

State Examination Commission – Physics Higher Level, 2008

Question 8

What is electromagnetic induction?

State the laws of electromagnetic induction. (18)

A bar magnet is attached to a string and allowed to swing as shown in the diagram. A copper sheet is then placed underneath the magnet. Explain why the amplitude of the swings decreases rapidly. (12)

What is the main energy conversion that takes place as the magnet slows down? (6)

A metal loop of wire in the shape of a square of side 5 cm enters a magnetic field of flux density 8 T. The loop is perpendicular to the field and is travelling at a speed of 5 m s⁻¹.

- (i) How long does it take the loop to completely enter the field? (6)
- (ii) What is the magnetic flux cutting the loop when it is completely in the magnetic field? (6)
- (iii) What is the average emf induced in the loop as it enters the magnetic field? (10)

What is electromagnetic induction?

The production of an emf in a conductor when there is a changing magnetic flux linking it.

State the laws of electromagnetic induction. (18)

Basic statements

A bar magnet is attached to a string and allowed to swing as shown in the diagram. A copper sheet is then placed underneath the magnet. Explain why the amplitude of the swings decreases rapidly. (12)

An emf is induced in the copper sheet which creates currents in the metal that circulate in such a way as to generate a magnetic field that opposes the motion that created it. (Lenz's law).

What is the main energy conversion that takes place as the magnet slows down? (6)

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- (i) How long does it take the loop to completely enter the field? (6)

If we assume that the loop experiences no deceleration as a consequence of the force on the leading edge due to induced currents flowing, then it will take a time of

$$t = \frac{0.05}{5} = 0.01 \text{ s}$$

- (ii) What is the magnetic flux cutting the loop when it is completely in the magnetic field? (6)

$$\Phi = BA = 8 \times (0.05)^2 = 2 \times 10^{-2} \text{ Wb}$$

- (iii) What is the average emf induced in the loop as it enters the magnetic field? (10)

$$\begin{aligned} \text{Average emf induced, } \mathcal{E} &= \frac{d\phi}{dt} \\ &= \frac{d(BA)}{dt} \\ &= B \frac{dA}{dt} \\ &= B \frac{d(0.05s)}{dt} \\ &= 0.05B \frac{ds}{dt} \\ &= 0.05Bv \\ &= 0.05 \times 8 \times 5 \\ &= 2 \text{ V} \end{aligned}$$

$$\begin{aligned} \text{or, } \mathcal{E} &= \frac{\text{change in flux}}{\text{time taken}} \\ &= \frac{(2 \times 10^{-2})}{0.01} \\ &= 2 \text{ V} \end{aligned}$$

