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Class: 12
Subject: Physics
Topic: Alternating Current
No. of Questions: 20

1. 220 volt a.c. is more dangerous than 220 volt d.c. Why?

   Sol.
   220 volt a.c. means the effective or virtual value of a.c. is 220 volt, i.e., E_u = 220 volt
   As peak value $E_0 = \sqrt{2}E_v$
   $\therefore$ $E_0 = 1.414 \times 220 = 311$ volt.
   But 220 volt d.c. has the same peak value (i.e. 220 volt only)
   Moreover, the shock of a.c. is attractive and that of d.c. is repulsive.
   Hence 220 volt a.c. is more dangerous than 220 volt d.c.

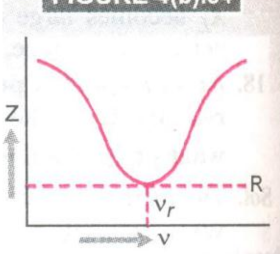
2. Sketch a graph showing the variation of impedance of LCR circuit with the frequency of applied voltage.
   Sol.
   The impedance of LCR circuit is

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{R^2 + \left(2\pi v L - \frac{1}{2\pi v C}\right)^2}$$

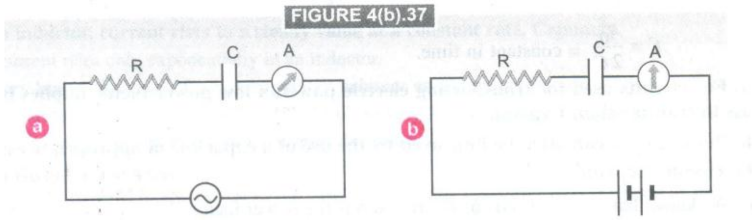
   The variation of Z with v is as shown in Fig. 4(b).34.

   At $v = v_r\,; X_L = X_C; X = R\ minimum.$

FIGURE 4(b).34



3. The hot wire ammeter A in Fig. 4(b).37(a) shows some deflection, but not in Fig. 4(b).37 (b). Why?
   Sol.
   This is because in Fig. 4(b).37(b), condenser blocks d.c. offering infinite resistance. Therefore, current in circuit of Fig. 4(b).37b is zero. In case of Fig.4(b).37 (a), a.c. is not blocked by condenser. Therefore, ammeter A shows some deflection.



4. An electric lamp having coil of negligible inductance connected in series with a capacitor and an a.c. source is glowing with certain brightness, Fig. 4(b).38. How does the brightness of the lamp change on reducing (i) capacitance (ii) frequency?
Justify your answer.

Sol.
Brightness of lamp $\propto I_v^2$
Assuming zero resistance and zero inductance of lamp, $I_v = \frac{E_v}{X_C} = \frac{E_v}{1/\omega C} = E_v(2\pi v)$C,
On reducing C or v; I_v would decrease.
Therefore, brightness of the lamp decrease.

5. An electromagnet has stored 648 J of magnetic energy, when a current of 9 A exists in its coils. What average e.m.f. is induced if the current is reduced to zero in 0.45 s?

Sol.
Here, $E = 648$ J, I= 9 A, e =?,dI = 9 – 0 = 9 A, dt = 0.45 s
From $E = \frac{1}{2}LI^2$
$648 = \frac{1}{2} \times L(9)^2$; $L = \frac{648\times2}{9\times9} = 16H$
As $e = \frac{LdI}{dt}$ ∴ $e = \frac{16(9)}{0.45} = 320\ v$

6. Air cored chokes are used for reducing low frequency a.c., why?

Sol.
Inductive reactance of a choke is $X_L = \omega\ L = 2\pi\ v\ L$. When v is high, L need be made high. Therefore, air cored choke will serve the purpose.

7. 11 kW of electric power can be transmitted to a distant station at (i) 220 V or (ii) 2200 V. Which of the two mods of transmission should be preferred and why? Support you answer with possible calculations.

Sol.
P = 11 kW = 1100 W

(i) $V_1 = 220$ V, $\therefore I_1 = \frac{P}{V_1} = \frac{11000}{220} = 50\ A$

Power loss = I_1^2 R = $(50)^2$ R = 2500R watt

(ii) $V_2 = 22000$ V

$\therefore I_2 = \frac{P}{V_2} = \frac{11000}{22000} = 0.5\ A$

Power loss = $I_2^2\ R = (0.5)^2$ R = R/4 watt.

