PROSPERITY ACADEMY

A2 PHYSCIS 9702

Crash Course

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MAGNETISM

COMPLETE NOTES

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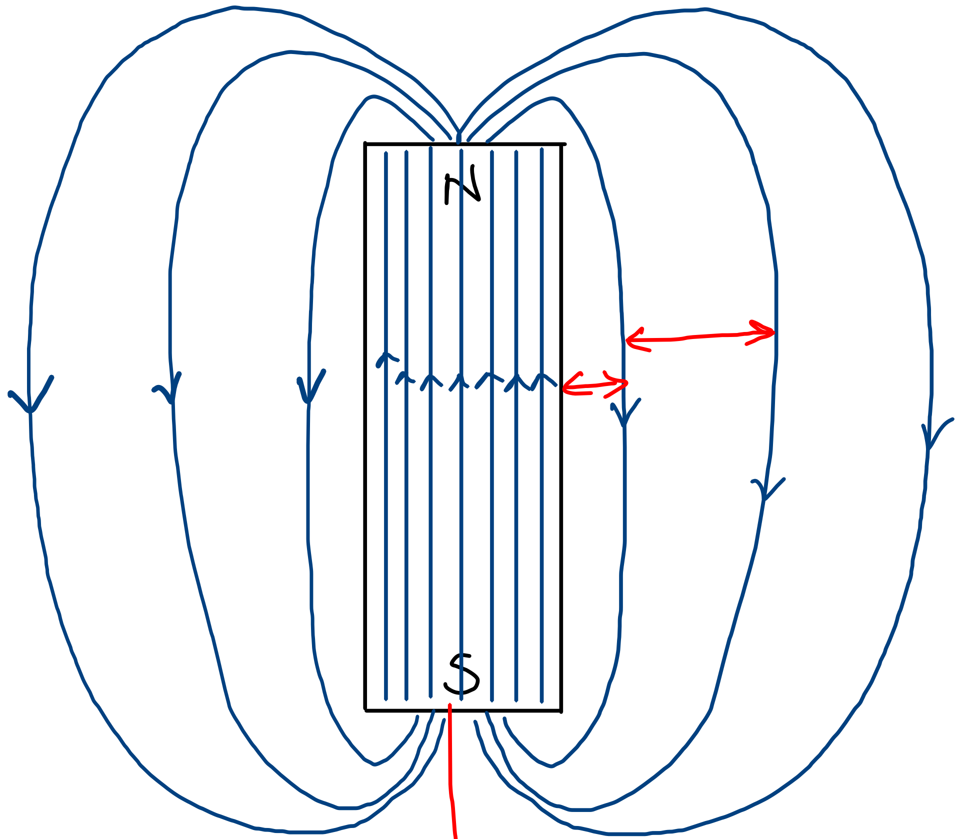
Magnetism:-

Magnetic fields:- A region or space where a current carrying conductor or a moving charge perpendicular to the field, or a permanent magnet or a magnetic material experiences a force.

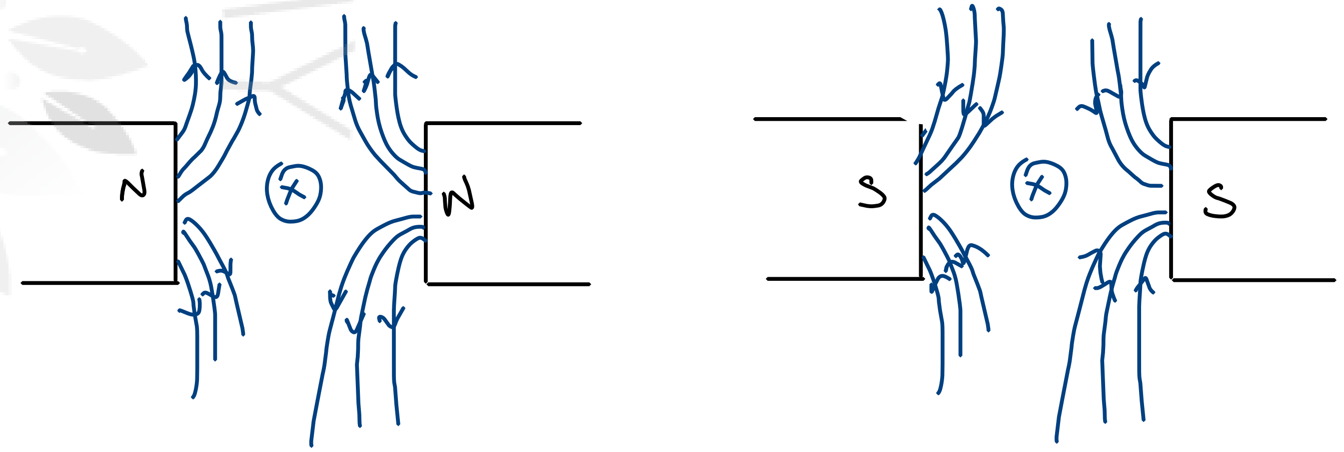


Moving away from the magnet, draw greater spaced lines as magnetic field gets weak further from the magnet.

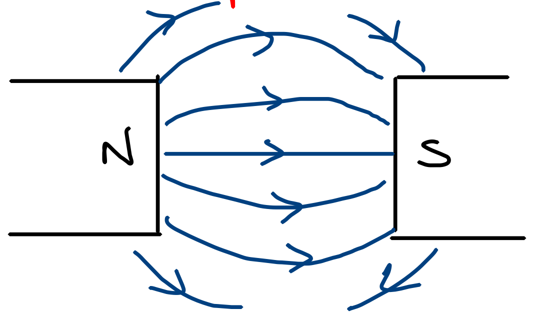
→ Inside magnet:- Uniform magnetic field

Points S → N

Like poles repel



Unlike poles attract



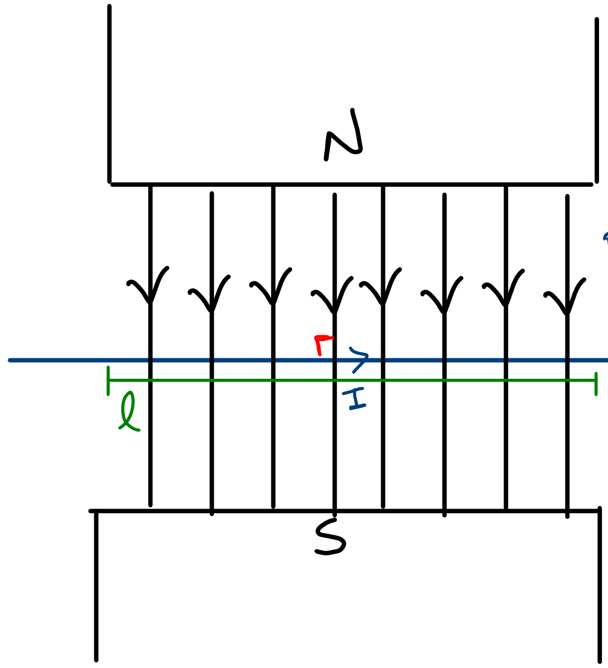
Magnetic field strength (B) :- Defined as:- (It is measured in Tesla (T))

1) Force acting per unit current, per unit length on a current carrying conductor placed perpendicular in a magnetic field.

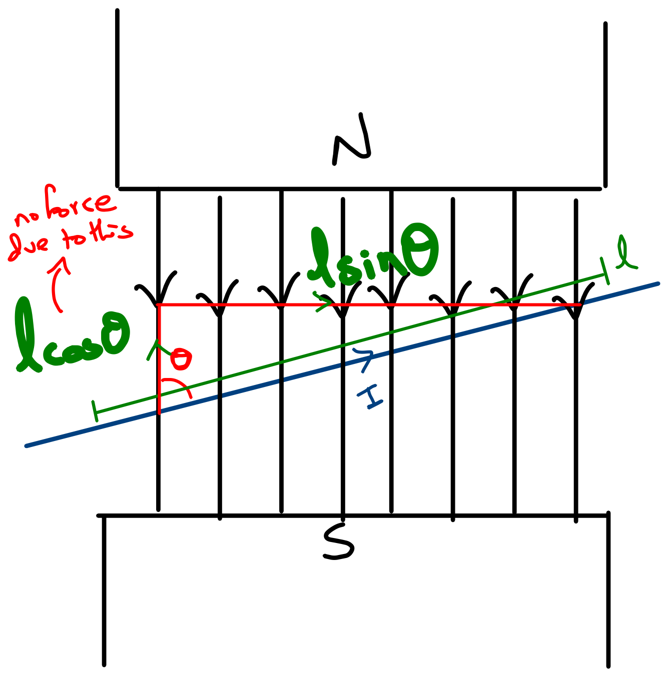
$$\boxed{B = \frac{F}{I \times l}} \Rightarrow \text{②} \boxed{F = BIl}$$

2) Force acting per unit charge, per unit velocity acting on a moving charge, moving perpendicular to the magnetic field.

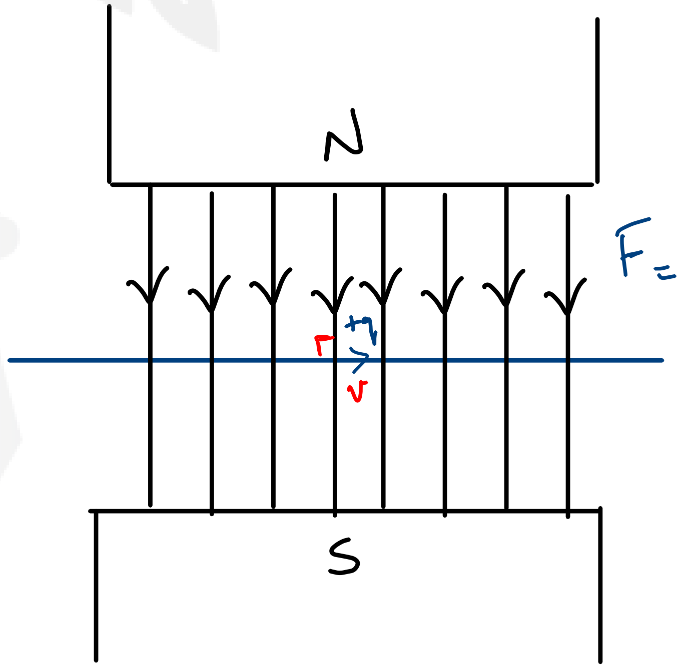
$$\boxed{B = \frac{F}{q \times v}} \Rightarrow \text{①} \boxed{F = Bqv}$$



