

Magnetic Fields & Moving Charges

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Magnetic Fields
Sub Topic	Magnetic Fields & Moving Charges
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: 83 minutes

Score: /69

Percentage: /100

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

- 1 (a) Define the *tesla*.

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.....

..... [2]

- (b) Two long straight vertical wires X and Y are separated by a distance of 4.5 cm, as illustrated in Fig. 5.1.

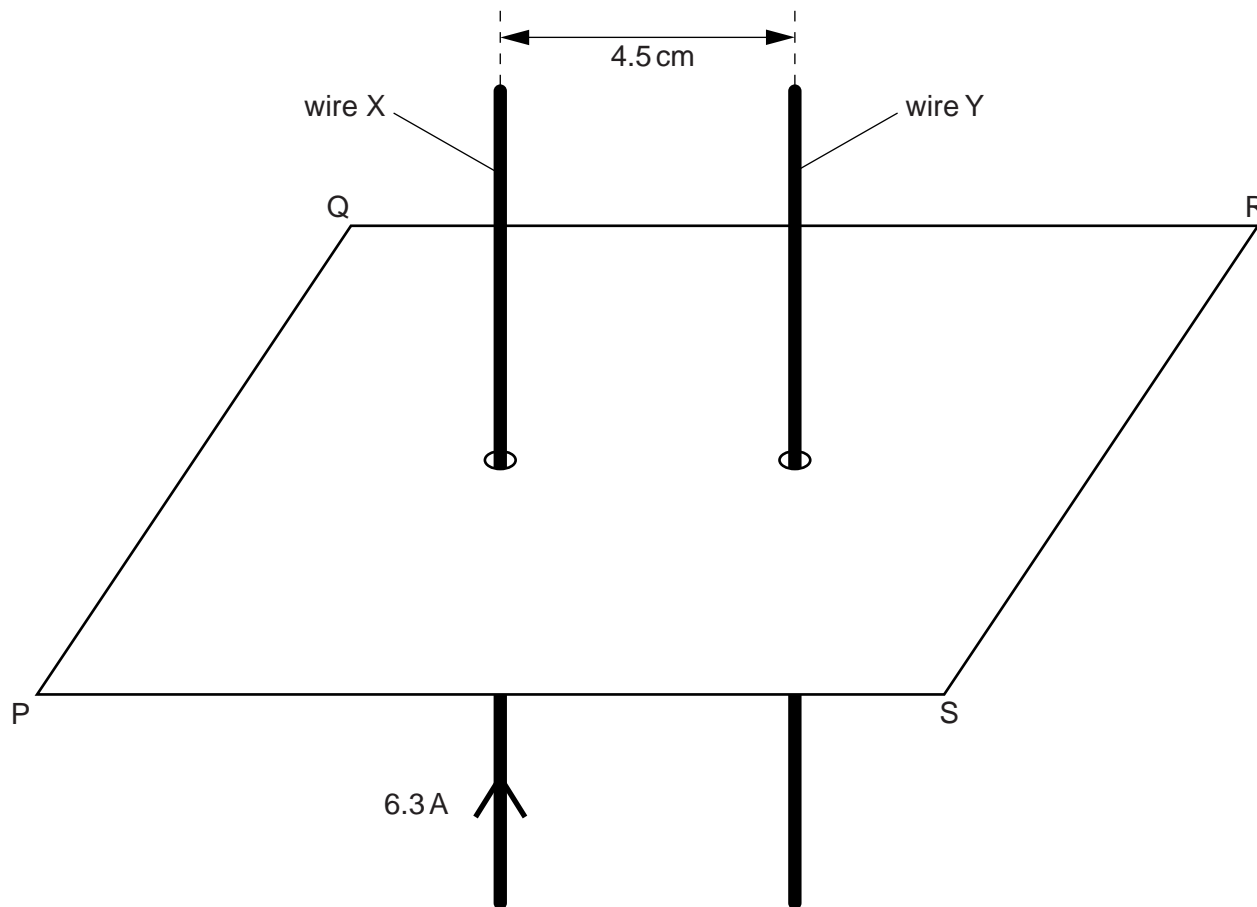


Fig. 5.1

The wires pass through a horizontal card PQRS.

