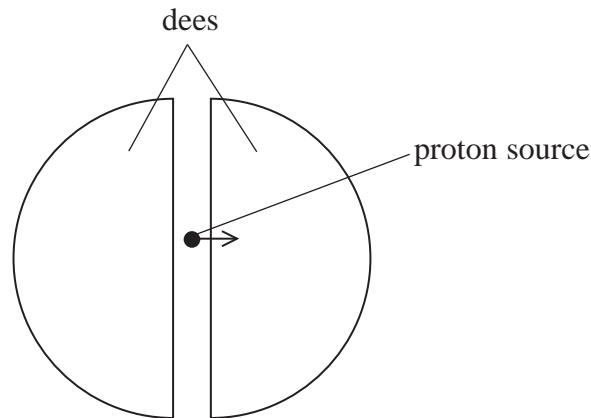


- 1 (a) A cyclotron is a particle accelerator which can be used to accelerate protons. The cyclotron consists of two semicircular electrodes called 'dees'. An alternating potential difference is applied across the gap between the dees. A uniform magnetic field is applied at right angles to the plane of the dees.



- (i) Complete the diagram to show the path of the protons. (1)
- (ii) State the direction of the magnetic field needed in order to produce the path you have sketched. (1)
- (iii) Explain how the kinetic energy of the protons is increased as they follow the path you have shown. (3)

(iv) Show that the magnetic flux density B of the applied magnetic field is given by

$$B = \frac{2\pi fm}{e}$$

where f is the frequency of the alternating potential difference, m is the mass of the proton and e is the charge on the proton.

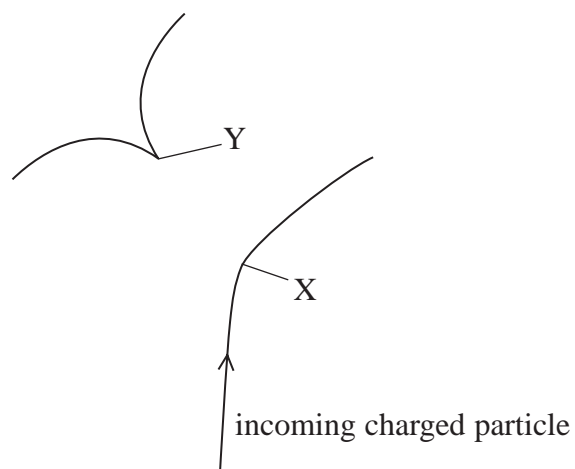
(3)

(v) In a particular cyclotron B is 1.2 mT.
Calculate the frequency f of the alternating potential difference.

(2)

$f =$

(b) The diagram shows the tracks produced in a bubble chamber.



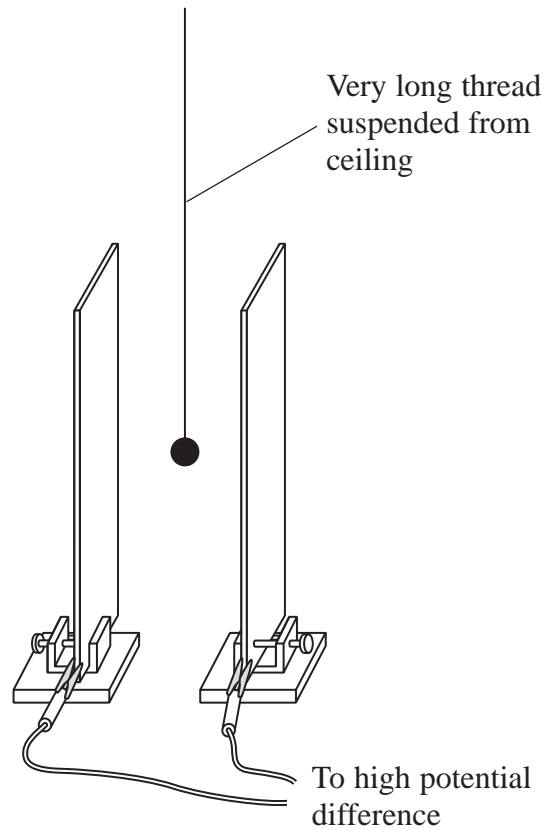
At X an incoming charged particle interacts with a stationary proton.