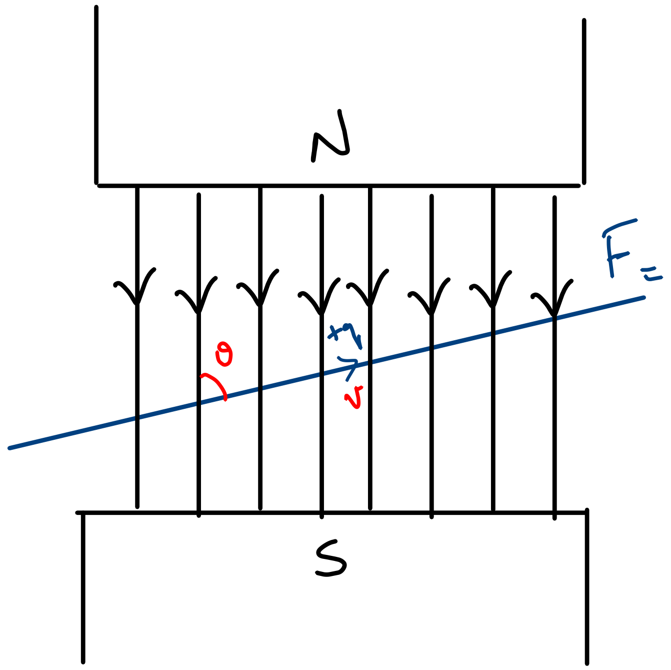
$F = BIl$



$F = BI\,l\sin\theta$



$F = Bqv$

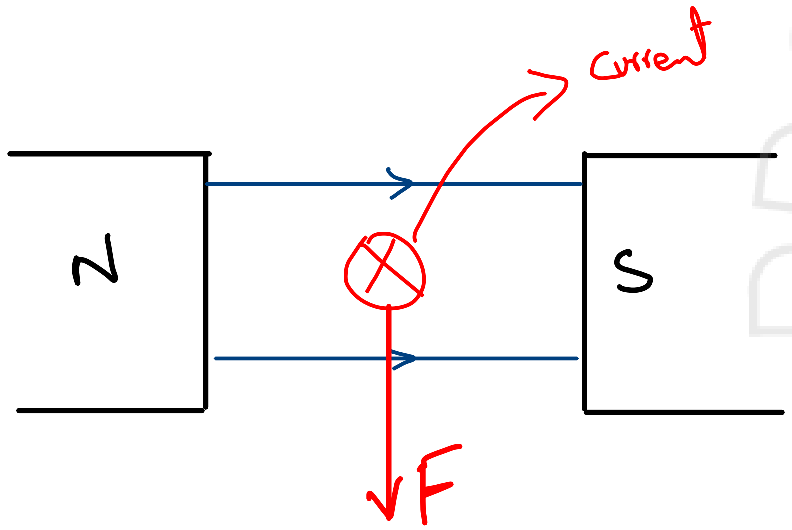


$F = Bqv\sin\theta$

Left Hand Flemming's rule:- Used when we Know

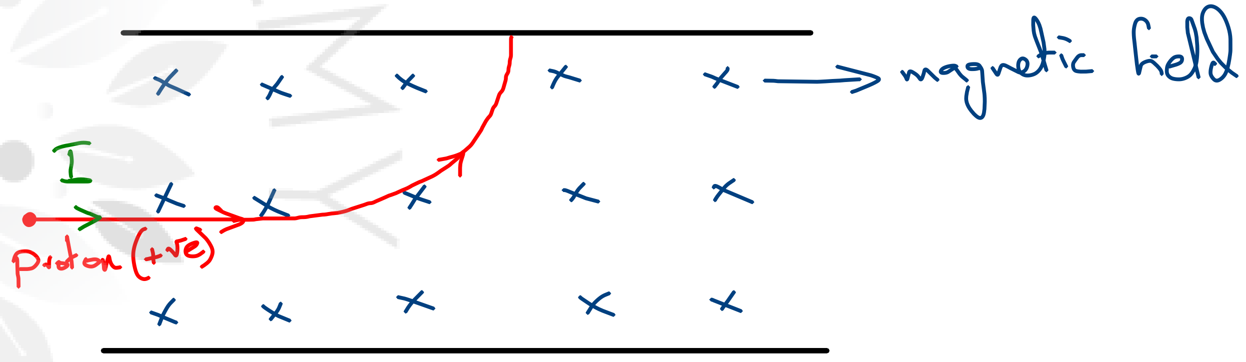
① Direction of the magnetic field (Pointer) ② Current (Middle finger)

and it will give you the direction of the Force (thumb)

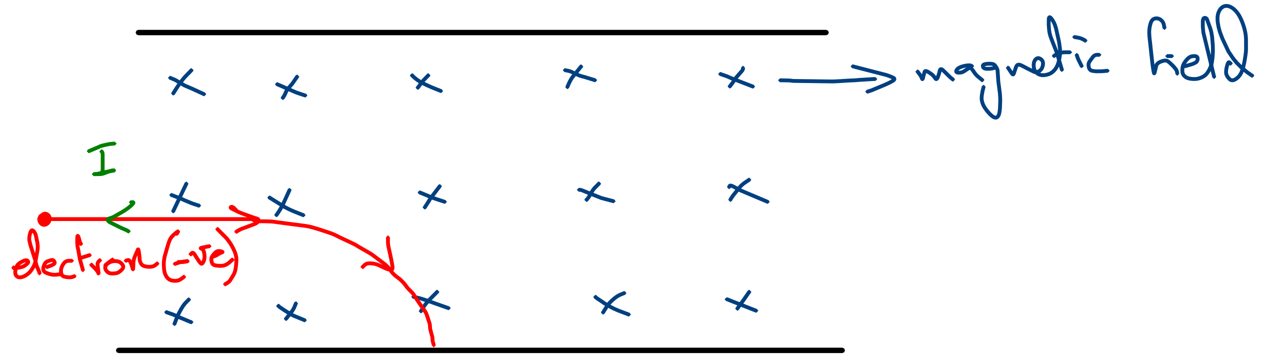


⊗ : into the page ⊙ : out of page

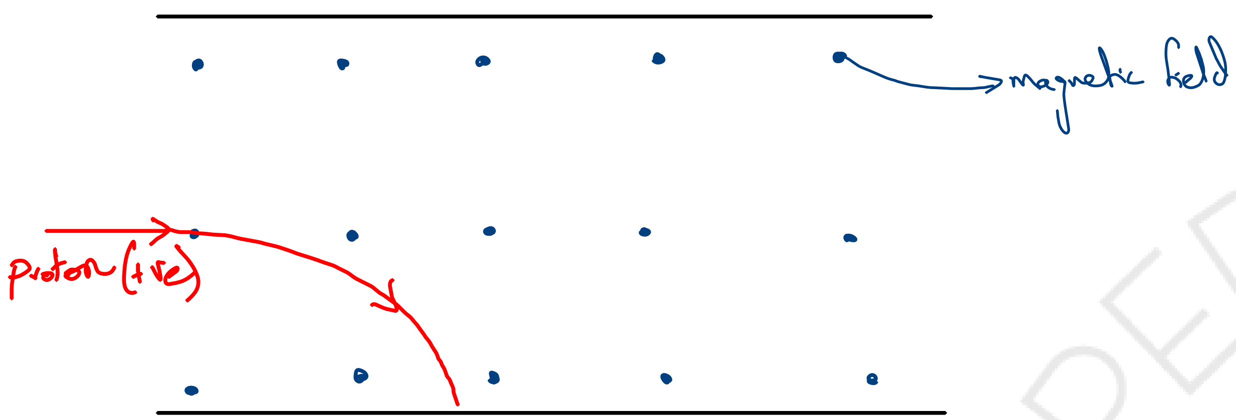
Current:- ⊕ → ⊖

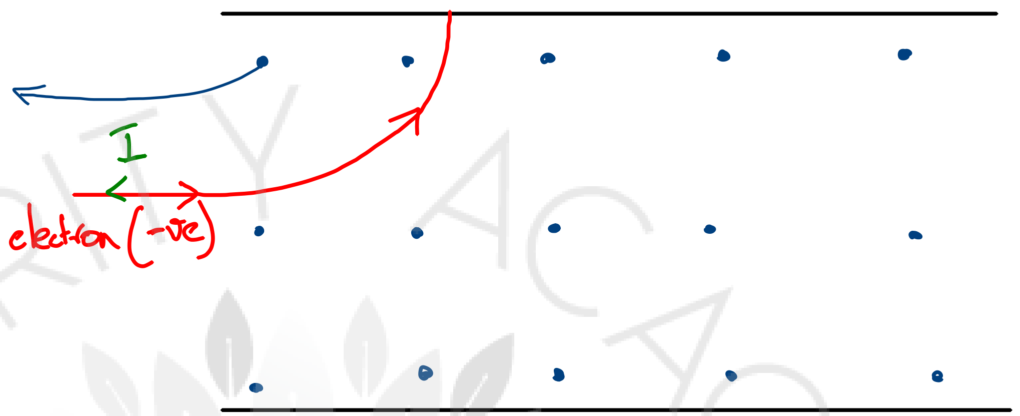


force will be upwards



force will be downwards





force will be downwards

force will be upwards

$1 = B = \frac{F}{I \times l} \rightarrow \frac{1N}{1A \times 1m}$

8 (a) Define the *tesla*.

The tesla is defined as a force of 1 N acting on a current carrying conductor placed perpendicular in a magnetic field carrying a current of 1 A and having a length of 1m in the magnetic field. [2]

(b) A stiff metal wire is used to form a rectangular frame measuring 8.0 cm × 6.0 cm. The frame is open at the top, and is suspended from a sensitive newton meter, as shown in Fig. 8.1.

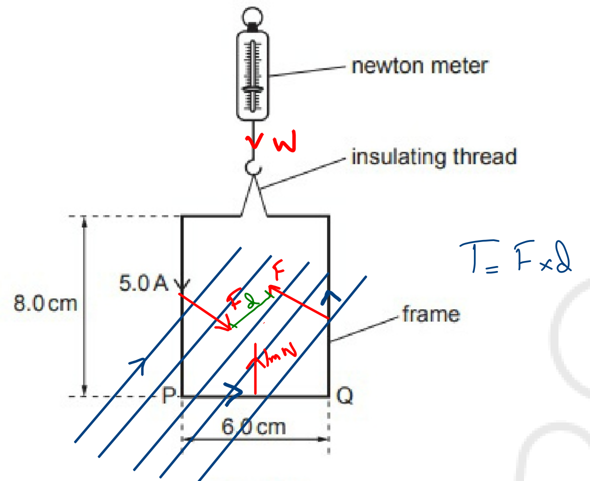
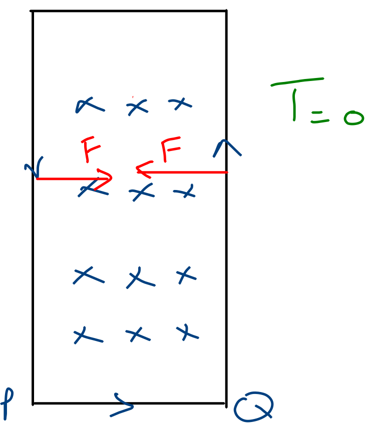
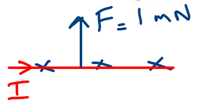


Fig. 8.1



The open ends of the frame are connected to a power supply so that there is a current of 5.0 A in the frame in the direction indicated in Fig. 8.1.

The frame is slowly lowered into a uniform magnetic field of flux density *B* so that all of side PQ is in the field. The magnetic field lines are horizontal and at an angle of 50° to PQ, as shown in Fig. 8.2.



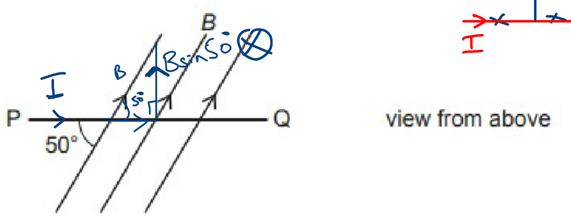


Fig. 8.2

When side PQ of the frame first enters the magnetic field, the reading on the newton meter changes by 1.0 mN.

(i) Determine the magnetic flux density *B*, in mT.

$F = BIl\sin\theta$

$(1\times10^{-3}) = B(5)(6\times10^{-2})\sin 50°$

$B = \frac{(1\times10^{-3})}{5(6\times10^{-2})\sin 50°} = 4.531\times10^{-3}$

B = 4.5 mT [2]

(ii) State, with a reason, whether the change in the reading on the newton meter is an increase or a decrease.

Using Left hand flemming's rule, the direction of the force due to the magnetic field is upward so reading is a decrease [1]

(iii) The frame is lowered further so that the vertical sides start to enter the magnetic field.

Suggest what effect this will have on the frame.

The frame will rotate until PQ becomes perpendicular. [1]

[Total: 6]

field strength

6 **(a)** A uniform magnetic field has constant flux density B. A straight wire of fixed length carries a current I at an angle θ to the magnetic field, as shown in Fig. 6.1.

