Fuzail

A bar magnet is suspended vertically from the free end of a helical spring, as shown in Fig. 5.1.

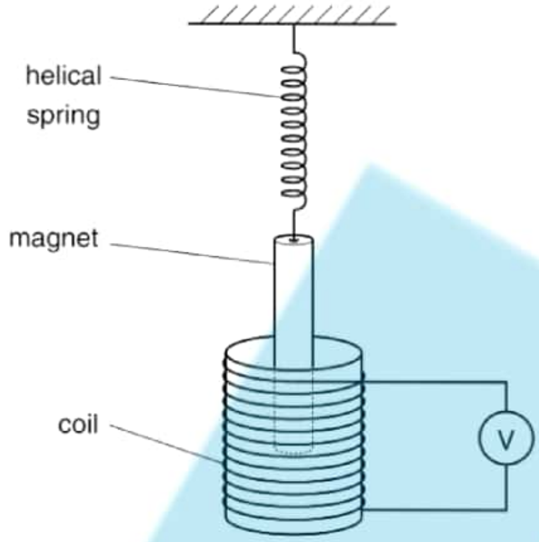


Fig. 5.1

One pole of the magnet is situated in a coil. The coil is connected in series with a high-resistance voltmeter.
The magnet is displaced vertically and then released.
The variation with time t of the reading V of the voltmeter is shown in Fig. 5.2.

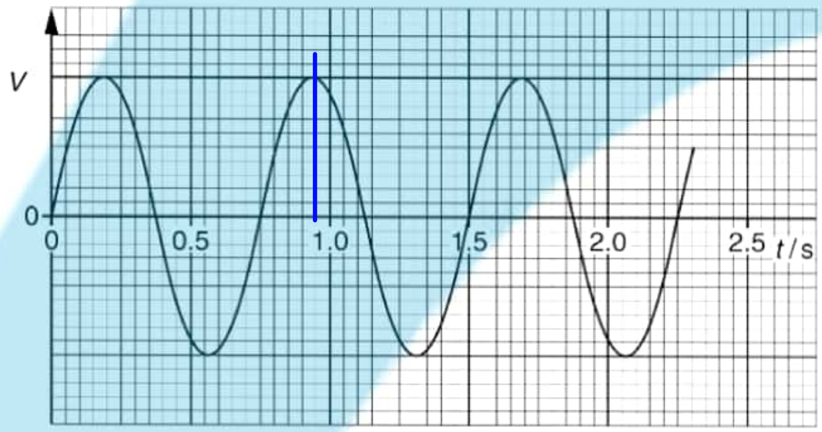


Fig. 5.2

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

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

[2]

(ii) Use Faraday's law to explain why

1. there is a reading on the voltmeter,

because there is a change magnetic field inside the coil

[1]

2. this reading varies in magnitude,

[1]

3. the reading has both positive and negative values.

Because the direction of displacement of magnet keeps reversing

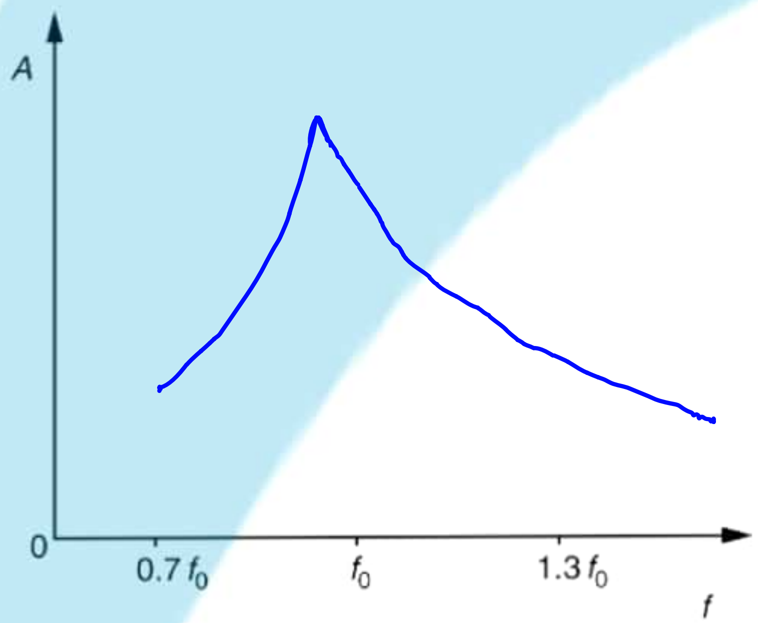
[1]

(b) Use Fig. 5.2 to determine the frequency f_0 of the oscillations of the magnet.

