(b) A flat coil consists of N turns of wire and has area A. The coil is placed so that its plane is at an angle θ to a uniform magnetic field of flux density B, as shown in Fig. 6.1.

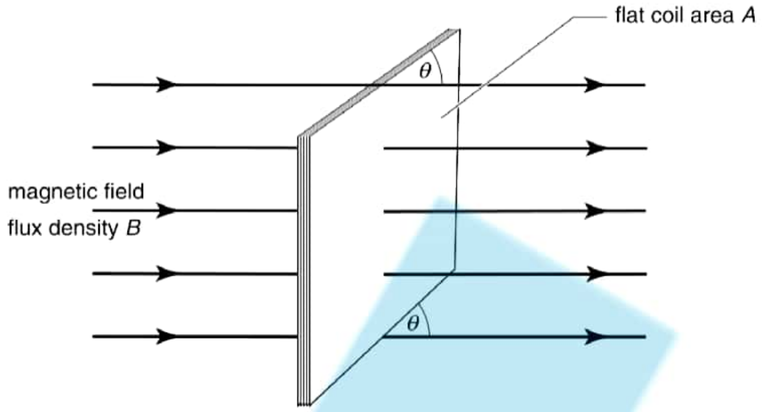


Fig. 6.1

Using the symbols A, B, N and θ and making reference to the magnetic flux in the coil, derive an expression for the magnetic flux linkage through the coil.

$\Phi = BNA \sin\theta$

[2]

(c) (i) State Faraday's law of electromagnetic induction.

The induced EMF is proportional to the rate of change of magnetic flux linkage [2]

(ii) The magnetic flux density B in the coil is now made to vary with time t as shown in Fig. 6.2.

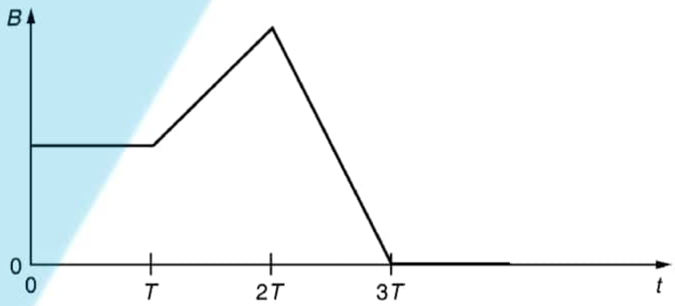
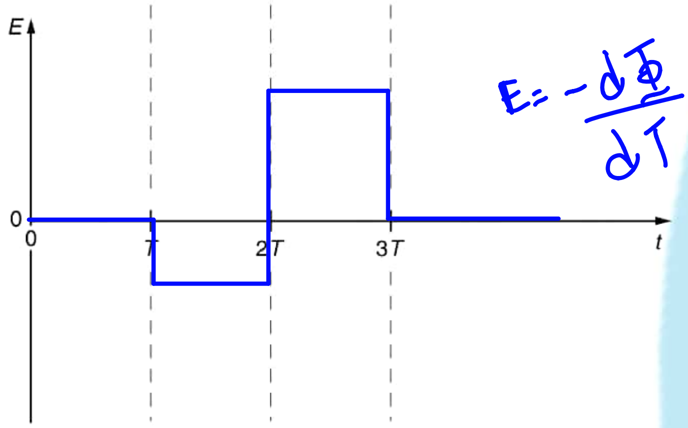


Fig. 6.2



$E = -\dfrac{d\Phi}{dT} = \dfrac{-dB}{dt} NA$

Fig. 6.3

On Fig. 6.3, sketch the variation with time t of the e.m.f. E induced in the coil. [3]

(b) A large horseshoe magnet produces a uniform magnetic field of flux density B between its poles. Outside the region of the poles, the flux density is zero.
The magnet is placed on a top-pan balance and a stiff wire XY is situated between its poles, as shown in Fig. 6.1.