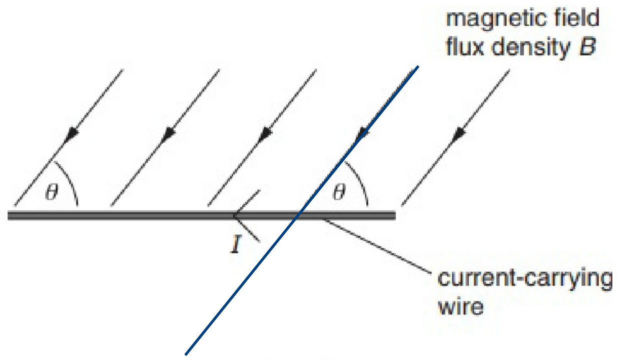
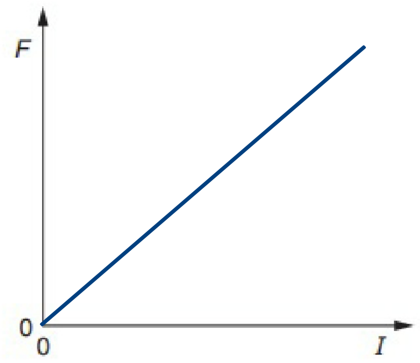


Fig. 6.1

(i) The current I in the wire is changed, keeping the angle θ constant.
On Fig. 6.2, sketch a graph to show the variation with current I of the force F on the wire.



$$F = \overset{\text{const}}{B} I \overset{\text{const}}{l} \underbrace{\sin\theta}_{\text{const}}$$

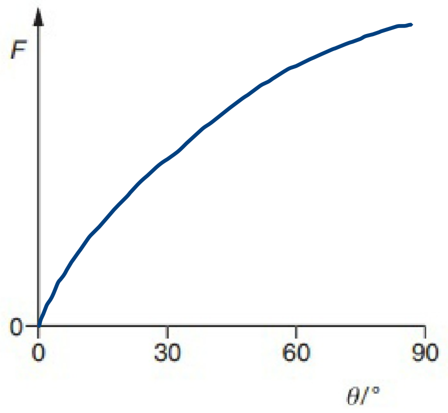
$$F \propto I$$

$$y \propto x$$

Fig. 6.2

[2]

(ii) The angle θ between the wire and the magnetic field is now varied. The current I is kept constant.
On Fig. 6.3, sketch a graph to show the variation with angle θ of the force F on the wire.

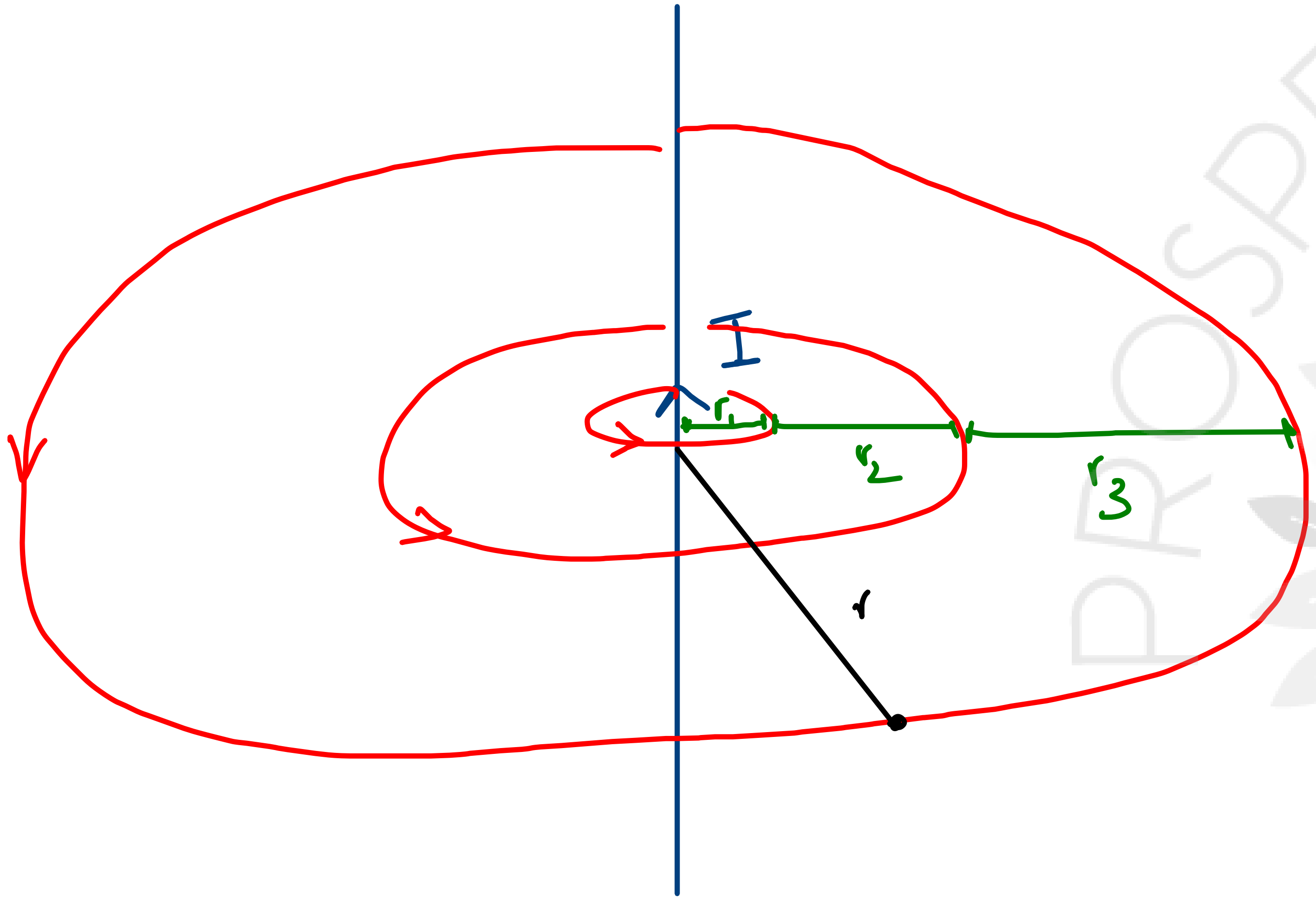


$$F = \overset{\text{const}}{\overline{BIl}} \sin\theta$$

$$F \propto \sin\theta$$

Fig. 6.3 [3]

