CONCEPT MAP

Electromagnetic Induction and Alternating Currents

Electromagnetic Induction: The phenomenon of generating current/emf by changing magnetic field.

Faraday's Law

First Law: Whenever the amount of magnetic flux linked with circuit changes, an emf is induced in the circuit. The induced emf last so long as the change in magnetic flux continues.

Second Law: The magnitude of emf induced in a circuit is directly proportional to the rate of change of magnetic flux linked with the circuit.

$$\varepsilon = -N\frac{d\phi}{dt}$$

Induced emf: The emf developed due to electromagnetic induction.

Induced Current: The current flows due to electromagnetic induction.

Eddy Current: It is the current induced in the body of conductor when amount of magnetic flux linked with the conductor, changes.

$$I = \frac{-d\phi/dt}{R}$$

Lenz's Law: It states that the direction of induced emf is such that it opposes the change in magnetic flux responsible for its production.

Alternating Current
Current which changes continuously in magnitude and periodically in direction.
$I = I_0 \sin\omega t$ or $I = I_0 \cos\omega t$

R.M.S Value of ac:
The value of steady current, which would generate the same amount of heat in a given resistance in a given time, as is done by the alternating current, when passed through the same resistance for the same time.

$$I_V = \frac{I_0}{\sqrt{2}} = 0.707\, I_0$$

Mean or Average Value:
Mean average value of alternati current over any half cycle is that val of steady current, which would se the same amount of charge through circuit in the time of half cyc (*i.e.* $T/2$) as is sent by ac through t same circuit in the same time.
Thus $(I_m \text{ or } I_{av})_0 \rightarrow T/2$

$$= \pm\frac{2}{\pi} I_0 = 0.637 I$$

Self Induction:
It is the property of a coil by virtue of which, the coil opposes any change in the strength of current flowing through it by inducing an emf in itself.

$$L = \frac{\mu_0 N^2 A}{l}$$

Mutual Induction:
The property of two coils by vitue of which each opposes any change in the strength of current flowing through the other by developing an induced emf.

$$M = \frac{\mu_0 N_1 N_2 A}{l}$$

Capacitive Reactance:
It is the resistance offered by a capacitor and is given by

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

Inductive Reactance:
The resistance offered by an inductor and is given by

$$X_L = \omega L = 2\pi\upsilon L.$$

AC Generator:
It produces alternating current energy from mechanical energy of rotation of a coil. The form of emf induced is $\varepsilon = \varepsilon_0 \sin\omega t$, where $\varepsilon_0 = NAB\omega$, max. emf induced.

Impedance:
The total effective resistance of LCR circuit is called impedance (Z) of the circuit. It is given by

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

The angle by which alternating voltage leads the alternating current in LCR circuit is given by

$$\tan\phi = \frac{X_L - X_C}{R}$$

Power in an accircuit:

- Instantaneous power $P = I_0 V_0 \cos\phi$
- Average power $P_{av} = \frac{V_0 I_0}{2}\cos\phi$
- Apparent power $P_v = \frac{V_0 I_0}{2}$

Combination of inductors:
Inductors in Series
$L_S = L_1 + L_2 + \ldots + L_n$
Inductors in Parallel

$$\frac{1}{L_p} = \frac{1}{L_1} + \frac{1}{L_2} + \ldots + \frac{1}{L_n}$$

Resonance:
The necessary condition for resonance is $X_L = X_C$.
Resonance frequency

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

Wattless Current: It is the current flowing through pure inductor or capacitor when average power associated over a complete cycle is zero.

Transformer: Transformer is an electrical device, which is used for changing alternating voltages.
For ideal transformer,

$$\frac{V_S}{V_P} = \frac{I_P}{I_S} = \frac{N_S}{N_P} = k$$

$$\text{Efficiency} = \frac{\text{Output power}}{\text{Input power}}$$

LC Oscillations:
When a condenser of capaci C charged to a certain potent is connected to an inductor energy stored in C oscillat between L and C. Th frequency of energ oscillations is given by

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

Symbols Used:

k = transformer ratio	ω = angular velocity
I_P = current in primary	l = length of the coil
I_S = current in secondary	A = area of cross section
N_S = number of turns in secondary	I_0 = peak value of current
N_P = number of turns in primary	I_v = root mean square value of current
N = total number of turns in the coil	I = instantaneous value of current
B = strength of magnetic field	