5.4 Magnetic Effects of Electric Currents

Question Paper

Course	DP IB Physics
Section	5. Electricity & Magnetism
Topic	5.4 Magnetic Effects of Electric Currents
Difficulty	Medium

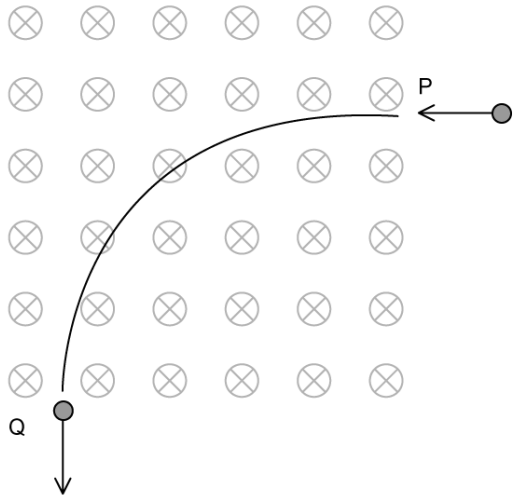
Time allowed: 70

Score: /51

Percentage: /100

Question 1a

A proton of mass *m* and electric charge *q* enters a region of magnetic field at point P and exits at point Q. The speed of the proton at P is *v*. The path followed by the proton is a quarter of a circle.



(a)
State and explain whether the speed of the proton at P is the same as the speed at Q.

[3 marks]

Question 1b

(b)
Outline why the path of the proton is circular.

[2 marks]

Question 1c

(c)

Show that the radius of the circular path is given by $R = \frac{mv}{qB}$, where B is the magnetic flux density.

[2 marks]

Question 1d

The speed of the proton is 3.2×10^6 ms^{-1} at P and the magnetic flux density is 0.21 T.

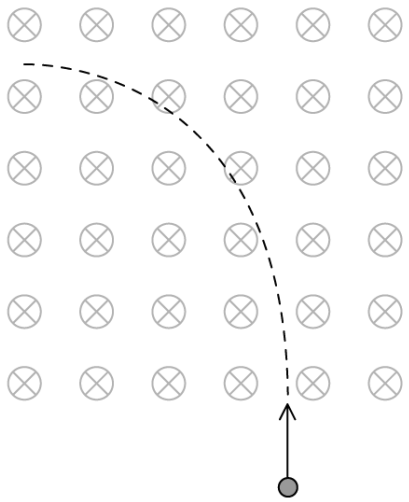
(d)

Show that the radius of the path is 16 cm.

[2 marks]

Question 2a

The diagram shows a charged particle entering a region of magnetic field that is directed into the page.



The path of the particle is a quarter circle.

(a)

Justify why the particle is positive.

[2 marks]

Question 2b

The proton enters the region with a speed of $5.4 \times 10^{6}\,ms^{-1}$. The magnetic flux density of the field is 0.35 T.

(b)
Calculate the radius of the protons circular path.

[3 marks]

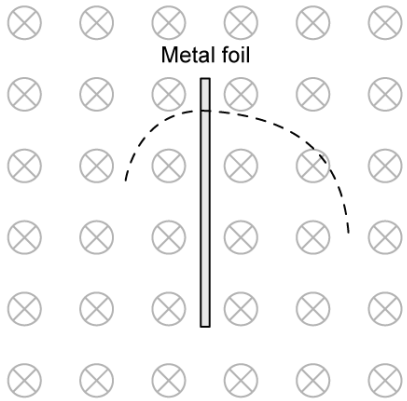
Question 2c

(c)
Calculate the time the proton spends in the region of the magnetic field.

[3 marks]

Question 2d

The diagram shows the path of a charged particle passing through a thin metallic foil.



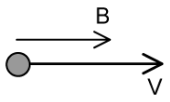
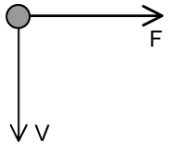
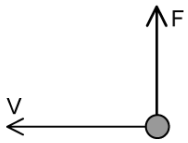
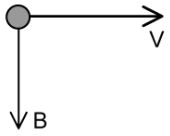
(d)
State and explain the direction of motion of the particle and the sign of its charge.

[3 marks]

Question 3a

Positive charges are seen passing through different magnetic fields.

