Class – 12 – Physics Chapter wise Mock test
Chapter – EMI and AC

Maximum Marks: 70 **Time allowed: 3 hours**

General Instructions:

1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. All the sections are compulsory.
4. **Section A** contains **sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, Section B** contains **five questions of two marks each, Section C** contains seven questions of three marks each, **Section D** contains **two case study-based questions of four marks each** and **Section E** contains **three long answer questions of five marks each.**
5. There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
6. Use of calculators is not allowed.

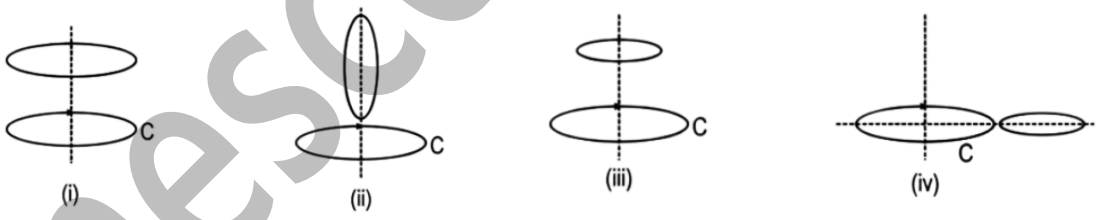
SECTION – A
Multiple Choice Question

(16×1)

1. A current-carrying coil C_1 is paired with another coil. An emf ε is induced in coil C_2 when the current through C_1 drops to zero from a non-zero value within 1s.
If the coil C_1 is paired with C_3, an emf 0.7 ε is induced in it, for the same rate of drop in the current through C_1 as earlier.
What is the ratio of mutual inductance M_{12} (for the pair of coils C_1 and C_2) to that of mutual inductance M_{13} (for the pair of coils C_1 and C_2)?

A. 0.7 B. 1 C. 1.42 D. 7

2. Coil C carries a steady current. A second coil is placed in close proximity to coil C in different configurations as shown.



Which of the following options represents the correct order of the mutual inductance values for the pair of coils in given configurations?

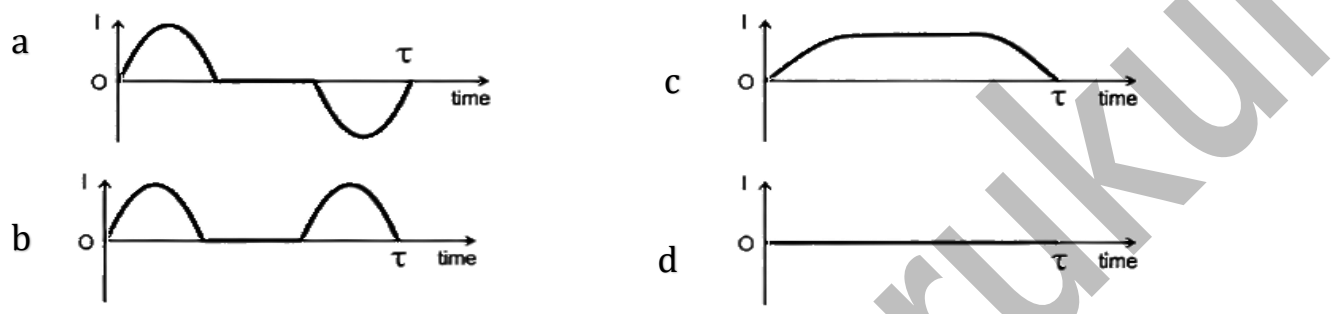
A. (i) > (iii) > (iv) > (ii) B. (iv) > (iii) > (i) > (ii)
C. (ii) > (iv) > (iii) > (i) D. (iii) > (i) > (ii) > (iv)

3. A long solenoid S has length l_1, area of cross-section A and number of turns N_1. A coil C of shorter length l_2, number of turns N_2 but same area of cross-section is wound over solenoid S. If a current I flow through the coil C, then which of the following represents the flux linked with the solenoid S?

