

APOLLO

Motion in electromagnetic fields

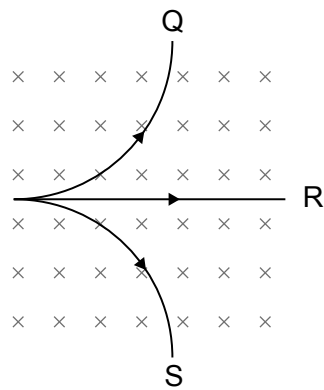
HL

Physics

First assessment 2025

8 questions | questions

25. The diagram shows possible paths Q, R, and S of particles moving into a region of uniform magnetic field. The field is directed into the plane of the page.



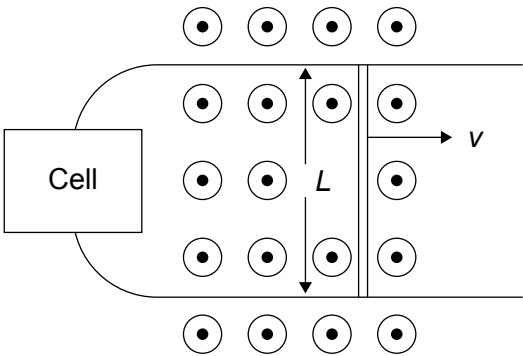
What particles are shown by each path?

	Q	R	S
A.	proton	neutron	electron
B.	neutron	electron	alpha particle
C.	electron	neutron	alpha particle
D.	proton	electron	neutron

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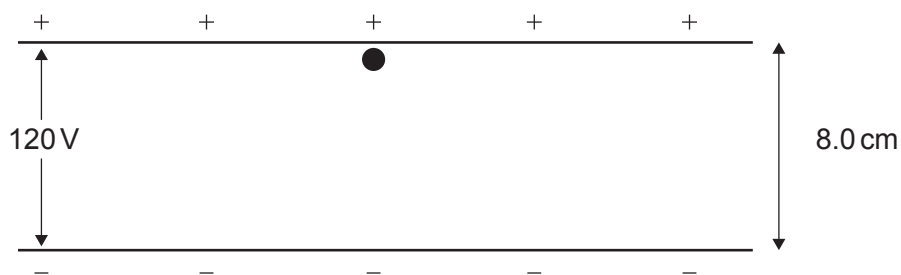
26. A circuit is created with a cell, two parallel conducting wires and a moveable metal rod of length L . When a uniform magnetic field B is directed out of the page through the circuit, the metal rod moves to the right with velocity v . The initial current in the circuit is I .



What is the direction of the current through the circuit and the initial force on the metal rod?

	Direction of I	Initial force on the metal rod
A.	anti-clockwise	$BIL \sin (90^{\circ})$
B.	clockwise	$BIL \sin (90^{\circ})$
C.	anti-clockwise	$BIL \sin (0^{\circ})$
D.	clockwise	$BIL \sin (0^{\circ})$

3. Two oppositely charged parallel plates are a distance 8.0 cm apart. The potential difference between the plates is 120 V. An alpha particle is placed on the positively charged plate and released from rest. Gravity is ignored.



- (a) Calculate the electric field between the plates. [1]

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- (b) (i) Show that the acceleration of the alpha particle is about $7 \times 10^{10} \text{ ms}^{-2}$. [2]

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- (ii) Calculate the time taken for the alpha particle to reach the negative plate. [2]

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- (iii) State, in eV, the kinetic energy of the alpha particle when it arrives at the negative plate. [1]

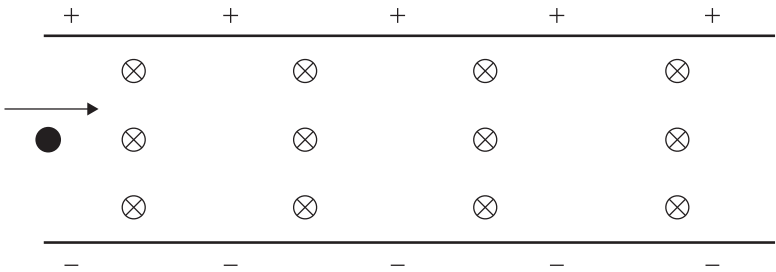
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(Question 3 continued)