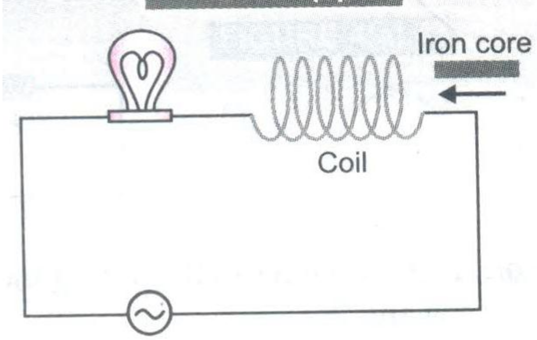
Power loss becomes 1/10000 times the power loss in the first cases. **Hence transmission at high voltages should be preferred.**

8. In India, domestic power supply is at 220 V, 50 hz, while in U.S.A, it is 110 V, 60 hz, Give one advantage and one disadvantage of 220 V supply over 110 V supply.
Sol.

For transfer of power (=V×I) at higher voltage (220 V instead of 110 V), current carried by wires is just half. Therefore, such wires need not be very thick, saving lot of transmission material and reducing the cost of transmission. This is one advantage of 220 V supply.
But to design a device of particular wattage,$P = \frac{V^2}{R}, as\ V^2$ is 4 times, R must be four times. If not, the dissipation of power in the form of heat will be larger on 220 V supply. This is one disadvantage of this supply.

9. A bulb connected in series with a solenoid is lit by a.c. source Fig. 4(a).37. If the soft iron core is introduced in the solenoid, will the bulb glow brighter?

FIGURE 4(a).37



Sol.

We know that the inductive reactance offered by the solenoid is $X_L = \omega L = 2 \pi v L$. On introducing soft iron core in the solenoid, its inductance L increases. Therefore, X_L increases.
As $I_v = E_v / X_L$, therefore, I_v decreases.
As glowing power of bulb = $I^2_v R$, therefore the bulb glows dimmer, and not brighter.

10. In a car spark coil, an emf of 40,000 volts is induced in its secondary windings when the current in its primary winding changes from 4 A to zero in 10 μs. The mutual inductance between the primary and the secondary windings of the spark coil is

A. H
B. H
C. H
D. H

Right Answer Explanation:

$$e = -M\frac{\Delta I}{\Delta t}$$

or $$M = -\frac{e\Delta I}{\Delta I} = -\frac{40{,}000 \times (10 \times 10^{-6})}{(-4-0)}$$

$$= 0.1 \text{ H}$$

The correct choice is (1).

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12. In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of 2.0 × 10^{10} Hz. What is the wavelength of the wave?

A. cm
B. 1.5 cm
C. cm
D. cm

Report Error

Right Answer Explanation:

$$\lambda = \frac{c}{\nu} = \frac{3\times10^8}{2.0\times10^{10}} = 1.5\times10^{-2}\text{ m} = 1.5\text{ cm, which}$$

is choice (2)

13. In Q. 12, if the peak value of the electric field is 60 Vm^{-1}, the average energy density (in Jm^{-3}) of the magnetic field of the wave will be (given $\mu_0 = 4\pi\times10^{-7}$ Fm^{-1})

A. $2\pi\times10^{-7}$
B. $4\pi\times10^{-7}$
C. $\frac{1}{2\pi}\times10^{-7}$
D. $\frac{1}{4\pi}\times10^{-7}$

Right Answer Explanation:

$$B_0 = \frac{E_0}{c} = \frac{60}{3\times10^8} = 2.0\times10^{-7}\text{ T}$$

$$u_m = \frac{B_0^2}{4\mu_0} = \frac{(2.0\times10^{-7})^2}{4\times4\pi\times10^{-7}} = \frac{1}{4\pi}\times10^{-7}\text{ Jm}^{-3}$$

Hence the correct choice is (4).

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14. An electromagnetic wave is produced by oscillating electric and magnetic fields **E** and **B**. Choose the only incorrect statement from the following.

A. **E** is perpendicular to **B**.
B. **E** is perpendicular to the direction of propagation of the wave.
C. **B** is perpendicular to the direction of propagation of the wave.
D. **E** is parallel to **B**.

Right Answer Explanation:
The only incorrect statement is choice (4).

15. Which of the following pairs of space and time varying **E** = ($\hat{i}E_x + \hat{j}E_y + \hat{k}E_z$) and **B** = ($\hat{i}B_x + \hat{j}B_y + \hat{k}E_z$) would generate a plane electromagnetic wave travelling in the z-direction?

A. E_x, B_z
B. E_y, B_z
C. E_z, B_x
D. E_x, B_y

Right Answer Explanation:
The correct choice is (4).

16. What is the self inductance of an air – core solenoid, 3.14 m long, cross-sectional area 10^{-3} m^2 and having 500 turns?

