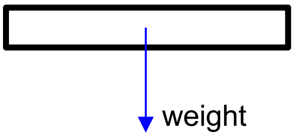
Raffles Institution
Year 5-6 Physics Department

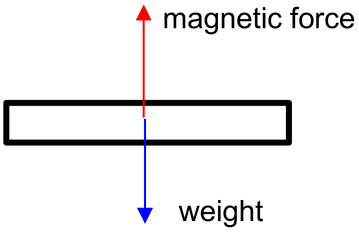
2025 Year 6 H2 Physics Remedial
Chapter 17: Electromagnetic Induction

Suggested Solutions

1 **(a)** **(i)**



(ii)



(b) **(i)** $\Delta\phi = BL\Delta y$

(ii) Average e.m.f. induced,

$$E = \frac{\Delta\phi}{\Delta t} = \frac{BL\Delta y}{\Delta t} = BLv_T$$

(iii) Induced current $I = \frac{E}{R} = \frac{BLv_T}{R}$

At constant speed, net force = 0

$$F_B = Mg$$

$$BIL = Mg$$

$$B\left(\frac{BLv_T}{R}\right)L = Mg$$

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

(c) Non-continuous operation: rod would reach the bottom and then have to be returned to its original height to start again.

2 **(a)** From graph, when x = 5.0 cm, B = 50 mT

Φ = NBA

= (150)(50 x 10^{-3})(0.40 x 10^{-4})

= 3.0 x 10^{-4} Wb (shown)

(b) **(i)** |ΔΦ| = N(|ΔB|)A

= (150)(50 x 10^{-3} – 8.0 x 10^{-3})(0.40 x 10^{-4})

= **2.52 x 10^{-4} Wb**

(ii) |ε| = |ΔΦ| / Δt

= (2.52 x 10^{-4}) / (0.30) = **8.4 x 10^{-4} V**

(c) Flux linkage decreases at a decreasing rate as distance increases, so speed must increase to keep rate of change constant.

(d) The solenoid may act as a transmitter that generates a changing magnetic flux. Since the small coil is linked to the changing magnetic flux, by Faraday's Law, an induced e.m.f. will be produced in the small coil which can be used to charge up the battery in the mobile phone.

[TPJC/Prelims 2014/P3/3]

3 (a) Whenever there is a *change in magnetic flux linkage* of a circuit or coil, an e.m.f. is induced in the circuit and the magnitude is directly proportional to the *rate of change* of magnetic flux linkage of the circuit or coil.

(b) $\Phi = NBA = 800 \times 5.0 \times 10^{-2} \times 2.5 \times 10^{-2} = 1.0$ Wb

(c) **(i)** $\Phi = NBA \cos \omega t$ where $\omega t = 0$ when $t = 0$ (eqn can be deduced from graph given)

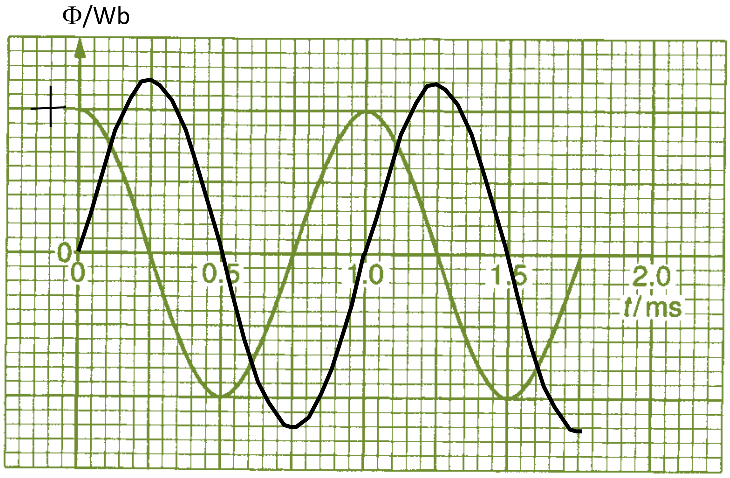
$$\text{e.m.f.} = -\frac{d\Phi}{dt} = -NBA\frac{d\cos \omega t}{dt} = -NBA\omega\,(-\sin \omega t)$$

$$\text{Max e.m.f.} = NBA\omega = 1.0 \times \left(\frac{2\pi}{1.0\times10^{-3}}\right) = 6280 \text{ V}$$

<u>Alternative method:</u>

$$\text{Max. e.m.f.} = -\,(\text{max. gradient}) = -\frac{(1.5 - 0)}{(0 - 0.25)\times10^{-3}} = 6000 \text{ V} \quad \{\text{accept 5400 to 6600 V}\}$$

