UNIT IV

ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENTS

Weightage Marks : 8

TOPICS TO BE COVERED

Electromagnetic induction; Faraday's laws induced emf and current; Lenz's law, Eddy currents self and mutual inductance.

Need for displacement current Altrenating currents, peak and rms value of altering current/voltage

Reactance and Impedance. Lc oscillations (qualitative treatment only).

LCR series circuit; Resaonance; Power in AC circuits, wattless current.

AC generator and transformer.

KEY POINTS

Physical Quantity	*Formulae*	*SI Unit*
Self-inductance of a long solenoid	$L = \mu_0 n^2 lA$	Henry (H)
Mutual inductance of two long solenoids (Theorem of reciprocity)	$M_{12} = M_{21} = M = \mu_0 n_1 n_2 Al$	
Factors affecting mutual inductance	$K = \frac{M}{\sqrt{L_1 L_2}}$	K → Coefficient of coupling
Magnetic Flux	$\phi = \vec{B}.\vec{A} = BA\cos\theta$	Tm^2 or Weber
Due to self induction	$\phi = LI$	
Due to mutual indication	$\phi_{21} = \mu_0 n_1 n_2 Al\, I_1 = MI_1$	
	$\phi_{12} = \mu_0 n_1 n_2 Al\, I_1 = MI_2$	
Induced EMF	$e = -N\frac{d\phi}{dt} = Blv = -L\frac{dI}{dt}$	Volt
Power produced due to induced EMF	$P = \frac{B^2 l^2 v^2}{R}$	Watt
Alternative current	$I = I_0 \sin \omega t$ Or $I = I_0 \cos \omega t$	A

Alternating EMF	$E = E_0 \sin \omega t$	
	Or $E = E_0 \cos \omega t$	v
Root Mean Square (RMS) or Virtual Value of AC		
Current	$I_v = \frac{I_0}{\sqrt{2}} = 0.707 I_0$	A
EMF	$E_v = \frac{E_0}{\sqrt{2}} = 0.707 E_0$	V
AC through an inductor		
Current	$I = \frac{E_0}{\omega L} \sin\left(\omega t - \frac{\pi}{2}\right)$	A
Inductive Reactance	$X_L = \omega L$	Ω
AC through a capacitor		
Current	$I = \omega C E_0 \sin\left(\omega t + \frac{\pi}{2}\right)$	A
	$= I_0 \cos \omega t$	
Capacitive reactance	$X_C = \frac{1}{\omega C}$	Ω
LCR series circuit		
Current	$I = \frac{E}{\sqrt{\left\{R^2 + (X_L - X_C)^2\right\}}}$	A

Impedance	$Z=\sqrt{\left\{R^2-(X_L-X_C)^2\right\}}$	Ω
Resonance condition	$X_L=X_C \Leftrightarrow \omega L=\frac{1}{\omega C}$	
	$\omega_0=\frac{1}{\sqrt{LC}} \Leftrightarrow \nu_0=\frac{1}{2\pi}\frac{1}{\sqrt{LC}}$	
Quality factor	$Q=\frac{\omega}{2\Delta\omega}=\frac{\omega_0 L}{R}=\frac{1}{\omega_0 RC}$	
Total Bandwidth	$2\Delta\omega=\frac{R}{L}=\frac{1}{RC}$	rad s^{-1}
Power factor	$\cos\phi=\frac{R}{Z}$	
Average power	$P_{av}=E_\upsilon I_\upsilon \cos\phi=I_\upsilon^2 Z\cos\phi$	Watt
Wattless current	$I_\upsilon \sin\phi$	
The energy of the oscillator		
Total energy stored in an inductor	$U=\frac{1}{2}LI^2{}_0$	
Total energy stored in the capacitor	$U=\frac{1}{2}\frac{q_0^2}{C}$	

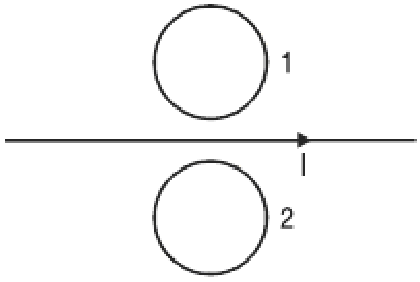
For LC oscillator	$U=\frac{1}{2}LI^2+\frac{1}{2}\frac{q^2}{C}$
LC oscillator loop (Kirchhoff's Law)	$\frac{q}{C}-L\frac{dI}{dt}=0$
Transformer	
Transformation ratio	$\frac{N_s}{N_p}=K$
EMF ratio vs current ratio	$\frac{E_s}{E_p}=\frac{I_p}{I_s}=\frac{N_s}{N_p}$
Efficiency of the transformer	$\eta=\frac{I_s E_s}{I_p E_p}$