A. mH
B. mH
C. mH
D. mH

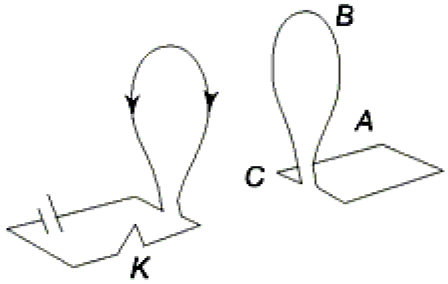
Right Answer Explanation:

$$L = \frac{\mu_0 N^2 A}{l} = \frac{4\pi \times 10^{-7} \times (500)^2 \times 10^{-3}}{3.14}$$

$$= 10^{-4}\ \text{H} = 0.1\ \text{mH}$$

Hence the correct choice is (1).

17. The figure below shows two coils placed close to each other. When the key K is pressed so that a current starts building up in one of the coils, then

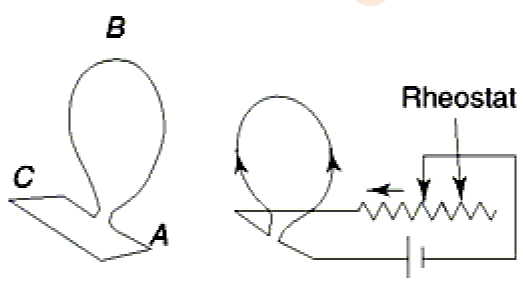


A. a current flows along ABC in the other coil
B. a current flows along CBA in the other coil
C. no current flows in the other coil
D. an alternating current flows in the other coil

Right Answer Explanation:

When the key is pressed, a current starts building up in the coil and the magnetic flux through the neighbouring coil increases. By Lenz's law, the induced current in this coil must oppose this increase in flux. Hence the induced current must flow in the anti-clockwise direction, i.e. along ABC.

18. The figure below shows two coils placed close to each other. When the current through one coil is decreased gradually by shifting the position of the rheostat, then



A. a current flows along ABC in the other coil
B. a current flows along CBA in the other coil
C. no current flows in the other coil
D. an alternating current flows in the other coil

Right Answer Explanation:
As the rheostat is being shifted, the resistance in series with the coil is decreasing and the curren in the coil is increasing. Hence, the magnetic flux through the neighbouring coil increases. By Lenz's law, the induced current in the coil must oppose the increase in flux. Therefore, the induced current must flow in the clockwise direction, i.e. along CBA. Hence, the correct choice is (2).

19. If the flux of magnetic induction through a coil of resistance R and having n turns changes from ϕ_1 to ϕ_2 , then the magnitude of the charge that passes through the coil is

A. $\frac{(\phi_2 - \phi_1)}{R}$
B. $\frac{n(\phi_2 - \phi_1)}{R}$
C. $\frac{(\phi_2 - \phi_1)}{nR}$
D. $\frac{nR}{(\phi_2 - \phi_1)}$

Right Answer Explanation:
Induced emf is $|e| = n\,\frac{\Delta\Phi}{\Delta t}$. Now

$$\Delta q = I\,\Delta t$$

$$= \frac{e}{R}\,\Delta t = \frac{n\Delta\Phi}{R\Delta t} \times \Delta t = \frac{n\Delta\Phi}{R}$$

$$= \frac{n(\Phi_2 - \Phi_1)}{R}$$

20. A metallic wheel with 8 metallic spokes, each of length r, is rotating at an angular frequency w in a plane perpendicular to the magnetic field B. The magnitude of the induced emf between the axle and the rim of the wheel is

A. $\frac{1}{2}\omega r^2 B$
B. $2\,\omega r^2 B$
C. $4\,\omega r^2 B$
D. $8\,\omega r^2 B$

Right Answer Explanation:

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Refer to figure. Let ν be the frequency of rotation. The time taken for 1 full rotation is $T = 1/\nu$. Therefore, rate of change of area is

$$\frac{A}{T} = \frac{\pi r^2}{T} = \pi r^2 \nu$$

Now, the emf induced between the axle and rim is $e = B \times$ rate of change of area

$$= B \times \pi r^2 \nu = \frac{1}{2} B r^2 \omega \quad (\because \omega = 2\pi\nu)$$

Since the same emf is produced between the ends of each spoke, and these emfs are in parallel as is evident from figure, the net emf between the axle and the rim of the wheel will be the same as that across each spoke. We notice that all the eight spokes are connected with one end at the rim and the other at the axle. Hence the magnitude of the net emf between the axle and the rim is independent of the number of spokes.