SELF ASSESSMENT PAPER - 4

SOLUTIONS

I. Multiple Choice Questions **[1 × 4 = 4]**

1. Option (B) is correct.

Explanation: At resonance, LCR circuit behaves as purely resistive circuit. For purely resistive circuit, power factor is 1.

2. Option (A) is correct.

Explanation: When a capacitor C is charged to a certain potential and connected to an inductor L, energy stored in C oscillates between L and C.

$$X_L = X_C$$

$$\therefore \quad f = \frac{1}{2\pi\sqrt{LC}}$$

3. Option (D) is correct.

Explanation: If current i flows through a coil of self-inductance L, then magnetic field energy stored in it is $\frac{1}{2} Li^2$

4. Option (A) is correct.

Explanation: If two coils of self inductance L_1 and L_2 are coupled together, their mutual inductance becomes $M = k\sqrt{L_1L_2}$ where k = coupling constant whose value lies between 0 and 1.

II. Assertion & Reason **[1 × 2 = 2]**

1. Option (A) is correct.

Explanation: The filament of bulb is an inductor (coil). During switching ON and OFF, the current changes from steady value to 0 or from 0 to a steady value within a very short time. So, from the relation $V = L di/dt$, it is evident that V will be high at that time. So, there remains a possibility of the bulb to fuse. So the assertion is true.

The surge is produced due to inductive effect at the time of switching ON and OFF. So, reason is also true.

The reason explains the assertion.

2. Option (C) is correct.

Explanation: Faraday's laws involve only transformation of energy into electrical energy.

So, it is a consequence of conservation of energy. So the assertion is true.

In purely resistive circuit, current and voltage are in phase. So the reason is false.

III. Competency Based Questions **[1 × 4 = 4]**

1. Option (C) is correct.

Explanation: Phenomenon involved in tuning a radio set to a particular radio station is resonance.

The capacitor has to be tuned in tandem corresponding to the frequency of a station. So, that the LC combination of the radio set resonates at the frequency of the desired station.

2. Option (C) is correct.

Explanation: A simple radio receiver is a simple crystal set with a coil & capacitor combination. Desired frequency is tuned by tuning the coil - capacitor combination. Tuning means to make Capacitive reactance (X_C) equal to the inductive reactance (X_L), so that the resonance occurs.

3. Option (B) is correct.

Explanation: The resonant frequency is given by

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

4. Option (C) is correct.

Explanation: At resonance, capacitive reactance (X_C) is equal to the inductive reactance (X_L). Circuit is totally resistive and the current amplitude becomes maximum.

5. Option (A) is correct.

Explanation: Capacitor used in old radio is parallel plate capacitor. It consists of two sets of parallel circular plates , one of which can rotate manually by means of a knob. The rotation causes overlapping areas of plates to change, thus changing its capacitance.

IV. Very Short Answer Type Questions **[1 × 3 = 3]**

1. Magnetic flux is defined as the total number of magnetic lines of force passing normally through an area placed in a magnetic field.

Square lies in x-y plane in $\vec{B}$.

So,

$$\vec{A} = L^2\hat{k}$$

$$\varphi = \vec{B}.\vec{A}$$

$$= B_0\,(2\hat{i}+3\hat{j}+4\hat{k})\,.\,L^2\hat{k}$$

$$= B_0L^2\,(2\hat{i}.\hat{k} + 3\hat{j}\,.\,\hat{k} + 4\hat{k}\,.\,\hat{k})$$

$$= B_0L^2\,(0 + 0 + 4)$$

$$= 4\,B_0\,L^2\text{ Wb}$$

2. The self inductance of coil or solenoid is given by

$$L = \mu_0 n^2 Al$$

where μ_0 is permeability of free space, n is number of turns per unit length of a coil, A is cross sectional area of coil and l is length of coil.

If A and l are constant terms then, inductance is directly proportional to square of number of turns. According to question, the number of turns in a coil is doubled. So, inductance of coil becomes four times.

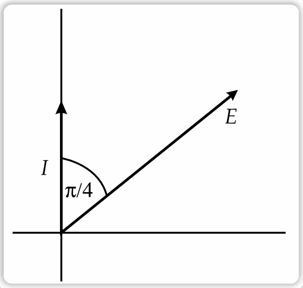
3. Relative permeability $= \mu_r = L/L_0$

$= 2.8/2 \times 10^{-3}$

$= 1400$

V. Short Answer Type Questions-I [2 × 3 = 6]

1.