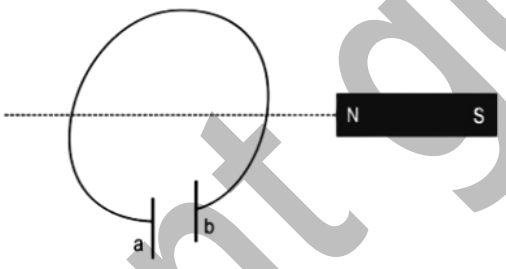
A. $\frac{\mu_0 N_1 N_2 Al}{l_2} l_1$ B. $\frac{\mu_0 N_1 N_2 Al}{l_1} l_2$ C. $\frac{\mu_0 N_1 N_2 Al}{l_1}$ D. $\frac{\mu_0 N_1 N_2 Al}{l_2} l_1$

4. There is a pair of concentric and coplanar conducting loops of radii R_1 and R_2 such that $R_2 = 0.01\ R_1$.
To which of the following is the mutual inductance M for this pair directly proportional?
A. $1/R_1^2$ B. R_1^2 C. $1/R_1$ D. R_1

5. A small conducting metal ring falls vertically down with its plane parallel to y-z plane. During the fall, the ring crosses a small region of the uniform magnetic field directed along the x-axis between the times t=0 and $t = \tau$ seconds.
Which of the following graphs represent the variation of current induced in the ring during the fall?



6. A capacitor is short-circuited as shown.



Match the possible motions listed in [A] of the bar magnet relative to the loop with the suitable responses listed in [B] due to the induced current, if any.

[A]
I. Magnet with N facing the loop moves towards the coil
II. Magnet with N facing the loop moves away from the coil
III. Magnet NS is stationary
IV. Magnet with S facing the loop moves towards the coil
V. Magnet with S facing the loop moves away from the coil

[B]
i. Excess electrons accumulate on plate a
ii. Excess electrons accumulate on plate b
iii. The plates a and b stay neutral

A. [I - i] , [II - ii], [III - iii], [IV - i], [V - ii] B. [I - iii] , [II - ii], [III – i], [IV – ii], [V – i]
C. [I -ii] , [II - i], [III - iii], [IV - i], [V -ii] D. [I - i] , [II - ii], [III - iii], [IV - ii], [V - i]

7. A square loop of a single turn is placed with its plane perpendicular to a uniform magnetic field. The magnetic flux through the square loop is 0.002 W_b.
The square loop is now reshaped into a circular loop. What is the flux (in W_b) through the circular loop?
A. $\pi/4$ B. 0.002 C. $0.008/\pi$ D. 0.0005π

8. If P_{av} represents average power dissipated and i_{av} is the average current through a resistor over one cycle of the input sinusoidal voltage, which of the following statements is correct for an ac circuit with resistor only?
A. $P_{av} = 0$ & $i_{av} > 0$ B. $P_{av} > 0$ & $i_{av} = 0$
C. $P_{av} > 0$ & $i_a > 0$ D. $P_{av} = 0$ & $i_{av} = 0$

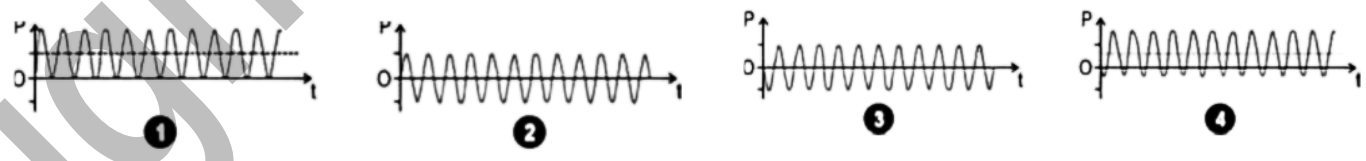
9. An LCR series circuit is connected to an ac supply of $\omega = 100$ rad/s. Given the values as R = 100-ohm, L = 500 mH, C = 5 μF, study the following statements carefully.
I. The given circuit (LCR) is dominantly capacitive
II. The instantaneous current in the circuit leads Vmax.
III. If w greater than $200\sqrt{10}$ rad/s, the circuit becomes dominantly inductive
IV. The LCR circuit can be made capacitive or inductive by simply changing the angular frequency of the input ac supply, keeping the voltage V_{max} constant.
Identify the correct option.
A. Only statement IV is correct B. Only statements I and II are correct
C. Only statements I and III are correct D. All statements are correct