The current in wire X is 6.3 A in the upward direction. Initially, there is no current in wire Y.

- (i) On Fig. 5.1, sketch, in the plane PQRS, the magnetic flux pattern due to the current in wire X. Show at least four flux lines. [3]

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

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

where I is the current in the wire and μ_0 is the permeability of free space.

Calculate the magnetic flux density at wire Y due to the current in wire X.

flux density = T [2]

- (iii) A current of 9.3 A is now switched on in wire Y. Use your answer in (ii) to calculate the force per unit length on wire Y.

force per unit length = Nm^{-1} [2]

- (c) The currents in the two wires in (b)(iii) are not equal.
Explain whether the force per unit length on the two wires will be the same, or different.

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..... [2]

- 2 (a) (i) State the condition for a charged particle to experience a force in a magnetic field.

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 [2]

- (ii) State an expression for the magnetic force F acting on a charged particle in a magnetic field of flux density B . Explain any other symbols you use.

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 [2]

- (b) A sample of a conductor with rectangular faces is situated in a magnetic field, as shown in Fig. 6.1.

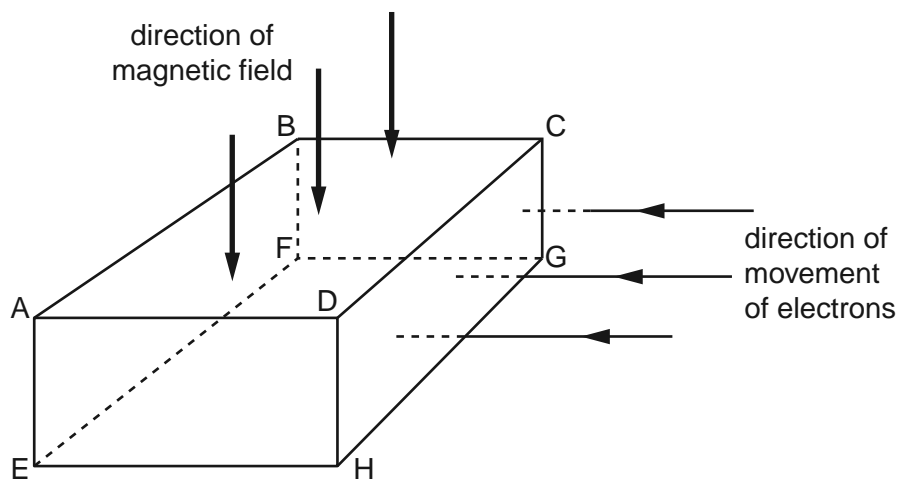


Fig. 6.1

The magnetic field is normal to face ABCD in the downward direction.

Electrons enter face CDHG at right-angles to the face. As the electrons pass through the conductor, they experience a force due to the magnetic field.

- (i) On Fig. 6.1, shade the face to which the electrons tend to move as a result of this force. [1]
- (ii) The movement of the electrons in the magnetic field causes a potential difference between two faces of the conductor.
 Using the lettering from Fig. 6.1, state the faces between which this potential difference will occur.

face and face [1]

- (c) Explain why the potential difference in (b) causes an additional force on the moving electrons in the conductor.

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 [2]

- 3 A proton of mass m and charge $+q$ is travelling through a vacuum in a straight line with speed v . It enters a region of uniform magnetic field of magnetic flux density B , as shown in Fig. 4.1.