Right Hand thumb rule :-



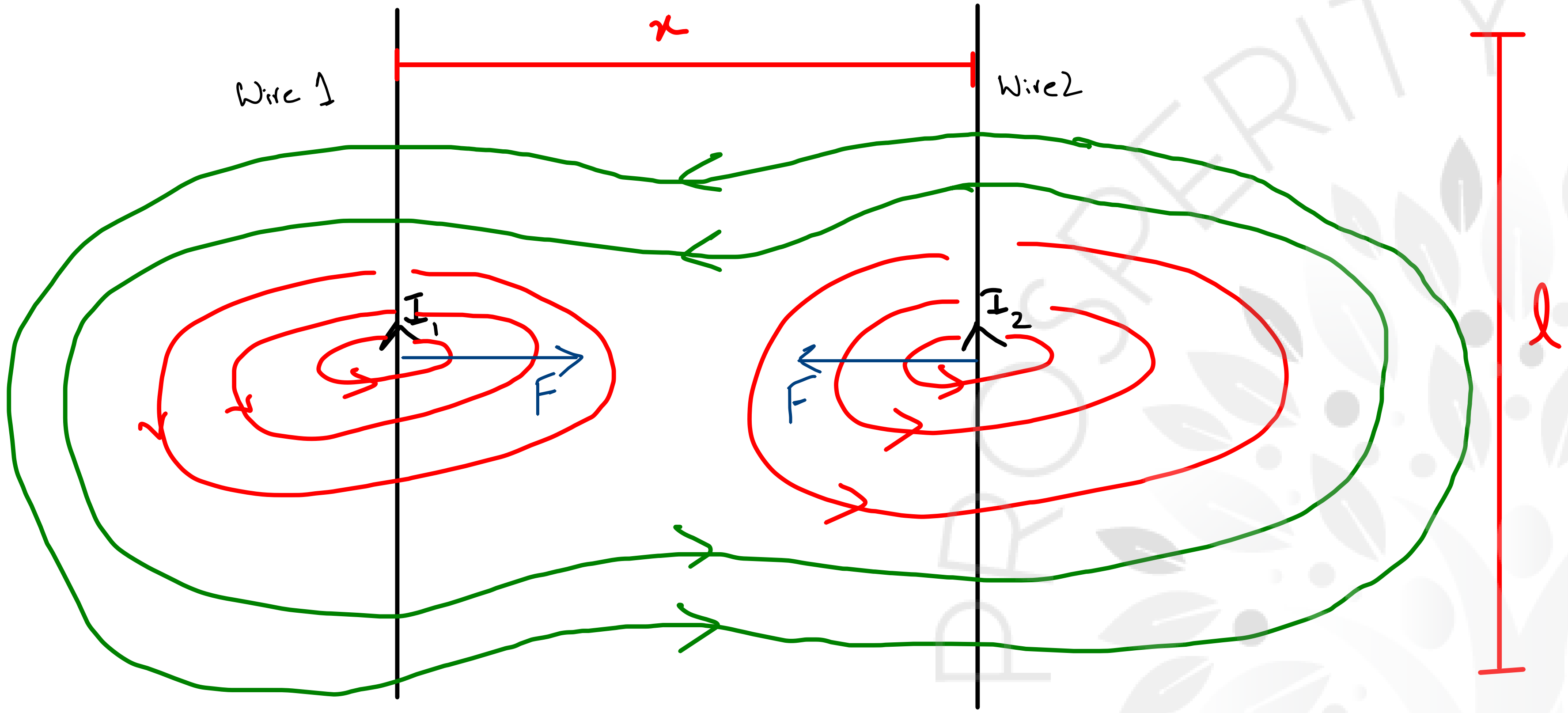
$$\boxed{B = \frac{\mu_0 I}{2\pi r}}$$

μ_0 :- $4\pi \times 10^{-7}$ Hm^{-1}

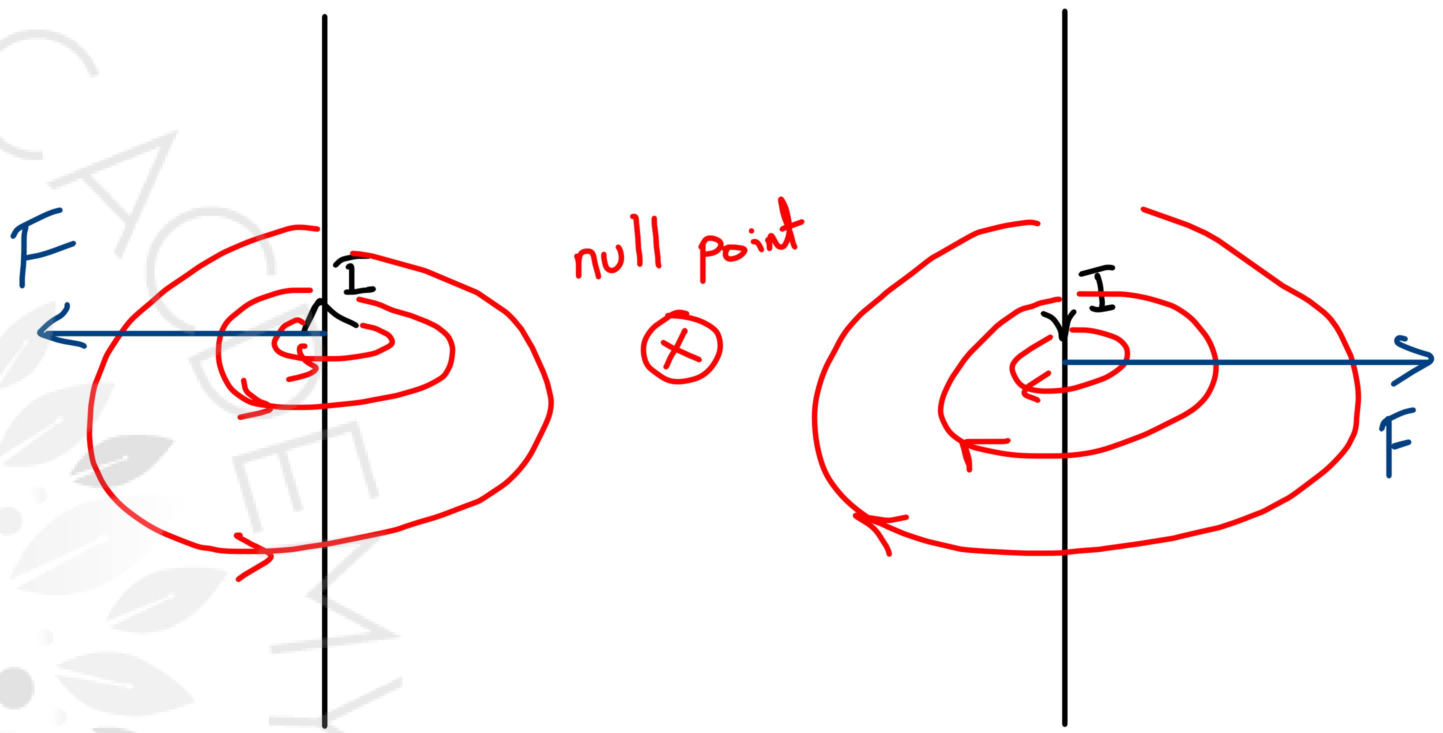
thumb : current

fingers: magnetic field

Force between 2 current carrying conductors:-



Like currents



Unlike currents

The B at wire 2 due to wire 1

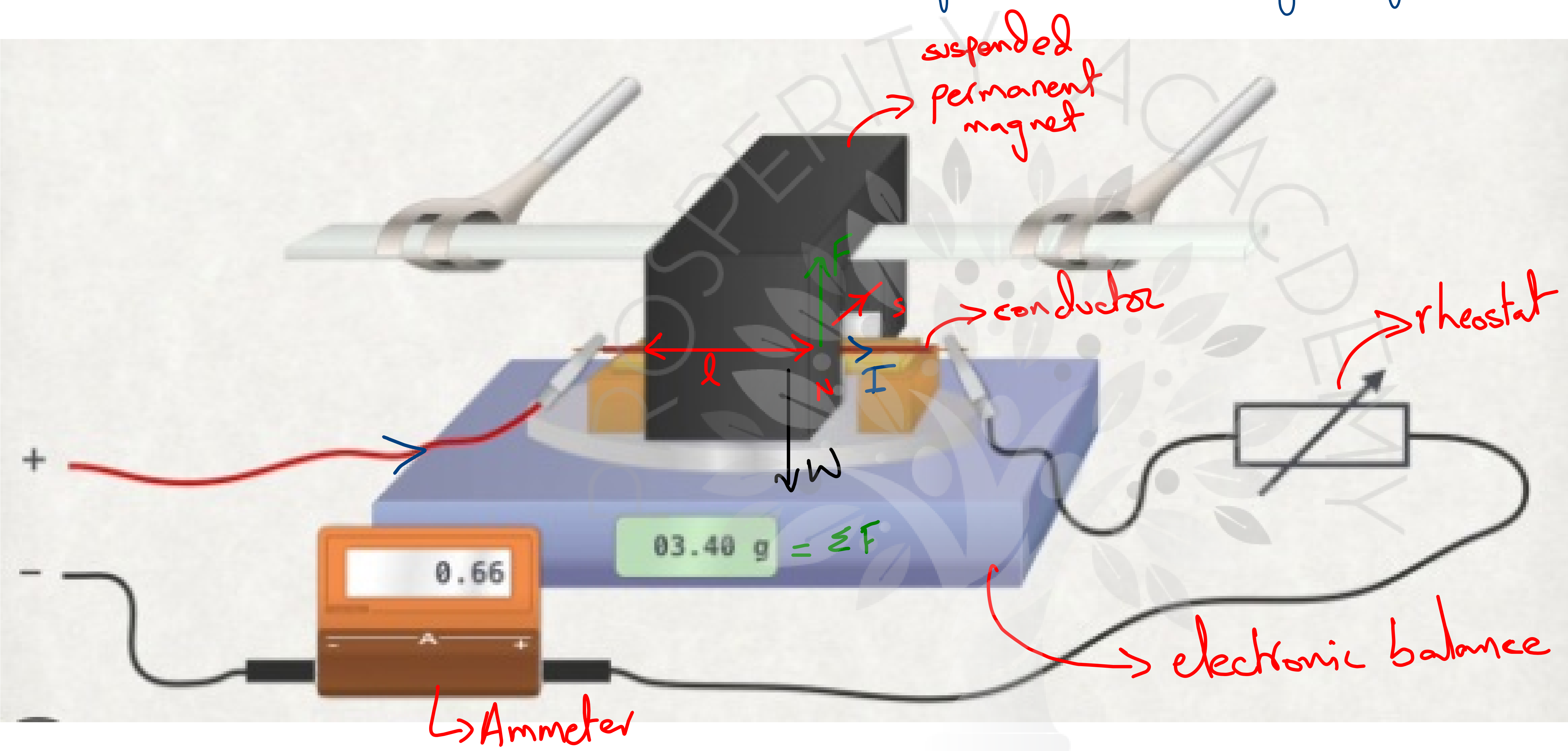
$$B_1 = \frac{\mu_0 I_1}{2\pi x}$$

Forces are same because

$$F = B_1 I_2 l \Rightarrow \boxed{F = \frac{\mu_0 I_1}{2\pi x} \times I_2 \times l} \Rightarrow F \propto I_1 \times I_2$$

or Newton's 3rd law

Current Balance :- Used to measure the magnetic field strength of a magnet.



$\Sigma F = W - F_{mag}$ ⟹ $F_{mag} = B\,I\,l$

8 **(a)** A long straight vertical wire carries a current I. The wire passes through a horizontal card EFGH, as shown in Fig. 8.1 and Fig. 8.2.

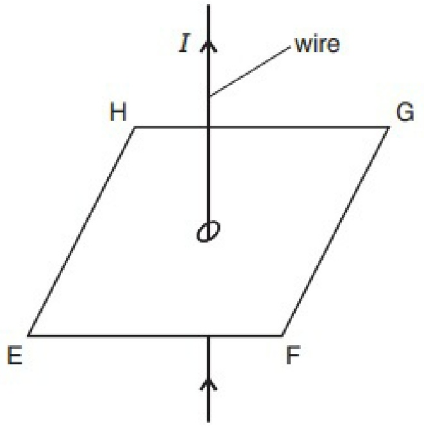
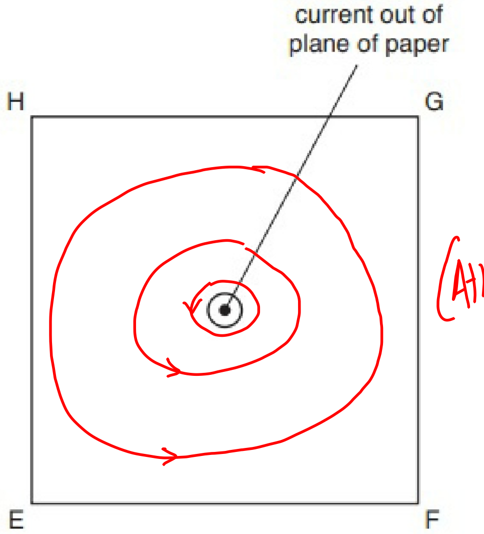


Fig. 8.1



(Atleast 3)

Fig. 8.2 (view from above)

On Fig. 8.2, draw the pattern of the magnetic field produced by the current-carrying wire on the plane EFGH. 3 [3]

(b) Two long straight parallel wires P and Q are situated a distance 3.1 cm apart, as illustrated in Fig. 8.3.

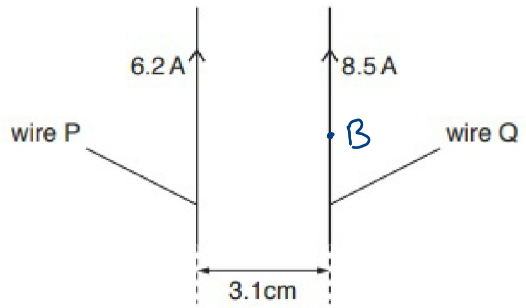


Fig. 8.3

The current in wire P is 6.2 A. The current in wire Q is 8.5 A.

The magnetic flux density B at a distance x from a long straight wire carrying current I is given by the expression

$$B = \frac{\mu_0 I}{2\pi x}$$

where μ_0 is the permeability of free space.

Calculate:

(i) the magnetic flux density at wire Q due to the current in wire P

$$B = \frac{\mu_0 I_P}{2\pi x} = \frac{\overset{2}{\cancel{4\pi}} \times 10^{-7} \times 6.2}{\cancel{2\pi}\,(3.1\times10^{-2})}$$

$$= 4.0\times10^{-5}$$

flux density = 4.0×10^{-5} T [2]

(ii) the force per unit length, in $N\,m^{-1}$, acting on wire Q due to the current in wire P.

$$F = B I_Q l \Rightarrow \frac{F}{l} = B \times I_Q$$

$$= (4\times10^{-5})\times 8.5$$

$$= 3.4\times10^{-4}\ N m^{-1}$$

force per unit length = 3.4×10^{-4} $N\,m^{-1}$ [2]

(c) The currents in wires P and Q are different in magnitude.

State and explain whether the forces per unit length on the two wires will be different.

They will be same as Newton's 3rd law states / because the force is directly proportional to the product of the currents in the wires. [2]

[Total: 9]

s20 qp41 q8

$(1)\ B = \frac{F\,(1)}{I\ l}$ (1) (1)

8 (a) Define the *tesla*.

....

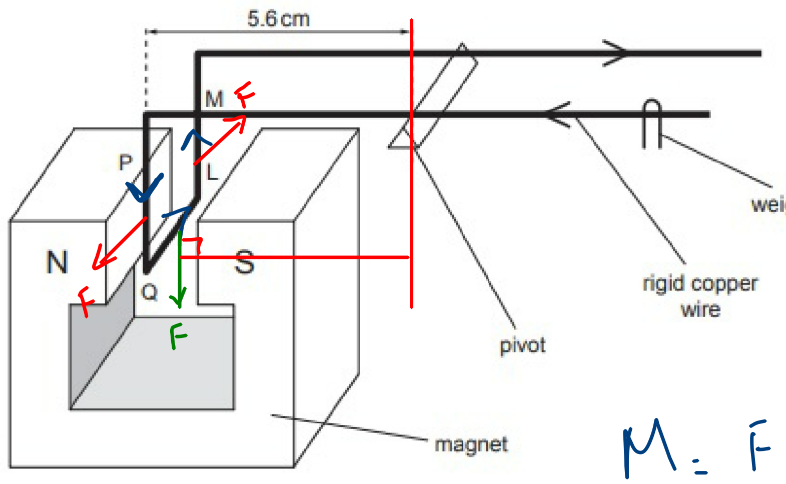
....

....

.... [3]

(b) A magnet produces a uniform magnetic field of flux density B in the space between its poles.

A rigid copper wire carrying a current is balanced on a pivot. Part PQLM of the wire is between the poles of the magnet, as illustrated in Fig. 8.1.



$M = F \times \perp d$

Fig. 8.1 (not to scale)

The wire is balanced horizontally by means of a small weight W.

The section of the wire between the poles of the magnet is shown in Fig. 8.2.

$\Sigma F = 0$

$\Sigma m = 0$

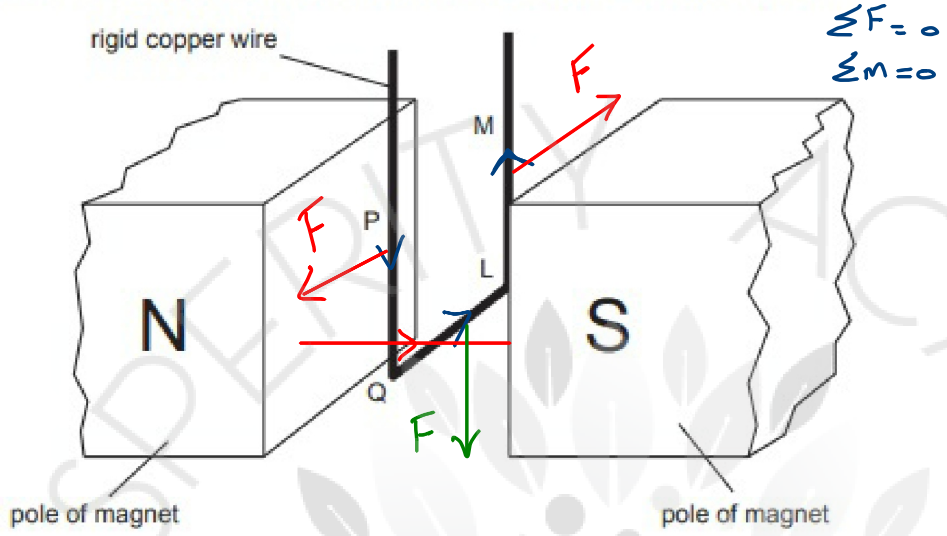


Fig. 8.2 (not to scale)

Explain why:

(i) section QL of the wire gives rise to a moment about the pivot

There is a vertical downward force in QL as it is placed perpendicular in the magnetic field. The force has a perpendicular distance from the pivot and so produces a moment [3]

(ii) sections PQ and LM of the wire do not affect the equilibrium of the wire.

Because the currents in them are in the opposite directions, so the forces in them are also opposite in direction and equal in magnitude. Therefore these 2 forces cancel out each other as well the respective moments [2]

(c) Section QL of the wire has length 0.85 cm.