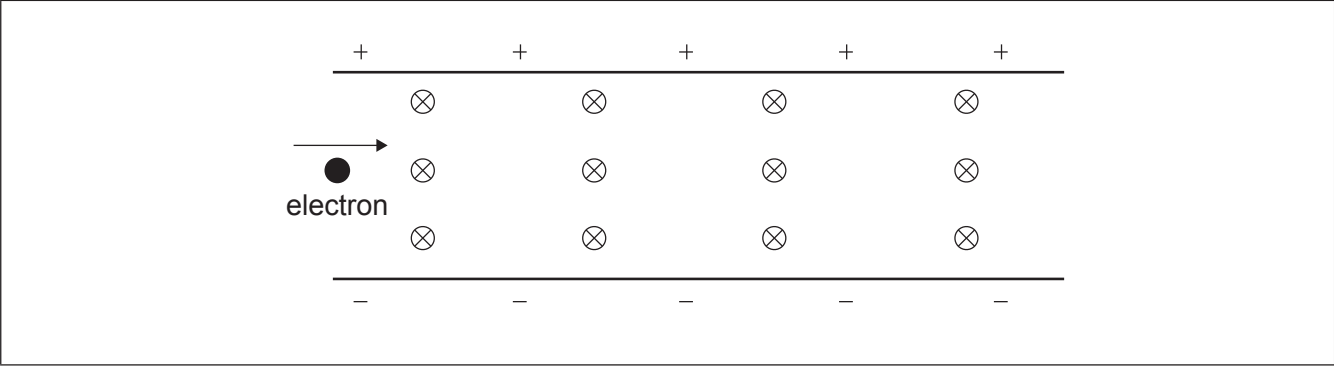
- (c) A magnetic field directed into the plane of the page is now established between the plates. An alpha particle enters the region between the plates with a horizontal speed of $5.0 \times 10^5 \text{ ms}^{-1}$. The particle is not deflected.



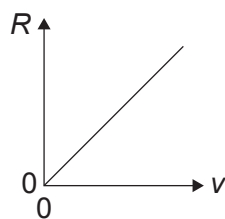
Calculate the magnitude of the magnetic field. [2]

- (d) The alpha particle in (c) is replaced by an electron. The electron enters the region between the plates with the same velocity as the alpha particle.

Draw, on the diagram, the path of the electron. [1]



28. An electron moves with speed v in a region of a uniform magnetic field of strength B . The path of the electron is a circle of radius R . The graph shows how R varies with v .



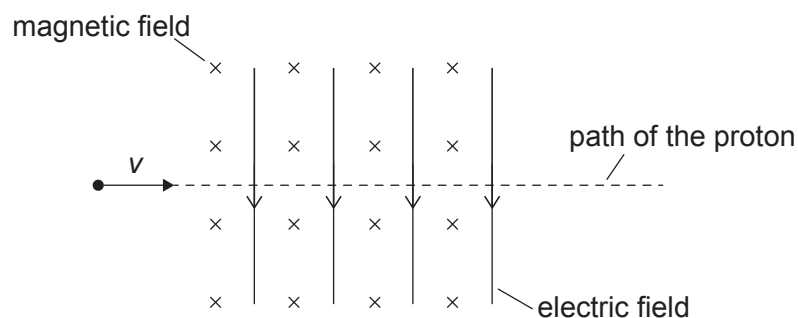
What is the gradient of the graph?

- A. $\frac{m_e B}{e}$
- B. $\frac{eB}{m_e}$
- C. $\frac{m_e}{eB}$
- D. $\frac{e}{m_e B}$

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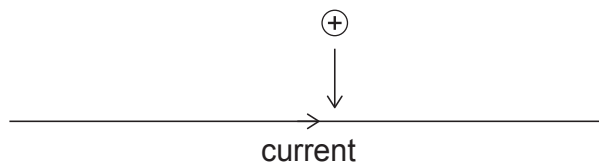
29. A proton enters a region where electric and magnetic fields are perpendicular to each other. The initial velocity v of the proton is perpendicular to both fields. The path of the proton is not deflected in the fields.