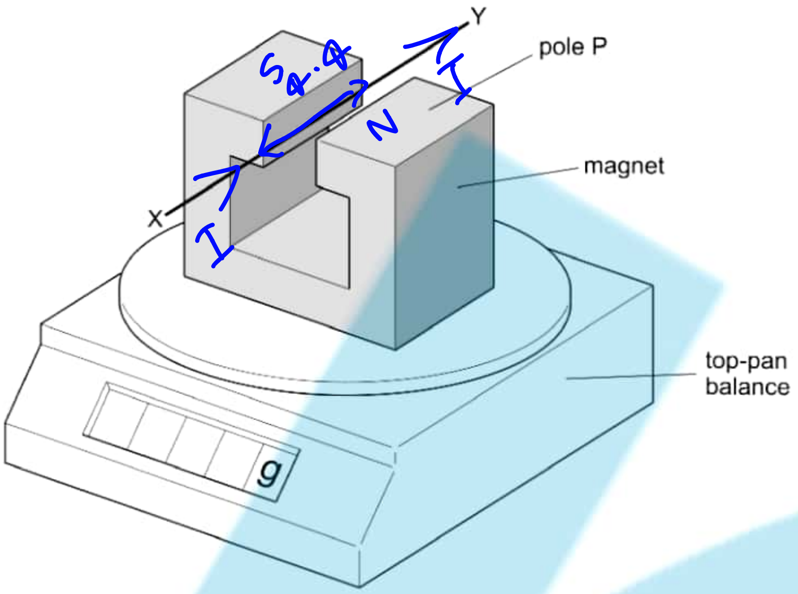


Fig. 6.1

The wire XY is horizontal and normal to the magnetic field. The length of wire between the poles is 4.4 cm.
A direct current of magnitude 2.6 A is passed through the wire in the direction from X to Y.
The reading on the top-pan balance increases by 2.3 g.

(i) State and explain the polarity of the pole P of the magnet.

According to Newtons 3rd law, if force on the balance increases, it means force on wire is upwards, Thus, using fleming's left hand rule, pole P is north pole. [3]

(ii) Calculate the flux density between the poles.

$F = BIL$

$B = \frac{F}{IL} =$

$f = mg = \frac{2.3}{1000} \times 9.81 = 0.022563$

$B = \frac{0.022563}{2.6 \times \frac{4.4}{100}} = 0.197\ T$

flux density = 0.2 T [3]

(c) The direct current in **(b)** is now replaced by a very low frequency sinusoidal current of r.m.s. value 2.6 A.
Calculate the variation in the reading of the top-pan balance.

A/C current chapter

variation in reading = ... g [2]

(a) A constant current is maintained in a long straight vertical wire. A Hall probe is positioned a distance r from the centre of the wire, as shown in Fig. 5.1.

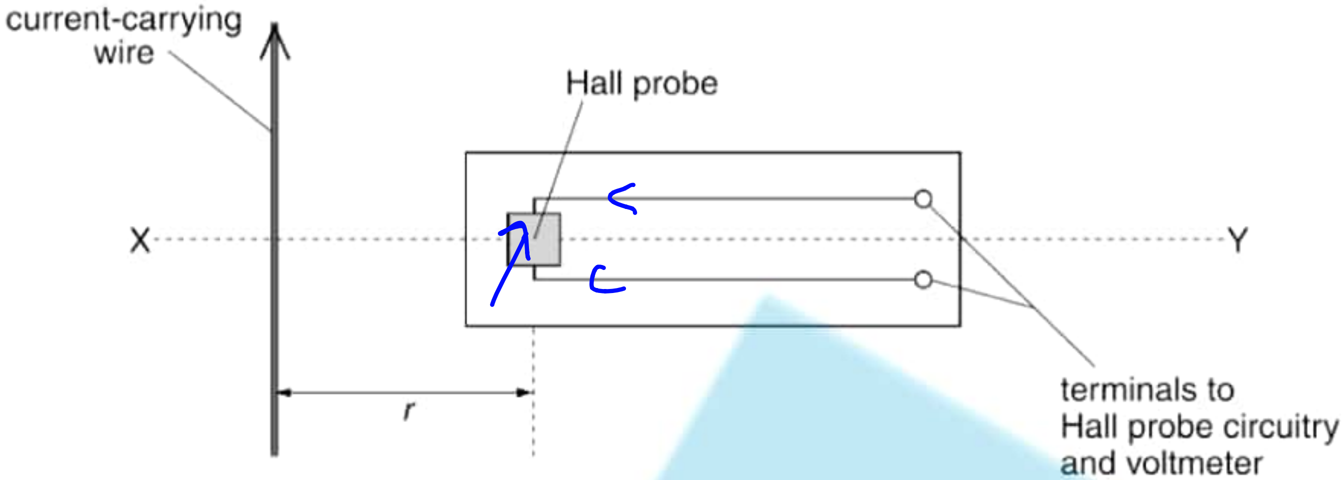


Fig. 5.1

(i) Explain why, when the Hall probe is rotated about the horizontal axis XY, the Hall voltage varies between a maximum positive value and a maximum negative value.