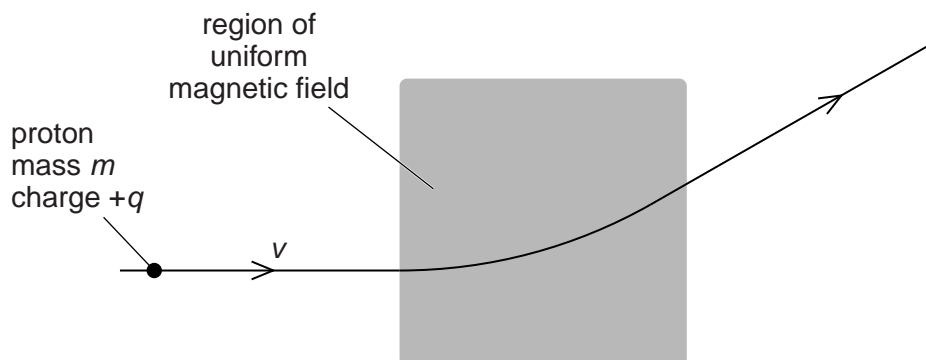


Fig. 4.1

The magnetic field is normal to the direction of motion of the proton.

- (a) Explain why the path of the proton in the magnetic field is an arc of a circle.

.....

 [2]

- (b) The angular speed of the proton in the magnetic field is ω .
 Derive an expression for ω in terms of B , q and m .

[4]

- 4 Two long straight parallel copper wires A and B are clamped vertically. The wires pass through holes in a horizontal sheet of card PQRS, as shown in Fig. 7.1.