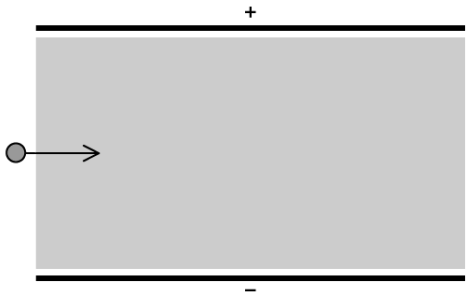
(a)
Determine the direction of the missing quantity between *B*, *v* and *F* for each:

		Direction
(i)		
(ii)		
(iii)		
(iv)		
(v)		

[5 marks]

Question 3b

The diagram shows two parallel plates. The electric field between them is directed from top to bottom and has a magnitude 2.6×10^3 N C^{-1}. The shaded region is a region of magnetic field normal to the page.



(b)

Deduce the magnetic field magnitude and direction so that an electron experiences zero net force when travelling through the plates with a speed of 3.0×10^5 ms^{-1}.

[3 marks]

Question 3c

(c)

Suggest and give a reason whether a proton shot with the same speed through the plates experiences zero net force.

[2 marks]

Question 3d

The electron's speed is halved.

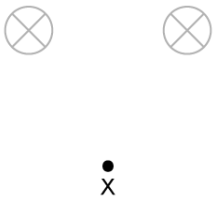
(d)
Suggest whether the electron would still be undeflected for the same magnetic field found in (b).

[3 marks]

Question 4a

In the national grid electricity is generated by current carrying wires within a magnetic field.

There are two wires carrying equal currents into the page.



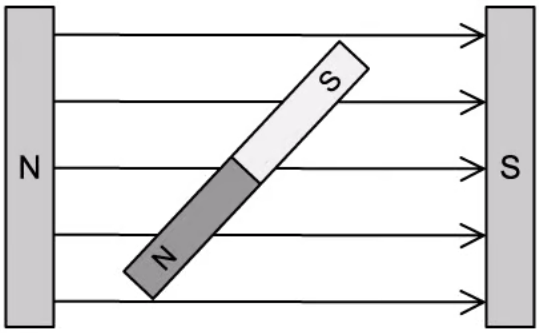
(a)
Determine the direction of the magnetic field at point X.

Use a diagram to help you with your answer.

[3 marks]

Question 4b

A bar magnet is placed in a uniform magnetic field as shown in the diagram.



(b)
Suggest whether there is a net force on the bar magnet, causing it to move to a different position. Explain your answer.

[2 marks]

Question 4c

(c)
The bar magnet does move in a specific type of motion. Determine how it will move.

[2 marks]

Question 4d

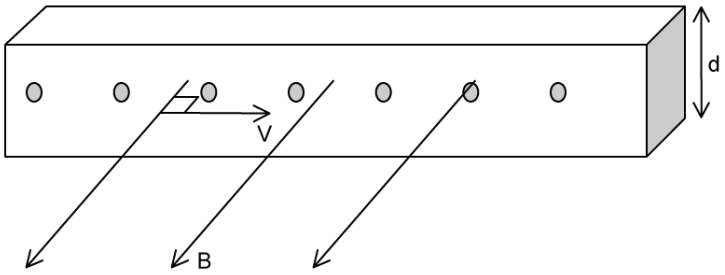
A taut electrical wire carries electricity between a generator and the step-up transformer. The current is 2000 A and the magnetic field of the Earth at the position of the wire is 4.50×10^{-5} T and makes an angle of 45º below the horizontal.

(d)
Calculate the force experienced by a 25.0 m length of this wire.

[2 marks]

Question 5a

A current *I* passes through a conductor. The electrons move with a drift speed *v*. A magnetic field *B* at right angles to the direction of motion of the electrons is also present in the conductor.



(a)
Draw the arrows to indicate the directions of the:

(i) Conventional current in the conductor

(ii) Magnetic force on the electron

[2 marks]

Question 5b

A is the cross-sectional area of the conductor, *q* is the charge of one electron, *n* is the number of electrons per unit volume and *v* is the drift speed of the electrons.

(b)
Show that the current on the conductor is given by $I = qnAv$.

[3 marks]

Question 5c

The number density of the electrons is 3.5×10^{28} m^{-3}. The current in the wire is 0.30 A and its cross-sectional area is 4.4×10^{-6} m^2.

(c)
Hence, calculate the drift velocity of the electrons moving in the conductor.

[2 marks]

Question 5d

The magnitude of the magnetic field within this current carrying conductor is 0.30 T.

(d)
Calculate the magnitude of the force on the electrons in the conductor.

[2 marks]