The perpendicular distance of QL from the pivot is 5.6 cm.

When the current in the wire is changed by 1.2 A, W is moved a distance of 2.6 cm along the wire in order to restore equilibrium. The mass of W is 1.3×10^{-4} kg.

(i) Show that the change in moment of W about the pivot is 3.3×10^{-5} N m.

$M = F \times \perp d$

$= (1.3\times10^{-4})(9.81) \times (2.6\times10^{-2})$

$= 3.3\times10^{-5}$ [2]

(ii) Use the information in **(i)** to determine the magnetic flux density B between the poles of the magnet.

$\Delta M_{acw} = \Delta M_{cw}$

$3.3\times10^{-5} = \Delta F \times \perp d$

$3.3\times10^{-5} = B\times\Delta I\times l \times \perp d$

$3.3\times10^{-5} = B\times(1.2)\times(0.85\times10^{-2})\times(5.6\times10^{-2})$

$B = 0.058$

$B =$ .... 0.058 .... T [3]

[Total: 13]

m19 qp42 q8

8 A horseshoe magnet is placed on a top pan balance. A rigid copper wire is fixed between the poles of the magnet, as illustrated in Fig. 8.1.

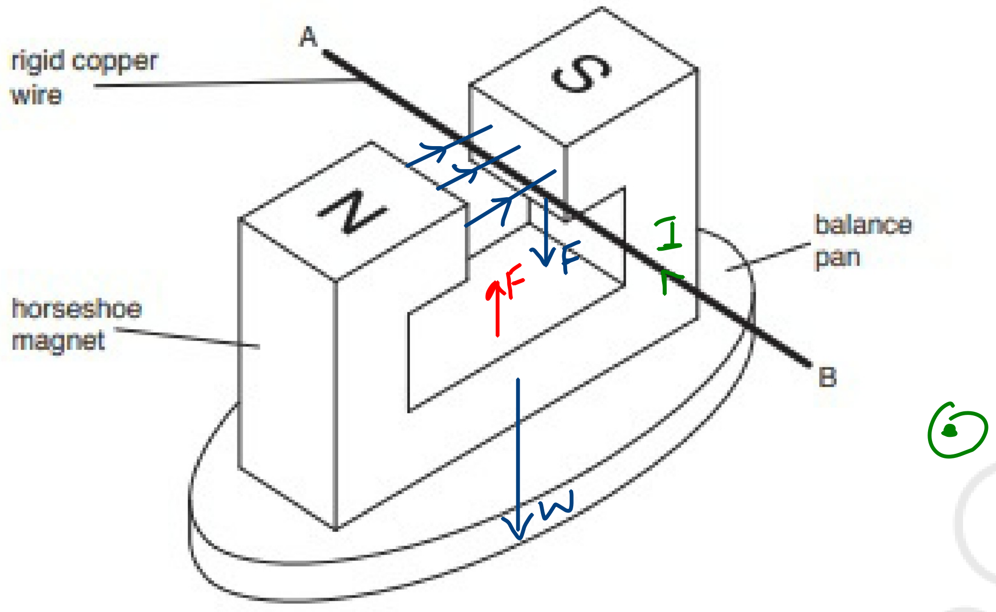


Fig. 8.1

The wire is clamped at ends A and B.

(a) When a direct current is switched on in the wire, the reading on the balance is seen to **decrease**.

State and explain the direction of:

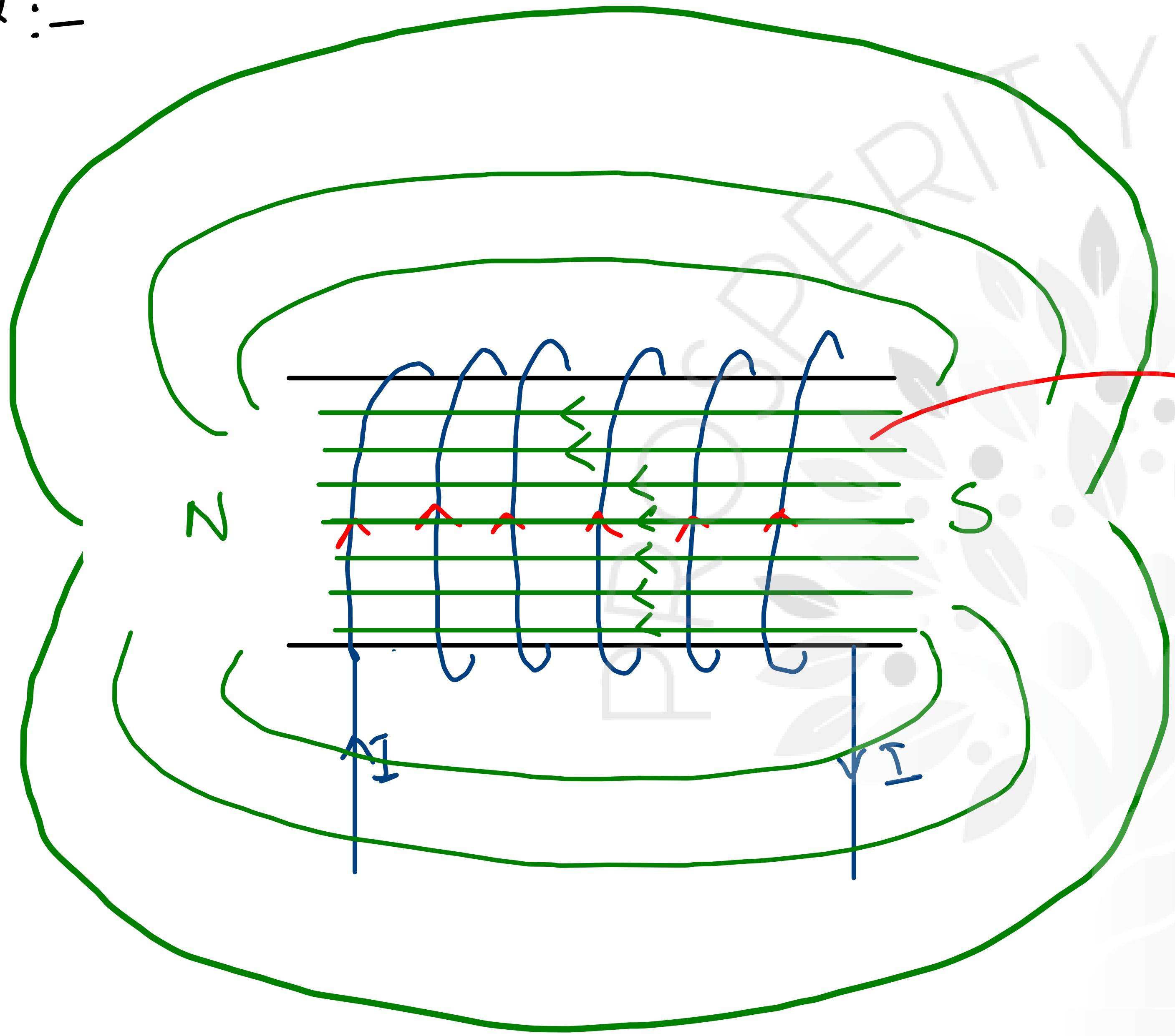
(i) the force acting on the wire

The magnetic force on the magnet must be upwards as the reading decreased. Using Newton's 3rd law, the force on the wire must be equal but downwards [3]

(ii) the current in the wire.

Current is B to A, as indicated by Left hand Flemming's rule. [2]

Solenoid:-



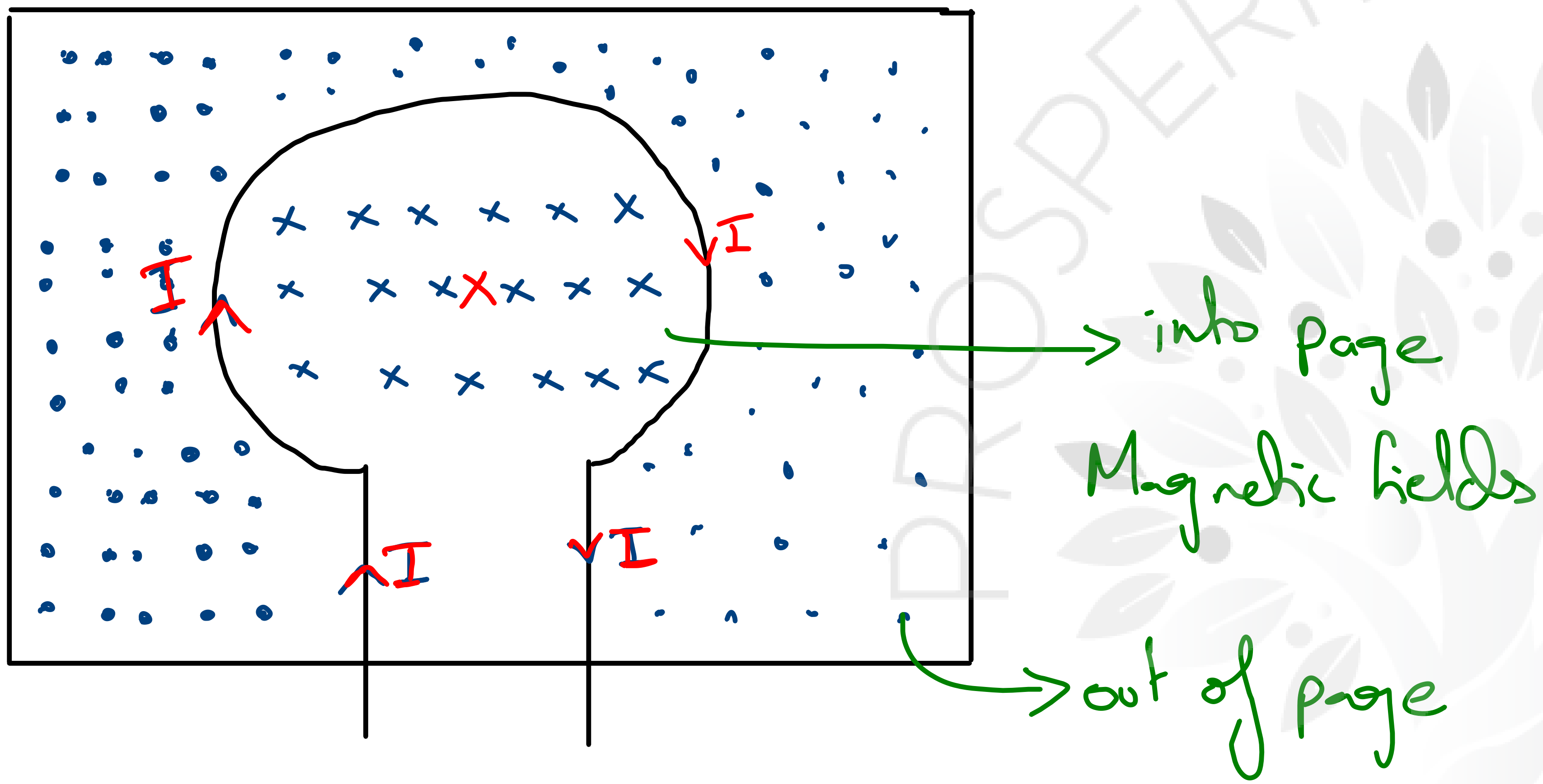
Inside:-
Uniform magnetic field

$$B_{inside} = \mu_0 \times \underbrace{n}_{\text{no. of turns per unit length}} \times I$$

$$n = \frac{\text{no. of turns on the solenoid}}{\text{length of the solenoid}}$$