10. In an ac circuit containing a resistor R, the power dissipated is P_1.
If a capacitor C is added to the above circuit, the power dissipated through the resistor changes to P_2.
If an inductor L replaces the capacitor C, the power dissipated through the resistor changes to P_3.
If the capacitive reactance offered by the capacitor equals the inductive reactance offered by the inductor, then which of the following represents the correct relation between P_1, P_2 and P_3?
A. P_1, P_2 and P_3 B. $P_3 > P_1 > P_2$ C. $P_1 < [P_2 = P_3]$ D. $P_1 > [P_2 = P_3]$

11. A 5-ohm resistor, a 5 mH inductor and a 5 μF capacitor, joined in series resonate with an ac source of frequency ω_o. If only the resistance is changed to 10 ohms, the circuit resonates at a frequency ω_1. If only the inductor is changed to 20 mH, the circuit resonates at a frequency ω_2.
Find the ratio ω_1/ω_2.
A. 0.5 B. 1 C. 2 D. 4

12. Which of the ac circuits with the following input voltage and current dissipates maximum power P?
A. Input voltage $V_o = 2$ volt, $I_o = 4$ ampere and phase angle $\Phi = \pi/4$.
B. Input voltage $V = V_o \sin \omega t$ volt and the current $I = I_0 \sin (\omega t - \pi/2)$ ampere
C. Input voltage $V = 2 \cos \omega t$ volt and the current $I = 4 \sin \omega t$ ampere
D. Input voltage $V = 100 \sin 100t$ volt and the current $I = 100 \sin (100t + \pi/3)$ milliampere

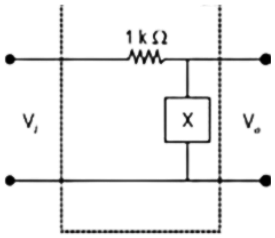
13. The four graphs below represent instantaneous power dissipated across various circuit elements such as resistor, capacitor & inductor connected either individually or in a combination to an ac supply.



Study the following statements carefully and select the correct option. I.
I. Average power dissipated in (2) & (3) is zero.
II. Average power dissipated in (1) is that in a resistor and is given as $P_{av} = I_{rms} . V_{rms}$
III. Average power dissipated in (4) is that in an LCR combination circuit and is always positive.
IV. Graphs (1), (2) & (3) represent power dissipation in resistor, capacitor, and inductor in an ac circuit respectively

A. Only I & II are correct
B. Only III & IV are correct
C. Only I, III & IV are correct
D. Only I, II & IV are correct

14. In a circuit, a resistor of 1 kilo-ohm is connected to an element X as shown. Aπ ac input voltage of V 10 mV is applied at variable frequencies.



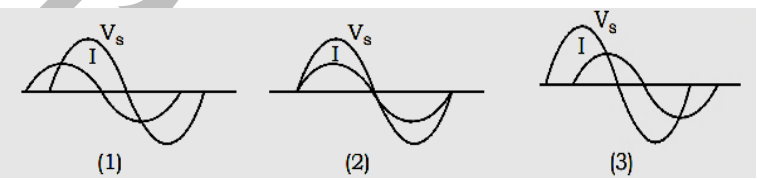
Given below is the data observed for output voltage V_o and total impedance Z of the circuit as a function of input voltage frequency v.

v	z	Vo
10 kHz	3×10^3 ohm	16.1 mV
100 kHz	1.04×10^3 ohm	1.6 mV
1 MHz	1.003×10^3 ohm	0.16 mV
10 MHz	10^3 ohm	16 mV

Study the following statements carefully and select the correct option given below.
I. The output current is expected to increase with the increase in input frequency.
II. The reactance offered by X increases with the increase in input frequency.
III. If the ac input is replaced by dc input of the same voltage, the output voltage V_o becomes zero.
IV. The circuit element X could be either a capacitor or an inductor.
A. Only statements I & II are correct
B. Only statements III & IV are correct
C. Only statements I & III are correct
D. Only statements II & IV are correct

15.
Sam wants to generate 10 mV of EMF by moving a wire at 5m/s through a steady magnetic field region of 0.06 T.
a. What should be the angle between the magnetic field and direction of motion so that the wire can be of the shortest length?
b. What should this shortest length of the wire be?