QUESTIONS

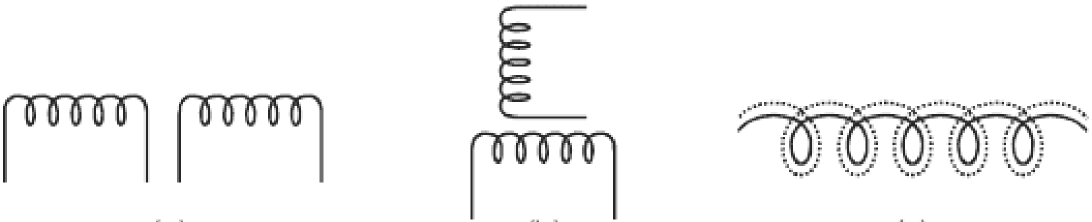
VERY SHORT ANSWER QUESTIONS (I Mark)

1. Why core of a transformer is laminated?

2. What is the direction of induced currents in metal rings 1 and 2 seen from the top when current I in the wire is increasing steadily?



3. In which of the following cases will the mutual inductance be (i) minimum (ii) maximum?



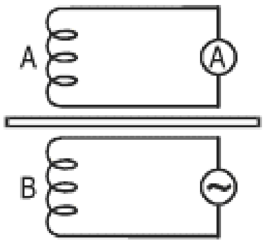
4. In a series *L–C–R* circuit, voltages across inductor, capacitor, and resistor are V_L, V_C and V_R respectively. What is the phase difference between (i) V_L and V_R (ii) V_L and V_C?

5. Why can't transformer be used to step up or step down dc voltage?

6. In an a.c. circuit, instantaneous voltage and current are $V = 200 \sin 300 t$ volt and $i = 8 \cos 300t$ ampere respectively. What is the average power dissipated in the circuit?

7. Sketch a graph that shows change in reactance with frequency of a series LCR circuit.

8. A coil A is connected to an A.C. ammeter and another coil B to A source of alternating e.m.f. What will be the reading in ammeter if a copper plate is introduced between the coils as shown.

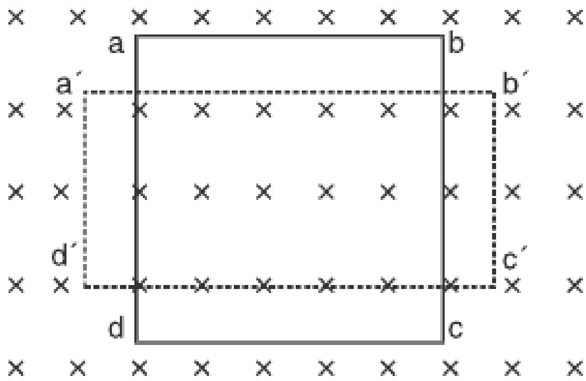


9. In a circuit instantaneously voltage and current are $V = 150 \sin 314$ volt and $i = 12 \cos 314\, t$ ampere respectively. Is the nature of circuit is capacitive or inductive?

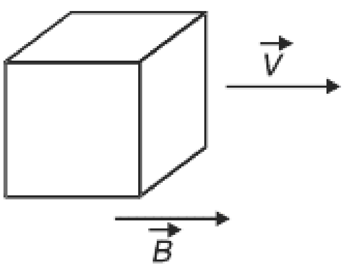
10. In a series L–C–R circuit $V_L = V_C \neq V_R$. What is the value of power factor?

11. In an inductor L, current passed I_0 and energy stored in it is U. If the current is now reduced to $I_0/2$, what will be the new energy stored in the inductor?

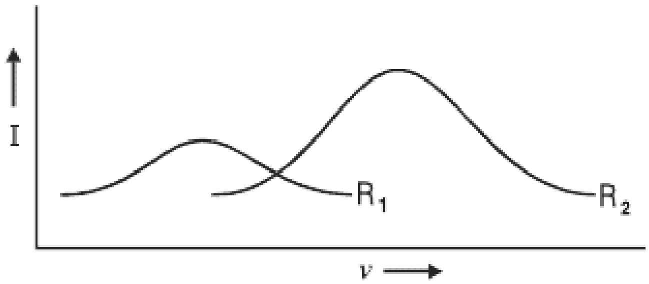
12. A rectangle loop *a b c d* of a conducting wire has been changed into a square loop *a′ b′ c′ d′* as shown in figure. What is the direction of induced current in the loop?



13. Twelve wires of equal lengths are connected in the form of a skeleton of a cube, which is moving with a velocity $\vec{V}$ in the direction of magnetic field $\vec{B}$. Find the *emf* in each arm of the cube.



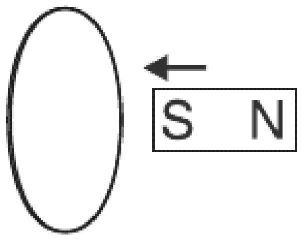
14. Current versus frequency ($I - \nu$) graphs for two different series L–C–R circuits have been shown in adjoining diagram. R_1 and R_2 are resistances of the two circuits. Which one is greater–R_1 or R_2?