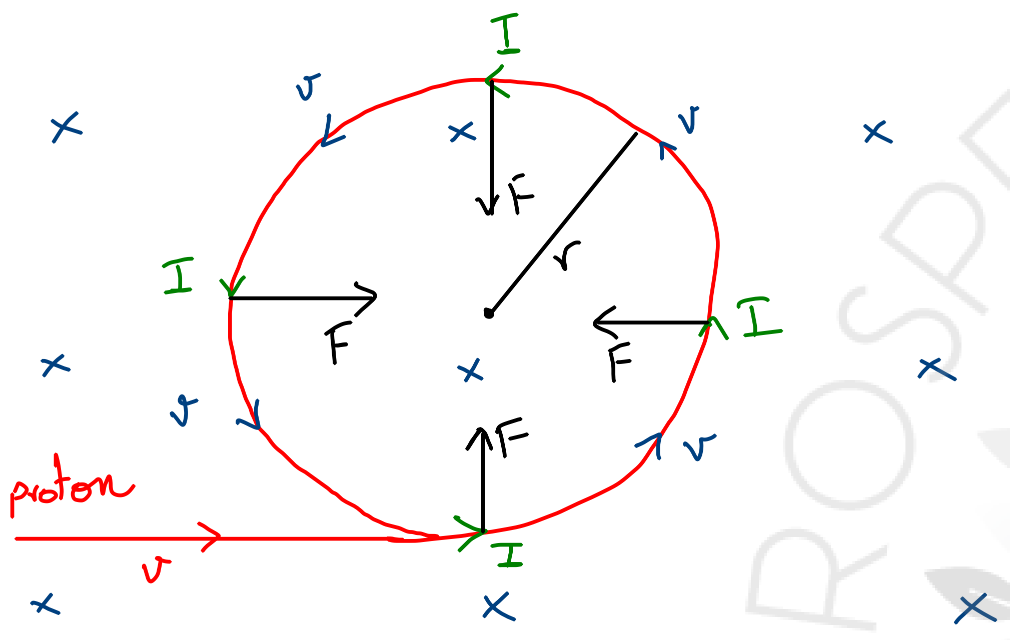
Right hand grip rule:-
1) Current → fingers
2) thumb → North pole

Single loop of wire :-



$$B_x \text{ (at centre)} = \frac{\mu_0 I}{2r}$$

Charges in a magnetic field :-



A moving charge will experience circular motion in a uniform magnetic field

$$F_{mag} = F_c$$

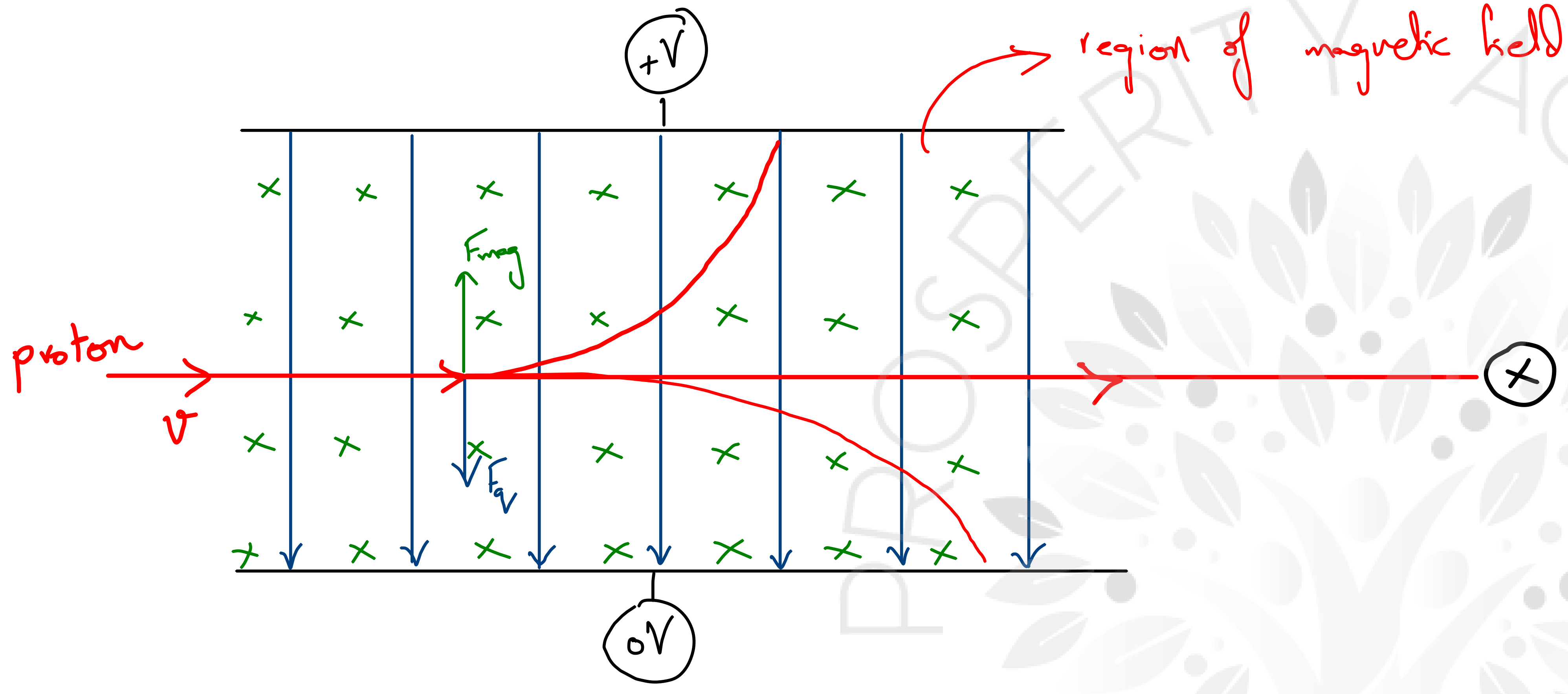
$$Bq\cancel{v} = \frac{mv^{\cancel{2}}}{r}$$

$$\boxed{r = \frac{mv}{Bq}}$$

radius of circular motion

Velocity selection:-

region of magnetic field + electric field = cross field



* Helmholtz coil is used to produce magnetic field.

$$E = \frac{V}{d} = \frac{F}{q}$$

$$F_q = \frac{Vq}{d}$$

$$F_{mag} = Bqv$$

$$F_{mag} = \mu_0 \times n \times I \times q \times v$$

Using voltage vary F_q

Using current vary F_{mag}

If particle is undeviated:-

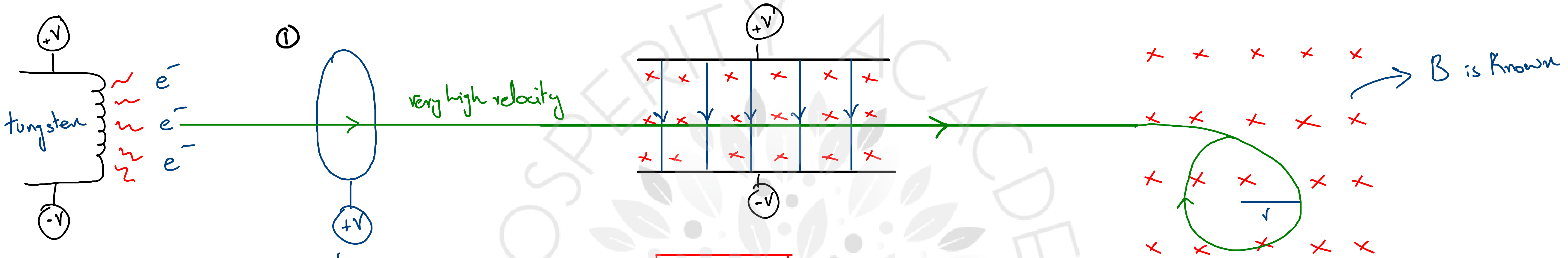
$$F_q = F_{mag}$$

$$\frac{V\cancel{q}}{d} = B\cancel{q}v$$

$$v = \underbrace{\frac{V}{d}}_{E} \times \frac{1}{B}$$

$$\boxed{v = \frac{E}{B}}$$

Fine tube experiment :- (this was used to find q/m ratio of an electron)



thermionic emission

large +ve DC voltage

$$\boxed{v = \frac{E}{B}}$$

electron starts performing circular motion

$$W = Vq = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2Vq}{m}}$$

Measure radius through a travelling microscope

$$F_c = F_{mag}$$

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

$$\boxed{\frac{v}{Br} = \frac{q}{m}}$$

8 (a) State what is meant by a *magnetic field*.

....

....

....[2]

(b) A particle of charge $+q$ and mass m is travelling in a vacuum with speed v. The particle enters, at a right angle, a uniform magnetic field of flux density B, as shown in Fig. 8.1.

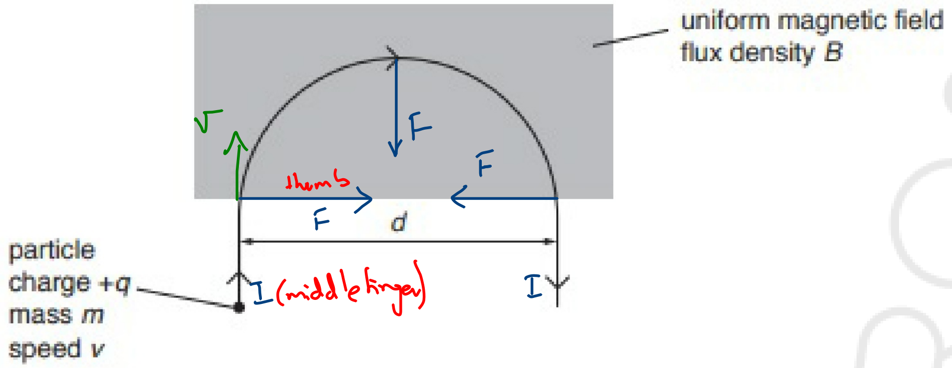


Fig. 8.1

The particle leaves the field after following a semi-circular path of diameter d.

(i) State the direction of the magnetic field.

out of the page [1]

(ii) Explain why the speed of the particle is not affected by the magnetic field.

The magnetic force provides the centripetal force which is always normal to velocity thus no component of the centripetal acceleration acts in the direction of velocity [2]

(iii) Show that the diameter d of the semi-circular path is given by the expression

$$d = \frac{2mv}{Bq}.$$

$$F_{mag} = F_c$$

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

[2]

(iv) Use the expression in **(b)(iii)** to show that the time T_F spent in the field by the particle is independent of its speed v.

$$v = \frac{d}{t} \rightarrow \frac{1}{2} \text{ circumference} \qquad C = 2\pi r \text{ or } \pi d$$

$$T_F = \frac{\frac{1}{2} \times \pi d}{v} \Rightarrow \frac{\frac{1}{\cancel{2}} \times \pi \times \frac{\cancel{2}m\cancel{v}}{Bq}}{\cancel{v}} \Rightarrow T_F = \frac{\pi m}{Bq}$$

[2]

[Total: 9]

9 **(a)** State what is meant by a *field of force*.

....

....

.... [2]

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

....

....

....

....

....

.... [4]

(c) A beam of charged particles enters a region of uniform magnetic and electric fields, as illustrated in Fig. 9.1.

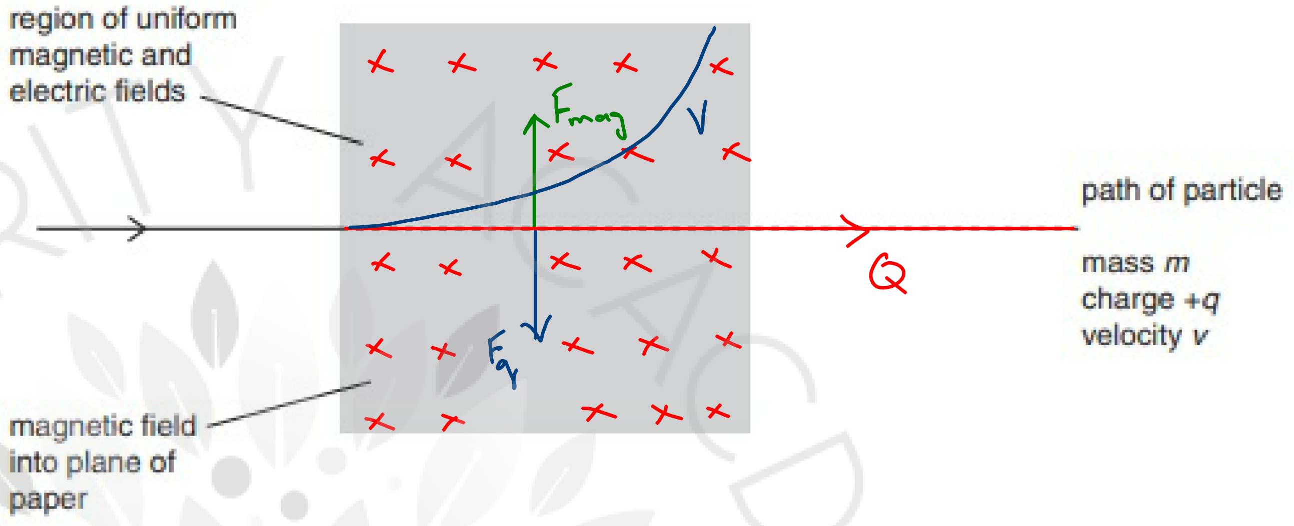


Fig. 9.1

The direction of the magnetic field is into the plane of the paper. The velocity of the charged particles is normal to the magnetic field as the particles enter the field.

