2025 Year 6 H2 Physics Remedial
Chapter 17: Electromagnetic Induction

1 Fig. 1.1 below shows a simple electric generator that can convert mechanical energy into electrical energy. A metal rod CD of mass M and is able to slide downwards while maintaining contact with two long smooth vertical metal rails PQ and ST. The rods are connected at the bottom by a resistor R, and the whole device is in a uniform magnetic field B perpendicular to the page.

When the rod is released from rest, it falls downwards and as a result, an electric current I flows around the circuit CDTQ. The rod speeds up initially before reaching a constant downward speed.

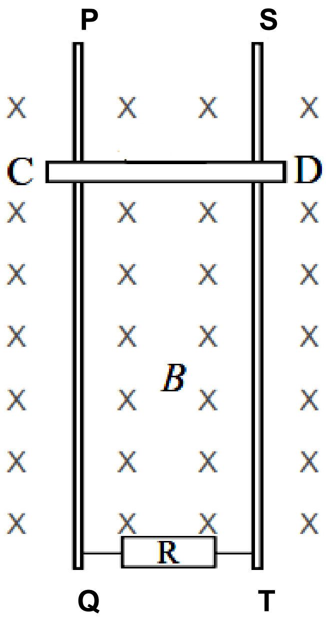
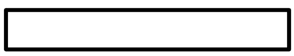


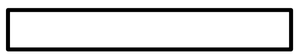
Fig. 1.1

(a) Draw on the diagrams below clearly labelled arrows to represent the vertical forces acting on the rod CD in the two cases. [2]

(i) just as it was released



(ii) falling with constant speed



(b) Fig. 1.2 below shows the rod descending a distance Δy in a time Δt at constant speed v_T.

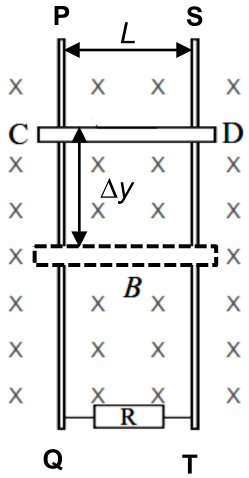


Fig. 1.2

(i) Write an expression for the change of magnetic flux $\Delta\phi$ as the rod CD falls through distance Δy. [1]

(ii) Hence show that the induced e.m.f. E is given by $E = BLv_T$. [1]

(iii) Using **(a)(ii)** and **(b)(ii),** show that the constant speed v_T is given by [3]

$$v_T = \frac{MgR}{B^2L^2}$$

Explain your working clearly.

(c) State a disadvantage of this type of generator compared to a conventional rotating generator. [1]

(HCI/Prelims/2014/III)

2 A small coil is positioned so that its axis lies along the axis of a large bar magnet as shown in Fig. 2.1.

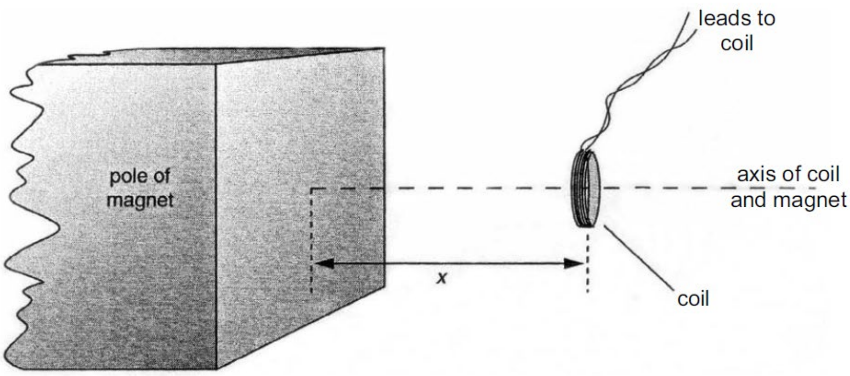


Fig. 2.1

The coil has a cross-sectional area of 0.40 cm^2 and contains 150 turns of wire.

The average magnetic flux density B through the coil varies with the distance x between the face of the magnet and the plane of the coil, as shown in Fig. 2.2.