The proton is replaced by an alpha particle that is also not deflected by the fields. What is the velocity of the alpha particle?

- A. $\frac{v}{2}$
- B. v
- C. $2v$
- D. $4v$

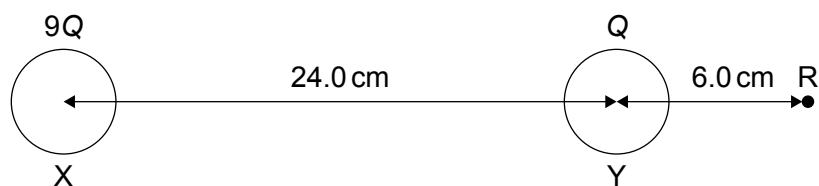
32. A positively charged particle is moving towards a current-carrying wire as shown.



What is the direction of the magnetic force acting on the charged particle?

- A. To the right
- B. To the left
- C. Into the page
- D. Out of the page

3. (a) Two identical conducting spheres X and Y that carry positive charges are separated by a centre-to-centre distance of 24.0 cm in a vacuum. The charge on X is $9Q$ and the charge on Y is Q . Point R is 6.0 cm from the centre of Y, as shown.



The resultant electric field at R is 32.6 MN C^{-1} . Determine Q , giving an appropriate unit. [2]

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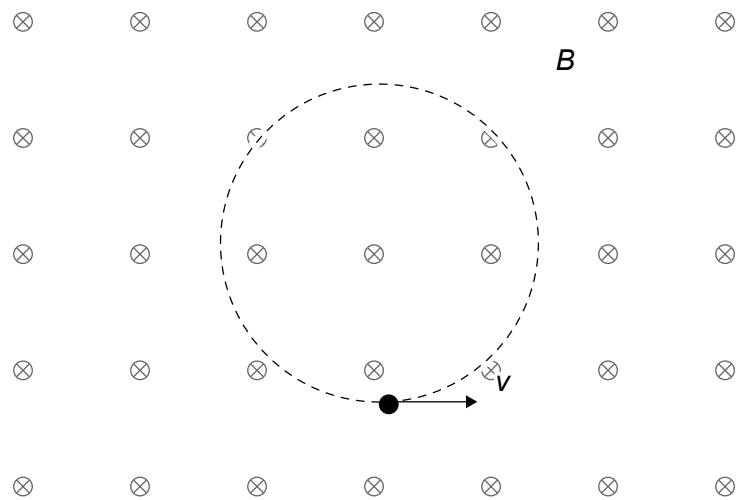
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(Question 3 continued)

- (b) A particle of mass m and positive charge q moves on a circular path with speed v in a vacuum. A uniform magnetic field B is directed into the plane of the page.



- (i) Show that the radius R of the circular path is given by $R = \frac{mv}{qB}$. [1]

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- (ii) Suggest why the speed of the particle stays constant, even though a force acts on the particle. [1]

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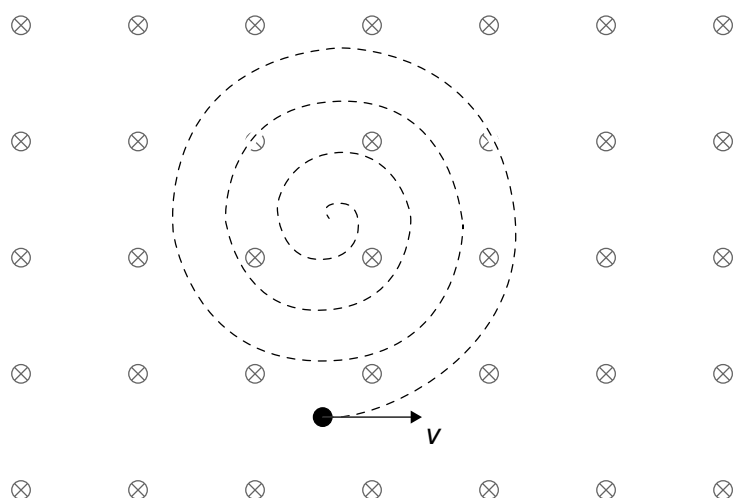
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(Question 3 continued)

- (c) The particle in (b), now moving in a region of magnetic field **in air**, follows the path shown.



