2024 S4 Assignment 20a

Electromagnetic Induction - Answers

General approach to electromagnetic induction phenomenon:

- Identify any relative motion between magnet and conductor
  ➔ Rate of cutting of magnetic field lines by the conductor (e.g. coil or solenoid)
  OR
  Rate of change (increase or decrease) magnetic flux linked to the conductor

  ➔ By Faraday's law, an e.m.f. is induced in the conductor (e.g. coil or solenoid)

  ➔ Observation of change in circuit (e.g. deflection in electrical meter, light bulb lights up, display on C.R.O.)

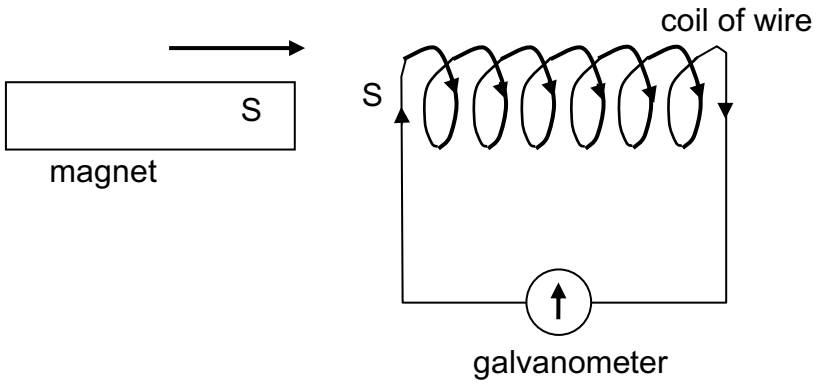
- ***Note:*** *Explain by applying a law means paraphrasing it suitably, not stating it.*

1(a) As the magnet moves into the coil, there is cutting of magnetic field lines by the coil

OR there is an increase the magnetic flux linked to the coil. *[not momentary change!]*

By Faraday's Law, an e.m.f is induced in the coil.

(b)



Correct direction of current in the coil

(c) As the magnet moves into the coil, the induced e.m.f. in the coil causes an induced current to flow in a direction to set up a S-pole on the left side of the coil to repel (or oppose) the motion of the magnet, by Lenz's Law.

The right hand grip rule is used to deduce the current direction shown.

(d) Any two ways:
(1) Move the magnet faster into the coil.
(2) Increase the number of turns in the coil.
(3) Use a stronger magnet.
(4) Insert a soft iron core in the coil (or wind the turns of the coil on a soft iron core) - note that this may prevent the magnet from entering the coil.

2(a) When the magnet accelerates towards the solenoid, there is an increasing rate of cutting of magnetic field lines by the solenoid.
By Faraday's law, there is an increasing e.m.f. induced in the solenoid resulting in an increase in the deflection of the galvanometer in one direction.

(b) The rate of cutting of magnetic field lines by the solenoid decreases to zero.
By Faraday's law, the e.m.f. induced in the solenoid decreases to zero as shown by the deflection of the galvanometer decreasing to zero.

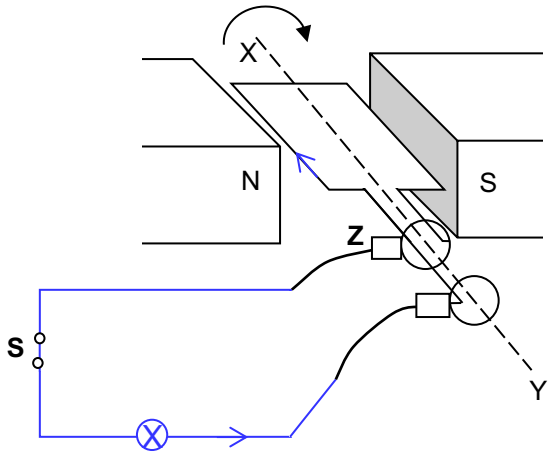
3(a) As the magnet falls towards the pipe, there is an increasing rate of cutting of magnetic field lines by the copper pipe.
By Faraday's Law, an e.m.f. is induced in the conducting pipe.

(b) The induced e.m.f. causes induced currents (or eddy currents) to flow in the pipe.
By Lenz's Law, these induced currents would flow in a direction to set up a magnetic field to oppose the motion of the falling magnet. The net downwards force on the magnet decreases. Therefore, the magnet falls with a decreasing acceleration.

Note: *The magnet does not slow down, it continues to fall but at a lower acceleration.*

(c) Copper is an electrical conductor, so there is induced e.m.f. which causes induced currents that oppose the motion of the falling magnet. Plastic is an electrical insulator that would not cause electromagnetic induction when the magnet falls through it, and has no effect on the motion of the magnet.
Hence the time taken to fall through the copper pipe will be longer than that of the plastic pipe.

4(a) As the coil rotates, there is rate of cutting of the magnetic field lines of the permanent magnets by the coil.
By Faraday's law, an e.m.f. is induced in the coil.
OR
As the coil rotates, there is a rate of change in the magnet flux of the permanent magnets linked to the coil. By Faraday's law, an e.m.f. is induced in the coil.



(b)(i) external circuit with light bulb and switch

(ii) direction of current shown above
polarity of Z is positive

(iii) The magnetic field and direction of motion of the coil are given. Using Fleming's right hand rule, the direction of the induced current in the coil is deduced as shown above.
The current on the right side of the coil is flowing out of the coil through the carbon brush at **Z** to the external circuit. Hence **Z** is positive.

5(a) Point **C**

This point represents the voltage when the coil is moving towards the position where its plane is perpendicular to the magnetic field (where the rate of cutting of magnetic flux is going to be minimum), i.e. the magnitude of the induced e.m.f. is decreasing towards zero.

(b)(i) The amplitude of the induced voltage would be doubled and

the frequency of the induced voltage would be doubled or its period is halved.

Note: *This question does not require an explanation.*

(ii)