1.

21. A particle has charge and mass. Which types of field cause a force to be exerted on the particle when it is moving in the direction of the field?

A. Electric, gravitational and magnetic fields

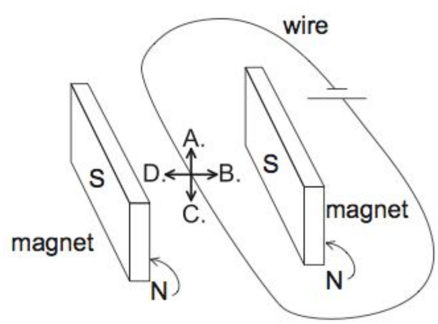
B. Electric and magnetic fields only

C. Gravitational and magnetic fields only

D. Electric and gravitational fields only

2.

21. A long, straight, current-carrying wire is placed between a pair of magnets as shown. What is the direction of the force on the wire?



3.

20. Three parallel wires, X, Y and Z, carry equal currents. The currents in X and Z are directed into the page. The current in Y is directed out of the page.

Which arrow shows the direction of the magnetic force experienced by wire Z?

A. 

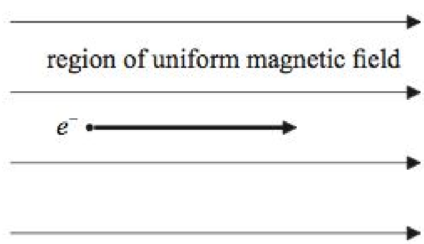
B. 

C. 

D. 

4.

19. An electron is travelling in a region of uniform magnetic field. At the instant shown, the electron is moving parallel to the field direction.



The magnetic force on the electron is

A. upwards.

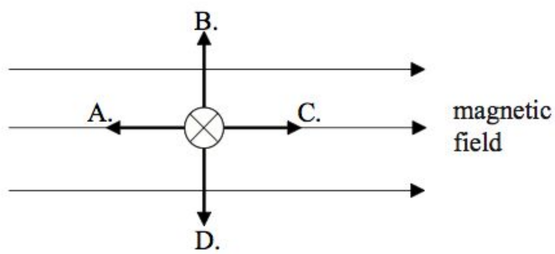
B. downwards.

C. to the right.

D. zero.

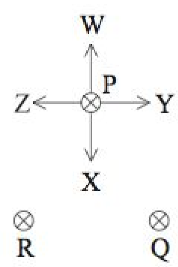
5.

21. A wire is placed in a magnetic field which is directed to the right. The wire carries a current directed into the page. Which of the following is the direction of the force on the wire?



6.

21. Three wires, P, Q and R, carry equal currents directed into the plane of the paper.



Which arrow correctly identifies the direction of the magnetic force on wire P?

A. W

B. X

C. Y

D. Z

7.

24. The magnetic field produced by a current in a straight wire is in

A. the same direction as the current.

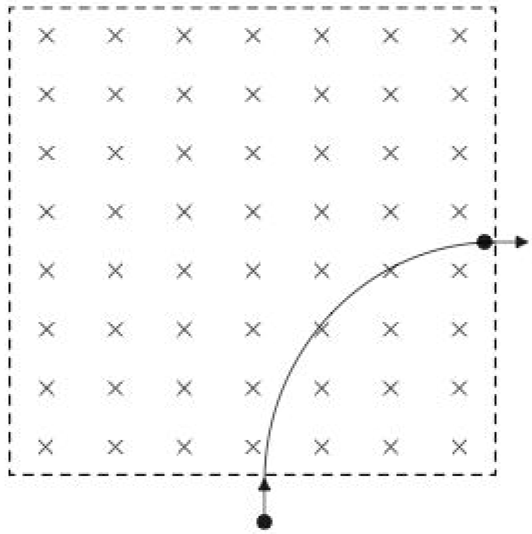
B. the opposite direction to the current.

C. the same plane as the wire.

D. any plane perpendicular to the wire.

1.

An electron, that has been accelerated from rest by a potential difference of 250 V, enters a region of magnetic field of strength 0.12 T that is directed into the plane of the page.