15. Why do we prefer carbon brushes than copper in an a.c. generator?

16. What are the values of capacitive and inductive reactance in a dc circuit?

17. Give the direction of the induced current in a coil mounted on an insulating stand when a bar magnet is quickly moved along the axis of the coil from one side to the other as shown in figure.

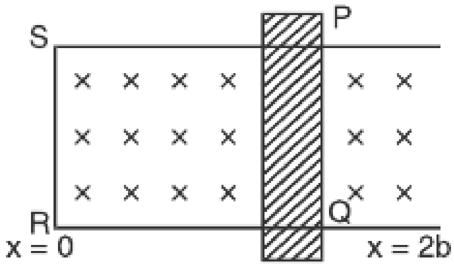


Ans : If observer is situated at the side from which bar magnet enters the loop. The direction of current is clockwise when magnet moves towards the loop and direction of current is anticlockwise when magnet moves away from the loop.

18. In figure, the arm PQ is moved from x = o to x = 2b with constant speed V. Consider the magnet field as shown in figure. Write

    (i) direction of induced current in rod

    (ii) polarity induced across rod.

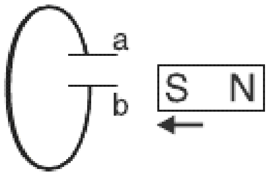


19. A wire moves with some speed perpendicular to a magnetic field. Why is emf induced across the rod?

 Ans : Lorentz force acting on the free charge carrier of conducting wire hence polarity developed across it.

20. Predict the polarity of the capacitor in the situation described in the figure below.

 Ans : Plate a will be negative with respect to 'b'.



21. A circular coil rotates about its vertical diameter in a uniform horizontal magnetic field. What is the average emf induced in the coil? **Ans :** Zero

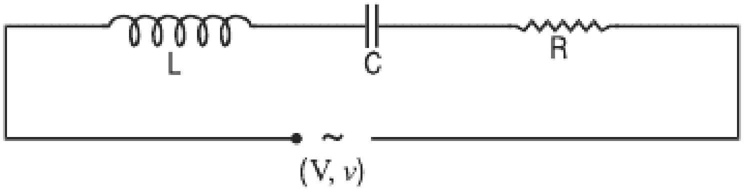
22. Define RMS Value of Current.

SHORT ANSWER QUESTIONS (2 Marks)

1. An ac source of rms voltage V is put across a series combination of an inductor L, capacitor C and a resistor R. If V_L, V_C and V_R are the rms voltage across *L, C* and *R* respectively then why is $V \neq V_L + V_C + V_R$? Write correct relation among V_L, V_C and V_R.

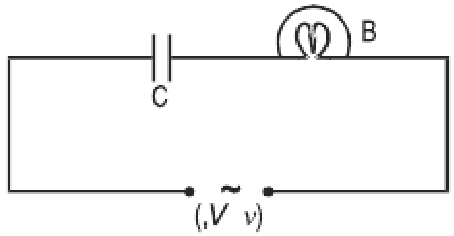
2. A bar magnet is falling with some acceleration 'a' along the vertical axis of a coil as shown in fig. What will be the acceleration of the magnet (whether $a > g$ or $a < g$ or $a = g$) if (*a*) coil ends are not connected to each other? (b) coil ends are connected to each other?

3. The series L–C–R circuit shown in fig. is in resonance state. What is the voltage across the inductor?

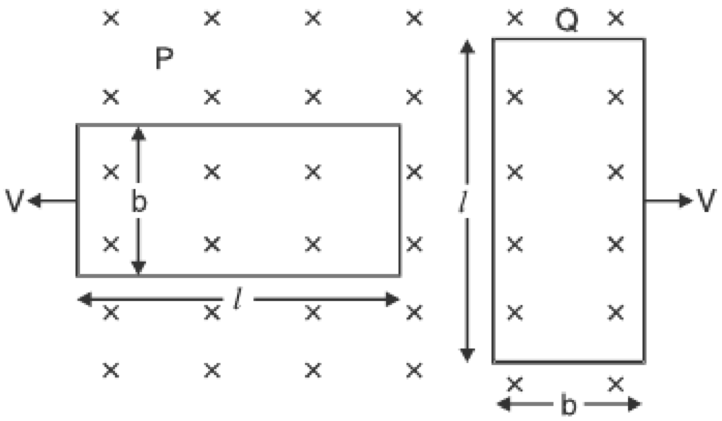


4. The divisions marked on the scale of an a.c. ammeter are not equally spaced. Why?

5. Circuit shown here uses an airfield parallel plate capacitor. A mica sheet is now introduced between the plates of capacitor. Explain with reason the effect on brightness of the bulb B.



6. In the figure shown, coils P and Q are identical and moving apart with same velocity V. Induced currents in the coils are I_1 and I_2. Find I_1/I_2.