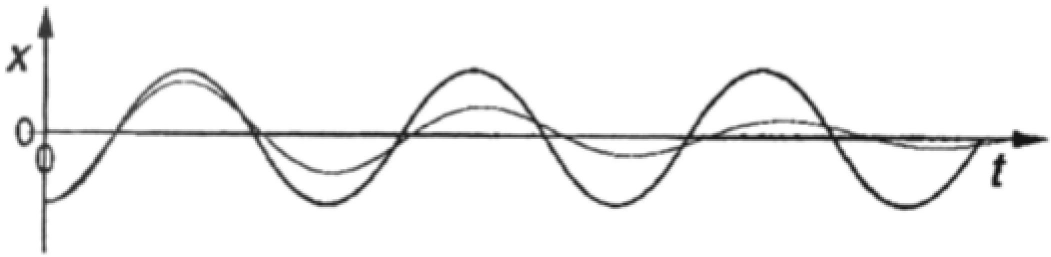
(ii)



<u>positive sine graph</u> of any amplitude
<u>same period</u> as the flux linkage

(d) As the coil turns, the <u>magnetic flux linkage decreases</u>.
By <u>Right-hand Grip Rule</u>, the current will flow in the direction PQRS so as to <u>enhance the magnetic flux linkage</u>.

4 (a) (i)



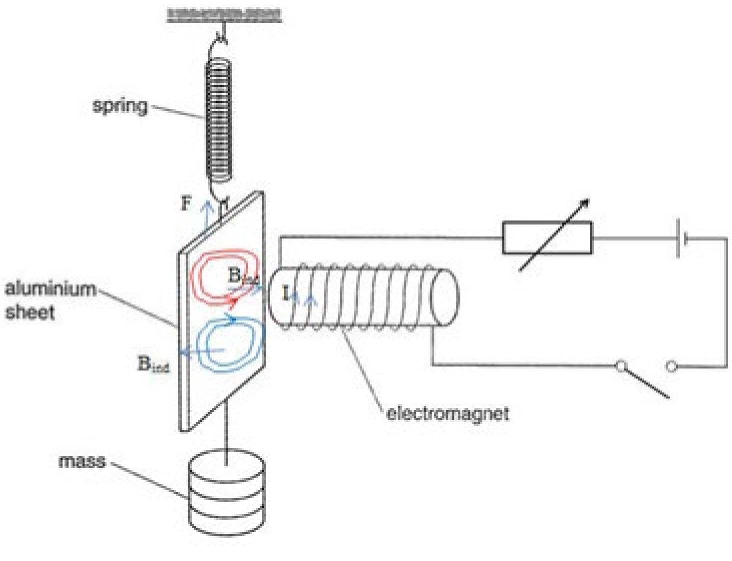
Shows decreasing amplitude throughout
Period same or slightly longer (up to 1.5 T)

(ii) Faraday's law state that the magnitude of the induced emf in a conductor (or circuit) is directly proportional to the rate of change of magnetic flux linkage experienced by the conductor (or linking the circuit).

When the electromagnet is switched on, as current flows through the coil, it generates a magnetic field.The oscillating aluminium sheet experiences a change in magnetic flux linkage / cuts magnetic field lines. According to Faraday's law, an emf will be induced in the aluminium sheet.

Since the aluminium sheet is a conductor / metal, induced (eddy) currents, circulates within it. The mechanical energy of the oscillating system has been converted to electrical energy, and dissipated as heat, hence damping occurs. (Since amplitude of the oscillation is proportional to the mechanical energy, amplitude decreases continuously.)

(iii)



Correct drawing and direction for,
I, *I*induced or eddy current (as shown), *B*induced (top section - towards electromagnet, bottom section – same direction). FB upwards

(b) The strength of the magnetic field produced by the electromagnet depends on the current following through it. (The current can be adjusted by the variable resistor.)
As the resistance of the variable resistor decrease, current increases, hence the strength of the magnetic field increase and the degree of damping increase / greater amt of electrical energy dissipated / more heat dissipated.
It will reach a point when the aluminium sheet (or mass) return to its equilibrium position in the shortest time, without overshooting (or crossing) the equilibrium position. This is called critical damping.
To detect the point of critical damping, a marker is attached to the aluminium sheet which traces out the displacement vs time curve on a scrolling paper, mounted vertically.

(c) For max B, needs max current, hence resistance of variable resistor = 0 Ω.

$$V = IR$$
$$15 = I(5.00)$$
$$I = 3.0A$$

At the centre of the solenoid,

$$B = \mu_o nI$$
$$= 4\pi \times 10^{-7} \times \frac{50}{0.0800} \times 3.0$$
$$= 2.36 \times 10^{-3} T \quad (or\ 2.4 \times 10^{-3} T)$$

At one end of the solenoid,

$$B = \frac{1}{2}(2.36 \times 10^{-3}) = 1.18 \times 10^{-3} T \quad (or\ 1.2 \times 10^{-3} T)$$