(a) The electron's path while in the region of magnetic field is a quarter circle. Show that the

(i) speed of the electron after acceleration is $9.4\times10^{6}\,\mathrm{m\,s^{-1}}$. *[2]*

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(ii) radius of the path is 4.5×10^{-4} m. *[2]*

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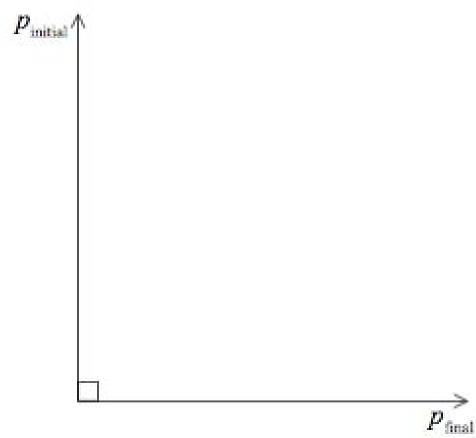
(b) The diagram below shows the momentum of the electron as it enters and leaves the region of magnetic field. The magnitude of the initial momentum and of the final momentum is 8.6×10^{-24} N s.



(i) On the diagram above, draw an arrow to indicate the vector representing the change in the momentum of the electron. *[1]*

(ii) Show that the magnitude of the change in the momentum of the electron is 1.2×10^{-23} N s. *[1]*

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(iii) The time the electron spends in the region of magnetic field is 7.5×10^{-11}s. Estimate the magnitude of the average force on the electron. *[1]*

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2.

Electrical leads used in physics laboratories consist of a central conductor surrounded by an insulator.

(e) Distinguish between an insulator and a conductor. *[2]*

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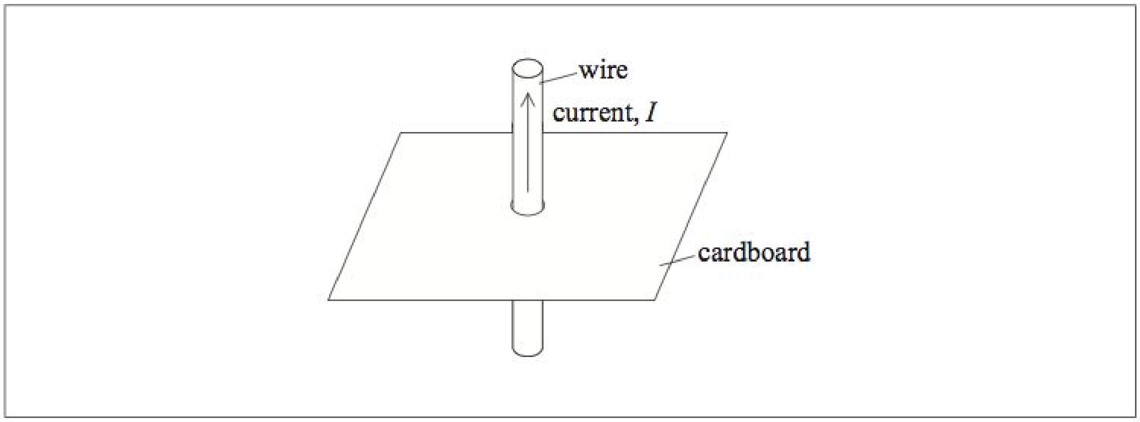
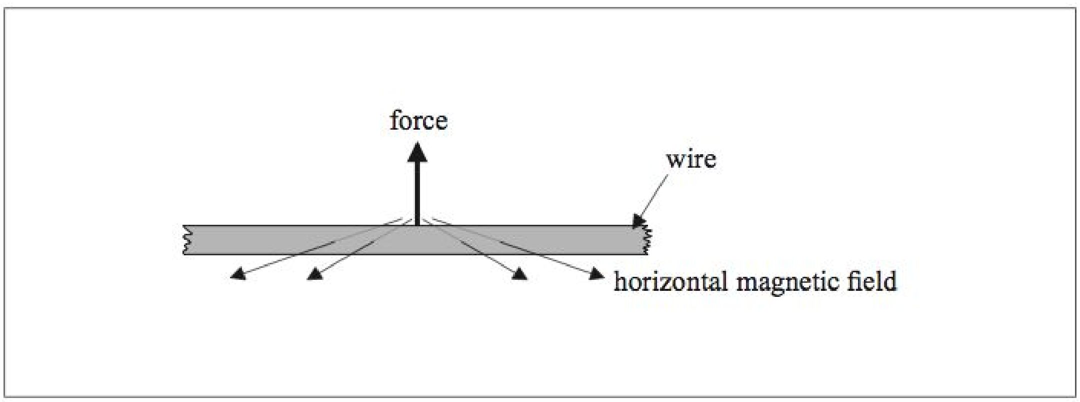
(f) The diagram shows a current I in a vertical wire that passes through a hole in a horizontal piece of cardboard.



