16. Electromagnetic Induction

Definitions

Faraday's Law: Whenever there is a change in magnetic flux linkage of a circuit or coil, an e.m.f is induced in the circuit/coil and the magnitude is directly proportional to the rate of change of magnetic flux linkage of the circuit or coil.

Magnetic Flux: The product of the area and the magnetic flux density that passes through the area perpendicularly. (ABcostheta)
Magnetic Flux Linkage: The magnetic flux passing through each turn multiplied by the number of turns of the coil.

Lenz's Law: The induced current always flows in a direction so as to oppose the change that produces it.

- For questions involving moving rod, the length used in calculations is the length of the rod in the magnetic field (exclude the length sticking out)
- Right hand: To find induced current
- Left hand: To find induced force
- 2 ways to induce e.m.f.
    - ➢ Relative motion between magnet and conductor
    - ➢ Increasing or decreasing flux linkage
- **NOTE:** In a rotating disc, the induced emf is given by 0.5Br^2omega, derived from Blv, except that v is given by v/2 or romega is given by romega/2 as it is the **average velocity that we must use**.
- ^emf induced in a rotating disc is due to different rate of changes of magnetic flux of the different radius
- Average e.m.f produced by a coil when rotated through 360 degrees is zero (RMB THE CONVO WITH JASON AND ERIC!!!!!!! Draw sin graph of e.m.f. and also from 0-90 and from 90-180 face of coil changes direction, therefore to achieve different current, e.m.f. polarity the same!

Questions

1. (Refer to lecture notes Example 10) Explain in terms of principle of conservation of energy, why this graph is different from your first graph.
Ans: Current flows in the circuit and hence, heat is produced. Heat energy is produced at the expense of mechanical energy because total energy is conserved. The oscillation dies off and the induced e.m.f. decreases in magnitude.

2. How to reduce Eddy currents?
Ans:

- Cut deep slots into the metal, eddy currents will be considerably reduced as they cannot flow across the many air gaps formed by the slots.
- OR… Laminate the core so that the induced e.m.f. acts at right angles to the laminations, thus preventing eddy currents from circulating.

3. When a coil is pushed towards a magnet, an induced current flows in the coil. Show how this direction of flow is consistent with the law of COE.

Ans: As the coil is pushed towards the magnet, there is a change in the magnetic flux linkage of the coil. This will result in an induced current flowing in the coil. By Lenz's law, the direction of the induced current is always to oppose the change in the magnetic flux linkage that produces it. The induced current sets up a force on the magnet, which the mover (magnet) must overcome. The work done in overcoming this force is converted to the electrical energy of the current.

4. Explain how the magnitude and direction of current in the ring changes throughout the motion in which the ring approaches, falls through and away from coil A.
Ans:

- As the ring approaches the coil, there is an **increase in magnetic flux linkage** through the ring and **by Faraday's law, an emf is induced.**
- The magnitude of the current **increases from zero** and flows in an **anti-clockwise direction** around the ring so as to set up a magnetic field to **oppose the increase in magnetic flux linkage** according to Lenz's law.
- When the ring falls through the coil, there is no change in magnetic flux linkage and hence **no induced current**.
- When the ring falls below the coil, there is a **decrease in magnetic flux linkage** through the ring and by **Faraday's Law**, **an emf is produced**.
- The induced current flows in a **clockwise direction** to oppose the **decrease in magnetic flux linkage** according to Lenz's law.
- When the ring is at a **great distance** from the coil, there is no change in magnetic flux linkage and hence no induced current flows in the ring.

5. Induced emf in frame.

- Faraday's → e.m.f.
- Since closed conducting path, by Lenz's law, induced current will flow in a direction that sets up a magnetic field that opposes the change which is the motion of the frame.
- Produces magnetic force on the frame to slow it down.