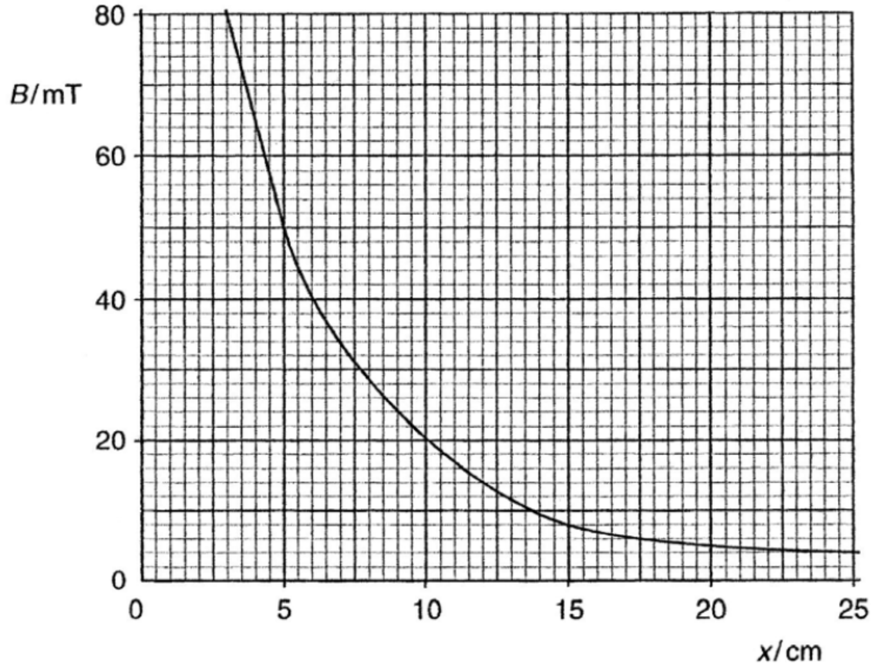


Fig. 2.2

(a) The coil is 5.0 cm from the face of the magnet. With reference to Fig. 14.2, show that the magnetic flux linkage of the coil is 3.0 x 10^{-4} Wb.

[2]

(b) The coil is moved along the axis of the magnet so that the distance x changes from x = 5.0 cm to x = 15.0 cm in a time of 0.30 s. Calculate

(i) the magnitude of the change in flux linkage of the coil,

[2]

(ii) the average e.m.f induced in the coil.

[2]

(c) State and explain the variation, if any, of the speed of the coil so that the induced e.m.f. remains constant during the movement in part (b).

[2]

(d) The magnet in Fig. 14.1 is now replaced with a solenoid connected to an alternating voltage, with the axis of the solenoid aligned to the axis of the small coil.

Suggest how such an arrangement may be applied in the "wireless charging" of mobile phones.

[2]

[TPJC/Prelims 2014/P3/3]

3 **(a)** State Faraday's law of electromagnetic induction. [1]

(b) A coil with 800 turns is placed in a uniform horizontal magnetic field of flux density 5.0×10^{-2} T. The area of the coil perpendicular to the field is 2.5×10^{-2} m^2, as shown in Fig. 3.1.

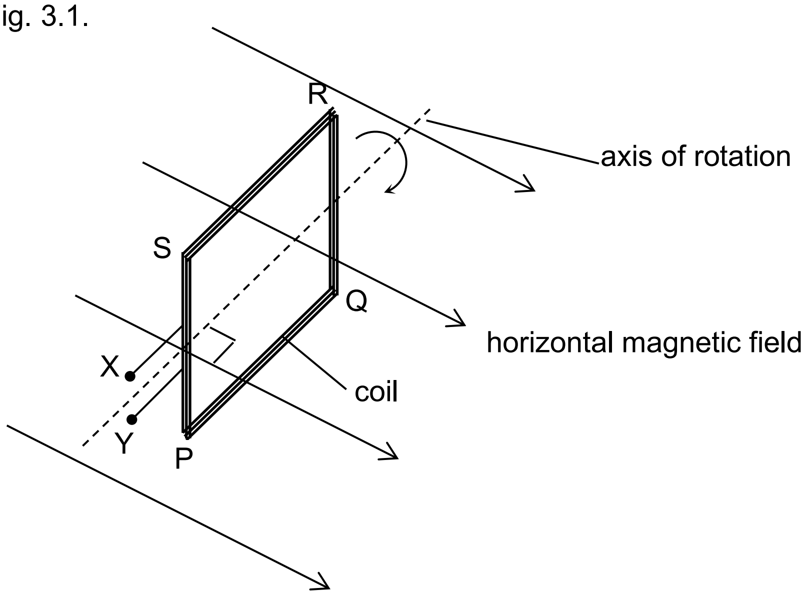


Fig. 3.1

Show that the magnetic flux linkage of the coil is 1.0 Wb. [1]

(c) The coil in **(b)** is rotated around the axis shown in Fig. 3.1. The flux linkage Φ of the coil varies with time t is as shown in Fig. 3.2.