Describe and explain what can be deduced about the interaction at X and subsequent events. You may add to the diagram to help your answer.

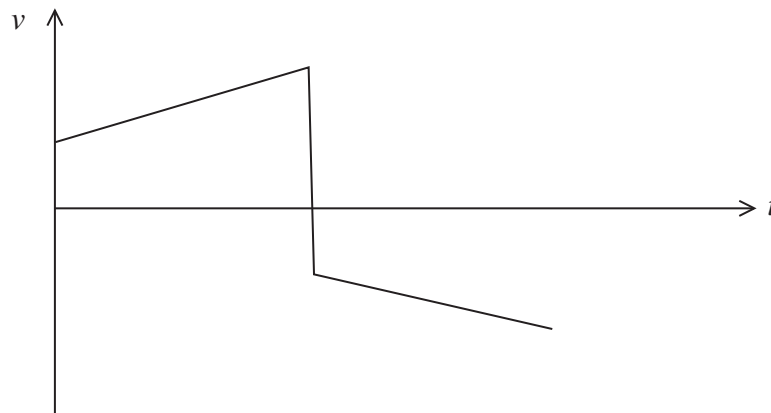
(5)

(Total for Question = 15 marks)

*2 A student has been asked to talk to her class about electric fields. As part of her presentation she hangs a table tennis ball, covered in a carbon coating, between two parallel plates connected to a high potential difference.



She pulls the ball across so that it touches one of the plates and then releases it. The ball then continues to bounce between the two plates. She sketches a graph of velocity v of the ball with time t from the time the ball leaves a plate until it returns.

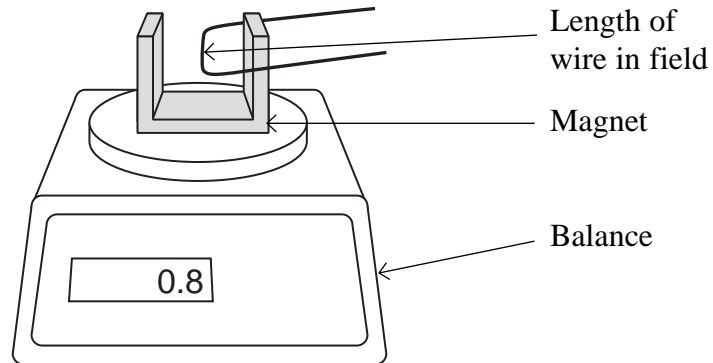


Explain the shape of the velocity-time graph for the ball from when it leaves one plate until it returns to the same plate. Ignore the weight of the ball.

(4)

(Total for Question = 4 marks)

- 3 The diagram shows a horizontal wire which is at right angles to a magnetic field. The magnetic field is produced by a horseshoe magnet which is on a balance adjusted to read zero when the current in the wire is zero.



When the current is 4 A, the reading on the balance is 0.8 gram.

The length of wire in the magnetic field is 0.05 m.

