ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

Important Notes and Points

- Whenever the magnetic flux linked with a closed coil changes, an emf (electromotive force) is induced and hence an electric current flows in the circuit. This current is called an induced current and the emf giving rise to such current is called an induced emf. This phenomenon is known as electromagnetic induction.
- The application of the phenomenon of Electromagnetic Induction is almost everywhere in the present day life. Right from home appliances to huge factory machineries, from cellphone to computers and internet, from electric guitar to satellite communication, all need electricity for their operation. There is an ever growing demand for electric power.
- All these are met with the help of electric generators and transformers which function on electromagnetic induction. The

modern, sophisticated human life would not be possible without the discovery of electromagnetic induction.

- ❖ Whenever magnetic flux linked with a closed circuit changes, an emf is induced in the circuit.
- ❖ The magnitude of induced emf in a closed circuit is equal to the time rate of change of magnetic flux linked with the circuit.
- ❖ Lenz's law states that the direction of the induced current is such that it always opposes the cause responsible for its production.
- ❖ The thumb, index finger and middle finger of right hand are stretched out in mutually perpendicular directions. If the index finger points the direction of the magnetic field and the thumb indicates the direction of motion of the conductor, then the middle finger will indicate the direction of the induced current.
- ❖ The frequency of the domestic AC supply is increased from 50–60 Hz to around 20–40 KHz before giving it to the coil in order to produce high frequency alternating magnetic field.
- ❖ Self-inductance or simply inductance of a coil is defined as the flux linkage of the coil when 1A current flows through it.

- Inductance of a coil is also defined as the opposing emf induced in the coil when the rate of change of current through the coil is 1 $A\ s^{-1}$.
- Emf can be induced by changing relative orientation between the coil and the magnetic field. This can be achieved either by rotating a coil in a magnetic field or by rotating a magnetic field within a stationary coil. Here rotating coil type is considered.
- Alternating emf is generated by rotating a coil in a magnetic field or by rotating a magnetic field within a stationary coil.
- The first method is used for small AC generators while the second method is employed for large AC generators. The rotating-field method is the one which is mostly used in power stations.
- If two alternating quantities of same frequency do not pass through a particular point, say zero point, in the same direction at the same instant, they are said to have a phase difference. The angle between zero points is the angle of phase difference.
- If the transformer converts an alternating current with low voltage into an alternating current with high voltage, it is called step-up transformer.

- An alternating voltage is the voltage which changes polarity at regular intervals of time and the direction of the resulting alternating current also changes accordingly.
- Interestingly, sine waves are very common in nature. The periodic motions like waves in water, swinging of pendulum are associated with sine waves. Thus sine wave seems to be nature's standard.
- If the waveform of alternating voltage is a sine wave, then it is known as sinusoidal alternating voltage.
- The average value of alternating current is defined as the average of all values of current over a positive half-cycle or negative half-cycle.
- 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.
- RMS value of alternating current is also called effective value and is represented as *Ieff*. It is used to compare RMS current of AC to an equivalent steady current.
- RMS value is also defined as that value of the steady current which when flowing through a given circuit for a given time produces the

same amount of heat as produced by the alternating current when flowing through the same circuit for the same time. The effective value of an alternating voltage is represented by *Veff.*

❖ For common household appliances, the voltage rating and current rating are generally specified in terms of their RMS value. The domestic AC supply is 230V, 50 Hz. It is the RMS or effective value. Its peak value will be $V_m = \sqrt{2}\, V_{rms} = \sqrt{2} \times 230 = 325\, V$.

❖ An inductor L is a closely wound helical coil. The steady DC current flowing through L produces uniform magnetic field around it and the magnetic flux linked remains constant. Therefore there is no self-induction and self-induced emf (back emf). Since inductor behaves like a resistor, DC flows through an inductor.

❖ The AC flowing through L produces time-varying magnetic field which in turn induces self-induced emf (back emf). This back emf, according to Lenz's law, opposes any change in the current. Since AC varies both in magnitude and direction, its flow is opposed in L. For an ideal inductor of zero ohmic resistance, the back emf is equal and opposite to the applied emf. Therefore L blocks AC.

- The phenomenon of electrical resonance is possible when the circuit contains both L and C. Only then the voltage across L and C cancel one another when V_L and V_C are 180° out of phase and the circuit becomes purely resistive. This implies that resonance will not occur in a RL and RC circuits.
- The Joule heating and radiation of electromagnetic waves from the circuit decrease the energy of the system. Therefore, the oscillations become damped oscillations.