On the cardboard, draw the magnetic field pattern due to the current. *[3]*

(g) (i) The diagram shows a length of copper wire that is horizontal in the magnetic field of the Earth.



The wire carries an electric current and the force on the wire is as shown. Identify, with an arrow, the direction of electron flow in the wire. *[1]*

(ii) The horizontal component of the magnetic field of the Earth at the position of the wire is $40\,\mu T$. The mass per unit length of the wire is $1.41 \times 10^{-4}\,kg\,m^{-1}$. The net force on the wire is zero. Determine the current in the wire. *[3]*

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3.

Diagram 1 below shows two long, parallel vertical wires each carrying equal currents in the same direction. The wires pass through a horizontal sheet of card. Diagram 2 shows a plan view of the wires looking down onto the card.

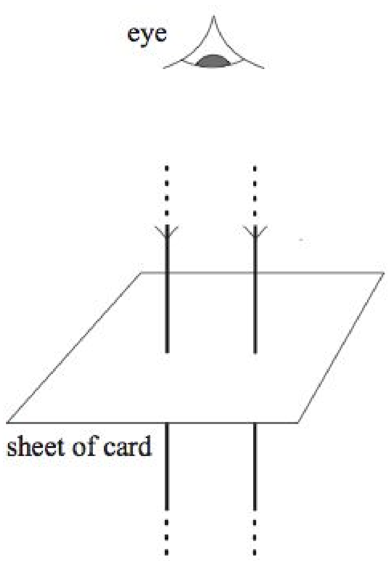

diagram 1

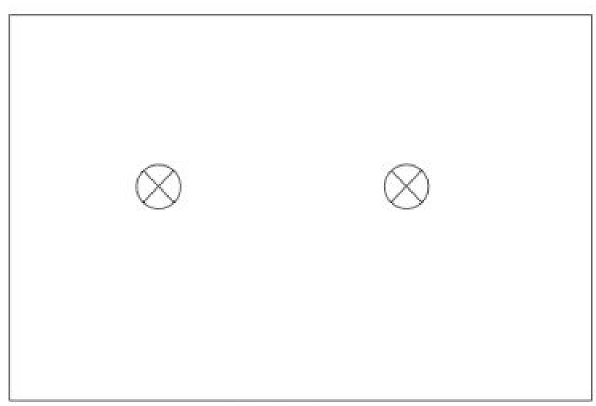

diagram 2

(a) (i) Draw on diagram 1 the direction of the force acting on each wire. *[1]*

(ii) Draw on diagram 2 the magnetic field pattern due to the currents in the wire. *[3]*

(b) The card is removed and one of the two wires is free to move. Describe and explain, the changes in the velocity and in acceleration of the moveable wire. *[3]*

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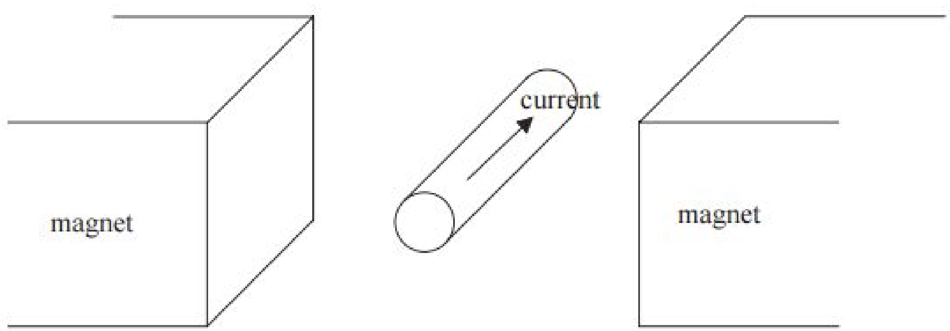
4.

Magnetism

(d) A current carrying rod is held horizontally between the poles of a magnet by a magnetic force.