A particle in the beam has mass m, charge $+q$ and velocity v. The particle passes undeviated through the region of the two fields.

On Fig. 9.1, sketch the path of a particle that has

(i) mass m, charge $+2q$ and velocity v (label this path Q), [1]

(ii) mass m, charge $+q$ and velocity slightly larger than v (label this path V). [2]

[Total: 9]

$F_q = \frac{Vq}{d}$ $\uparrow F_{mag} = Bqv\uparrow$

$F_q = \frac{Vq}{d}$ $F_{mag} = Bqv$

$2F_q = \frac{V(2q)}{d}$ $2F_{mg} = B(2q)v$

8 An electron is travelling in a vacuum at a speed of $3.4 \times 10^7\,\text{m s}^{-1}$. The electron enters a region of uniform magnetic field of flux density 3.2 mT, as illustrated in Fig. 8.1.

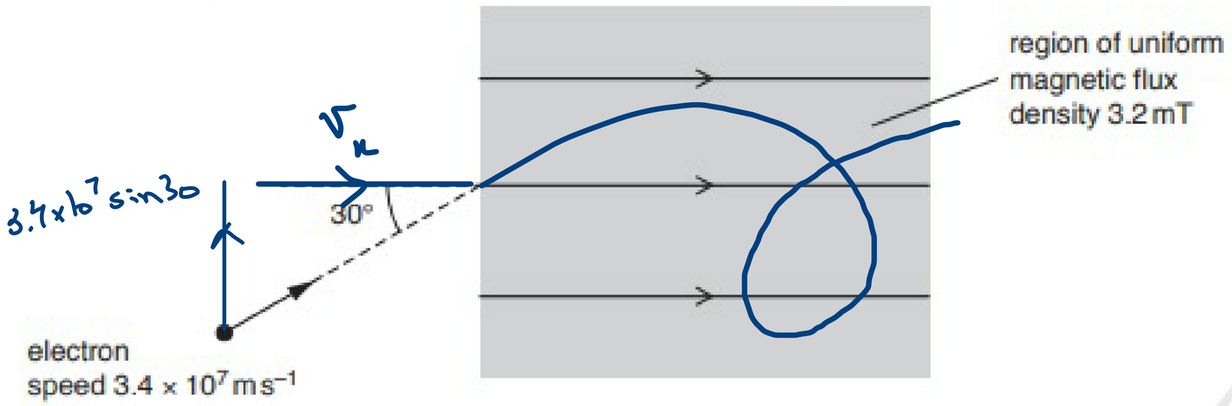


Fig. 8.1

The initial direction of the electron is at an angle of 30° to the direction of the magnetic field.

(a) When the electron enters the magnetic field, the component of its velocity v_N normal to the direction of the magnetic field causes the electron to begin to follow a circular path.

Calculate:

(i) v_N

$v_N = 3.4 \times 10^7 \times \sin 30$

$v_N =$ 1.7×10^7 m s^{-1} [1]

(ii) the radius of this circular path.

$F_c = F_{mag}$

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

$r = \frac{mv}{Bq}$

$$\frac{(9.1\times10^{-31})(1.7\times10^{7})}{(3.2\times10^{-3})(1.6\times10^{-19})}$$

$= 0.0322$

radius = 0.032 m [3]

(b) State the magnitude of the force, if any, on the electron in the magnetic field due to the component of its velocity along the direction of the field.

zero [1]

(c) Use information from **(a)** and **(b)** to describe the resultant path of the electron in the magnetic field.

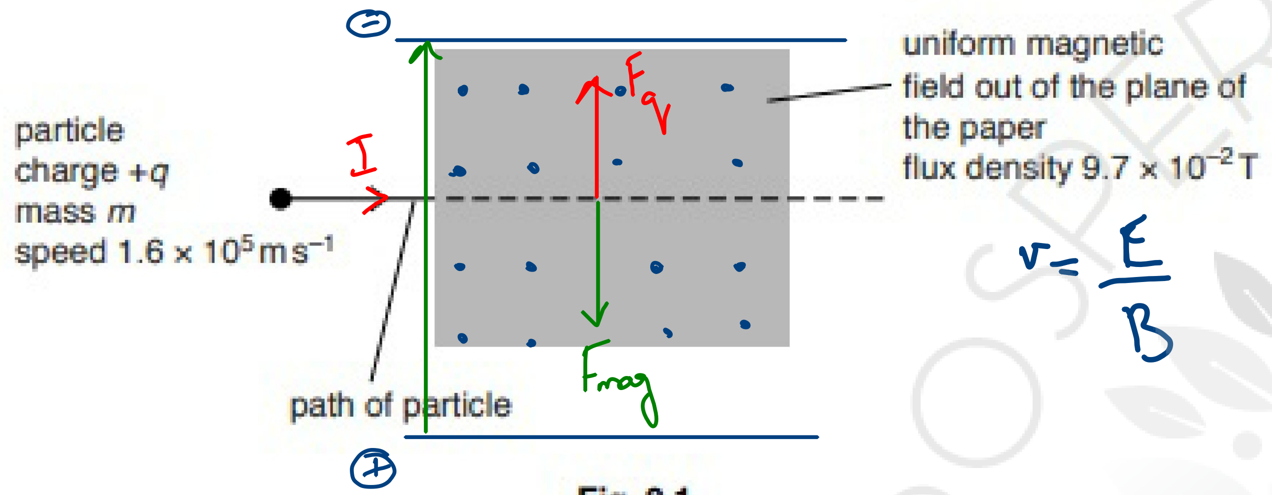
helix / coil (shown in diagram)

[1]

[Total: 6]

m16 qp42 q9

9 A particle of charge $+q$ and mass m is travelling with a constant speed of $1.6 \times 10^5\,\mathrm{m\,s^{-1}}$ in a vacuum. The particle enters a uniform magnetic field of flux density $9.7 \times 10^{-2}\,\mathrm{T}$, as shown in Fig. 9.1.



$$v = \frac{E}{B}$$

Fig. 9.1

The magnetic field direction is perpendicular to the initial velocity of the particle and perpendicular to, and out of, the plane of the paper.

A uniform electric field is applied in the same region as the magnetic field so that the particle passes undeviated through the fields. $F_q = F_{mag}$

(a) State and explain the direction of the electric field.

It must be upwards as the magnetic force is downwards. So the electric force must be equal and opposite hence electric field is upwards ..... [2]

(b) Calculate the magnitude of the electric field strength.

Explain your working.

$F_q = F_{mag}$

$\frac{V\cancel{q}}{d} = B\cancel{q}v$

$v = \frac{V}{d} \times \frac{1}{B} \Rightarrow v = \frac{E}{B}$

$1.6 \times 10^5 = \frac{E}{9.7 \times 10^{-2}}$

$E = 15520$

electric field strength = 16000 $\mathrm{V\,m^{-1}}$ [3]

(c) The electric field is now removed so that the positively-charged particle follows a curved path in the magnetic field. This path is an arc of a circle of radius 4.0 cm.

Calculate, for the particle, the ratio $\frac{q}{m}$.

$F_{mag} = F_c$

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

$\frac{q}{m} = \frac{v}{Br}$

$\frac{1.6 \times 10^5}{(9.7 \times 10^{-2})(4 \times 10^{-2})} = \frac{q}{m}$

$\frac{q}{m} = 4.1 \times 10^7$

ratio = 4.1×10^7 $\mathrm{C\,kg^{-1}}$ [3]

(d) The particle has a charge of $3e$ where e is the elementary charge.

(i) Use your answer in **(c)** to determine the mass, in u, of the particle.

$\frac{q}{m} = 4.1 \times 10^7$

$\frac{3 \times (1.6 \times 10^{-19})}{m} = 4.1 \times 10^7$

$m = 1.17 \times 10^{-26}\ \mathrm{kg}$

$1.66 \times 10^{-27}\ \mathrm{kg} : 1u$

$1.17 \times 10^{-26}\ \mathrm{kg} : x\,u$

$x = 7$

mass = 7 u [2]

(ii) The particle is the nucleus of an atom. State the number of protons and the number of neutrons in this nucleus.

number of protons = 3

number of neutrons = 4

[1]

[Total: 11]

8 **(a)** Define *magnetic flux density* (B)

....

....

.... [2]

(b) Electrons, each of mass *m* and charge *q*, are accelerated from rest in a vacuum through a potential difference *V*.

Derive an expression, in terms of *m*, *q* and *V*, for the final speed *v* of the electrons. Explain your working.

E.p.e = K.E

$Vq = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2Vq}{m}}$

[2]

(c) The accelerated electrons in **(b)** are injected at point S into a region of uniform magnetic field of flux density *B*, as illustrated in Fig. 8.1.

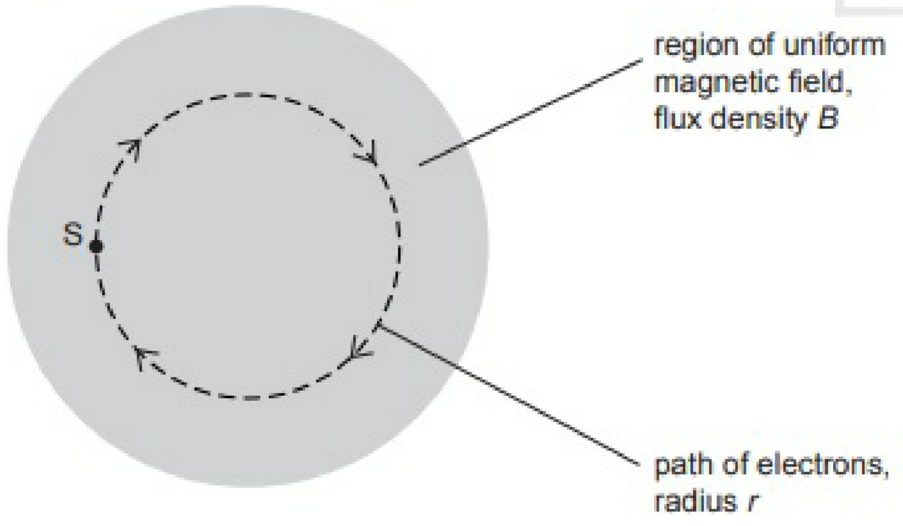


Fig. 8.1

The electrons move at right angles to the direction of the magnetic field. The path of the electrons is a circle of radius *r*.

(i) Show that the specific charge $\frac{q}{m}$ of the electrons is given by the expression

$$\frac{q}{m} = \frac{2V}{B^2r^2}.$$

Explain your working.

$F_c = F_{mag}$

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

$\frac{q}{m} = \frac{v}{Br}$

$\left(\frac{q}{m}\right)^2 = \left(\sqrt{\frac{2Vq}{m}} \div Br\right)^2$

$\frac{q^{\cancel{2}}}{m^{\cancel{2}}} = \frac{2V\cancel{q}}{\cancel{m}} \times \frac{1}{B^2r^2}$

$\frac{q}{m} = \frac{2V}{B^2r^2}$

[2]

(ii) Electrons are accelerated through a potential difference *V* of 230 V. The electrons are injected normally into the magnetic field of flux density 0.38 mT.
The radius *r* of the circular orbit of the electrons is 14 cm.

Use this information to calculate a value for the specific charge of an electron.

$\frac{q}{m} = \frac{2 \times 230}{(0.38\times10^{-3})^2(14\times10^{-2})^2}$

$= 1.63 \times 10^{11}$

specific charge = 1.6×10^{11} C kg^{-1} [2]

(iii) Suggest why the arrangement outlined in **(ii)**, using the same values of *B* and *V*, is not practical for the determination of the specific charge of α-particles.