Explain the shape of this path.

[2]

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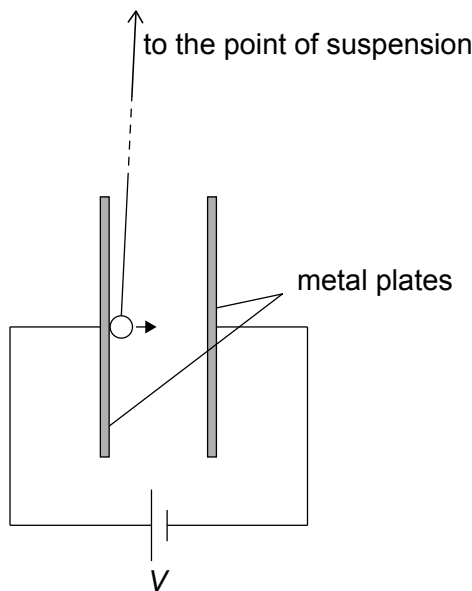
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1. A group of students investigate the motion of a conducting ball suspended from a long string. The ball is between two vertical metal plates that have an electric potential difference V between them. The ball is touched to one plate so that it becomes electrically charged and is repelled from the plate. For a given potential difference, the ball bounces between the plates with a constant period.

diagram not to scale



- (a) The students vary V and measure the time T for the ball to move **once** from one plate to the other. The table shows some of the data.

V / kV	$T / \text{s} \pm 0.1 \text{ s}$
3.00	1.4
5.00	0.8
7.00	0.6

- (i) V is provided by two identical power supplies connected in series. The potential difference of each of the power supplies is known with an uncertainty of 0.01 kV .

State the uncertainty in the potential difference V .

[1]

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(Question 1 continued)

- (ii) T is measured with an electronic stopwatch that measures to the nearest 0.1 s.

Describe how an uncertainty in T of less than 0.1 s can be achieved using this stopwatch.

[2]

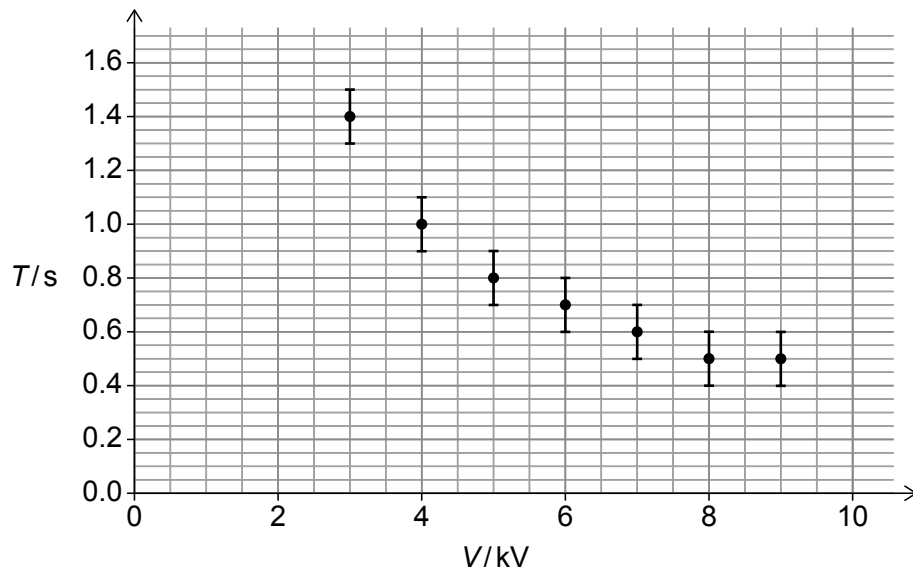
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The graph shows the variation of T with V . The uncertainty in V is not plotted.