$V_H = BI$, a B will vary V_H will vary, when net Hall probe is normal B , V_H is max and when Hall probe is parallel to B, V_H is 0 , and V_H will be -ve when its rotated 180° from starting position

[2]

(ii) The maximum Hall voltage V_H is measured at different distances r.
Data for V_H and the corresponding values of r are shown in Fig. 5.2.

V_H / V	r / cm
0.290	1.0
0.190	1.5
0.140	2.0
0.097	3.0
0.073	4.0
0.060	5.0

Fig. 5.2

It is thought that V_H and r are related by an expression of the form

$$V_H = \frac{k}{r}$$

where k is a constant.

1. Without drawing a graph, use data from Fig. 5.2 to suggest whether the expression is valid.

$R = V_H \times r$

$0.29 \times 1 = 0.29 \sim 0.3$

$3 \times 0.097 = 0.291 \sim 0.3$

$5 \times 0.06 = 0.3 \approx 0.3$

The values of ~~k~~ are constant to 1 s.f. therefore eqn is valid

[2]

2. A graph showing the variation with $\frac{1}{r}$ of V_H is plotted.

State the features of the graph that suggest that the expression is valid.

A straight passing through origin

[1]

(b) The Hall probe in **(a)** is now replaced with a small coil of wire connected to a sensitive voltmeter. The coil is arranged so that its plane is normal to the magnetic field of the wire.

(i) State Faraday's law of electromagnetic induction and hence explain why the voltmeter indicates a zero reading.

The induced EMF is proportional to the rate of change of magnetic flux linkage and because the value of current is constant, the value of magnetic flux linkage is constant, thus the induced EMF is 0

B is proportional to I because $B = \frac{\mu_0 I}{2\pi x}$

[3]

(ii) State three different ways in which an e.m.f. may be induced in the coil.

1. Vary r constantly

2. vary I constantly, [use ACurrent]

3. Rotate the coil

[3]

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A bar magnet is suspended from the free end of a helical spring, as illustrated in Fig. 3.1.

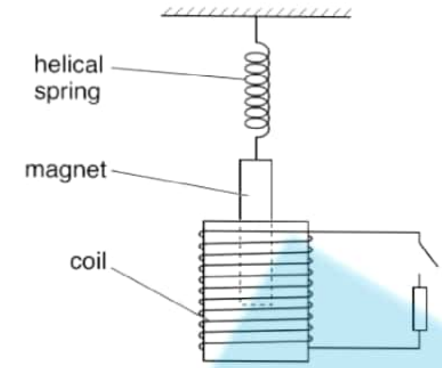

Fig. 3.1

One pole of the magnet is situated in a coil of wire. The coil is connected in series with a switch and a resistor. The switch is open.

The magnet is displaced vertically and then released. As the magnet passes through its rest position, a timer is started. The variation with time t of the vertical displacement y of the magnet from its rest position is shown in Fig. 3.2.

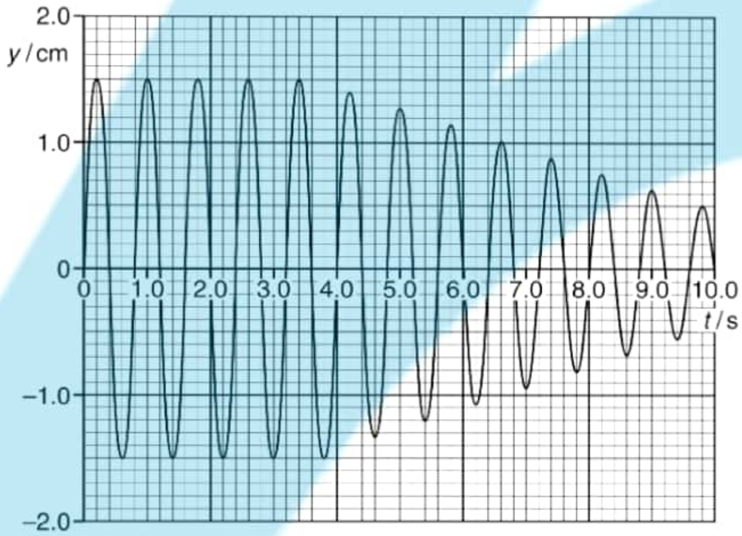

Fig. 3.2

At time t = 4.0 s, the switch is closed.