$f = \frac{1}{T} = \frac{1}{0.95} = 1.053$

f_0 = ...1.05...... Hz [2]

(c) The magnet is now brought to rest and the voltmeter is replaced by a variable frequency alternating current supply that produces a constant r.m.s. current in the coil.
The frequency of the supply is gradually increased from $0.7 f_0$ to $1.3 f_0$, where f_0 is the frequency calculated in **(b)**.
On the axes of Fig. 5.3, sketch a graph to show the variation with frequency f of the amplitude A of the new oscillations of the bar magnet.



?

[2]

Fig. 5.3

(d) **(i)** Name the phenomenon illustrated on your completed graph of Fig. 5.3.

......Resonance...... [1]

For Examiner's Use

(ii) State one situation where the phenomenon named in **(i)** is useful.

......occilation of a child swing......

...... [1]

Positively charged particles are travelling in a vacuum through three narrow slits S_1, S_2 and S_3, as shown in Fig. 5.1.

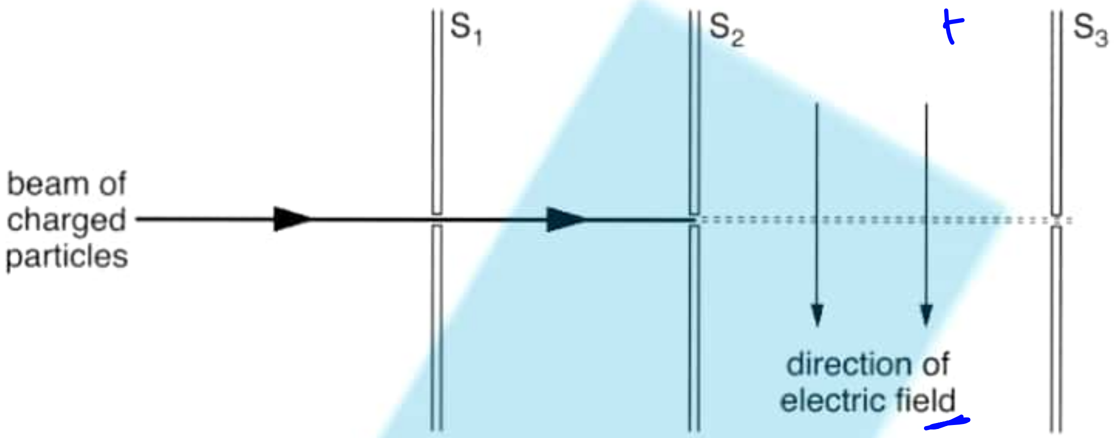


Fig. 5.1

Each particle has speed v and charge q.
There is a uniform magnetic field of flux density B and a uniform electric field of field strength E in the region between the slits S_2 and S_3.

(a) State the expression for the force F acting on a charged particle due to

(i) the magnetic field,

F= BqVSinθ ....[1]

(ii) the electric field.

F=Eq ....[1]

(b) The electric field acts downwards in the plane of the paper, as shown in Fig. 5.1. State and explain the direction of the magnetic field so that the positively charged particles may pass undeviated through the region between slits S_2 and S_3.

Into the screen, because only then the the force will be opposite to the electric force, thus the +ve particles will pass undeviated ....[2]

A uniform magnetic field of flux density B makes an angle θ with a flat plane PQRS, as shown in Fig. 5.1.

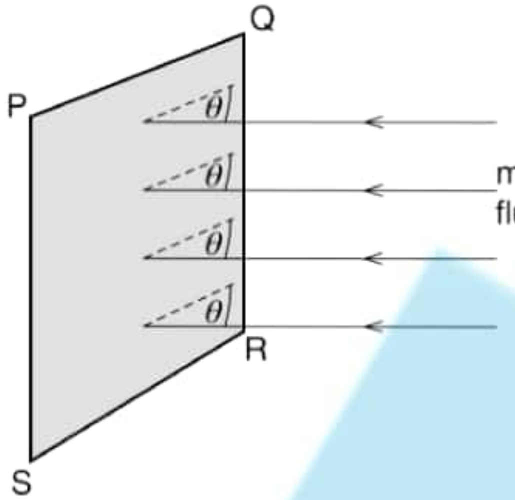


Fig. 5.1

The plane PQRS has area A.

(a) State

(i) what is meant by a *magnetic field*,

A region of space where a magnetic pole experiences a force .... [1]

(ii) an expression, in terms of A, B and θ, for the magnetic flux Φ through the plane PQRS.

$\Phi = BA\sin\theta$ .... [1]

(b) A vertical aluminium window frame DEFG has width 52 cm and length 95 cm, as shown in Fig. 5.2.