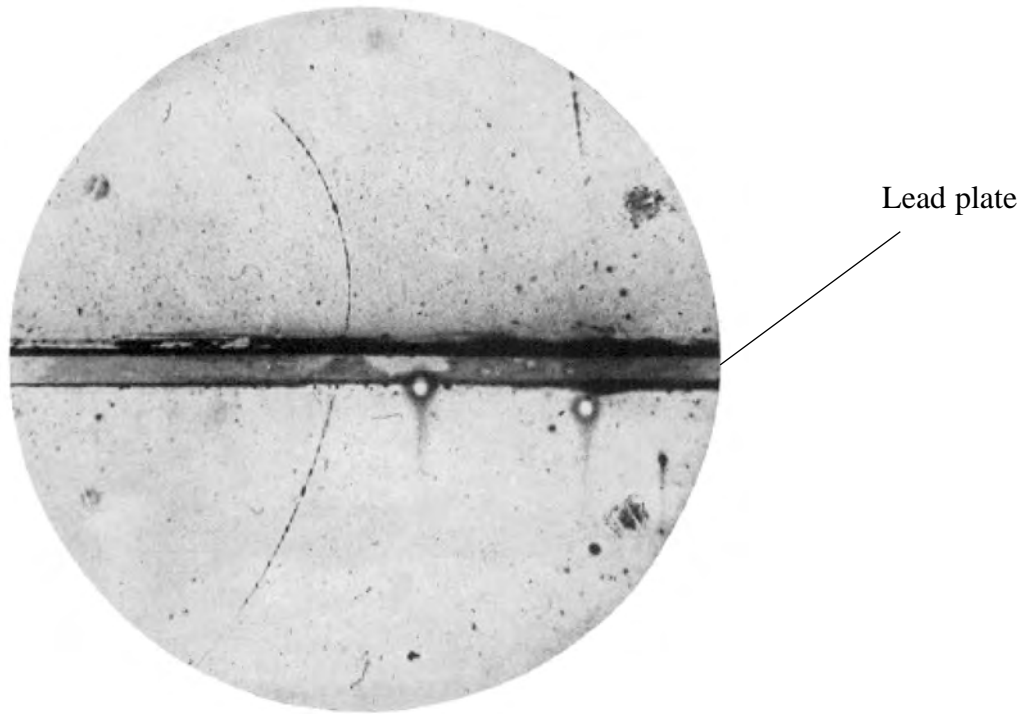
Calculate the average magnetic flux density along the length of the wire.

(3)

Magnetic flux density =

(Total for Question = 3 marks)

4 The photograph shows the track of a positively charged particle either side of a lead plate.



The particle was deflected by a magnetic field of magnetic flux density 1.5 T. The field is perpendicular to the plane of the photograph.

(a) (i) Estimate the actual radius of the track above the lead plate.

The lead plate is 6 mm thick.

(3)

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Radius =

- (ii) Calculate the momentum of this particle above the lead plate.
Particle charge = 1.6×10^{-19} C

(2)

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Momentum =

- (b) Explain whether this particle was moving up or down through the lead plate.

(3)

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- (c) On the list below circle the correct direction of the magnetic field.

(1)

Into the page from left to right down the page out of the page up the page

(d) This particle was identified as a positron.

(i) Calculate the speed of the positron while it is moving above the lead plate.

(2)

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Speed =

(ii) Comment on your answer.

(2)

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(Total for Question = 13 marks)

- 5 The magnetic force F that acts on a current-carrying conductor in a magnetic field is given by the equation

$$F = BIl.$$

- (a) State the condition under which this equation applies.

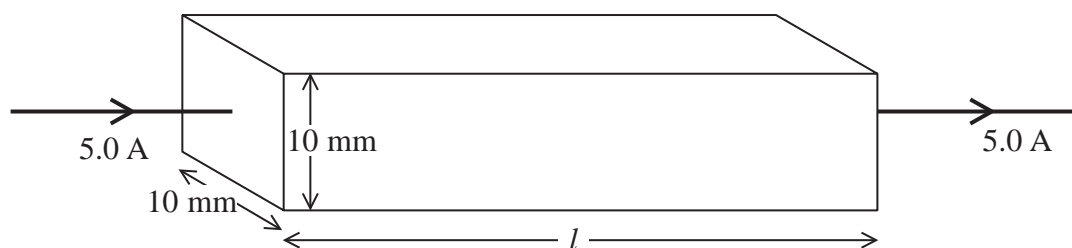
(1)

- (b) The unit for magnetic flux density B is the tesla.

Express the tesla in base units.

(2)

- (c) The diagram shows a rectangular bar of aluminium which has a current of 5.0 A through it.



The bar is placed in a magnetic field so that its weight is supported by the magnetic field.

Calculate the minimum value of the magnetic flux density B needed for this to occur.

density of aluminium = $2.7 \times 10^3 \text{ kg m}^{-3}$

(3)

Minimum $B =$

- (d) State the direction of the magnetic field.

(1)

(Total for Question = 7 marks)