(a) Use Fig. 3.2 to

(i) state the evidence for the magnet to be undergoing free oscillations during the period t = 0 to t = 4.0 s,

Value of A remains Constant

.... [1]

(ii) state, with a reason, whether the damping after time t = 4.0 s is light, critical or heavy,

light damping because gradually

decreasing

.... [2]

(iii) determine the natural frequency of vibration of the magnet on the spring.

$f = \frac{1}{T}$ $\quad \frac{1}{0.8}$

frequency = 1.25 Hz [2]

(b) (i) State Faraday's law of electromagnetic induction.

....

....

....[2]

(ii) Explain why, after time $t = 4.0$ s, the amplitude of vibration of the magnet is seen to decrease.

As current is induced in the coil as the magnet moves in the coil, this current in the resistor will give rise to a heating effect, because of which energy is lost, thus the amplitude decreases

....[4]

(a) State the relation between magnetic flux density B and magnetic flux Φ, explaining any other symbols you use.

$\phi = BA\sin\theta$

A is the area through magnetic field lines pass, θ is angle between B and A

[2]

(b) A large horseshoe magnet has a uniform magnetic field between its poles. The magnetic field is zero outside the space between the poles.
A small Hall probe is moved at constant speed along a line XY that is midway between, and parallel to, the faces of the poles of the magnet, as shown in Fig. 5.1.

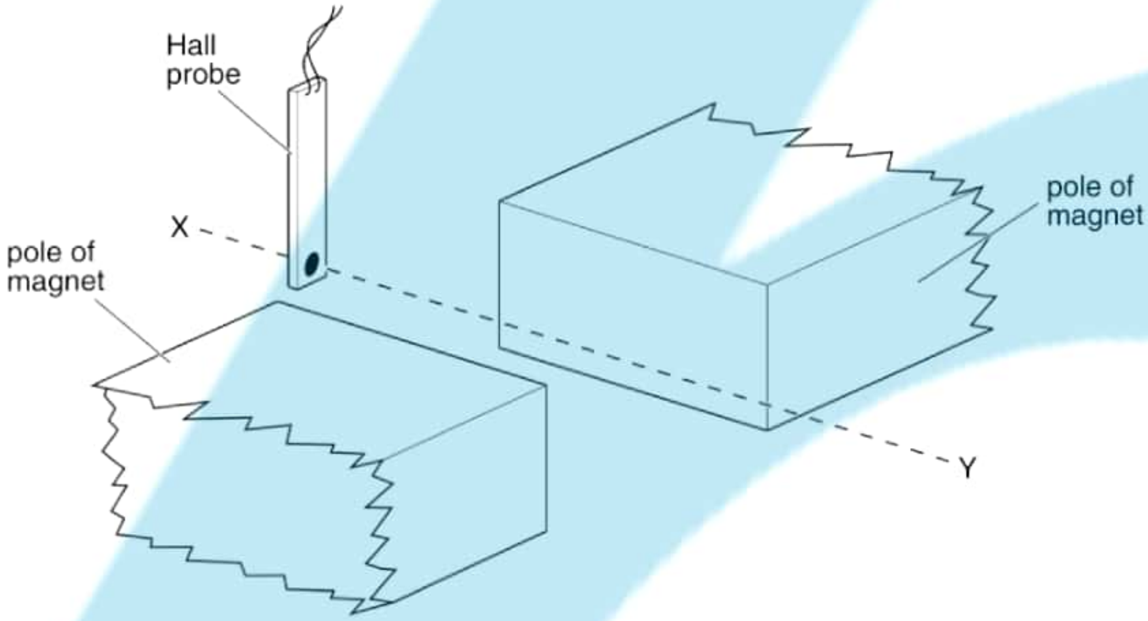

Fig. 5.1

An e.m.f. is produced by the Hall probe when it is in the magnetic field.
The angle between the plane of the probe and the direction of the magnetic field is not varied.

On the axes of Fig. 5.2, sketch a graph to show the variation with time t of the e.m.f. V_H produced by the Hall probe.