(i) On the diagram above label with the letter N the north pole of the magnet. Explain your choice. *[1]*

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(ii) The weight of the rod is 4.0 N and its length is 0.80 m. The magnitude of the magnetic field strength is 0.20 T. Determine the current in the rod. *[2]*

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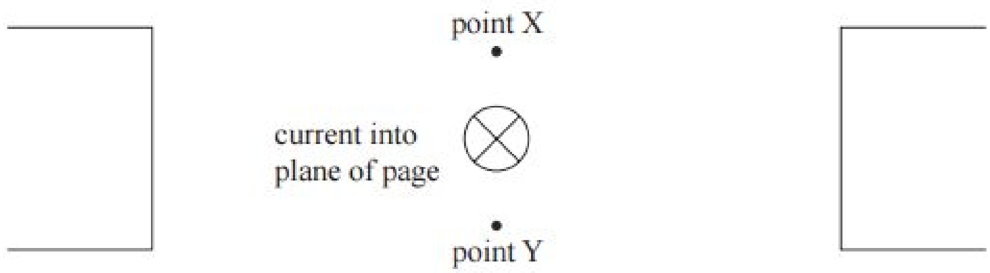
(iii) The diagram below shows two points X and Y that are at equal distances from the current carrying rod in (d).



State and explain at which point (X or Y) the magnetic field strength is greatest. *[2]*

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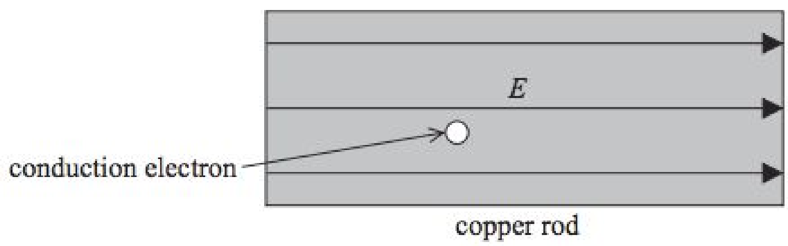
5.

Part 2 Electrical conduction and the force on a conductor in a magnetic field

(a) The diagram below shows a copper rod inside which an electric field of strength E is maintained by connecting the copper rod in series with a cell. (Connections to the cell are not shown.)



(i) On the diagram, draw an arrow to show the direction of the force on the conduction electron shown. Label this arrow with the letter F. *[1]*

(ii) Describe how the electric field enables the conduction electrons to have a drift velocity in a direction along the copper rod. *[3]*

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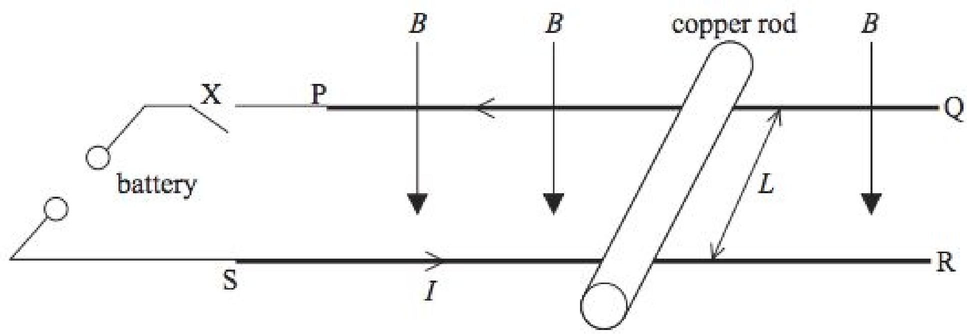
(b) A copper rod is placed on two parallel, horizontal conducting rails PQ and SR as shown below. The conducting rails are connected to a battery and switch X.

The rails and the copper rod are in a region of uniform magnetic field of strength B. The magnetic field is normal to the plane of the conducting rods as shown in the diagram below.



The length of the copper rod between the rails is L. The mass of the copper rod is M. Friction between the copper rod and the rails is negligible.

The switch X is now closed and the current in the copper rod is I and in the direction shown in the diagram.

(i) On the diagram, draw an arrow to show the direction of the force F on the copper rod. *[1]*

(ii) Derive an expression in terms of B, L, M and I, for the initial acceleration a of the copper rod. *[2]*

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(c) The copper rod in (b) eventually moves with constant speed v. When moving at this constant speed, the power supplied by the battery is equal to rate at which work is done by the force F.

