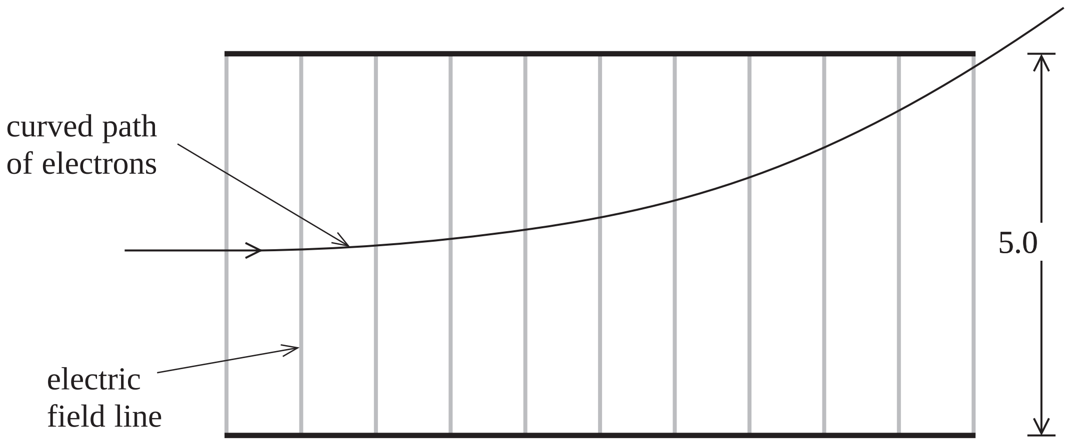
1 A teacher uses an electron beam tube to demonstrate the behaviour of electrons in an electric field. The diagram shows the path of an electron in a uniform electric field between two parallel conducting plates.



(a) Mark on the diagram the direction of the electric field.

(1)

(b) The conducting plates are 5.0 cm apart and have a potential difference of 160 V across them.
Calculate the force on the electron due to the electric field.

(3)

Force =

(c) Explain why the path of the electron is curved between the plates and straight when it has left the plates.

(3)

(d) The electron was initially released from a metal by thermionic emission and then accelerated through a potential difference before entering the region of the electric field.

(i) State what is meant by thermionic emission.

(1)

(ii) In order to be able to just leave the plates as shown, the electron must enter the electric field between the plates with a speed of 1.2×10^{7} m s^{-1}.

Calculate the potential difference required to accelerate an electron from rest to this speed.

(3)

Potential difference =

(Total for Question = 11 marks)

2 (a) A speedometer can be fitted to a bicycle. A magnet is attached to a spoke on one wheel. The magnet passes a sensor once during each revolution of the wheel and an e.m.f. is generated across the sensor. This produces pulses of e.m.f. as the wheel turns. The radius of the wheel and the time between the pulses are used to determine the speed of the bicycle.

(i) The radius of the bicycle wheel including the inflated tyre is 0.40 m.
Calculate the speed of the bicycle if the magnet passes through the sensor once every 1.2 s.

(2)

Speed =

(ii) Explain how the reading on the speedometer is affected if the tyre is **not** fully inflated.

(2)

(iii) In normal use there is a small current in the sensor. When the magnet passes the sensor the magnetic field is perpendicular to the velocity of the electrons. There is a magnetic force on the electrons.

Calculate the magnitude of the magnetic force on an electron moving at 7.4×10^{-4} m s^{-1}.

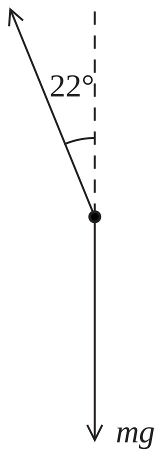
magnetic flux density = 0.050 T

(2)

Magnetic force =

(b) A cyclist leans to one side as he travels around a bend as shown.

The cyclist is travelling at 9.0 m s^{-1} and leans at an angle of 22° to the vertical.
A simplified free-body force diagram for the cyclist and the bicycle is shown below.



Determine the radius of the bend.

