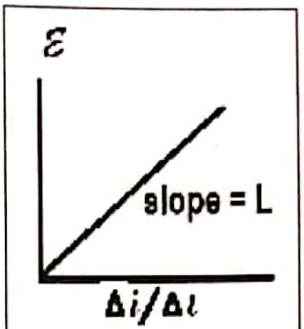
CONCEPTUAL QUESTIONS

15.1 Sketch a graph of e.m.f. induced in an inductive coil against rate of change of current. What is the significance of the gradient?

Ans: The magnitude of self-emf induced in an inductive coil can be represented mathematically as;

$$\varepsilon = L\frac{\Delta i}{\Delta t}$$



Sh. Q. 15.1

Gradient of this plot is the ratio of emf ε and $(\Delta i / \Delta t)$.
Significance of the gradient is that it makes us able to calculate the self-inductance L of the coil.

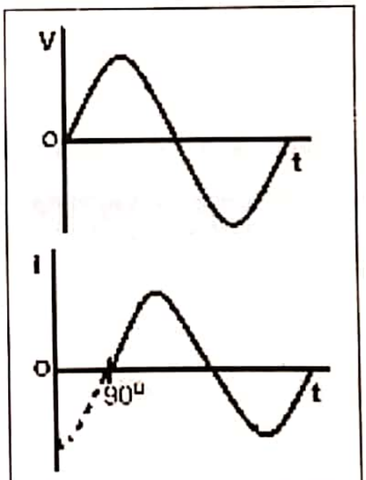
15.2 Explain why it is difficult to measure the rate of change of current?

Ans: When a current is passing through a circuit or coil, it sets up a magnetic field that produces a magnetic flux through the same coil or circuit. The magnetic flux through the coil changes when the current changes. This causes an induced e.m.f in the coil in accordance with Faraday's law. This induced emf, according to Lenz's law, always opposes the change in the current that caused the emf and thus makes it difficult for variations in current to be measured.

15.3. How do graphs of emf against time and current against time make it possible to measure self- inductance?

Ans: Magnitude of emf produced due to a coil of inductance "L" is given by;

$$L = \frac{\varepsilon}{\Delta i/\Delta t} \qquad (1)$$



Short question 15.3

From the graph shown in figure we find the instantaneous value of induced emf such that "Δt" approaches to zero. Calculate the change in current "Δi" in the same interval "Δt". By putting the values in equation (1) we can measure an unknown self-inductance.

15.4. (a) Current and voltage provided by an AC generator are sometimes negative and sometimes positive. Explain why for, an AC generator connected to a resistor, power can never be negative? (b) Explain, using sketch graphs, why the frequency of variation of power in an AC generator is twice as that of the current and voltage.

Ans

(a) Power P in an AC generator connected to a resistor of resistance R is given by i^2R. As power is proportional to current squared, therefore it cannot be negative in pure resistive AC circuit.

(b) For a pure inductive circuit connected across a generator, current and are voltage are given by relations;

$$i = i_o \sin \omega t \quad (1)$$

$$V = V_o \cos \omega t \quad (2)$$

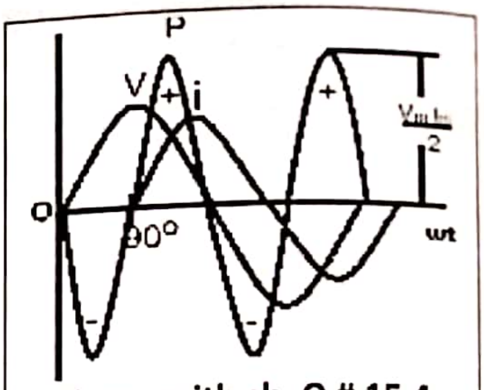


Figure with sh. Q # 15.4

Now the power is;

$$P = i\,V$$

⇒ $P = (i_o \sin \omega t)(V_o \cos \omega t)$

⇒ $P = i_o V_o (\sin \omega t \cos \omega t)$

Multiplying and dividing the above equation by 2, we get;

$$P = \frac{i_0 V_0}{2} \times 2 \sin \omega t \cos \omega t$$

⇒

Putting $2 = \sqrt{2} \times \sqrt{2}$ & $2 \sin \omega t \cos \omega t = \sin(2\omega t)$