(i) Deduce that the power P supplied by the force F acting on the copper rod when it is moving at constant speed v is given by the expression

$$P = Fv.$$ *[2]*

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(ii) Use the expression in (i) and the data below to determine the speed v. *[3]*

e.m.f. of the battery	= 0.80 V
length of copper rod L	= 0.60 m
field strength B	= 0.25 T

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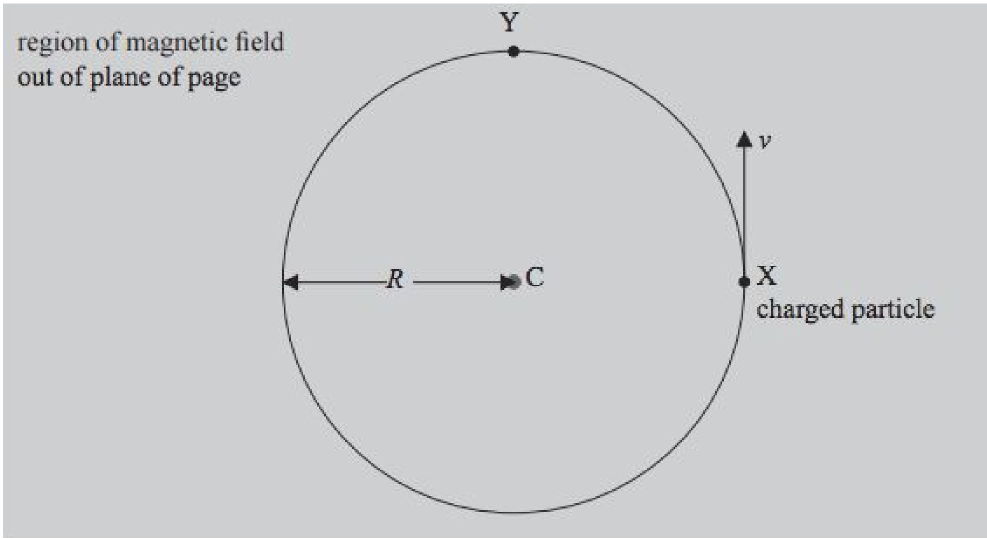
6.

A charged particle is projected from point X with speed v at right angles to a uniform magnetic field. The magnetic field is directed out of the plane of the page. The particle moves along a circle of radius R and centre C as shown in the diagram below.



(a) On the diagram above, draw arrows to represent the magnetic force on the particle at position X and at position Y. *[1]*

(b) State and explain whether

(i) the charge is positive **or** negative. *[1]*

. . . .

(ii) work is done by the magnetic force. *[2]*

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(c) A second identical charged particle is projected at position X with a speed $\frac{v}{2}$ in a direction opposite to that of the first particle. On the diagram above, draw the path followed by this particle. *[2]*

1. D	2. C	3. A	4. D	5. D	6. B	7. D

A2. (a) (i) $v = \sqrt{\frac{2eV}{m}}$;

$v = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 250}{9.1 \times 10^{-31}}}$;

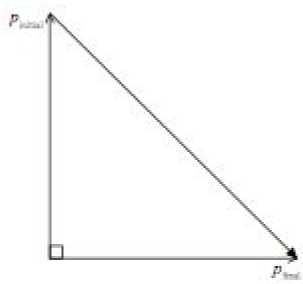
$= 9.4 \times 10^{6}\,\text{m s}^{-1}$ ***[2]***

(ii) $evB = m\frac{v^2}{r}$;

$r = \frac{9.1 \times 10^{-31} \times 9.4 \times 10^{6}}{1.6 \times 10^{-19} \times 0.12}$;

$= 4.5 \times 10^{-4}\,\text{m}$ ***[2]***

(b) (i) vector as shown; ***[1]***



(ii) $\Delta p = \left(\sqrt{\left[8.6 \times 10^{-24}\right]^2 + \left[8.6 \times 10^{-24}\right]^2}\right)$;

$= 1.2 \times 10^{-23}\,\text{N s}$ ***[1]***

(iii) $F\left(= \frac{\Delta p}{\Delta t} = \frac{1.2 \times 10^{-23}}{7.5 \times 10^{-11}}\right) = 1.6 \times 10^{-13}\,\text{N}$; ***[1]***

Part 2 Electric and magnetic fields

(e) conductor has free electrons/charges that are free to move within/through it / insulator does not have free electrons/charges that are free to move within/ through it;
electrons act as charge carriers;
when a pd acts across a conductor a current exists when charge (carriers) move; ***[2 max]***
Do not allow "good/bad conductor/resistor" or reference to conductivity/resistivity.