Equal length of phasors ½

Current leads voltage ½

phase difference is $\frac{\pi}{4}$ **1**

[CBSE Marking Scheme, 2018]

2. A transformer is based on the principle of mutual induction which states that due to continuous change in the current in the primary coil, an emf gets induced across the secondary coil.

Electric power generated at the power station, is stepped-up to very high voltages by means of a step-up transformer and transmitted to a distant place. At receiving end, it is stepped down by a step-down transformer.

3. **(i)** Resonance frequency $= \omega_0 = \frac{1}{\sqrt{LC}}$

or, $\omega_0 = \frac{1}{\sqrt{50\times10^{-3}\times80\times10^{-6}}}$

or, $\omega_0 = 500$

or, $2\pi f = 500$

$\therefore$ $f = \frac{500}{2\pi} = 80\text{Hz}$

(ii) Quality factor $= Q = \frac{\omega_0 L}{R}$

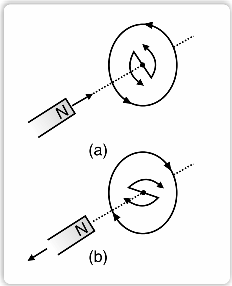
or, $Q = \frac{500\times50\times10^{-3}}{40}$

$\therefore$ $Q = 0.625$

VI. Short Answer Type Questions-II [3 × 2 = 6]

1. **Lenz's law:** The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it.

Explanation:



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When the north pole of a bar magnet is pushed towards a close coil, the magnetic flux through coil increases and a current is induced in the coil in such a direction that it opposes the increase in flux. This is possible when the induced current in the coil is in the anti clockwise direction. The opposite will happen when the north pole is moved away from the coil. ½

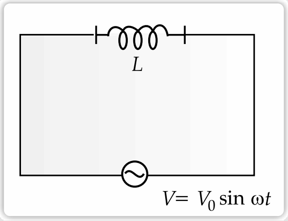
In either case, it is the work done against the force of magnetic repulsion/attraction that gets 'converted' into the induced emf. **2**

2. Derivation of instantaneous current **2**

Derivation of average power dissipated **1**

Given: $V = V_0 \sin \omega t$

$V = L\frac{di}{dt} \Rightarrow di = \frac{V}{L}dt$



$\therefore$ $di = \frac{V_0}{L}\sin \omega t dt$ ½

Integrating, $i = -\frac{V_0}{\omega L}\cos \omega t$ ½

$\therefore$ $i = \frac{V_0}{\omega L}\sin\left(\frac{\pi}{2} - \omega t\right)$

$= i_0 \sin\left(\frac{\pi}{2} - \omega t\right)$ ½

where, $i_0 = \frac{V_0}{\omega L}$

Average power,

$P_{av} = \int_0^T Vi dt$ ½

$= \frac{-V_0^2}{\omega L}\int_0^T \sin \omega t \cos \omega t \, dt$

$$= \frac{-V_0^2}{2\omega L}\int_0^T \sin(2\omega t)dt$$

$$= 0$$ 1

[CBSE Marking Scheme, 2017]

VII. Long Answer Type Question **[5 × 1 = 5]**

1.

(i) The device X is a capacitor ½

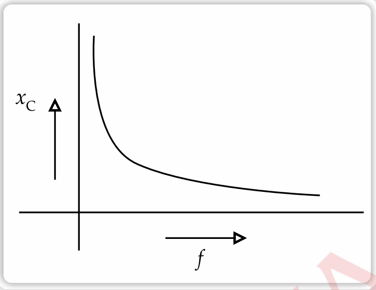
(ii) Curve $B \rightarrow$ voltage

Curve $C \rightarrow$ current

Curve $A \rightarrow$ power ½

Reason : The current leads the voltage in phase, by $\frac{\pi}{2}$, for a capacitor. ½

(iii) $$X_c = \frac{1}{\omega C} \text{ or } \left(X_c \propto \frac{1}{\omega}\right)$$ ½

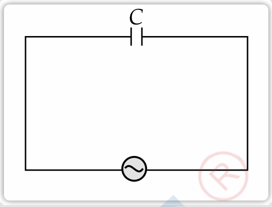


½

(iv) $$V = V_0 \sin \omega t$$

$$q = VC = CV_0 \sin \omega t$$ ½

$$I = \frac{dq}{dt} = \omega CV_0 \cos \omega t$$ ½



$$V = V_0 \sin \omega t$$ ½

$$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$ ½

Current leads the voltage, in phase, by $\frac{\pi}{2}$ ½

[Note If the student identifies the device X as an Inductor but writes correct answer to parts (iii) and (iv) (in terms of an inductor), the student will be given full marks for (only) these two parts]

[CBSE Marking Scheme, 2017]