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Electromagnetic Induction and Alternating Current

Maximum Marks : 25 **PHYSICS** **Time: 50 Minutes**

Choose the correct answer :- **3x1=3**

1. An inductor 20 mH, a capacitor 50 μF and a resistor 40 Ω are connected in series across a source of emf V = 10 sin 340 t. The power loss in AC circuit is
(a) 0.76 W (b) 0.89 W (c) 0.46 W (d) 0.67 W

2. A step-down transformer reduces the supply voltage from 220 V to 11 V and increase the current from 6 A to 100 A. Then its efficiency is
(a) 1.2 (b) 0.83 (c) 0.12 (d) 0.9

3. The power factor of a circuit is defined as
(a) sin ϕ (b) tan ϕ (c) cos ϕ (d) sec ϕ

Answer the following :- **3x2=6**

4. Mention the ways of producing induced emf.
5. How will you define RMS value of an alternating current?
6. A 400 mH coil of negligible resistance is connected to an AC circuit in which an effective current of 6 mA is flowing. Find out the voltage across the coil if the frequency is 1000 Hz.

Answer any two of the following:- **2x3=6**

7. Obtain an expression for motional emf from Lorentz force.
8. Mention the various energy losses in a transformer.
9. Find the instantaneous value of alternating voltage $v = 10\sin(3\pi \times 10^4 \text{ t})$ volt at
i) 0 s ii) 50 μ s iii) 75 μ s.

Answer the following :- **2x5=10**

10. (a) Explain the construction and working of transformer.

(OR)

(b) Derive an expression for phase angle between the applied voltage and current in a series RLC circuit.

11. i) What is meant by mutual induction?
ii) A 200 turn circular coil of radius 2 cm is placed co-axially within a long solenoid of 3 cm radius. If the turn density of the solenoid is 90 turns per cm, then calculate mutual inductance of the coil and the solenoid.

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Answer key attached in next page!!!

This page is to prevent seeing answer key

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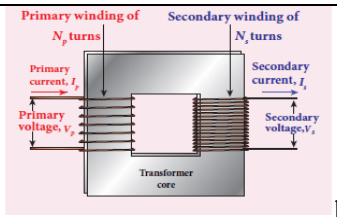
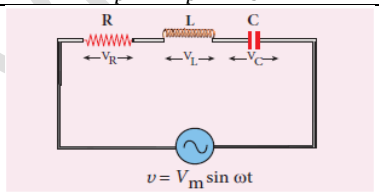
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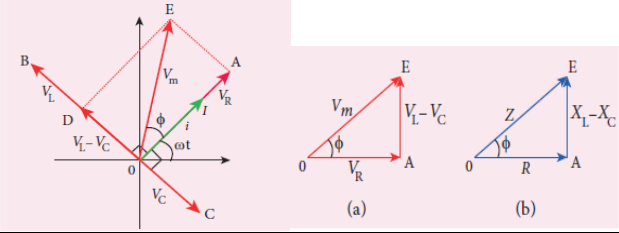
ANSWER KEY

Q NO	ANSWERS	MARKS
1.	(C) 0.46 W	**1**
2.	(B) 0.83	**1**
3.	(D) cos ϕ	**1**
4.	The induced emf can be produced by changing magnetic flux in any of the following ways. (i) By changing the magnetic field *B* (ii) By changing the area *A* of the coil and (iii) By changing the relative orientation θ of the coil with magnetic field	**2**
5.	The root mean square value of an alternating current is defined as the square root of the mean of the squares of all currents over one cycle. It is denoted by I_{RMS} . For alternating voltages, the RMS value is given by V_{RMS}.	**2**
6.	$X_L = L\omega = L.2\pi f = 2512\ \Omega$ $V = I X_L = 15.072$ V (RMS)	**2**
7.	$\overrightarrow{F_B} = -e(\vec{v} \times \vec{B})$ $\overrightarrow{F_E} = -e\vec{E}$ $\lvert\overrightarrow{F_B}\rvert = \lvert\overrightarrow{F_E}\rvert \Longrightarrow \lvert-e(\vec{v} \times \vec{B})\rvert = \lvert-e\vec{E}\rvert$ $vBsin90° = E$ $vB = E$ $V = El$ $V = vBl$ $\varepsilon = Blv$	**3**
8.	**Core loss or Iron loss** - When transformer core is magnetized and demagnetized repeatedly by the alternating voltage applied across primary coil, hysteresis takes place due to which some energy is lost in the form of heat. Hysteresis loss is minimized by using steel of high silicon content in making transformer core. Alternating magnetic flux in the core induces eddy currents in it. Therefore there is energy loss due to the flow of eddy current, called eddy current loss which is minimized by using very thin laminations of transformer core.	**3**

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	Copper loss - Transformer windings have electrical resistance. When an electric current flows through them, some amount of energy is dissipated due to Joule heating. This energy loss is called copper loss which is minimized by using wires of larger diameter. **Flux Leakage** - Flux leakage happens when the magnetic lines of primary coil are not completely linked with secondary coil. Energy loss due to this flux leakage is minimized by winding coils one over the other.	
9.	$v = 10\sin(3\pi \times 10^4 t)$ i) at t = 0s, $v = 0V$ ii) at t = $50\mu s$, $v = -10\ V$ iii) at t = $75\mu s$, $v = 7.07V$	**3**
10. a	 p • Transformer is a stationary device used to transform electrical power from one circuit to another without changing its frequency. • The principle of transformer is the mutual induction between two coils. That is, when an electric current passing through a coil changes with time, an emf is induced in the neighbouring coil • In the simple construction of transformers, there are two coils of high mutual inductance wound over the same transformer core. • The core is generally laminated and is made up of a good magnetic material like silicon steel. Coils are electrically insulated but magnetically linked via transformer core. • The coil across which alternating voltage is applied is called primary coil *P* and the coil from which output power is drawn out is called secondary coil *S*. The assembled core and coils are kept in a container which is filled with suitable medium for better insulation and cooling purpose. • $\varepsilon_p = -N_p \frac{d\phi_B}{dt}$, $v_p = -N_p \frac{d\phi_B}{dt}$ • $\varepsilon_s = -Ns \frac{d\phi_B}{dt}$, $v_s = -N_s \frac{d\phi_B}{dt}$ • $\frac{v_s}{v_p} = \frac{N_s}{N_p} = \frac{i_p}{i_s} = K$	**5**
10. b	 $v = V_m \sin\omega t$ The length of these phasors are OI = I_m, OA = $I_m R$, OB = $I_m X_L$; OC = $I_m X_C$ By parallelogram law, $V_m^2 = V_R^2 + (V_L - V_C)^2 \quad \Rightarrow \quad V_m = I_m\sqrt{R^2 + (X_L - X_C)^2}$ $I_m = \frac{V_m}{Z}$, $Z = \sqrt{R^2 + (X_L - X_C)^2}$	**5**

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	tan ϕ = V_L – V_C / V_R = X_L – X_C / R 	
11	i) When an electric current passing through a coil changes with time, an emf is induced in the neighbouring coil. This phenomenon is known as **mutual induction** and the emf induced is called mutually induced emf. ii) M =$\mu_0 \cdot n_1 \cdot N_2 \cdot A$ M = 2.84 mH	**5**

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