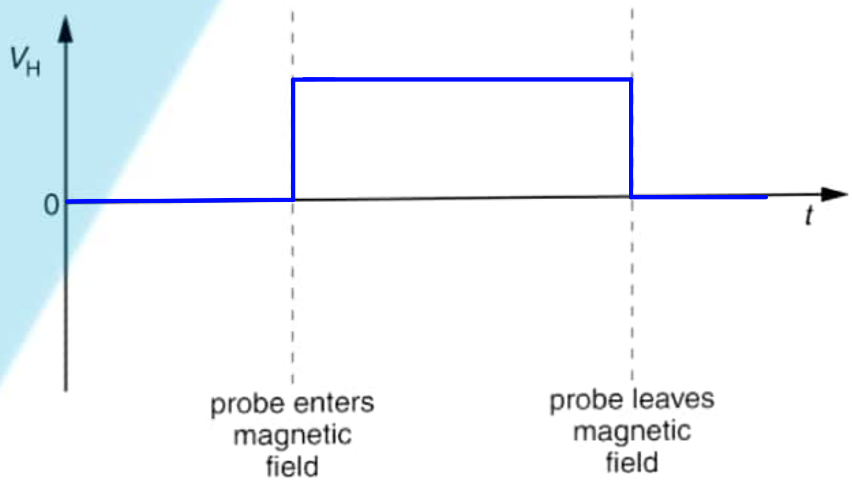

Fig. 5.2

[2]

(c) **(i)** State Faraday's law of electromagnetic induction.

The induced emf is proportional to the rate of change of magnetic flux linkage

.... [2]

(ii) The Hall probe in **(b)** is replaced by a small flat coil of wire. The coil is moved at constant speed along the line XY. The plane of the coil is parallel to the faces of the poles of the magnet.

On the axes of Fig. 5.3, sketch a graph to show the variation with time *t* of the e.m.f. *E* induced in the coil.

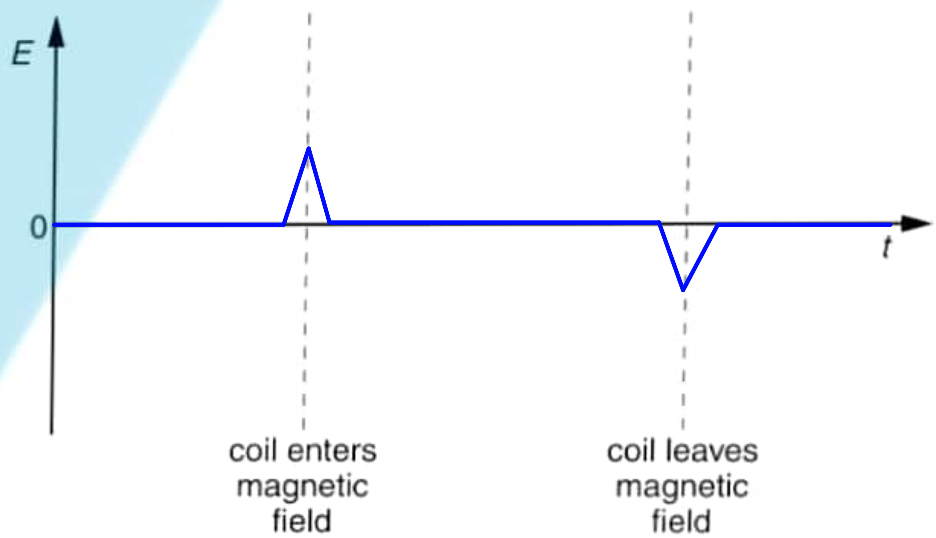

Fig. 5.3

[3]

(a) A Hall probe is placed near one end of a solenoid that has been wound on a soft-iron core, as shown in Fig. 9.1.

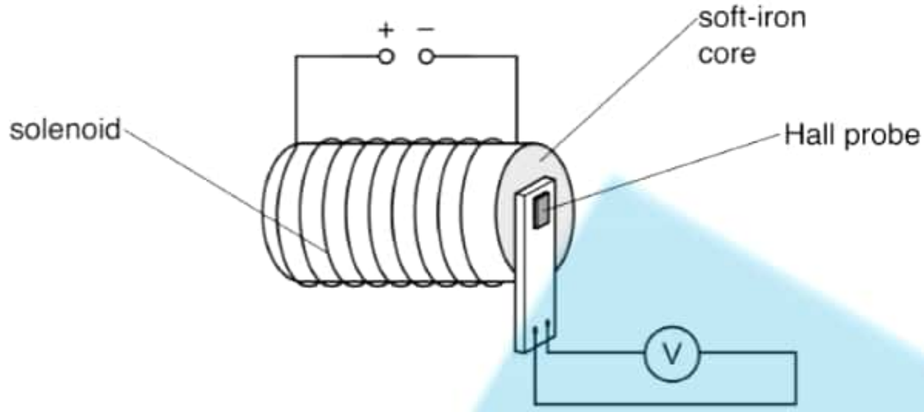

Fig. 9.1

The current in the solenoid is switched on.
The Hall probe is rotated until the reading V_H on the voltmeter is maximum.