- (iii) Outline why it is unlikely that the relationship between T and V is linear.

[1]

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- (iv) Calculate the largest fractional uncertainty in T for these data.

[2]

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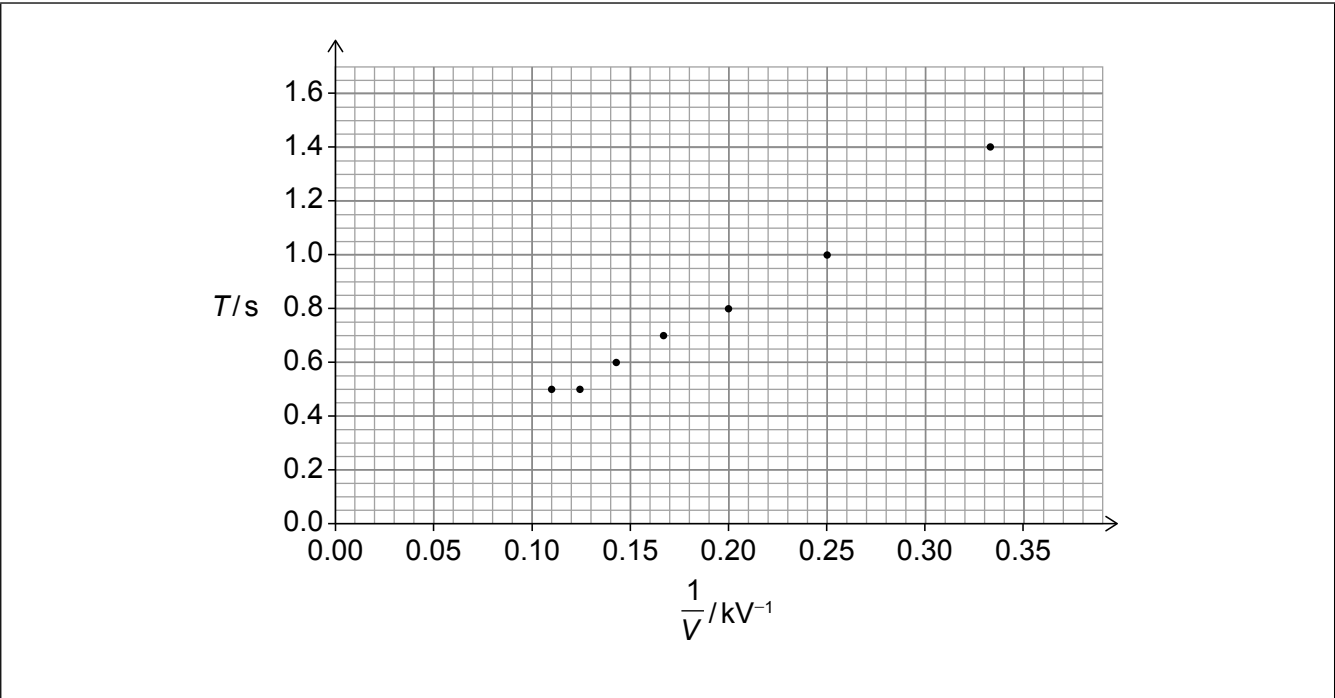
(Question 1 continued)

(b) The students suggest the following theoretical relationship between T and V :

$$T = \frac{A}{V}$$

where A is a constant.

To verify the relationship, the variation of T with $\frac{1}{V}$ is plotted.



(i) Determine A by drawing the line of best fit. [3]

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(Question 1 continued)

(ii) State the units of A . [1]

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(iii) The theoretical relationship assumes that the ball is only affected by the electric force.

Suggest why, in order to test the relationship, the length of the string should be much greater than the distance between the plates. [2]

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