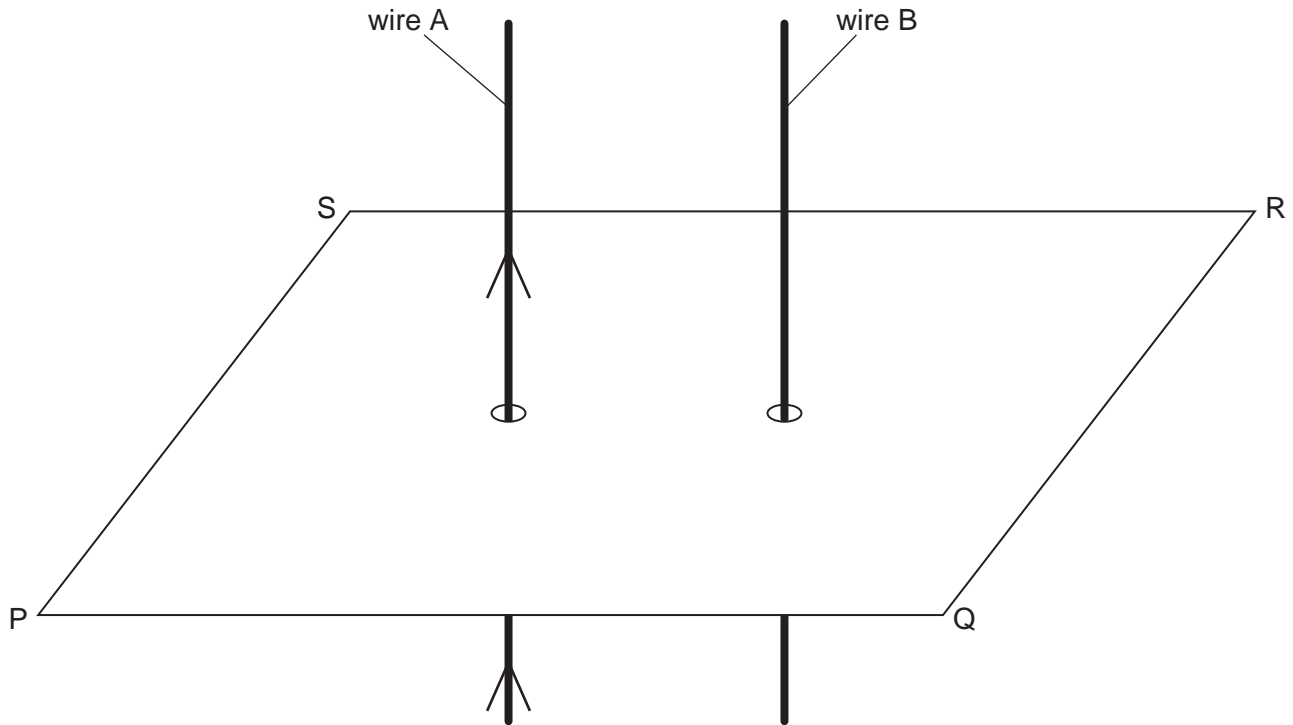


Fig. 7.1

- (a) There is a current in wire A in the direction shown on Fig. 7.1.
On Fig. 7.1, draw four field lines in the plane PQRS to represent the magnetic field due to the current in wire A. [3]
- (b) A direct current is now passed through wire B in the same direction as that in wire A.
The current in wire B is larger than the current in wire A.
- (i) On Fig. 7.1, draw an arrow in the plane PQRS to show the direction of the force on wire B due to the magnetic field produced by the current in wire A. [1]
- (ii) Wire A also experiences a force. State and explain which wire, if any, will experience the larger force.

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 [2]

- (c) The direct currents in wires A and B are now replaced by sinusoidal alternating currents of equal peak values. The currents are in phase.
Describe the variation, if any, of the force experienced by wire B.

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 [3]

5 (a) Define the *tesla*.

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.....[3]

(b) A horseshoe magnet is placed on a balance. A stiff metal wire is clamped horizontally between the poles, as illustrated in Fig. 5.1.

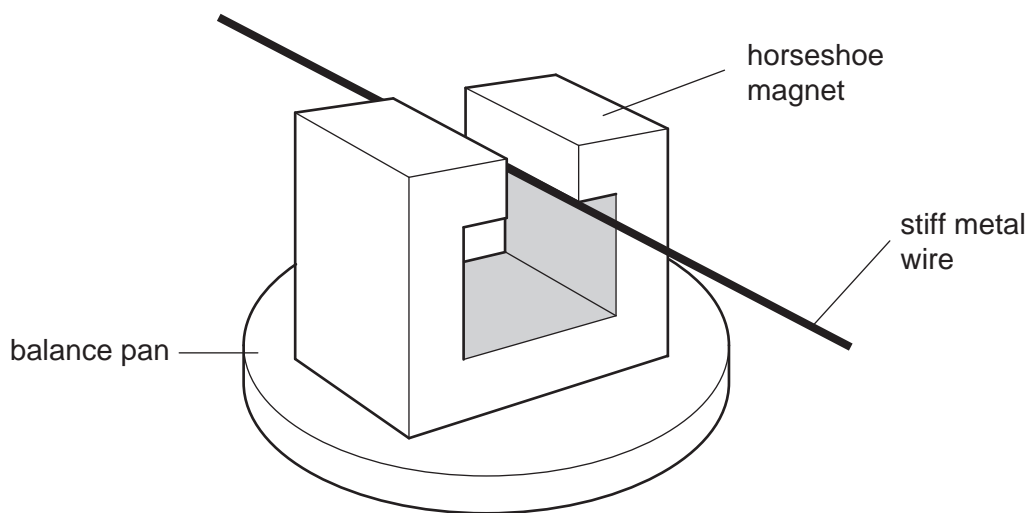


Fig. 5.1

The magnetic flux density in the space between the poles of the magnet is uniform and is zero outside this region.

The length of the metal wire normal to the magnetic field is 6.4 cm.

When a current in the wire is switched on, the reading on the balance increases by 2.4 g. The current in the wire is 5.6 A.

(i) State and explain the direction of the force on the wire due to the current.

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.....[3]

- (ii) Calculate the magnitude of the magnetic flux density between the poles of the magnet.

flux density = T [2]

- (c) A low frequency alternating current is now passed through the wire in (b).
The root-mean-square (r.m.s.) value of the current is 5.6 A.

Describe quantitatively the variation of the reading seen on the balance.

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..... [2]

- 6 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.