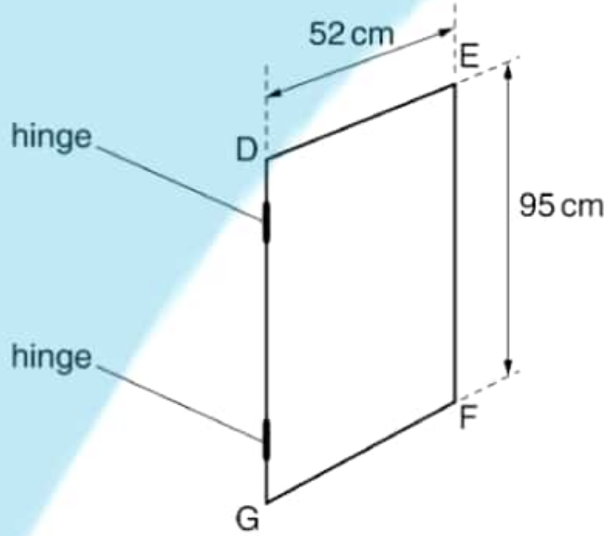


Fig. 5.2

The frame is hinged along the vertical edge DG.
The horizontal component B_H of the Earth's magnetic field is 1.8×10^{-5} T. For the closed window, the frame is normal to the horizontal component B_H.
The window is opened so that the plane of the window rotates through 90°.

(i) Explain why, when the window is opened, the change in magnetic flux linkage due to the vertical component of the Earth's magnetic field is zero.

because then the M field line are parallel to the surface of aluminimum window [1]

(ii) Calculate, for the window opening through an angle of 90°, the change in magnetic flux linkage.

$NBA\sin\theta$

$1 \times 1.8\times10^{-5} \times (0.95 \times 0.52) \times \sin 90 = 8.892\times10^{-6}$

change in flux linkage = 8.90 Wb [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 window in **(b)** is opened in a time of 0.30 s.
Use your answer in **(b)(ii)** to calculate the average e.m.f. induced in the window frame.

$$\frac{8.90\times10^{-6}}{0.3} = 29.64$$

e.m.f. = 2.97×10^{-5} V [1]

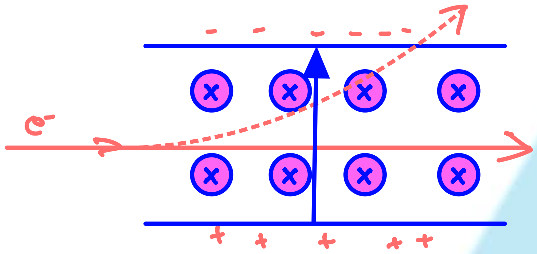
(iii) State the sides of the window frame between which the e.m.f. is induced.

between side DG and side EF [1]

For Examiner's Use

Do with sir

(a) Explain the use of a uniform electric field and a uniform magnetic field for the selection of the velocity of a charged particle. You may draw a diagram if you wish.



when an e- passes through a magnetic field its deflected in the dotted line path, however if there is an electric field too from shown by the blue arrow, there is a force on the particles towards the bottom of the screen. the electric field strength can be varied to change the deflection of the electrons ..... [3]

(b) Ions, all of the same isotope, are travelling in a vacuum with a speed of $9.6 \times 10^{4}\,\mathrm{m\,s^{-1}}$. The ions are incident normally on a uniform magnetic field of flux density 640 mT. The ions follow semicircular paths A and B before reaching a detector, as shown in Fig. 6.1.

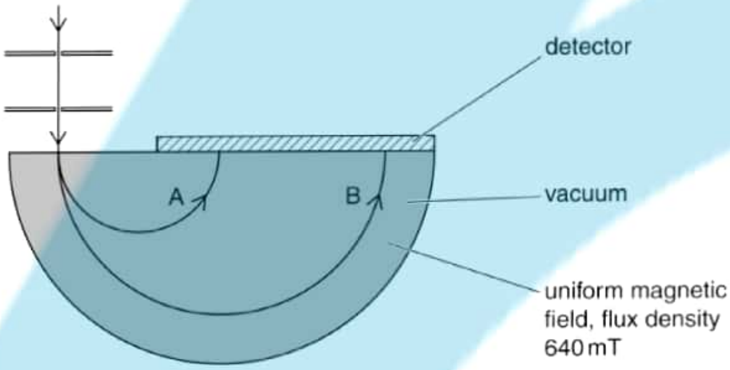


Fig. 6.1

Data for the diameters of the paths are shown in Fig. 6.2.

path	diameter/cm
A	6.2
B	12.4

Fig. 6.2

The ions in path B each have charge $+1.6 \times 10^{-19}$ C.