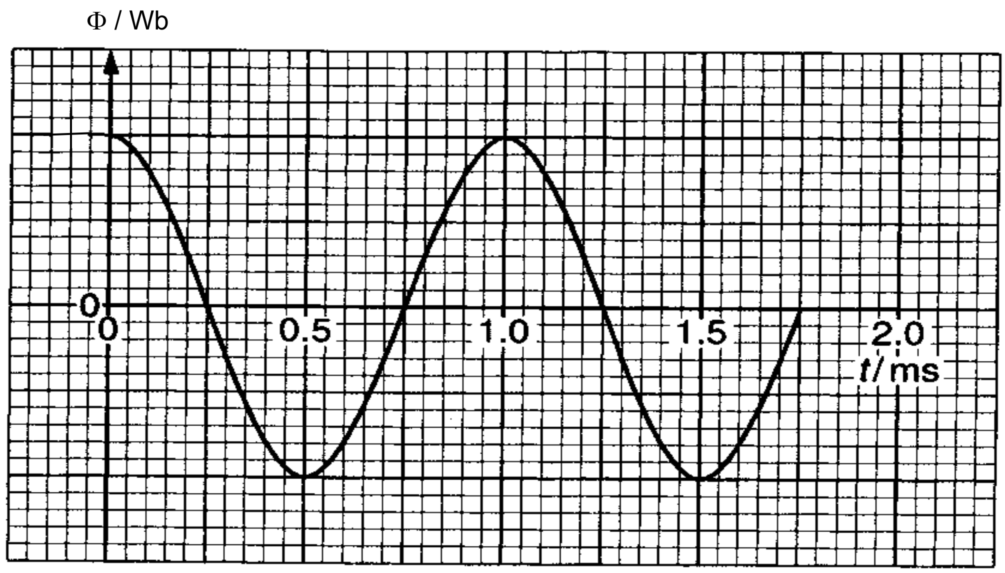


Fig. 3.2

(i) Calculate the maximum e.m.f. across **XY** (the two ends of the coil). [2]

(ii) Sketch on Fig. 4.2 the variation with time of the e.m.f. across **XY**. [2]

(d) A resistor is now connected across **XY**.

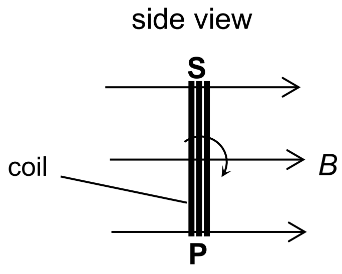


Fig. 3.3

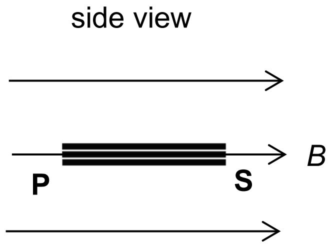


Fig. 3.4

Explain the direction of flow of current in the coil as it rotates from its vertical position (Fig. 3.3) until its plane is parallel to the magnetic field *B* (Fig. 3.4). [2]

(SAJC/Prelims/2014/II)

