

Electromagnetic induction

Name & set

1. An aeroplane of wingspan 40 metres flies horizontally at a speed of 1200 km hr^{-1} . If the flux density of the vertical component of the earth's field is $4 \times 10^{-5} \text{ T}$, what is the p.d. set up between the wing tips?

[4]

2. A bicycle wheel 0.80 m in diameter is spun at 180 rpm in a vertical plane at right angles to the magnetic meridian.

(i) If the horizontal component of the earth's field is $1.8 \times 10^{-5} \text{ T}$, at what rate does a spoke cut flux?

[2]

(ii) What is the emf set up between the ends of the spoke?

[2]

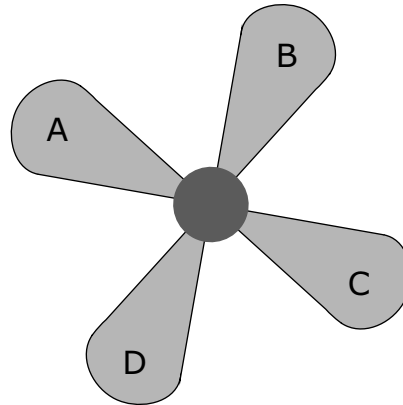
3. A solid metal wheel 1.2 m in diameter spins in a vertical plane at right angles to the magnetic meridian at a rate of 4.0 Hz. It is found that there is a p.d. between the centre and the rim of the disc of $85 \mu\text{V}$. What is the horizontal component of the earth's field?

[2]

4. A car aerial is 1.5 m long. Calculate the e.m.f. induced across it when the car is travelling at 30 ms^{-1} in an East-West direction. The horizontal component of the earth's field is $18 \mu\text{T}$. Assume that the aerial is vertical.

[2]

- 5 An electric fan is placed so that the axis about which the blades rotate is parallel to the earth's magnetic field lines. The magnetic flux density of the earth's field is $60 \mu\text{T}$. The fan has four blades each adjacent blade is perpendicular to its neighbours.



If the fan rotates at 3600 r.p.m., calculate the e.m.f. induced

- (a) between the tip of any one of the blades and the axle,

[2]

- (b) between the tips of two blades directly opposite to one another (e.g. A & C),

[2]

- (c) between tips of adjacent blades (e.g. D & C).

[2]

- 6 A bicycle wheel is rotated in a horizontal plane at a place where the total magnetic flux density of the earth's magnetic field is $60 \mu\text{T}$. If the radius of the wheel is 35 cm and it is rotating at 100 rev/min in a plane *perpendicular* to the magnetic field, calculate the voltage generated between the axle and rim of the wheel.

[3]

7 (a) (i) State Lenz's law of electromagnetic induction

[2]

(ii) Describe an experiment which demonstrates the truth of this law. Illustrate your description with a suitable diagram.

[4]

(b) Discuss the consequences, in the experiment which you describe, if the direction of the induced e.m.f. were other than that which the law predicts.

[3]

8 A small fan, having blades 15.0 cm long, rotates at $3000 \text{ rev min}^{-1}$.

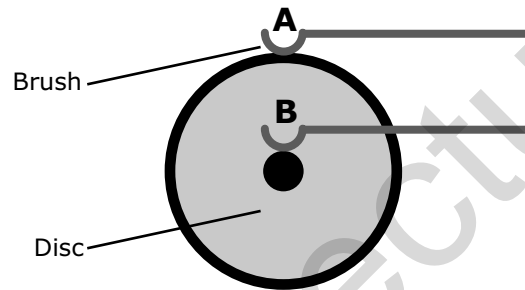
(a) How should the axis of rotation of the fan be orientated so that the maximum e.m.f. is induced between the tips of the blades and the axel if the only magnetic field present is that of the earth?

[2]

(b) What would be the value of this e.m.f. if the magnetic flux density of the earth is $60 \mu\text{T}$?

[2]

9 A metal disc rotates anticlockwise at an angular velocity ω in a uniform magnetic field that is directed into the paper in the diagram, and covers the whole of the disc. A and B are the brushes.



(a) By considering an electron between the brushes show that a potential difference exists between A and B.

(b) Explain what changes, if any, will be needed in the torque required to keep the disc rotating at the same angular velocity ω if A and B are connected by a resistor

- 10 (a) Diagram 1 shows an electron of charge e moving with velocity v at right angles to a magnetic field of strength B .

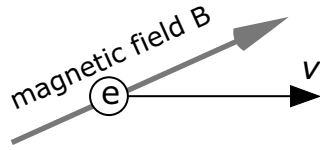


diagram 1

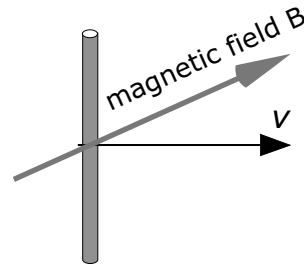


diagram 2

Write down a formula for the force on the electron *and* add an arrow to diagram 1 to indicate the direction of this force.

_____ [2]

- (b) A straight wire is now moved with a velocity v , at right angles to the magnetic field, of strength B , as shown in diagram 2 above:

- (i) How is this situation similar to that in part (a)?

 _____ [1]

- (ii) Explain how this leads to an induced e.m.f. across the wire.

 _____ [3]

- (iii) What additional information do you need in order to calculate the induced e.m.f.?

 _____ [1]

- (iv) Write down the formula for the induced e.m.f..