(i) Determine the mass, in u, of the ions in path B.

$$Bq\cancel{v} = \frac{mv^{\cancel{2}}}{r}$$

$$m = \frac{Bqr}{v} = \frac{640 \times 10^{-3} \times 1.6 \times 10^{-19} \times \frac{12.4}{100}}{9.6 \times 10^{4}} = 1.322 \times 10^{-25}$$

mass = 1.3×10^{-25} u [4]

(ii) Suggest and explain quantitatively a reason for the difference in radii of the paths A and B of the ions.

$$\frac{m_b}{r_1} = \frac{m_a}{r_2}$$

$$\therefore \frac{1.322 \times 10^{-25}}{\left(\frac{12.4}{100}\right)} = \frac{m_a}{\frac{6.2}{100}}$$

The mass of ions in path B is 1.1×10^{-2} so $m_a = 6.61 \times 10^{-26}$, the radii of ions in path A is half the radii of ions in path B, that is because the mass of ions B is twice of ions A [3]

A thin slice of conducting material is placed normal to a uniform magnetic field, as shown in Fig. 8.1.

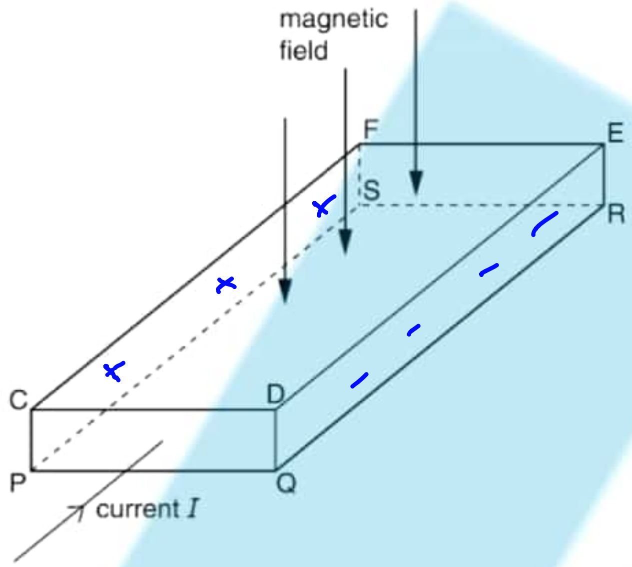


Fig. 8.1

The magnetic field is normal to face CDEF and to face PQRS.

The current I in the slice is normal to the faces CDQP and FERS.

A potential difference, the Hall voltage V_H, is developed across the slice.

(a) (i) State the faces between which the Hall voltage V_H is developed.

DERQ and CESP [1]

(ii) Explain why a constant voltage V_H is developed between the faces you have named in **(i)**.

because there is a force on the electrons towards DERQ Force, which pushes them towards that face and puts it at a lower potential than the other side. thus a potential diff is formed between the 2 faces, known as Hall voltage

[4]

(b) Two slices have similar dimensions. One slice is made of a metal and the other slice is made of a semiconductor material.

For the same values of magnetic flux density and current, state which slice, if either, will give rise to the larger Hall voltage. Explain your reasoning.

semi conductor, because there are less mobile e⁻ thus more resistance and thus a higher Hall voltage.

[2]

[Total: 7]

A Hall probe is placed near to one end of a current-carrying solenoid, as shown in Fig. 9.1.

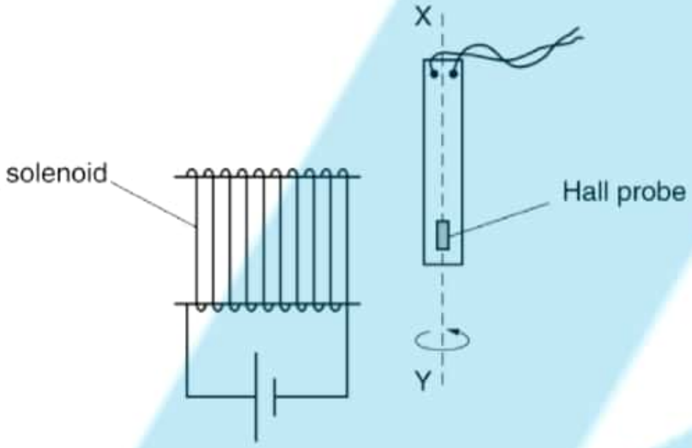


Fig. 9.1

The probe is rotated about the axis XY and is then held in a position so that the Hall voltage is maximum.