4 A spring is attached to a sheet of aluminium and a mass, as illustrated in Fig. 2.1.

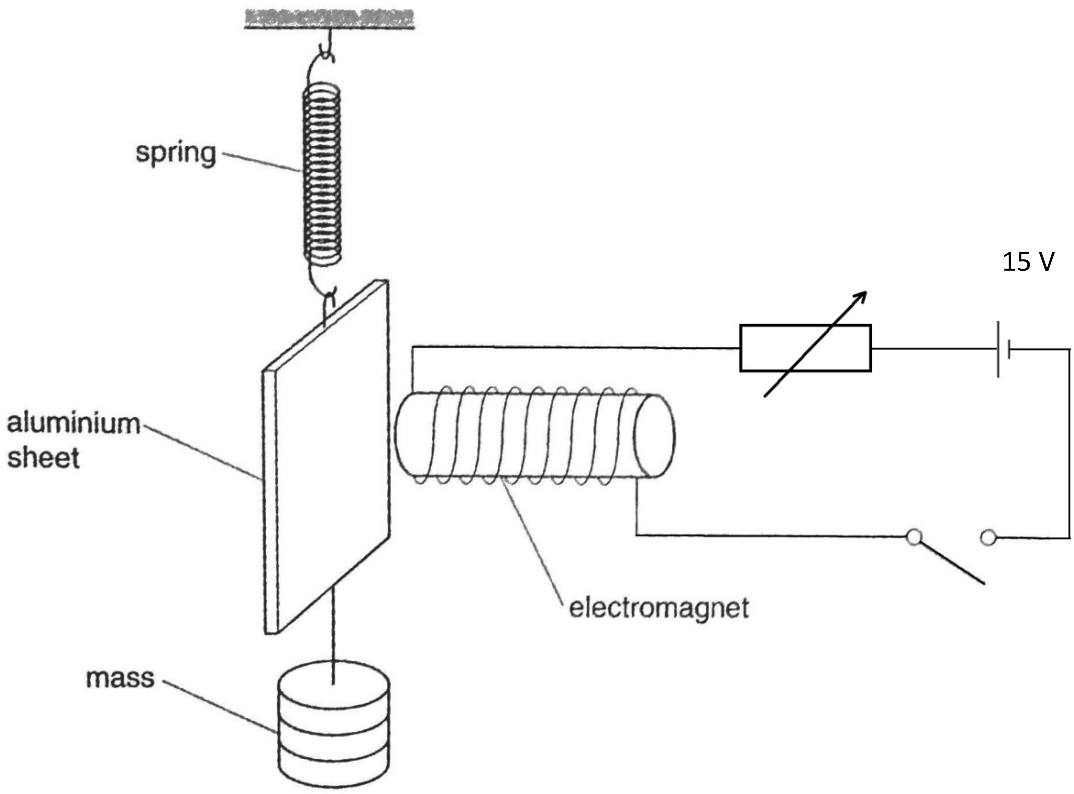


Fig 4.1

An electromagnet is placed near to the centre of the aluminium sheet. The mass is displaced vertically and, with the electromagnet **switched off**, the mass is released. The variation with time *t* of the displacement x of the mass is shown in **Fig. 4.2**.

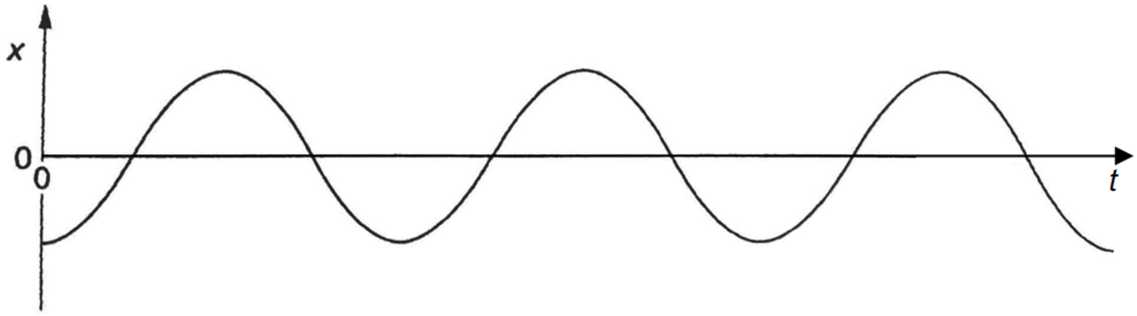


Fig 4.2

(a) The electromagnet is **switched on** and the experiment is repeated with the same initial displacement. Damped oscillations are observed.

(i) On **Fig 4.2**, sketch the new variation with time t of the displacement x of the mass.

[2]

(ii) State Faraday's law of electromagnetic induction, and explain why the oscillations of the mass are damped, using principle of conservation of energy.

[6]

(iii) Draw and label on Fig 4.1 the followings, as the aluminium sheet moves down during the damped oscillation, the direction of

1. the current in the coils of the solenoid. [1]

2. the eddy currents in the aluminium sheet [1]

3. the direction of the induced magnetic field due to the eddy currents in the aluminium sheet. [1]

4. the resultant force on the aluminium sheet. [1]

(b) Suggest how critical damping can be demonstrated using the apparatus of Fig 4.1.

[4]

(c) The coil has a length 8.00 cm, radius of 1.00 cm, 50 turns and a resistance of 5.00 Ω. The variable resistor has a range of 0 – 20 Ω. The magnetic flux density B at the centre of a solenoid is given by

$$B = \mu_o nI$$

where n is the number of turns per unit length.

Calculate the maximum magnetic flux density at one end of the solenoid.

[4]

[ACJC/Prelims 2014/P3/8]