The current in the solenoid is then varied, causing the magnetic flux density to change.
The variation with time t of the magnetic flux density B at the Hall probe is shown in Fig. 9.2.

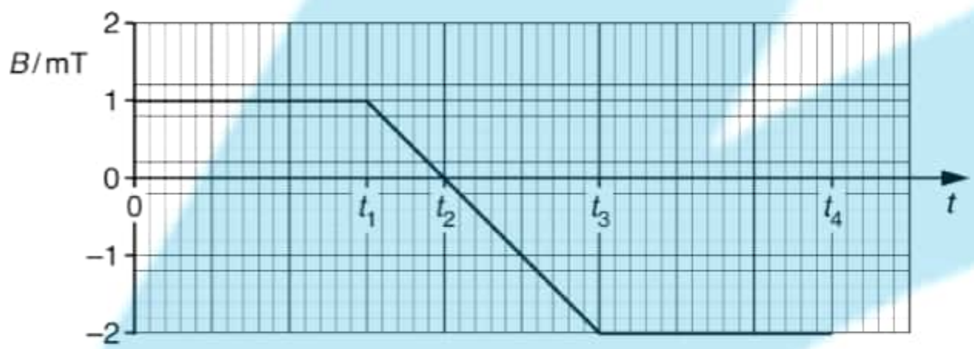

Fig. 9.2

At time $t = 0$, the Hall voltage is V_0.
On Fig. 9.3, draw a line to show the variation with time t of the Hall voltage V_H for time $t = 0$ to time $t = t_4$.

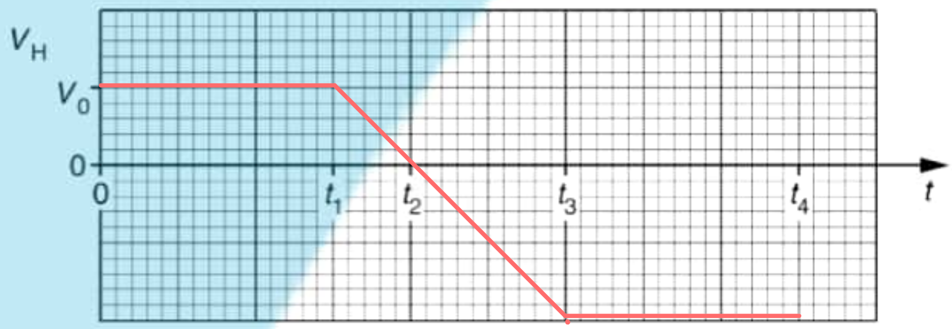

Fig. 9.3

[2]

(b) The Hall probe in **(a)** is now replaced by a small coil of wire connected to a sensitive voltmeter, as shown in Fig. 9.4.

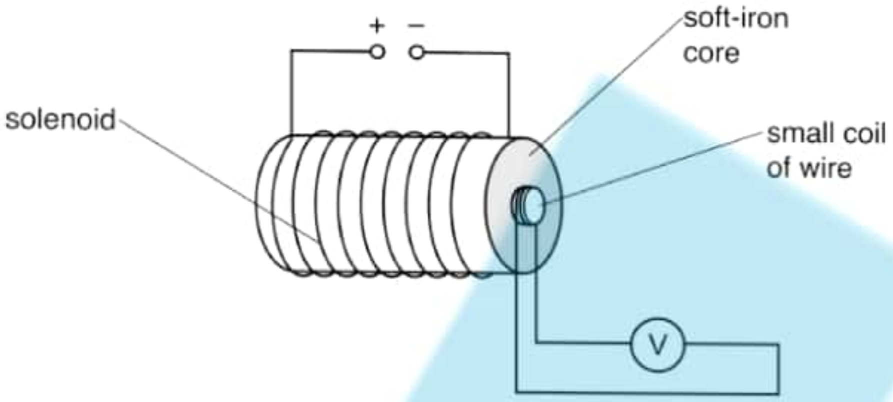

Fig. 9.4

The magnetic flux density, normal to the plane of the small coil, is again varied as shown in Fig. 9.2.