(f) anti-clockwise arrows;
at least three circles centred on wire;
increasing in separation from centre; ***[3]***

(g) (i) arrow to the right; ***[1]***

(ii) $\frac{F}{l} = BI$;

$I = \left(\frac{mg}{lB} =\right) \frac{1.41 \times 10^{-4} \times 9.8}{40 \times 10^{-6}}$;

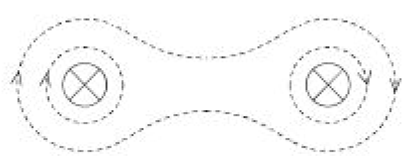
35 (A); ***[3]***

*Award **[3]** for a bald correct answer.*

Allow use of $g = 10\,m\,s^{-2}$ which also gives an answer of 35 (A).

A3. (a) (i) →←; ***[1]***

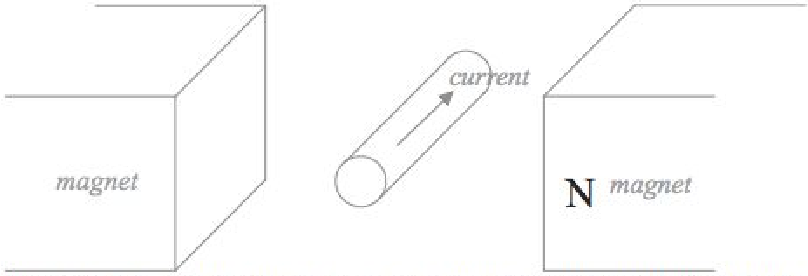
(ii)



general shape: at least one circle around each wire and one loop around both wires;
appropriate spacing of lines: increasing separation with distance from wires;
correct direction of field; ***[3]***

(b) velocity increases;
acceleration increases;
because the force is getting larger the closer the wires get together; ***[3]***
Watch for ECF if force is drawn in wrong direction in (a) (i) i.e. velocity increases, acceleration decreases, force gets smaller.

(d) (i)



because the magnetic force on the rod must be vertically upward and the law for the magnetic force requires field directed to the left, hence right pole is N; *[1]*

(ii) $0.20 \times I \times 0.80 = 4.0$;
and so $I = 25\,\text{A}$; *[2]*

(iii) at Y;
the magnetic fields of the wire and of the magnet add; *[2]*
*Award **[0]** for a correct answer with no explanation or with an incorrect explanation.*
Watch for ECF in case they got the polarity of the magnets wrong earlier in which case the answer is X.

Part 2 Electrical conduction and the force on a conductor in a magnetic field

(a) (i) $\longleftarrow$; *[1]*

(ii) the force on the electrons produced by the electric field causes them to accelerate along the direction of the rod;
however, they will (soon) collide with a lattice ion but after collision will again be accelerated (along the rod) before making another collision / *OWTTE*;
hence the electrons gain a drift/net velocity in the direction of the wire / in the (opposite) direction to the field even though they still have random velocities / *OWTTE*; *[3]*

(b) (i) $\longleftarrow$; *[1]*

(ii) $F = BIL = Ma$;
to give $a = \dfrac{BIL}{M}$; *[2]*

(c) (i) let the body move a distance Δx in time Δt, then work one by F is $W = F\Delta x$;
therefore rate of working = power = $P = \dfrac{F\Delta x}{\Delta t} = Fv$; *[2]*
i.e. Look for expression for work done and identifying power as rate of working.

(ii) $P = BILv = EI$;
to give $v = \dfrac{E}{BL}$;
$v = \left(\dfrac{0.8}{0.60 \times 0.25}\right) = 5.3\,\text{m}\,\text{s}^{-1}$; *[3]*

A3. (a) (i) **two** arrows directed towards the centre of the circular path, within ± 0.5 cm of the centre. *[1]*

(b) (i) negative by stating any rule for the direction of the magnetic force; *[1]*

(ii) the work done is zero;
since the force is at all times normal to the velocity; *[2]*

(c) a curved path starting at X and in the right direction i.e. counterclockwise;
circular path of radius $\frac{R}{2}$; *[2]*

Allow diameter 3-4 cm and be generous with how round the circle is.