⇒ $P = \frac{i_0}{\sqrt{2}} \times \frac{V_0}{\sqrt{2}} \times \sin(2\omega t)$

Putting $\frac{i_0}{\sqrt{2}} = i_{rms}$ & $\frac{V_0}{\sqrt{2}} = V_{rms}$

⇒ $P = i_{rms} \times V_{rms} \times \sin(2\omega t) \quad (3)$

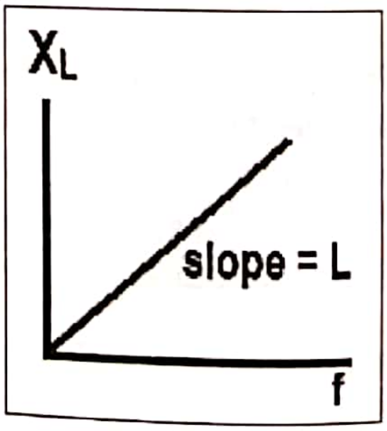
By using eq.1, eq.2 and eq.3, the graph drawn as shown the figure above shows the sketch for the variation of current, voltage and power. It is quite evident from the graph that when current or voltage completes its one cycle then power has completed its two cycles. This shows that frequency of variation of power in an AC generator is twice as that of the current and voltage.

15.5 What determines the gradient of a graph of inductive reactance against frequency?

Ans: Inductive reactance X_L is given by;

$$X_L = \omega L = 2\pi f L$$

⇒ $L = \frac{X_L}{2\pi f}$



The graph of inductive reactance X_L versus frequency f is a straight line and gradient of graph of inductive reactance X_L against frequency f gives us inductance L of the coil. Therefore, this gradient is a measure of inductance of the coil.

15.6 How does doubling the frequency affect the reactance of (a) an inductor (b) a capacitor?

Ans: (a) As inductive reactance X_L is given by the equation

$$X_L = 2\pi f L$$

By doubling the frequency the ne reactance is;

$$X'_L = 2\pi f' L = 2\pi (2f) L \qquad (\text{since } f' = 2f)$$

$$X'_L = 2\,(2\pi f L) = 2\,X_L$$

So by doubling the frequency f, inductive reactance X_L is also doubled.

Capacitive reactance X_c is given by the equation

$$X_c = \frac{1}{2\pi f C}$$

$$X'_c = \frac{1}{2\pi f' C} = \frac{1}{2\pi (2f) C} = \frac{1}{2\,(2\pi f C)}$$

$$X'_c = X_c/2$$

So by doubling the frequency, capacitive reactance X_c will become half.

15.7 If peak value of a sine wave is 1000 volts, what is its effective value?

Ans: Given that V_p = 1000 V and effective value, also called V_{rms} value, is related to peak value by the equation

$$V_{rms} = \frac{V_p}{\sqrt{2}} = 0.707 \times 1000 = 707\ V$$

15.8 Show that reactance is measured in ohms for both inductors and capacitors?

Ans: In accordance with Ohm's law,

$$R = \frac{V}{i}$$

$$\Rightarrow \quad \text{ohm} = \frac{\text{volt}}{\text{ampere}}$$

For capacitor

$$X_c = \frac{1}{\omega C}$$

$$\Rightarrow \quad X_c = \frac{V_m}{V_m \times \omega C} \qquad (i_m = V_m\,\omega C)$$

$$\Rightarrow \quad X_c = \frac{V_m}{i_m}$$

$$\Rightarrow \quad \text{ohm} = \frac{\text{volt}}{\text{ampere}}$$

For inductor,

$$\Rightarrow \quad X_L = \omega L$$

$$\Rightarrow \quad X_c = \frac{i_m \times \omega L}{i_m} \qquad (V_m = i_m\,\omega L)$$

$$\Rightarrow \quad X_c = \frac{V_m}{i_m}$$

$$\Rightarrow \quad \text{ohm} = \frac{\text{volt}}{\text{ampere}}$$

Hence we can say that both inductive reactance and capacitive reactance are measured in Ohms.

15.9 Describe the principle of ECG?

Ans: The ECG works on the detection and amplification of the tiny electrical changes on skin that are caused when the heart muscle depolarizes during each heart beat. Our heart produces time varying voltages when it beats. These beats produce small voltage differences between points on our skin that can be measured and used to diagnose the condition of our heart. These small voltages (waves) are registered by electrodes placed on certain parts of the body which are then printed on a paper in the form of wavy curves.