16. The graphs shown below are for three different Inductance, Capacitance, and Resistance (LCR) circuits. Identify their nature based on the phase difference between V_s and I.



(a) Inductive, Capacitive, and Resistive.
(b) Capacitive, Resistive, and Inductive.
(c) Resistive, Capacitive, and Inductive.
(d) Inductive, Resistive, and Capacitive.

SECTION – B

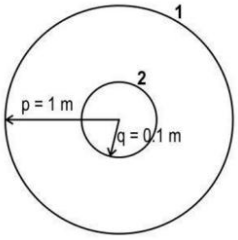
(13×2)

Very Short type questions

1. A constant magnetic field B = 1 T acts perpendicularly on a static square copper coil of 100 turns with each

side of 10 cm. The coil is removed from the magnetic field within 0.5 s and then replaced in another 0.5 s.
a. Calculate an average emf that develops in the coil during the entire motion lasting for 1 s.
b. Find the net thermal energy dissipated in the coil during the entire motion.
Take resistance of the coil as 1 ohm.

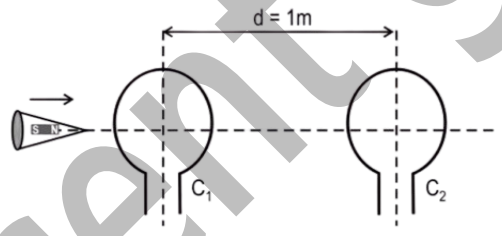
2. Given two coplanar and concentric loops 1 and 2 as shown.



A time-varying voltage $(3 + 2t)$ is applied to the larger loop 1. If the resistance of the loops is $R_1 = 10$ ohm and $R_2 = 1$ ohm, then determine the current induced in the smaller loop.

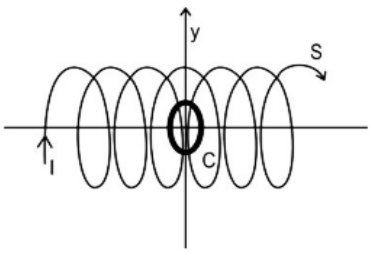
3. The Earth's magnetic field in the northern hemisphere has a downward component that can be assumed to be uniform. Consider an airplane flying through this magnetic field from India towards Russia in the north. A motional emf develops across the tips of its two wings.
(a) Identify the polarities developed on the left-wing and the right-wing. Explain the answer.
(b) An insulated wire along with a light bulb connects the tips of the right and the left-wing of the airplane. Will the bulb glow due to the induced emf? Explain the answer.

4. A projectile with an enclosed tiny magnet is projected with a speed v through a pair of identical coaxial coils C_1 and C_2 as shown.



(a) Plot a graph of induced emf $\in$ versus time t for the period of passage of the projectile through two successive coils. Take the counter-clockwise direction of the induced current in a coil as seen from the starting point of the incoming projectile as positive.
(b) If the time interval between two emf pulses observed in C_1 and C_2 respectively is 3 ms, determine the speed of the projectile.

5. A solenoid S of radius 50 cm with 100 turns per unit length is aligned along the x-axis carrying a current of 10 A.
A coil C of radius 10 cm is coaxially placed inside the solenoid such that it can rotate about its diameter directed along the y-axis. Refer to the diagram below.



If the coil C of 50 turns revolves with a constant angular speed of π rad/s, determine the emf generated in coil C.
(Note: The final answer may be written in terms of constants μ_o and π)

6. An LCR circuit is connected to an ac voltage of fixed V_{max} and angular frequency.
Current through the circuit is I_{max} and the resistance R equals the inductive reactance X_L in the circuit.
Now if the distance of separation between the capacitor plates is doubled, the current I_{max} in the circuit is reduced to half.
Determine the initial relation between resistance R and capacitive reactance Xc.

7. An ac source with $V_{max} = 100$ V and frequency 50 Hz is connected across a 1 μF capacitor. Assuming that at time $t = 0$, the energy stored in the capacitor is zero, determine the following:
(a) the current in the capacitor at time $t = 1/100$ s.
(b) maximum current in the circuit.