(a) Explain why

(i) a Hall probe is made from a *thin slice* of material,

so the magnetic field lines pass through it fully and easily

....[2]

(ii) in order for consistent measurements of magnetic flux density to be made, the current in the probe must be constant.

extra emf induced if current varies ?

....

....[1]

20

(b) The probe is now rotated through an angle of 360° about the axis XY.
At angle $\theta = 0$, the Hall voltage V_H has maximum value V_{MAX}.

On Fig. 9.2, sketch the variation with angle θ of the Hall voltage V_H for one complete revolution of the probe about axis XY.

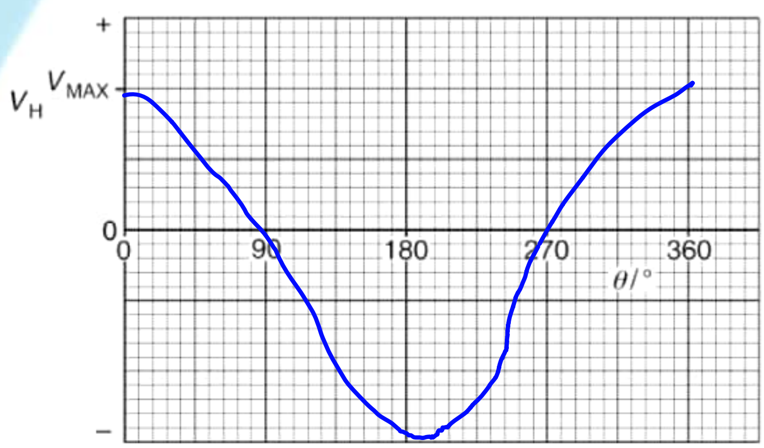


Fig. 9.2

[3]

[Total: 6]

(a) Define *magnetic flux density.*

$F = BqV$

$B = \frac{F}{qV}$, where F is the charged particle, q is charge of the particle, V is the velocity ⊥ to the field lines

[3]

(b) A stiff copper wire is balanced horizontally on a pivot, as shown in Fig. 8.1.

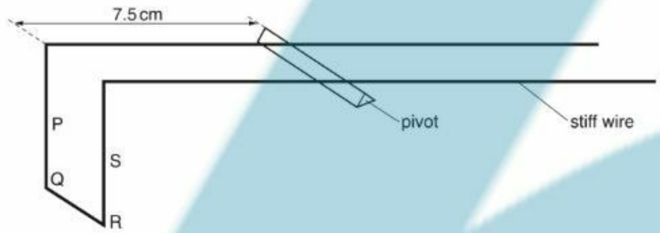


Fig. 8.1

Sections PQ, QR and RS of the wire are situated in a uniform magnetic field of flux density *B* produced between the poles of a permanent magnet.
The perpendicular distance of PQRS from the pivot is 7.5 cm.

When a current of 2.7 A is passed through the wire, a small mass of 45 mg is placed a distance 8.8 cm from the pivot in order to restore the balance of the wire, as shown in Fig. 8.2.

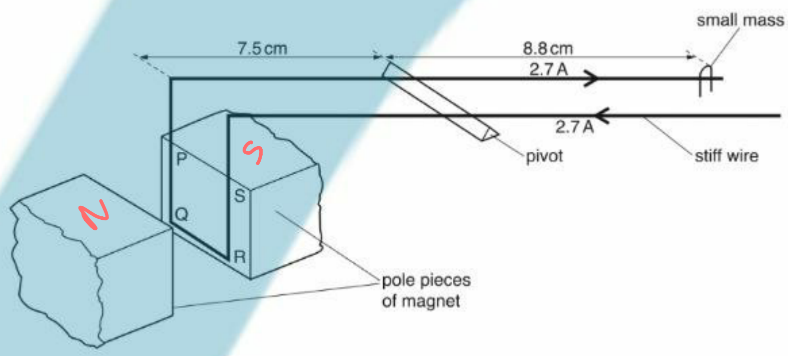


Fig. 8.2

(i) Explain why, when the current is switched on, the current in the sections PQ and RS of the wire does not affect the balance of the wire.

the force of PQ and SR, is equal but opposite, ∴ net force = 0

[2]

(ii) The length of section QR of the wire is 1.2 cm.
Calculate the magnetic flux density *B*.

$F_B = mg$

$\frac{7.5}{100} \times B \times 2.7 \times \frac{1.2}{100} = 45\times10^{-6} \times 9.81 \times \frac{8.8}{100}$

$B = 1.5987 \times 10^{-3}$

B = 1.6×10^{-3} T [3]