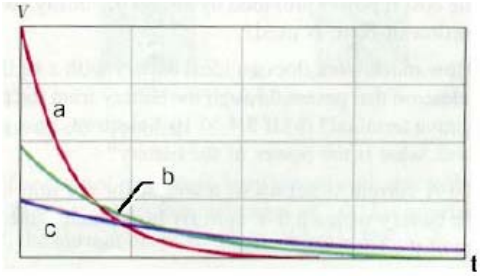
C_1 has area of A and a separation of 2d.
C_2 has area of 2A and a separation of 2d.
C_3 has area of A and a separation of 4d.



Which of the following statements is **correct**?

A. Plot *a* goes with capacitor C_1, plot *b* goes with capacitor C_2, and plot *c* goes with capacitor C_3.
B. Plot *a* goes with capacitor C_3, plot *b* goes with capacitor C_1, and plot *c* goes with capacitor C_2.
C. Plot *a* goes with capacitor C_1, plot *b* goes with capacitor C_3, and plot *c* goes with capacitor C_2.
D. Plot *a* goes with capacitor C_2, plot *b* goes with capacitor C_1, and plot *c* goes with capacitor C_3.
E. None of the above.

15. The figure shows the plots of V(t) for three capacitors (a, b, c) that discharge (separately) through the same resistor. Which of the following statements is **correct**?



A. $C_a > C_b > C_c$
B. $C_a > C_c > C_b$
C. $C_b > C_a > C_c$
D. $C_c > C_b > C_a$
E. None of the above

16. Which of the following statements is inconsistent with Maxwell's equations?

A. The total magnetic flux through a closed surface is always zero.
B. The total electric flux through a closed surface depends on the total charge enclosed.
C. If the magnetic flux through a surface is constant in time, then it cannot result in an induced electric field.
D. If the electric flux through a surface changes with time, this can create an induced magnetic field.
E. The integral of the tangential component of magnetic field around a closed loop is always zero.

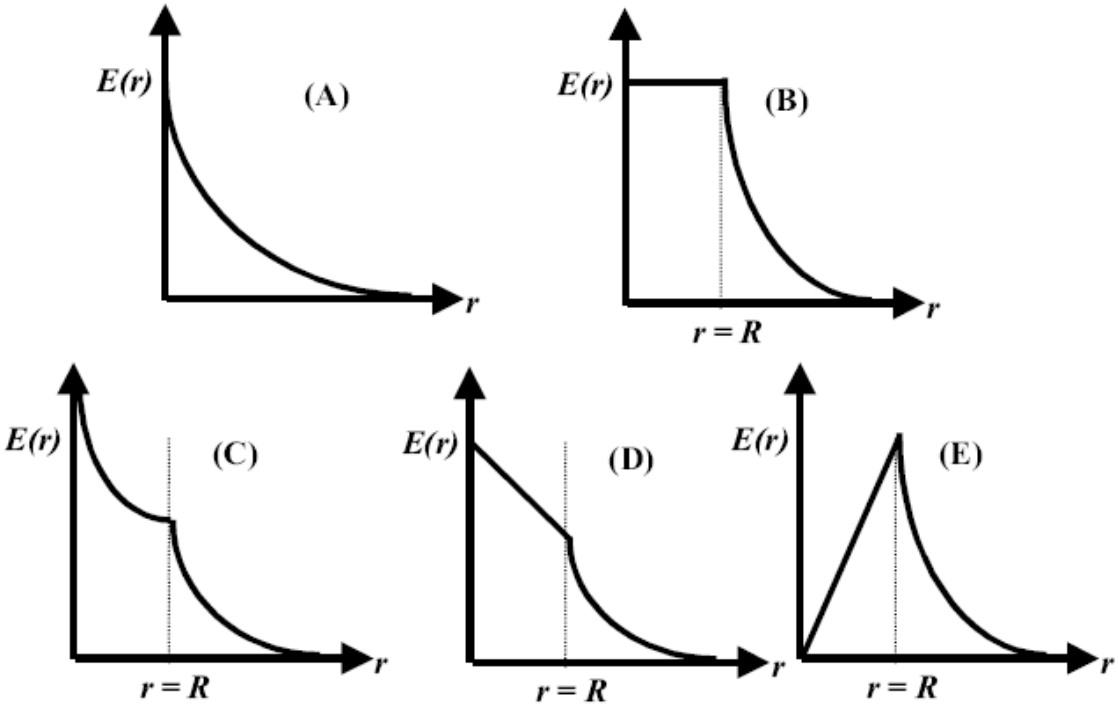
17. An **electron** is moving with constant speed along the **+*y*** direction and enters a region of space where a uniform magnetic field exists along the **+*z*** direction. Which of the following statements is **FALSE**?