On Fig. 9.5, draw a line to show the variation with time t of the e.m.f. E induced in the small coil for time $t = 0$ to time $t = t_4$.

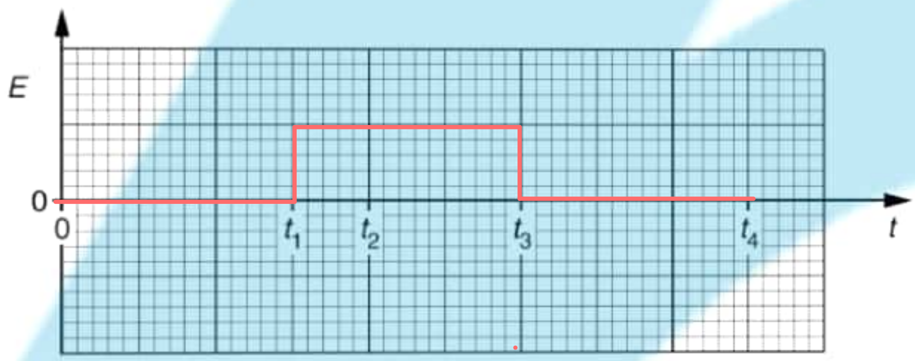

Fig. 9.5

[3]

A rigid copper wire is held horizontally between the pole pieces of two magnets, as shown in Fig. 9.1.

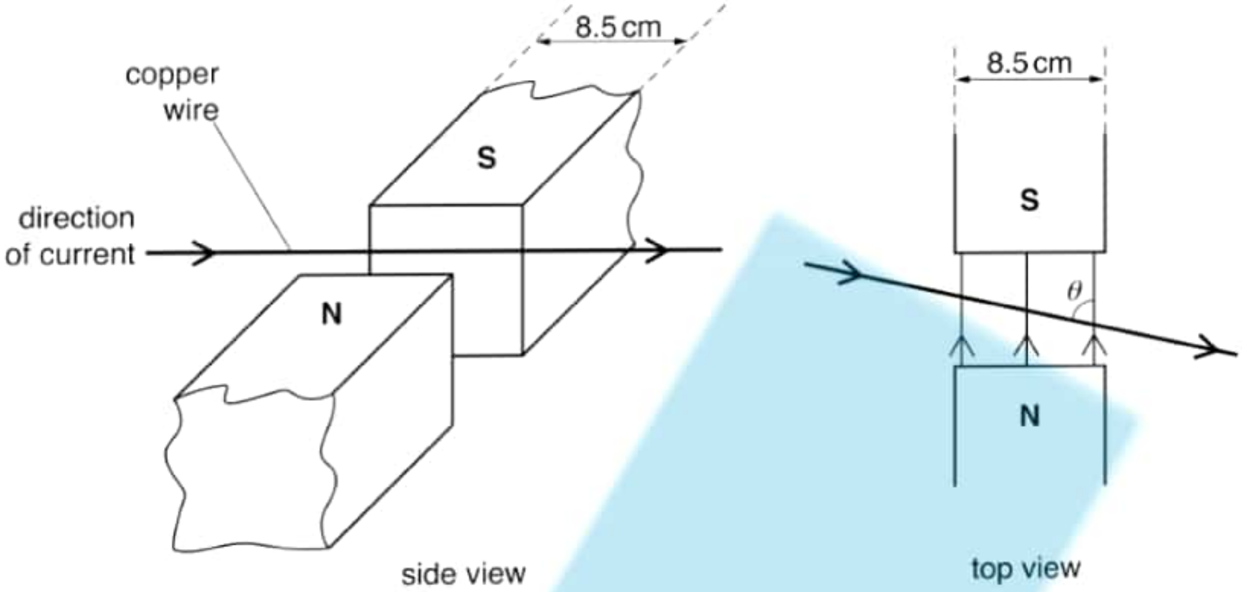

Fig. 9.1

The width of each pole piece is 8.5 cm.
The uniform magnetic flux density B in the region between the poles of the magnets is 3.7 mT and is zero outside this region.
The angle between the wire and the direction of the magnetic field is θ.
The current in the wire is in the direction shown on Fig. 9.1.

(a) By reference to the **side** view of Fig. 9.1, state and explain the direction of the force on the **magnets**.

according to Flemings left hand rule the force on the wire is upwards, thus according to newtons 3rd law the force on the magnet is downwards [2]

(b) The constant current in the wire is 5.1 A.