7. A 1.5 μ F capacitor is charged to 5 7V. The charging battery is then disconnected, and a 12 mH coil is connected in series with the capacitor so that LC Oscillations occur. What is the maximum current in the coil? Assume that the circuit has no resistance.

8. The self inductance of the motor of an electric fan is 10H. What should be the capacitance of the capacitor to which it should be connected in order to impart maximum power at 50Hz?

9. How does an inductor behave in a DC circuit after the current reaches to steady state? Justify.

10. How does an inductor behave in a AC circuit at very high frequency? Justify.

11. An electric bulb is commected in series with an inductor and an AC source. When switch is closed and after sometime an iron rod is inserted into the interior of inductor. How will the brightness of bulb be affected? Justify your answer.

Ans : Decreases, due to increase in inductive reactance.

12. Show that in the free oscillation of an LC circuit, the sum of energies stored in the capacitor and the inductor is constant with time.

Ans : Hint : $U=\frac{1}{2}LI^2+\frac{1}{2}\frac{q^2}{c}$

13. Show that the potential difference across the LC combination is zero at the resonating frequency in series LCR circuit

Ans : Hint P.d. across L is = IX_L

P.D. across C is – IX_C

$\Rightarrow \qquad V = IX_L - IX_C$

at resonance $X_L = X_C$

$\Rightarrow \qquad V = O.$

14. How does an capacitor behave in a DC circuit after the steady state? Explain your answer.

Ans : Capacitor acts as an open key.

15. For circuits used for transmitting electric power, a low power factor implies large power loss in transmission. Explain.

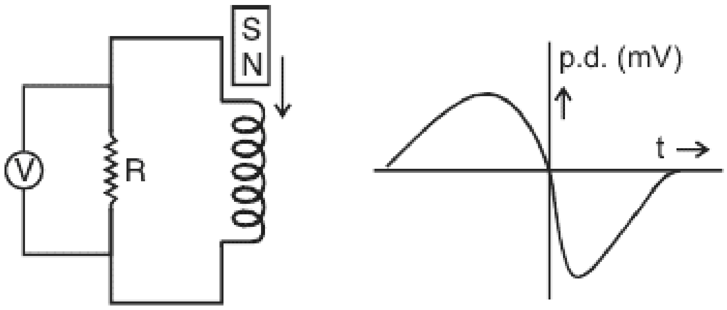
$\therefore \quad P = VI \cos \phi$

Or $\quad I=\frac{P}{V\cos\theta}$

if Cos θ is Low I will be high $\Rightarrow$ Large power loss.

16. An applied Voltage signal consists of a superposition of DC Voltage and an AC Voltage of high frequency. The circuit consists of an inductor and a capacitor in series. Show that the DC signal will appear across C where as AC signal will appear across L.

17. A bar magnet M is dropped so that is falls vertically through the coil C. The graph obtained for voltage produced across the coil Vs time is shoin figure



(i) Explain the shape of the graph

(ii) Why is the negative peak longer than the positive peak?

18. What is the Significance of Q-factor in a series LCR resonant circuit?

19. How does mutual inductance of a pair of coils kept coaxially at a distance in air change when

(i) the distance between the coils is increased?

(ii) an iron rod is kept between them?

SHORT ANSWER QUESTIONS (3 Marks)

1. Obtain an expression for the self inductance of a straight solenoid of length l and radius r ($l >> r$).

2. Distinguish between : (i) resistance and reactance (ii) reactance and impedance.

3. In a series L–C–R circuit X_L, X_C and R are the inductive reactance, capacitive reactance and resistance respectively at a certain frequency f. If the frequency of a.c. is doubled, what will be the values of reactances and resistance of the circuit?

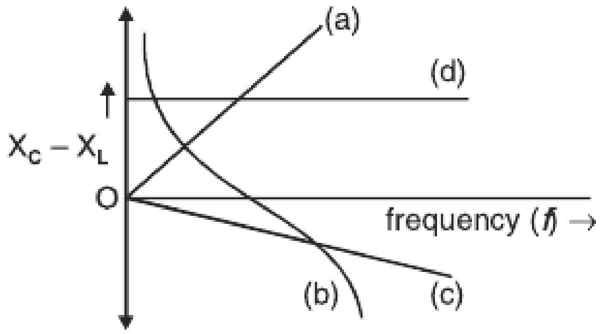
4. What are eddy currents? Write their any four applications.

5. In a series L–R circuit, X_L = R and power factor of the circuit is P_1. When capacitor with capacitance C such that $X_L = X_C$ is put in series, the power factor becomes P_2. Find P_1/P_2.

6. Instantaneous value of a.c. through an inductor L is $e = e_0 \cos \omega t$. Obtain an expression for instantaneous current through the inductor. Also draw the phasor diagram.

7. In an inductor of inductance L, current passing is I_0. Derive an expression for energy stored in it. In what forms is this energy stored?

