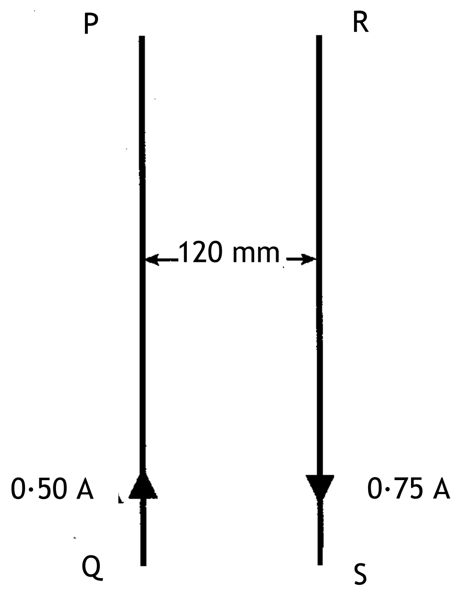
Homework – Magnetic Fields

1. A 2·0 m long straight conductor PQ carries a current of 0·50 A.

   (a) Calculate the magnetic induction at a point 60 mm from the conductor PQ.

   (b) A second 2·0 m long straight conductor RS is place 120 mm from PQ. The conductors are parallel as shown in the diagram below.



Conductor RS carries a current of 0·75 A in the opposite direction to the current in PQ.

(i) State the direction of the force acting on conductor PQ.

(ii) Calculate the magnetic induction at a point 60 mm from the conductor RS.

(iii) Calculate the magnitude and direction of the magnetic induction at a point midway between the two conductors.

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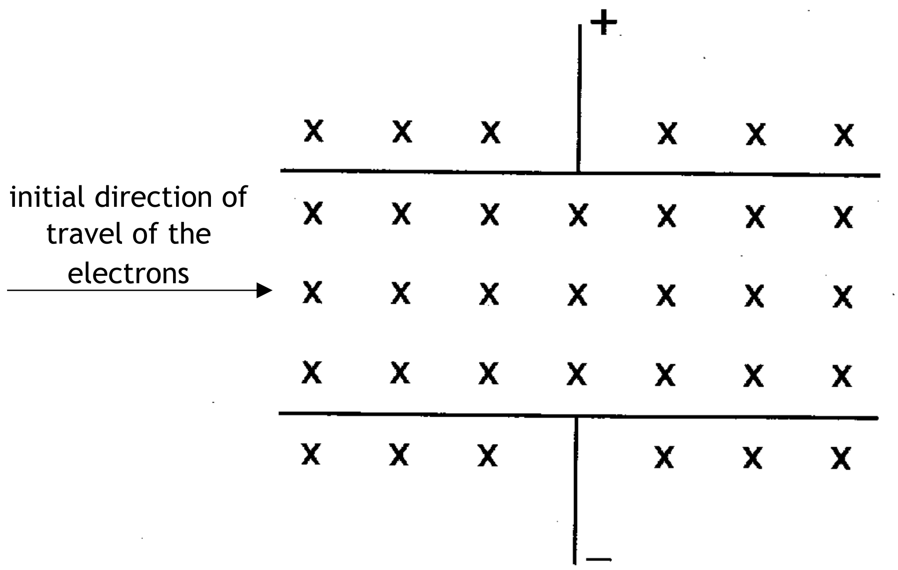
2. Electrons are fired through a vacuum containing a region of uniform electric and magnetic fields. The fields are perpendicular to each other.

   The initial direction of travel of the electrons is shown is the diagram below.



   (a) The field strengths are adjusted until the path of the electrons is a straight line.

      (i) State why the path of an electron is a straight line.
      You must justify your answer in terms of the forces acting.

      (ii) The electric field strength is $4{\cdot}2 \times 10^{3}$ NC^{-1} and the magnetic field has a magnetic induction of $2{\cdot}8 \times 10^{-3}$ T.
      Calculate the speed of the electrons.

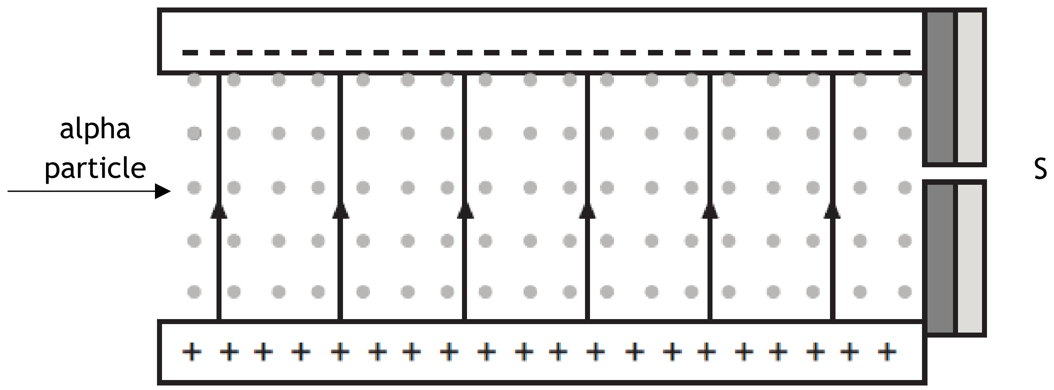
   (b) Alpha particles are now fired in the same direction through the above electric and magnetic fields.