(i) For angle θ equal to 90°, calculate the force on the wire.

$F = BIL \sin 90$

$= 3.7 \times 10^{-3} \times 5.1 \times \frac{8.5}{100} \times 1$

$= 1.60395 \times 10^{-3}$

force = 1.6×10^{-3} N [2]

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(ii) The angle θ is changed to 60°.

The length of wire in the magnetic field is $\left(\dfrac{8.5}{\sin 60°}\right)$ cm.

Calculate the force on the wire.

$BIL\sin\theta$

$3.7 \times 10^{-3} \times 5.1 \times \left(\dfrac{8.5}{\sin 60}\right) \times \sin 60$

force = 1.6×10^{-3} N [1]

(c) The constant current in the wire is now changed to an alternating current of frequency 20 Hz and root-mean-square (r.m.s.) value 5.1 A.

The angle between the wire and the direction of the magnetic field is 90°.

On Fig. 9.2, sketch a graph to show the variation with time t of the force F on the wire for two cycles of the alternating current.

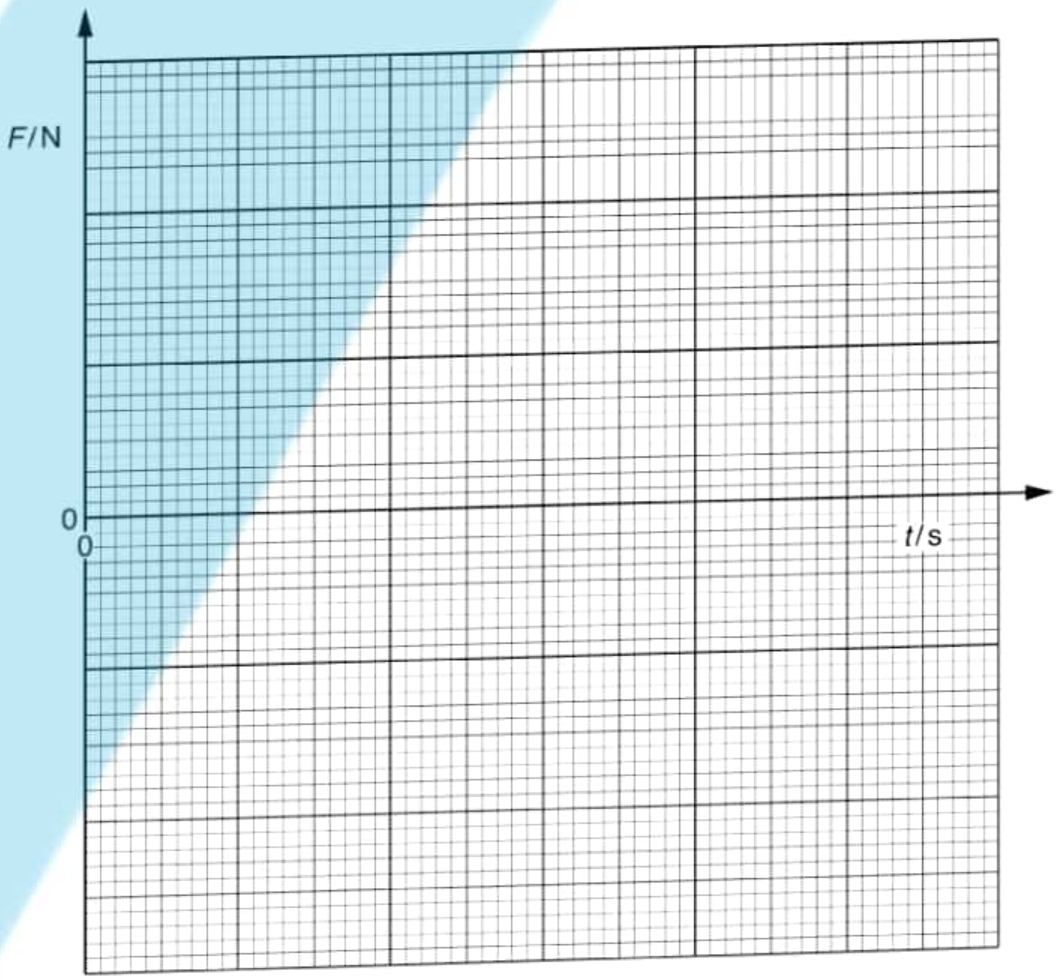

Fig. 9.2

[3]

[Total: 8]