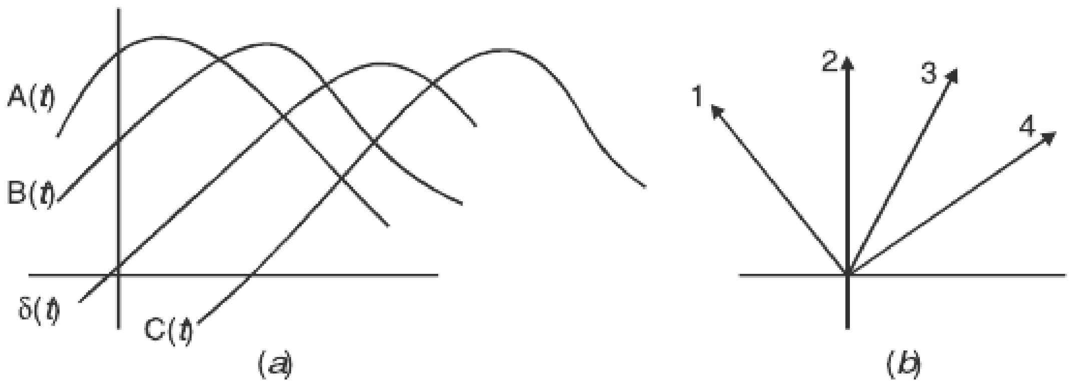
8. Which of the following curves may represent the reactance of a series LC combination.



[**Ans. :** (b)]

9. A sinusoidal e.m.f. device operates at amplitude E_0 and frequency ν across a purely (1) resistive (2) capacitive (3) inductive circuit. If the frequency of driving source is increased. How would (a) amplitude E_0 and (b) amplitude I_0 increase, decrease or remain same in each case?

10. The figure shows, in (a) a sine curved $\delta(t) = \sin \omega t$ and three other sinusoidal curves A(t), B(t) and C(t) each of the form $\sin (\omega t - \phi)$. (a) Rank the three curves according to the value of ϕ, most positive first and most negative last (b) Which curve corresponds to which phase as in (b) of the figure? (c) which curve leads the others? [**Ans. :** (a) C, B, A; (b) 1, A; 2, B; (c) A]



11. In an LC circuit, resistance of the circuit is negligible. If time period of oscillation is T them :

 (i) at what time is the energy stored completely electrical

 (ii) at what time is the energy stored completely magnetic

 (iii) at what time is the total energy shared equally between the inductor and capacitor.

Ans : (i) $t = 0, T/2, 3T/2, \ldots\ldots\ldots$

(ii) $t = T/4, 3T/4, 5T/4 \ldots\ldots\ldots$

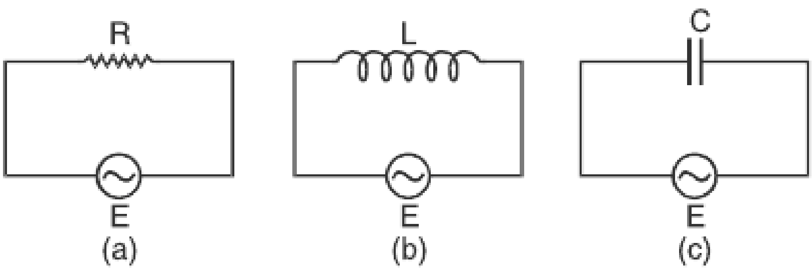
(iii) $t = \frac{T}{8}, \frac{3T}{8}, \frac{5T}{8}, \ldots\ldots\ldots$

12. An alternating voltage of frequency f is applied across a series LCR circuit. Let f_r be the resonance frequency for the circuit. Will the current in the circuit lag, lead or remain in phase with the applied voltage when (i) $f > f_r$ (ii) $f < f_r$? Explain your answer in each case.

Ans : (i) Current will Lag because.
$V_L > V_C$ Hence $V_L - V_C > O$

(i) Current will lead, because.
$V_L < V_C$ Hence $v_L - V_C < O$

13. Figure (a), (b), (c) Show three alternating circuits withe equal currents. If frequency of alternating emf be increased, what will be the effect on current in the three cases? Explain.



Ans : (i) No effect, R is not affected by frequency.

(ii) Current will decrease as X_L increase.

(iii) Current will increase as X_C decrease.

LONG ANSWER QUESTIONS (5 Marks)

1. Draw a labelled diagram to explain the principle and working of an a.c. generator. Deduce the expression for emf generated. Why cannot the current produced by an a.c. generator be measured with a moving coil ammeter?

2. Explain, with the help of a neat and labelled diagram, the principle, construction and working of a transformer.

3. An L – C circuit contains inductor of inductance L and capacitor of capacitance C with an initial charge q_0. The resistance of the circuit is negligible. Let the instant the circuit is closed be $t = 0$.

   (i) What is the total energy stored initially?

   (ii) What is the maximum current through inductor?

   (iii) What is frequency at which charge on the capacitor will oscillate?