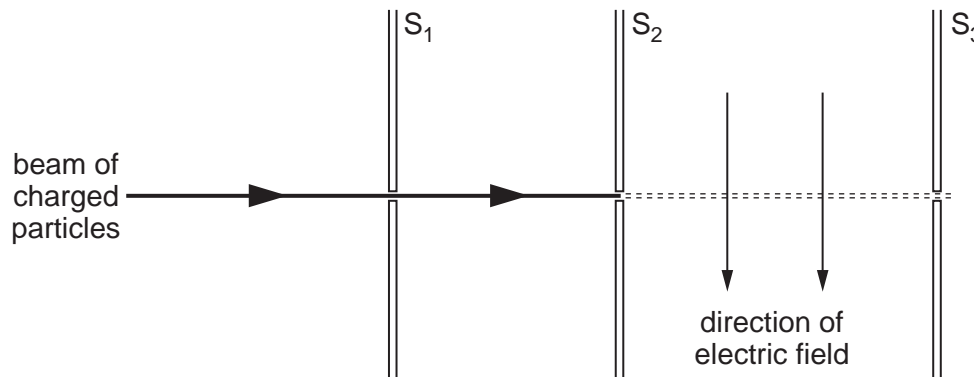


Fig. 5.1

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,

.....[1]

- (ii) the electric field.

.....[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 .

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.....[2]

7 (a) Define the *tesla*.

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.....

..... [3]

(b) A charged particle of mass m and charge $+q$ is travelling with velocity v in a vacuum. It enters a region of uniform magnetic field of flux density B as shown in Fig. 6.1.

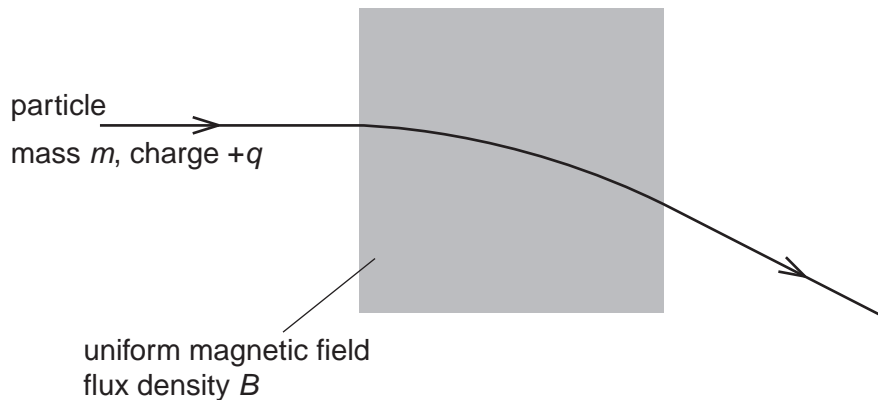


Fig. 6.1

The magnetic field is normal to the direction of motion of the particle. The path of the particle in the field is the arc of a circle of radius r .

(i) Explain why the path of the particle in the field is the arc of a circle.

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..... [2]

(ii) Show that the radius r is given by the expression

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

(c) A uniform magnetic field is produced in the region PQRS, as shown in Fig. 6.2.

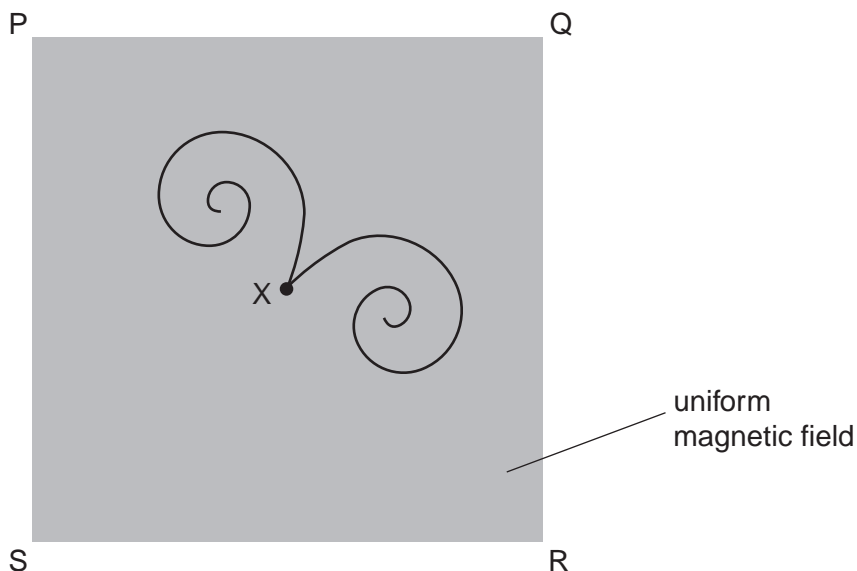


Fig. 6.2

The magnetic field is normal to the page.