A. The speed of the electron does not change.
B. The electron begins moving in a circular orbit.
C. On first entering the region of magnetic field, the electron experiences an acceleration along the **+*x*** direction.
D. The acceleration of the electron constantly changes in direction.
E. The kinetic energy of the electron does not change.

18. A student has 3 copper wires of different lengths and cross-sectional areas. Wire A has length ***L*** and diameter ***D***, wire B has length ***2L*** and diameter ***2D***, and wire C has length ***3L*** and diameter ***D/3***. Rank the wires in order of **increasing** resistance.

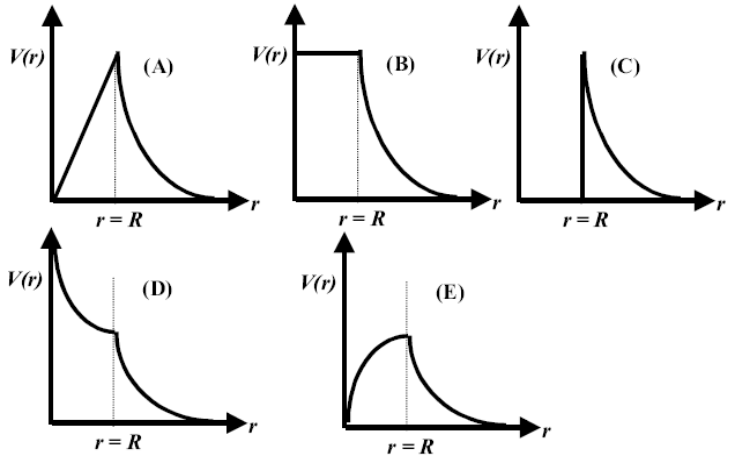
A. ABC
B. BCA
C. CBA
D. BAC
E. A and B tie, then C

19. A very long **insulating** solid cylinder of radius **R** carries a charge **uniformly** distributed over its volume. Use Gauss' Law to determine which of the figures below correctly describes the magnitude of the electric field as a function of the distance r from the cylinder axis.