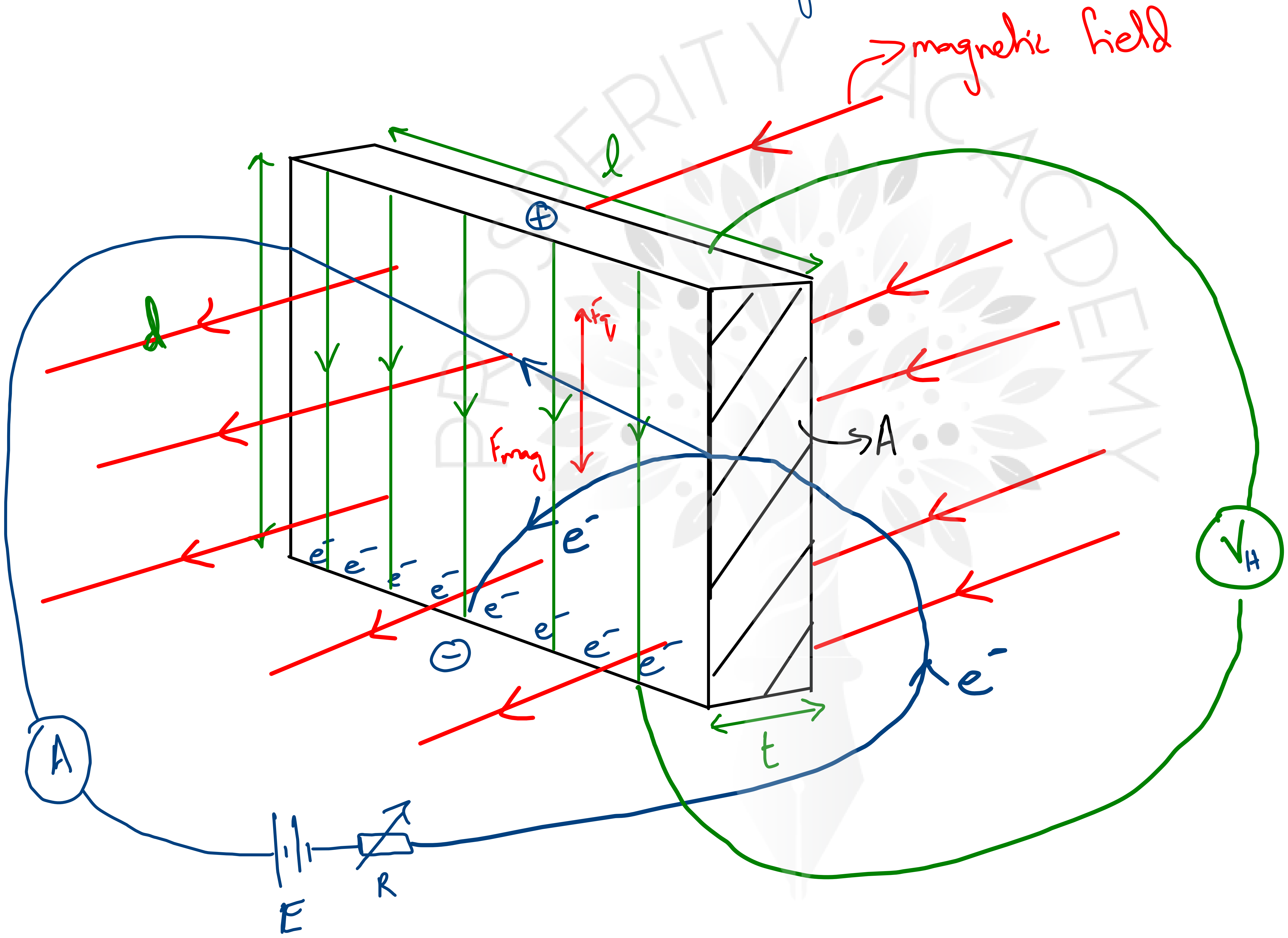
if B and V are constant $\frac{q}{m} \propto \frac{1}{r^2}$. As an alpha particle has a lower q/m ratio, its radius will be too big to measure [2]

$\frac{q}{m} = \frac{\boxed{2V}}{B^2r^2}$ const

alpha	e^-
2e	e
$2(1.66\times10^{-27})$	9.1×10^{-31}
low $\frac{q}{m}$	high $\frac{q}{m}$

$\downarrow \frac{q}{m} \propto \frac{1}{r^2} \uparrow$

Hall probe :- Used to measure magnetic field strength. (Semiconductor: has a small n)



1) Initially, electrons deflect downwards

2) The bottom face of the hall probe becomes negative and so an electric field develops that gets stronger as more electrons deposit at bottom.

3) At a certain point, the electric force will increase as much to cancel out the magnetic force. No more electrons will be deposited at the bottom. The electric field strength will increase to a certain maximum value.

Basically the voltage increases to a maximum till all the electrons start passing straight through. This voltage is known as the hall voltage.

Hall voltage:-

As electrons are undeviated:-

$F_q = F_{mag}$

$\frac{V\cancel{q}}{d} = B\cancel{q}v$

$v = \frac{V}{d} \times \frac{1}{B} \Rightarrow v = \frac{E}{B}$

number of electrons per unit volume

$I = n \times A \times v \times q$

$I = n \times d \times t \times \frac{E}{B} \times q$

$I = n \times \cancel{d} \times t \times \frac{V_H}{\cancel{d}} \times \frac{1}{B} \times q$

$$\boxed{V_H = \frac{BI}{ntq}}$$

Q. Why is a hall probe not metal?

$\downarrow V_H \propto \frac{1}{n\uparrow}$

V_H will be too small to measure

9 **(a)** State what is meant by a *magnetic field*.

....

....

.... [2]

(b) A rectangular piece of aluminium foil is situated in a uniform magnetic field of flux density B, as shown in Fig. 9.1.

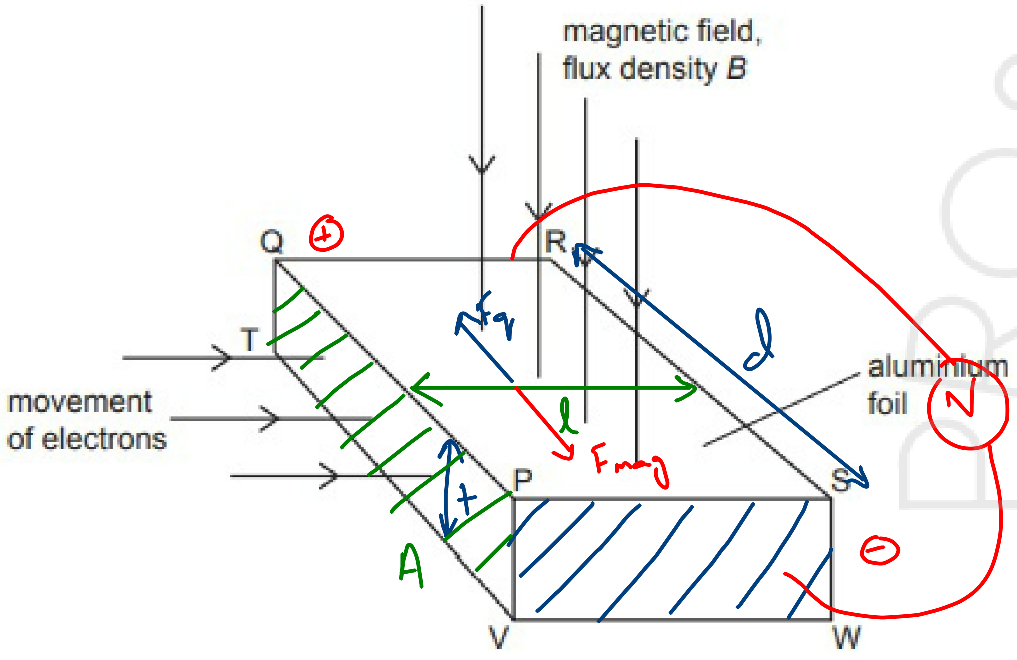


Fig. 9.1

The magnetic field is normal to the face PQRS of the foil.

Electrons, each of charge $-q$, enter the foil at right angles to the face PQTV.

(i) On Fig. 9.1, shade the face of the foil on which electrons initially accumulate. [1]

(ii) Explain why electrons do not continuously accumulate on the face you have shaded.

Initially, the electrons accumulate as there is a magnetic force. The accumulating electrons will make face PSVW negative, therefore repelling more incoming electrons. At some point, enough electrons will accumulate causing the electric force to equal the magnetic force so they will start passing straight through

[3]

(c) The Hall voltage V_H developed across the foil in **(b)** is given by the expression

$$V_H = \frac{BI}{ntq}$$

where I is the current in the foil.

(i) State the meaning of the quantity n.

Number density of electrons

[1]

(ii) Using the letters on Fig. 9.1, identify the distance t.

PV or SW or QT [1]

(d) Suggest why, in practice, Hall probes are usually made using a semiconductor material rather than a metal.

Metals have high n, so as $V_H \propto \frac{1}{n}$, the Hall voltage produced is too small to measure [1]

[Total: 9]

m18 qp42 q9

9 A thin slice of conducting material has its faces PQRS and VWXY normal to a uniform magneti field of flux density B, as shown in Fig. 9.1.

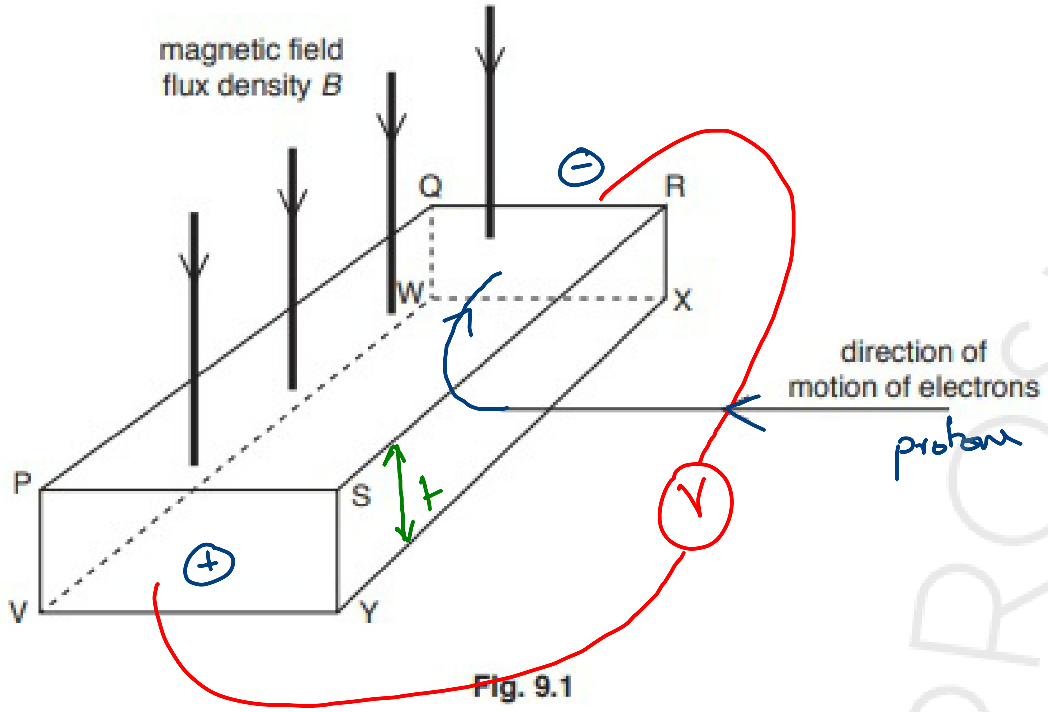


Fig. 9.1

Electrons enter the slice at right-angles to face SRXY.

A potential difference, the Hall voltage V_H, is developed between two faces of the slice.

(a) **(i)** Use letters from Fig. 9.1 to name the two faces between which the Hall voltage is developed.

PSYV and QRXW [1]

(ii) State and explain which of the two faces named in **(a)(i)** is the more positive.

Using Left hand Fleming rule electrons accumulate on QRXW so face PSYV must be more positive [2]

(b) The Hall voltage V_H is given by the expression

$$V_H = \frac{BI}{ntq}.$$

(i) Use the letters in Fig. 9.1 to identify the distance t.

SY [1]

(ii) State the meaning of the symbol n.

number density of electrons

[1]

(iii) State and explain the effect, if any, on the polarity of the Hall voltage when negative charge carriers (electrons) are replaced with positive charge carriers, moving in the same direction towards the slice.

There will be no change as positive charge carries will still deflect to face PSVY making it more positive [2]

[Total: 7]

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