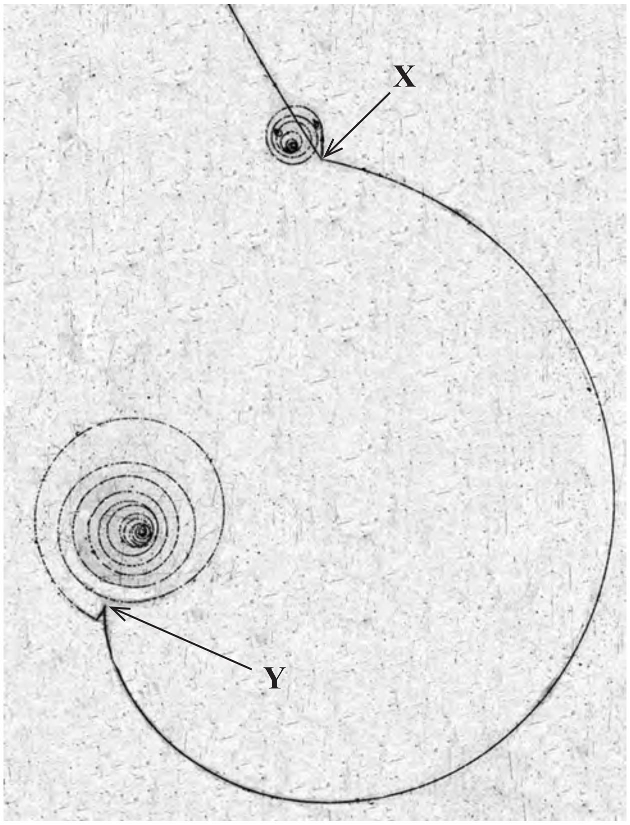
combined mass of cyclist and bicycle = 80 kg

(3)

Radius =

(Total for Question = 9 marks)

3 The photograph shows tracks in a particle detector.



(a) Explain the role of a magnetic field in a particle detector.

(2)

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(b) Explain how you can tell that track XY was produced by a particle moving from X to Y rather than from Y to X.

(2)

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(c) The particle that produced track XY was a π^+. Deduce the direction of the magnetic field in the photograph.

(1)

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(d) At Y, the π^+ decayed into a positively charged muon (μ^+) and a muon neutrino. The μ^+ has a very short range before decaying into various particles, including a positron which produced the final spiral.

(i) Give **two** reasons why you can deduce that the muon neutrino is neutral.

(2)

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2..

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(ii) Explain the evidence from the photograph for the production of the muon neutrino at Y.

(3)

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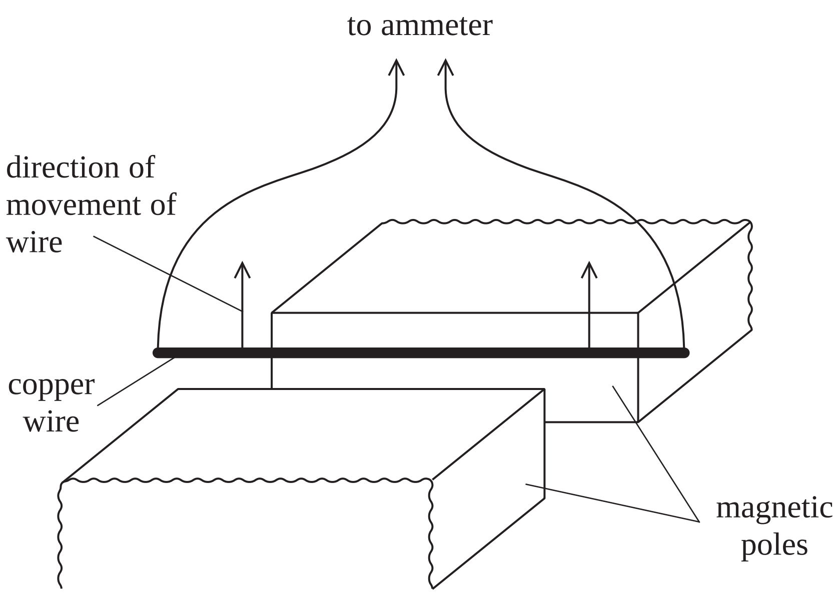
(Total for Question 10 marks)

4 A student is investigating electromagnetic induction using a U-shaped magnet. The magnetic flux density between the poles of the magnet is 74 mT. The magnetic field outside the region of the poles is negligible.

She places a stiff copper wire between the poles of the magnet as shown in the diagram. The wire is connected to an ammeter of resistance 0.25 Ω.



(a) The rectangular poles measure 6.0 cm × 2.4 cm.

Show that the magnetic flux between the poles of the magnet is about 1×10^{-4} Wb.

(3)

(b) The student holds the wire as shown in the diagram and moves it vertically upwards at a constant speed of 1.2 m s^{-1}.
Calculate the e.m.f. induced in the wire when it is moving.

(3)

Induced e.m.f. =

(c) According to Lenz's law, a force will act on the wire to oppose the motion of the wire.

Calculate the magnitude of the force that opposes the motion and comment on this value.

(4)

Magnitude of force =

Comment

(Total for Question = 10 marks)