8. The ratio of the turns in the primary and the secondary coil in a given transformer is 1:10. If the load resistor draws a current of 1.2 A from the secondary coil, determine the current in the primary coil, assuming that the transformer has an efficiency of only 90%.

9. A given ac power supply has a voltage rating of 80 V. An LCR series circuit draws a current of 5A when connected to this ac power supply. Determine the range of values of the average power that can be delivered by the ac power source to the circuit.

10. The household power supply is at 200 V and 60 Hz. Find the time required for:
a. the value of current to change from 0 to its rms value
b. the value of voltage to change from its rms value to 0.

11. An alternating current is sent through a 100 km long telephone wire of capacitance 0.01 μF/km at a frequency of 8 kHz. Find out what value of an inductor that must be connected in series to this wire, so that the current through the wire is maximum.

12. Given is a coil of resistance R and inductance L connected to a power supply.
If the power supply is 50 V dc, a current of 0.5 A flows through the coil.
If the power supply is 50 V ac of frequency 50 Hz, a current of 0.2 A flows through the coil.
Determine the resistance R and inductance L of the coil.

13. An inductor L is connected to an ac power source of frequency 'v' Hz. The inductor L undergoes alternate cycles of magnetization and demagnetization due to sinusoidal variation of current through L.
If the time taken for a successive magnetization and demagnetization of the inductor is 8 ms, determine the frequency 'v' of the input ac power source.

SECTION – C

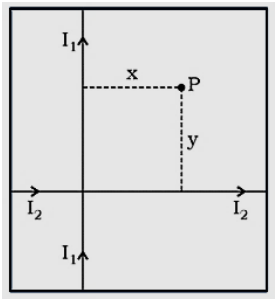
(5×3)

Short Answer Type Questions

1. Coil 1 has self-inductance L_1 which is 3 times the self-inductance L_2 of coil 2. If during a certain instant, the rate of increase in current and the power dissipated in these two coils is the same, then determine the ratio of (a) their induced voltages, (b) currents, (c) energy stored in the two coils at that instant.

2. A series LCR circuit is capacitive if the ac supply is at angular frequency ω_1 with the phase angle $\Phi = -30$. The circuit becomes inductive if the ac supply is changed to angular frequency ω_2 while keeping the maximum value of source voltage constant and the corresponding phase angle becomes $\Phi = 30$.
What is the change in power delivered in the circuit due to a change in angular frequency from ω_1 to ω_2? Explain your answer.

3. a. Give the expression for the power factor in an LR circuit in terms of the resistance 'R' and inductive reactance 'X_L'.
b. Two long wires carrying current are kept crossed (not touching each other) as shown in figure. If resultant magnetic induction at P is zero, then find the relation between I_1 and I_2.



c. An inductor-resistor circuit (LR) series circuit connected to an alternating current (a. c.) source of 220 V, 50 Hz, the resistor value is 11 ohms, and the power factor is $1/\sqrt{2}$. Calculate the value of inductance in the circuit.

4. a. The first diagram depicts a bar magnet of pole strength 'm' and separation between the poles 'l'. If the magnetic moment in the first diagram is 'M', then the new magnetic dipole moment in the second diagram is:

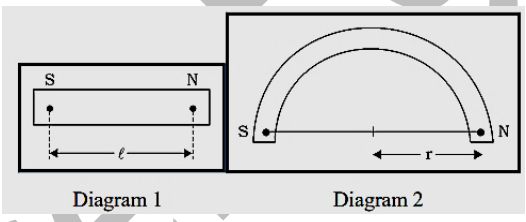


Diagram 1 Diagram 2

b. Observe the two diagrams and state which diagram corresponds to diamagnetic and ferromagnetic.

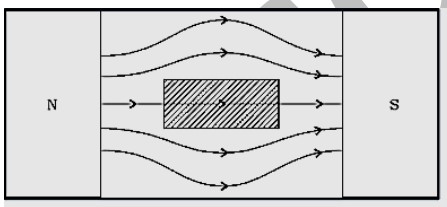


Figure 1

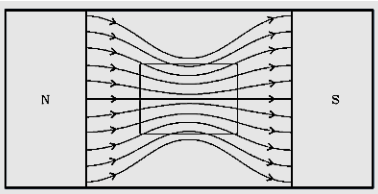
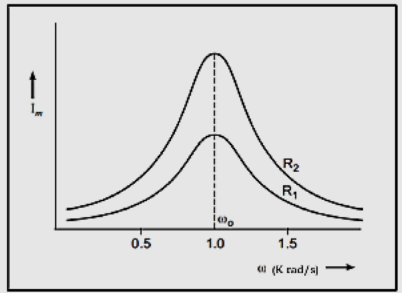


Figure 2

c. A long straight wire in the horizontal plane carries a current of 50 A in the north-to-south direction. Give the magnitude and direction of 'B' at a point 2.5 m east of the wire.