   (iv) If a resistor is inserted in the circuit, how much energy is eventually dissipated as heat?

4. An a.c. $i = i_0 \sin \omega t$ is passed through a series combination of an inductor (L), a capacitor (C) and a resistor (R). Use the phasor diagram to obtain expressions for the (a) impedance of the circuit and phase angle between voltage across the combination and current passed in it. Hence show that the current

   (i) leads the voltage when $\omega < \frac{1}{\sqrt{LC}}$

   (ii) is in phase with voltage when $\omega = \frac{1}{\sqrt{LC}}$.

5. Write two differences in each of resistance, reactance and impedance for an ac circuit. Derive an expression for power dissipated in series LCR circuit.

NUMERICALS

1. In a series C–R circuit, applied voltage is V = 110 sin 314t volt. What is the (i) The peak voltage (ii) Average voltage over half cycle?

2. Magnetic flux linked with each turn of a 25 turns coil is 6 milliweber. The flux is reduced to 1 mWb in 5 s. Find induced emf in the coil.

3. The current through an inductive circuit of inductance 4mH is $i = 12 \cos 300t$ ampere. Calculate :

   (i) Reactance of the circuit.

   (ii) Peak voltage across the inductor.

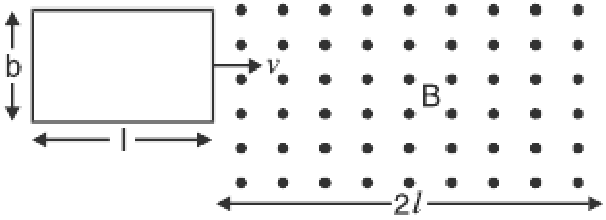
4. A power transmission line feeds input power at 2400 V to a step down ideal transformer having 4000 turns in its primary. What should be number of turns in its secondary to get power output at 240V?

5. The magnetic flux linked with a closed circuit of resistance 8Ω varies with time according to the expression $\phi = (5t^2 - 4t + 2)$ where ϕ is in milliweber and t in second. Calculate the value of induce current at $t = 15$ s.

6. A capacitor, a resistor and $\frac{4}{\pi^2}$ henry inductor are connected in series to an a.c. source of 50 Hz. Calculate capacitance of capacitor if the current is in phase with voltage.

7. A series C–R circuit consists of a capacitance 16 mF and resistance 8Ω. If the input a.c. voltage is (200 V, 50 Hz), calculate (i) voltage across capacitor and resistor. (ii) Phase by which voltage lags/leads current.

8. A rectangular conducting loop of length l and breadth b enters a uniform magnetic field B as shown below.



The loop is moving at constant speed v and at $t = 0$ it just enters the field B. Sketch the following graphs for the time interval $t = 0$ to $t = \frac{3l}{v}$.

   (i) Magnetic flux – time

   (ii) Induced emf – time

   (iii) Power – time

   Resistance of the loop is R.

9. A charged 8mF capacitor having charge 5mC is connected to a 5mH inductor. What is :

   (i) the frequency of current oscillations?

   (ii) the frequency of electrical energy oscillations in the capacitor?

   (iii) the maximum current in the inductor?

   (iv) the magnetic energy in the inductor at the instant when charge on capacitor is 4mC?

10. A 31.4Ω resistor and 0.1H inductor are connected in series to a 200V, 50Hz ac source. Calculate

    (i) the current in the circuit

    (ii) the voltage (rms) across the inductor and the resistor.

    (iii) Is the algebraic sum of voltages across inductor and resistor more than the source voltage? If yes, resolve the paradox.

11. A square loop of side 12 cm with its sides parallel to X and Y-axis is moved with a velocity of 8 cm/s in positive x-direction. Magnetic field exists in z-directions.

    (i) Determine the direction and magnitude of induced current if field changes with 10^{-3} Tesla/cm along negative x-direction.

    (ii) Determine the direction and magnitude of induced current if field changes with 10^{-3} Tesla/s.

    Ans : (i) Rate of change of flux = induced emf = $(0.12)^2 \times 10^{-3} \times 8$

    $= 11.52 \times 10^{-5}$ Wb/s.

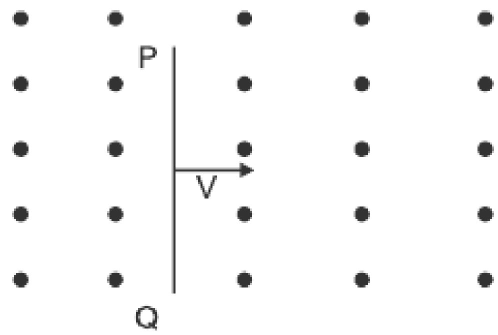
    (ii) Rate of change of flux = induced emf = $(0.12)^2 \times 10^{-3}$