At point X, a gamma-ray photon interaction causes two particles to be formed. The paths of these particles are shown in Fig. 6.2.

(i) Suggest, with a reason, why each of the paths is a spiral, rather than the arc of a circle.

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 [2]

(ii) State and explain what can be deduced from the paths about

1. the charges on the two particles,

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 [2]

2. the initial speeds of the two particles.

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 [2]

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

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 [2]

(b) A charged particle of mass m and charge $+q$ is travelling with velocity v in a vacuum. It enters a region of uniform magnetic field of flux density B , as shown in Fig. 5.1.

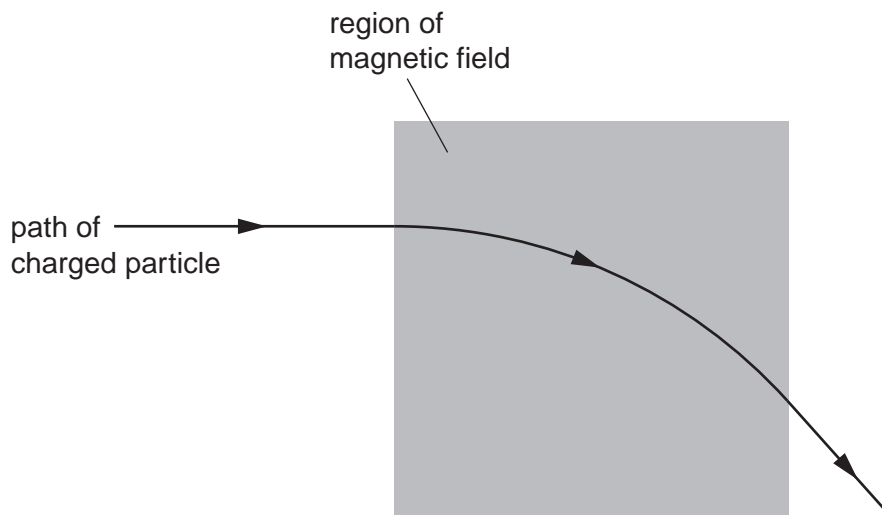


Fig. 5.1

The magnetic field is normal to the direction of motion of the particle. The path of the particle in the field is the arc of a circle of radius r .

(i) Explain why the path of the particle in the field is the arc of a circle.

.....

 [2]

(ii) Show that the radius r is given by the expression

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

- (c) A thin metal foil is placed in the magnetic field in (b).
 A second charged particle enters the region of the magnetic field. It loses kinetic energy as it passes through the foil. The particle follows the path shown in Fig. 5.2.

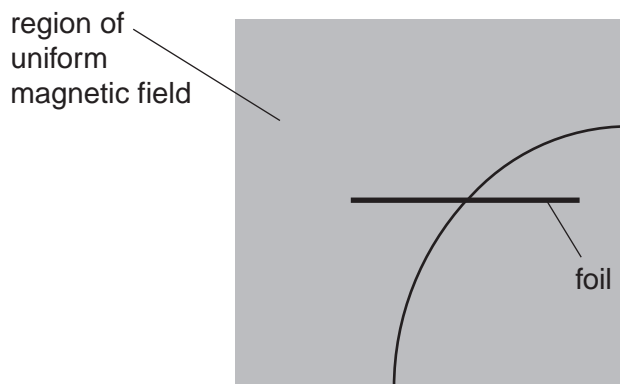


Fig. 5.2

- (i) On Fig. 5.2, mark with an arrow the direction of travel of the particle. [1]

- (ii) The path of the particle has different radii on each side of the foil.
 The radii are 7.4cm and 5.7 cm.
 Determine the ratio

$$\frac{\text{final momentum of particle}}{\text{initial momentum of particle}}$$

for the particle as it passes through the foil.

ratio = [2]