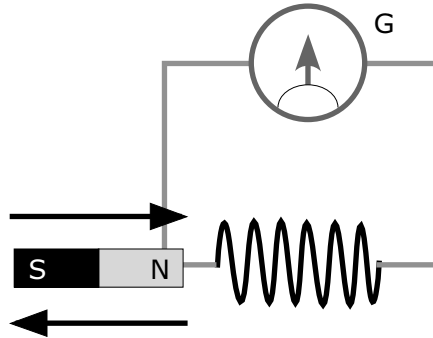
 _____ [1]

- (c) An aeroplane with a wingspan of 20m flies horizontally at a speed of 300ms^{-1} .

If the Earth's vertical component of magnetic flux density is $5.2 \times 10^{-5} \text{ T}$, calculate the e.m.f. induced between its wingtips.

 _____ [2]

- 11 A solenoid is connected to a sensitive galvanometer, G. A bar magnet is pushed quickly into the solenoid and then removed at the same speed.



- (a) State the effect you would expect this action to have on the galvanometer.

[4]

- (b) Explain these observations.

[5]

- (c) The action is now repeated at a higher speed. State and explain what difference you would expect to see in the response of the galvanometer.

[2]

- 12 (a) Calculate the magnetic flux density of the magnetic field inside a 150 turn air cored solenoid of length 60 cm, carrying a current of 1.2 A.

(permeability of free space $\mu_0 = 4\pi \times 10^{-7} \text{ Hm}^{-1}$.)

- (b) A second coil of 50 turns and diameter 5 cm is wound tightly on the solenoid. The current in the solenoid is switched off and falls to zero in 0.1s.

- (i) Calculate the e.m.f. induced across the second coil.

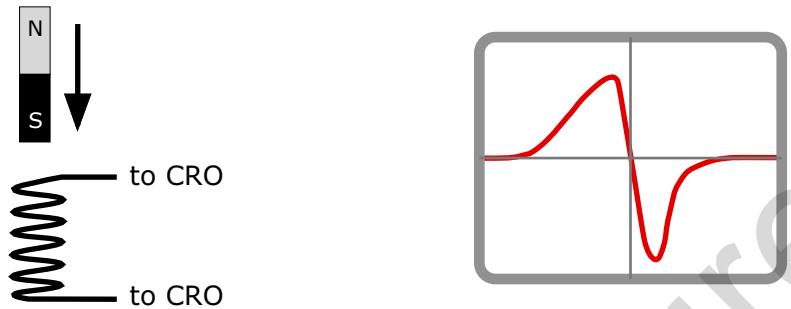
- (ii) What assumption did you make in this calculation?

- (c) In another experiment the current in the solenoid is reversed rapidly. The e.m.f. across the second coil is found to be the same as in (b). How long did it take to reverse the current?

13 (a) State Lenz's Law of electromagnetic induction.

[2]

(b) A magnet is dropped vertically through a coil of wire. A CRO connected to the coil displays a trace of the e.m.f. induced in the coil.



Explain the following features of the trace:

(i) The positive peak

[3]

(ii) The negative peak

[2]

(iii) The relative magnitudes of the two peaks

[2]

(iv) The duration in time of the two peaks

[1]

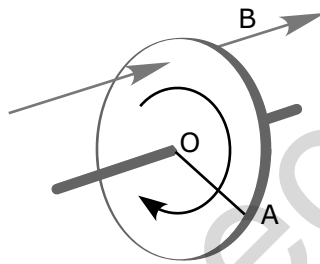
15 (a) (i) State the relationship between magnetic field strength, B , and magnetic flux, ϕ

[2]

(ii) State the SI units of each quantity.

[2]

(b) A conducting disc of diameter 5cm is mounted with its plane perpendicular to a uniform magnetic field of 0.1T. It rotates at 25 revolutions per second.



(i) Calculate the flux cut by a radial line AO as the disc makes one revolution.

[2]

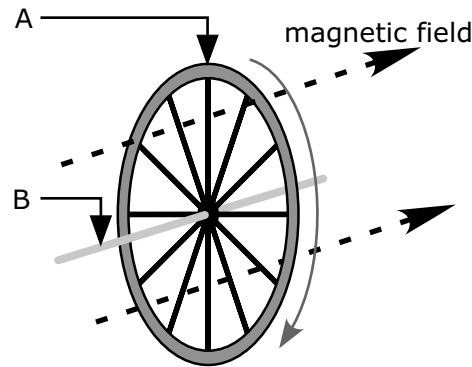
(ii) Hence calculate the emf induced between the centre of the disc and a point on its rim.

[2]

(iii) What is the emf induced between the end points of a diameter of the disc?

[1]

- 16 A bicycle wheel is mounted vertically on a metal axle in a horizontal magnetic field. Sliding contacts are made to the metal rim of the wheel and the axle. The wheel is set to rotate freely.



- (a) (i) Explain why an e.m.f. is generated between the contacts.

[2]

- (ii) State two ways in which this e.m.f. could be varied.

[2]

- (b) A small light bulb is connected between the contacts. State and explain what you would observe about:

- (i) The light bulb

[2]

- (ii) The rotation of the wheel

[2]

- (c) A second wheel is mounted in the same way at the same orientation to the field and rotated at same angular speed. The emf measured is $\frac{1}{4}$ that of the first wheel.

What do you conclude about this wheel?

[3]

- 17 (a) Describe an experiment to demonstrate Lenz's Law using a bar magnet and a solenoid.
What other equipment would you need?

[4]

- (b) Describe the energy changes that take place during the experiment and show that Lenz's Law is consistent with energy conservation.

[6]

Mega Lecture