5. The graph here shows a variation of I_{rms} with angular frequency 'ω' for two different LCR circuits. Which of the two will have: (a) lower power factor.
(b) calculate resonance frequency for the two different LCR circuits.



(c) A student was given a frequency generator, a source, an inductor, a capacitor, a resistor and an ammeter. After connecting the circuit correctly, the student tabulated the readings as shown below.

S.No.	*Frequency(kHz)*	*Ammeter reading (mA)*
1	1.20	13.8
2	1.38	16.3
3	1.71	19.4
4	2.08	22.0
5	2.39	19.5
6	2.57	17.6
7	2.79	16.0
8	3.10	14.5

i. What is the resonant frequency of the circuit?
ii. Plot the graph for the given data using proper axes.

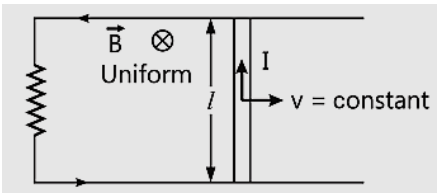
SECTION – D

(8×1)

Case Study Based Questions

Case Study: 01

Q. 29. The emf induced across the ends of a conductor due to its motion in a magnetic field is called motional emf. It is produced due to the magnetic Lorentz force acting on the free electrons of the conductor. For a circuit shown in figure, if a conductor of length 7 moves with velocity v in a magnetic field B perpendicular to both its length and the direction of the magnetic field, then all the induced parameters are possible in the circuit.



Read the given passage carefully and give the answer of the following questions:
Q1. Direction of current induced in a wire moving in a magnetic field is found by which rule?

Q2. A conducting rod of length l is moving in a transverse magnetic field of strength B with velocity v. The resistance of the rod is R. What is the current in the rod?

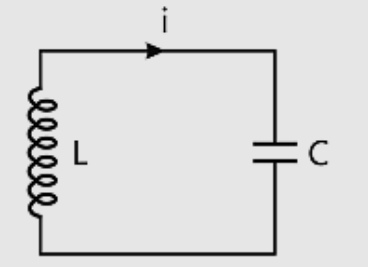
Q3. A 0.1 m long conductor carrying a current of 50 A is held perpendicular to a magnetic field of 1.25 mT. What will be the required mechanical power to move the conductor with a speed of 1 ms^{-1} is?

Q4. A bicycle generator creates 1.5 V at 15 km/hr. What is the emf generated at 10 km/hr?

Q5. What is the dimensional formula for emf Ɛ in MKS system?

Case Study: 02

Q. 30. An LC circuit also called a resonant circuit or tank circuit or tuned circuit, is an electric circuit consisting of an inductor represented by the letter L and a capacitor, represented by the letter C connected together. An LC circuit is an idealised model since it assumes there is no dissipation of energy due to resistance.



An LC circuit contains a 20 mH inductor and a 50 μF capacitor with an initial charge of 10 mC. The resistance of the circuit is negligible. Let the instant of circuit is closed be t = 0. Read the given passage carefully and give the answer of the following questions:

Q1. What will be the total energy stored initially?

Q2. What will be the natural frequency of the circuit?

Q3. At what time is the energy stored completely electrical?

Q4. At what time is the energy stored completely magnetic?

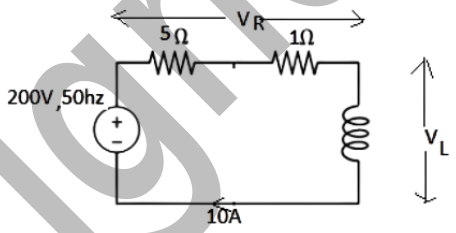
Q5. Calculate the value of X_L.