    $= 1.44 \times 10^{-5}$ Wb/s

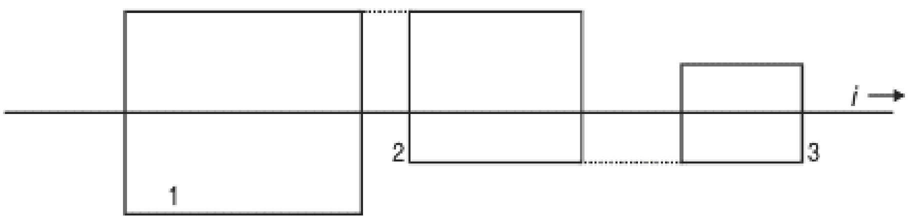
HOTS

VERY SHORT ANSWER QUESTIONS (I Mark)

1. A conducting rod PQ is in motion at speed v in uniform magnetic field as shown in Fig. What are the polarities at P and Q?



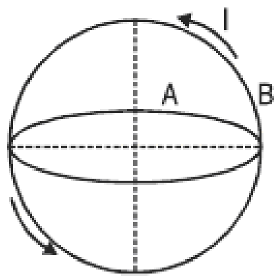
2. A long straight wire with current *i* passes (without touching) three square wire loops with edge lengths 2L, 1.5L land L. The loops are widely spaced (so as to not affect one another). Loops 1 and 3 are symmetric about the long wire. Rank the loops according to the size of the current induced in them if current *i* is (a) constant and (b) increasing greatest first.



3. In an L–C circuit, current is oscillating with frequency 4×10^6 Hz. What is the frequency with which magnetic energy is oscillating?

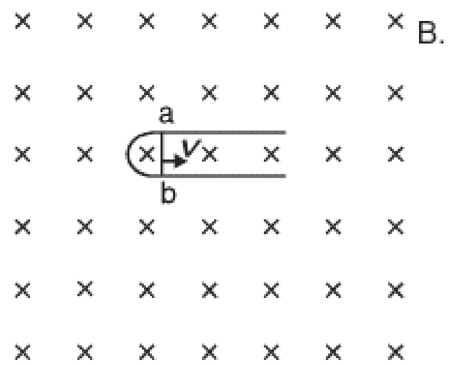
SHORT ANSWER QUESTIONS (2 Marks)

1. Two circular conductors are perpendicular to each other as shown in figure. If the current is changed in conductor B, will a current be induced in the conductor A,



NUMERICALS

1. Figure shows a wire ab of length l which can slide on a U-shaped rail of negligible resistance. The resistance of the wire is R. The wire is pulled to the r ight with a constant speed v. Draw an equivalent circuit diagram representing the induced emf of a battery. Find the current in the wire using this diagram.

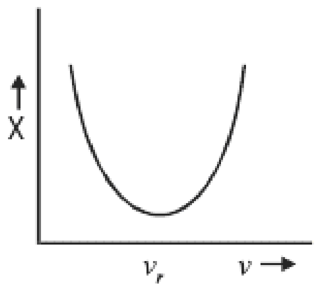


ANSWERS

I MARK QUESTIONS

1. To reduce loss due to eddy currents
2. Ring 1 clockwise, Ring 1, anticlockwise.
3. (i) b; (ii) c.
4. (i) $\pi/2$; (ii) π.
5. In steady current no induction phenomenon will take place.
6. Capacitor circuit, $P_{av} = 0$.
7. Reactance = $X_L - X_C$

   $v_r \rightarrow$ resonant frequency



8. Reading of ammeter will be zero.

9. As current leads voltage by $\pi/2$: purely capacitive circuit.

10. Resonance : $\cos \phi = 1$.

11. Energy $U_L \propto I^2 \quad \Rightarrow \quad U' = \frac{U}{4}$.

12. Clockwise.

13. emf in each branch will be zero.

14. $R_1 > R_2$ as current is smaller at larger resistance.

15. Corrosion free and also with small expansion on heating maintains proper contact.

16. Capacitive reactance – infinity

    Inductive reactance – zero.

2 MARKS QUESTIONS

2. (i) $a = g$ because the induced emf set up in the coil does not produce any current and hence no opposition to the falling bar magnet.

   (ii) $a < g$ because of the opposite effect caused by induced current.

3. Current at resonance $I = \frac{V}{R}$.

   $\therefore$ Voltage across inductor $V_L = I.X_L = I.\omega L = \frac{V}{R}(2\pi\nu) L$.

4. A.C. ammeter works on the principle of heating effect $H \propto I^2$.

5. Brightness of bulb depends on current. $P \propto I^2$ and

$$I = \frac{V}{Z} \quad \text{where} \quad Z = \sqrt{X_c^2 + R^2} \qquad \text{and}$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu C}$$

$X_C \ \alpha \ \frac{1}{C}$, when mica sheet is introduced capacitance C increases

$\left(C = \frac{K \epsilon_0 \ A}{d}\right)$,

X_C decreases, current increases and therefore brightness increases.