      The alpha particles are also found to travel in a straight line.
      State how the speed of the alpha particles compare to the speed of the electrons in part (a) (ii).
      You must justify your answer.

   (c) The electric field is switched off leaving only the magnetic field. Alpha particles and then electrons with the same velocity are fired, in the same direction as before, into this region.

      Create a sketch showing the approximate paths followed by the alpha particles and the electrons.
      You must clearly labelled the sketch.

3. An alpha particle passes through a region that has perpendicular electric and magnetic fields, as shown in the diagram below.



The magnetic induction is 6·8 T and is directed out of the page.

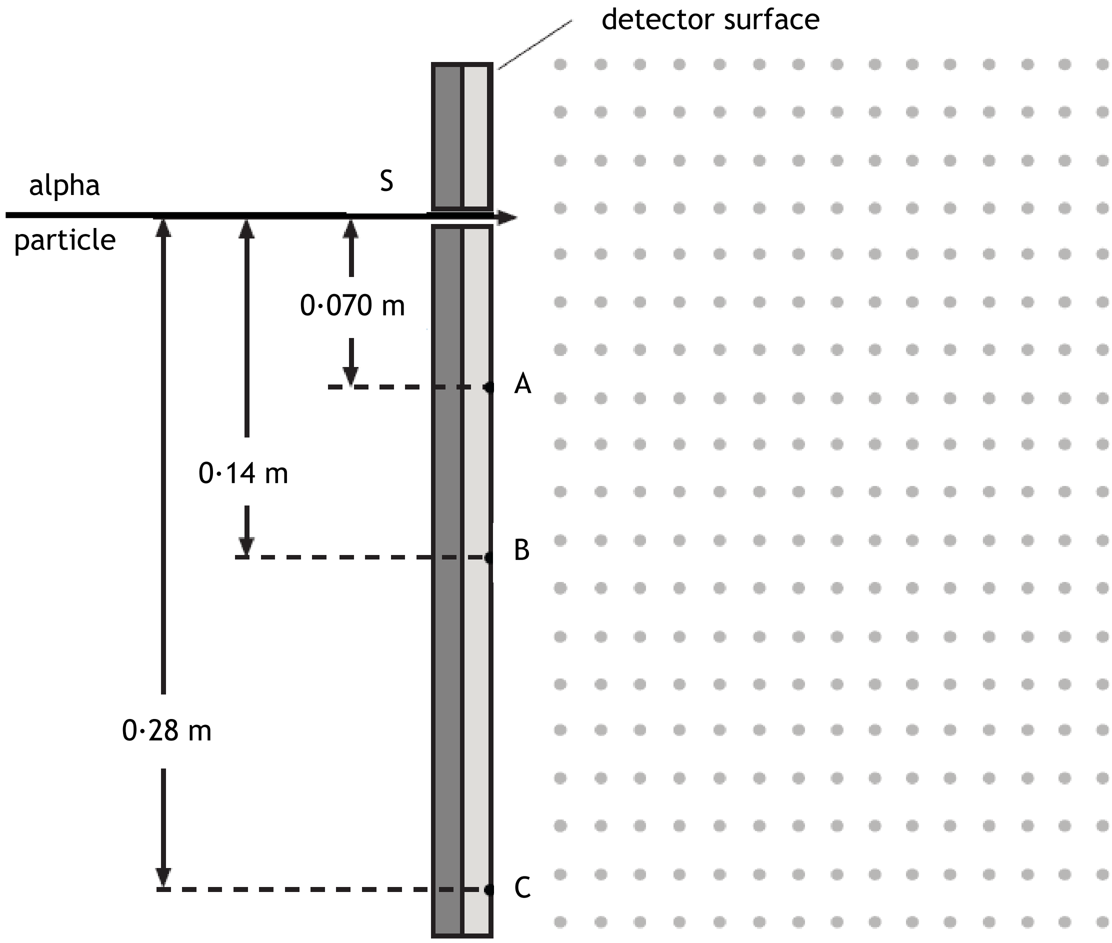
The force on the alpha particle due to the magnetic field is 5·0 x 10^{-11} N.

(a) Show that the velocity of the alpha particle is 2·3 x 10^{7} ms^{-1}.

In order that the alpha particle exits through slit S, it must pass through the region undeflected.

(b) Calculate the strength of the electric field that ensures the alpha particle exists through slit S.

(c) After passing through slit S, the alpha particle enters a region where there is the same uniform perpendicular magnetic field but no electric field as shown in the diagram below.



This magnetic field causes the alpha particle to travel in a semi-circular path and hit the detector surface.

Points A, B and C are at distance of 0·070 m, 0·14 m and 0·28 m respectively from slit S.

Show, by calculation, which point on the detector surface is nit by the alpha particle.

(d) An electron travelling at the same speed as the alpha particle passes though slit S into the region of uniform magnetic field.

State two difference in the semi-circular path of the electron compared to the path of the alpha particle.
Justify your answer.