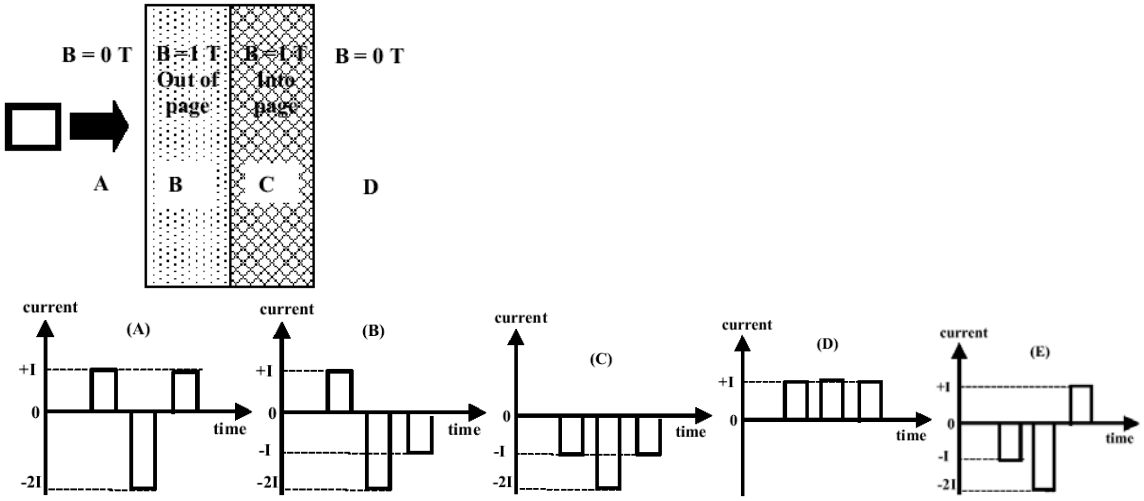
A. A
B. B
C. C
D. D
E. E

20. A **metal** sphere of radius ***R*** carries an excess **positive** charge. Which of the figures below correcty depicts the variation of the electric potential as a function of the distance ***r*** from the center of the sphere?



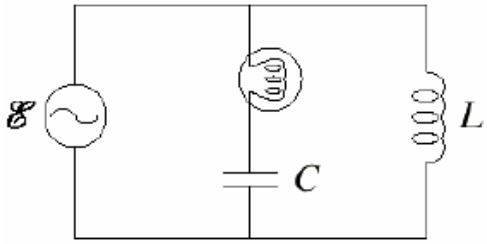
A. A
B. B
C. C
D. D
E. E

21. A loop of wire moves at a **constant speed** through regions of varying magnetic field as shown. Which of the graphs correctly depicts the current in the loop? (A **clockwise** current is to be taken as **positive**, and a **counter-clockwise** current is **negative**.)



A. A
B. B
C. C
D. D
E. E

22. In the circuit shown, the light bulb has a resistance *R*, and the ac emf drives the circuit with a frequency ω. Assuming that the brightness of a bulb is proportional to the power dissipated, which of the following statements is **correct**?

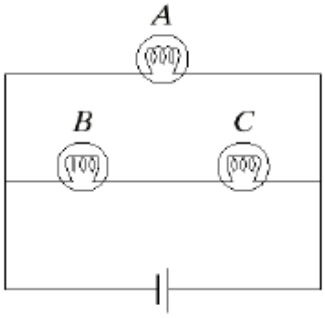


A. The light bulb does not glow at any frequency because AC current cannot flow through the bulb due to the presence of the capacitor.
B. The light bulb glows most brightly at very low frequencies.
C. The light bulb glows most brightly at very high frequencies.
D. The light bulb glows with the same brightness at all frequencies.
E. The light bulb glows most brightly at the frequency $\omega = 1/\sqrt{LC}$.

23. Susan studies the interaction between three pieces of **charged** tape. It is found that tapes 1 and 2 attract each other and that tapes 2 and 3 repel each other. From this we can conclude that:

A. 1 is positively charged and 3 is negatively charged.
B. 1 and 3 carry charges of equal sign.
C. all three carry the charges of the same sign.
D. all three carry the charges of the same sign.
E. we need to do more experiments to determine the sign of the charges.

24. The three light bulbs in the adjacent circuit all have the same resistances. Which of the statements that follows is correct?



A. Bulbs B and C are brighter than bulb A.
B. Bulb A is brighter than bulbs B and C.
C. All of the bulbs are of the same brightness.
D. Bulb A is brightest and bulb B is brighter than bulb C.
E. None of the above are correct.

25. Three capacitors with values 1 *mF*, 2 *mF* and 10 *mF* are placed in **SERIES** across a battery. Which of the following statements is **correct**?

A. The 10 *mF* capacitor carries the most potential difference.
B. The 1 *mF* capacitor carries the most charge.
C. The 10 *mF* capacitor has five times as much potential difference as the 2 *mF* capacitor.
D. The 1 *mF* capacitor has ten times as much potential difference as the 10 *mF* capacitor.
E. The 10 *mF* capacitor has five times as much charge as the 2 *mF* capacitor.