6. Current $I = \varepsilon/R =$

In coil P, $I_1 = E_1/R = \frac{Bvb}{R}$

In coil Q, $I_2 = E_2/R = \frac{Bvl}{R}$ $\qquad I_1/I_2 = b/l$.

7. em energy is conserved

$$\mu_E(\text{max}) = \mu_B(\text{max})$$

$$1/2 \frac{Q^2}{C} = \frac{1}{2} LI^2$$

$$I = 637 \text{ mA}$$

8. 10^{-6} F.

NUMERICALS

1. (i) $V_0 = 110$ volt

(ii) $V_{av\ 1/2} = \frac{2V_0}{\pi} = \frac{2 \times 110 \times 7}{22} = 70\text{volt}$.

2. Induced emf $\quad \varepsilon = -N \frac{d\phi}{dt} = -25 \frac{(1-61) \times \ 0^{-3}}{.5} = 0.25$ volt.

3. (i) Reactance $X_L = \omega L = 300 \times 4 \times 10^{-3} = 1.2 \ \Omega$.

(ii) Peak Voltage $V_0 = i_0 . X_L = 12 \times 1.2 = 14.4$ volt.

4. In ideal transformer $P_{in} = P_0$

$$V_P I_P = V_s I_s$$

$$\frac{V_S}{V_P} = \frac{I_P}{I_S} = \frac{N_S}{N_P} \qquad N_S = \left(\frac{V_S}{V_P}\right) N_P = \frac{240}{2400} \times 4000 = 400$$

5. Induced current $I = \varepsilon / R$

where $\varepsilon = \dfrac{-d\phi}{dt} = -10t + 4$

$$\varepsilon = -10(15) + 4 = -146 \text{ mV}$$

where $\phi = 5t^2 - 4t + 2$ and R = 8Ω $\therefore$ $I = -\dfrac{.146}{8}$ A = – .018A

6. When V and I in phase

$$X_L = X_C, \quad \nu = \frac{1}{2\pi}\frac{1}{\sqrt{LC}}$$

$$C = \frac{1}{4\pi^2\nu^2 L} = \frac{1}{4\pi^2 \times 50 \times 50 \times \dfrac{4}{\pi^2}}$$

$$= 2.5 \times 10^{-5} = 25 \ \mu\text{F}.$$

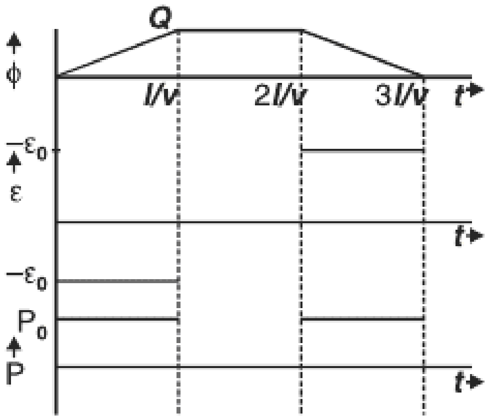
7. Current in the circuit $I = \dfrac{V}{Z}$

When $Z = \sqrt{X_c^2 + R^2}$, $X_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi\nu C}$

Then total voltage across capacitor and resistor

$$V_C = i X_C, \qquad V_R = IR.$$

8.



(i) $\phi = Blb$

(ii) $\varepsilon_0 = Bvb$

(iii) $P_0 = \dfrac{\varepsilon_0^2}{R}$

$= \dfrac{B^2v^2b^2}{R}$

9. (i) Frequency of current oscillations

$$\nu = \frac{1}{2\pi\sqrt{LC}}$$

(ii) Frequency of electrical energy oscillation $\nu_c = 2\nu$

(iii) Maximum current in the circuit $I_0 = \dfrac{q_0}{\sqrt{LC}}$

(iv) Magnetic energy in the inductor when charge on capacitor is 4mC.

$$U_L = U - U_C = \frac{1}{2}\frac{q_0^2}{C} - \frac{1}{2}\frac{q^2}{C} = \frac{q_0^2 - q^2}{2C}$$

Here $q_0 = 5\text{mC}$; $q = 4\text{mC}$

10. Current in the circuit :

(i) $I = \dfrac{V}{Z}$, where $Z = \sqrt{X_L^2 + R^2}$

(ii) RMS voltage across L and R

$V_L = I \,.\, X_L$; $V_R = IR$

(iii) $(V_L + V_R) > V$ because V_L and V_R are not in same phase.

ANSWERS OF HOTS

I MARK QUESTIONS

1. P (–) Q (+)
2. (a) No induced current

   (b) Current will be induced only in loop 2.
3. Frequency of magnetic energy oscillation is equal to $v_m = 2v = 8 \times 10^6$ Hz

2 MARKS QUESTIONS

1. No current is induced in coil A since θ is 90°.

NUMERICAL

1 $I = {}^{\varepsilon}/_{R}$

$\varepsilon = Bvl$