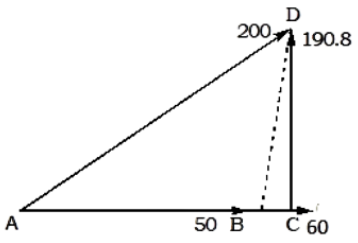
SECTION – E

(3 × 5)

Long Answer Type Question

31. (a) An arc lamp takes 10 A at 50 V. Calculate the impedance of a choke of 1-ohm resistance to be connected in series with an arc lamp so that the lamp may be used on 200 V, 50 Hz supply. Use the data from the circuit diagram and the phasor voltage triangle and calculate the total active power and the power factor.
AB – drop across arc lamp
BC – drop across 1-ohm resistance of the choke
CD – drop across the inductor
BD – total drop across the choke





(b) Power Corporation of India wanted to transmit power of 11 kW from tower 1 to tower 2 at 220 V or 22000 V. Which of the two voltages is better for transmission of alternating current (a. c.) power? Support the answer with a mathematical calculation.

(c) Match the following:

1.	$\omega L > \frac{1}{\omega C}$	(i)	The current is in phase with voltage V.
2.	$\omega L < \frac{1}{\omega C}$	(ii)	The current lags in phase with voltage V.
3.	$\omega L = \frac{1}{\omega C}$	(iii)	The current leads in phase with voltage V.

(d) In an inductance-capacitance-resistance (LCR) series circuit, which is connected to an alternating current (a. c.) source of a frequency (ν), its signal voltage (v) is equal to v_x for an instantaneous time between 0 and half its time period (T) and equal to zero during the next half period.
(a) Suppose the frequency of the source is gradually increased, what happens to inductance and capacitance?
(b) Calculate the root mean square (r. m. s.) voltage of the signal.
(c) If $X_C = 2_{XL} = R$, calculate the total impedance of the circuit.

32. (a) Two circular coils, one of radius r and the other of radius R are placed coaxially with their cur centres coinciding. For R >>r, obtain an expression for the mutual inductance of the arrangement.

(b) Fig. 1.38 shows a conducting rod PQ in contact with metal rails RP and SQ, which are 25 cm apart in a uniform field of flux density 0.4 T acting perpendicular to the plane of the paper. Ends R and S are connected through a 5Ω resistance. What is the e.m.f., when the rod moves to the right with a velocity of 5 m s^{-1}? What is the magnitude and the direction of the current through the 5 Ω resistor? If the rod PQ moves towards the left with the same speed, what will be the new current and its direction?

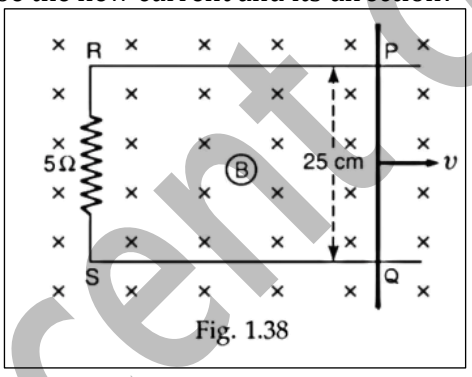


Fig. 1.38

33. (a) A series LCR-circuit is connected to an a.c. source (220 V-50 Hz) as shown in Fig. 2.34

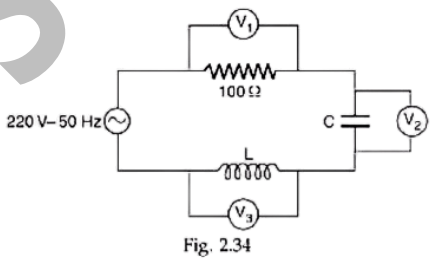


Fig. 2.34

If the readings of the three voltmeter V_1, V_2 and V_3 are 65 V, 415 V and 204 V respectively, calculate: (i) the current in the circuit; (ii) the value of the inductor L; (iii) the value of the capacitor C; and (iv) the value of C (for the same L) required to produce resonance

(b) A LCR-circuit has L = 10mH R = 30Ω and C = 1μF and is connected in series to a source of 20 sin ωt volt. Calculate the current amplitude at a frequency 20% lower than the resonance frequency of the circuit.