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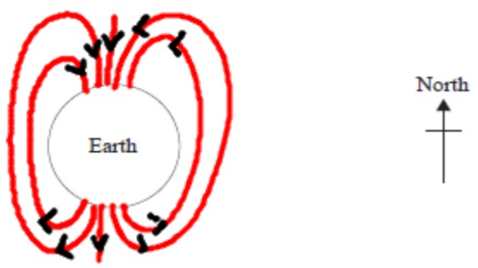
A3. This question is about magnetic fields.

(a) Using the diagram below, draw the magnetic field pattern of the Earth. *[2]*



(b) State what other object produces a magnetic field pattern similar to that of the Earth. *[1]*

bar magnet , solenoid

(This question continues on the following page)

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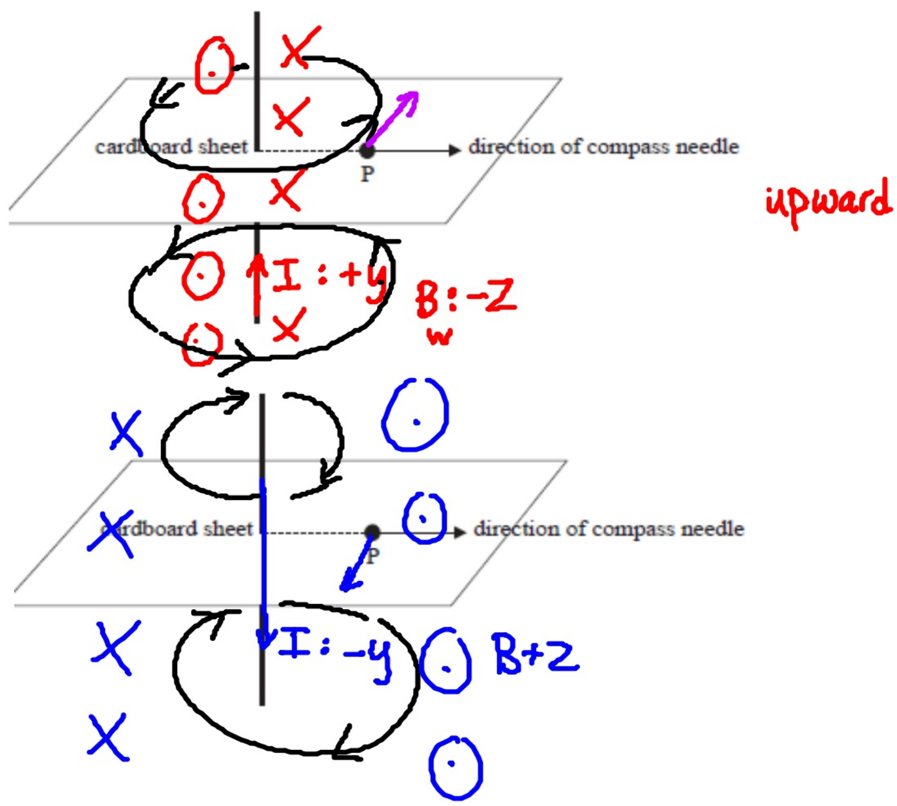

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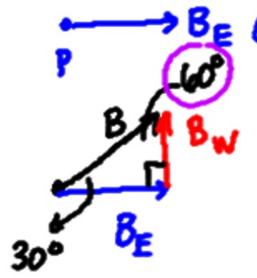
(ii) The magnetic field strength at point P due to the current in the wire is B_W and the strength of the horizontal component of the Earth's magnetic field is B_E.

Deduce, by drawing a suitable vector diagram, that

$$B_E = B_W \tan 60°.$$ [2]



$\tan\theta = \dfrac{opp}{adj}$

$\tan 60° = \dfrac{B_E}{B_W}$

$\therefore B_E = B_W \tan 60°$

(iii) The point P is 2.0 cm from the wire and the current in the wire is 4.0 A. Calculate the strength of the horizontal component of the Earth's magnetic field at point P. [2]

$B_W = \dfrac{\mu_0 I}{2\pi r} = \dfrac{(4\pi\times10^{-7}\,\frac{Tm}{A})(4.0A)}{2\pi(.02m)} = 4.0\times10^{-5}T$

$\mu_0 = 4\pi\times10^{-7}\,\frac{Tm}{A}$

$r = 2cm = .020m$

$I = 4.0A$

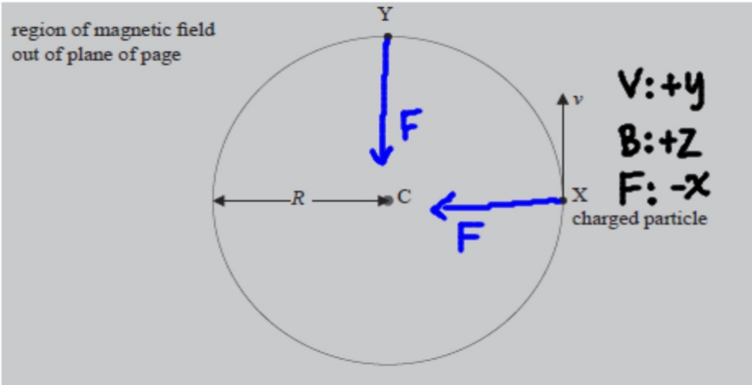
$B_E = B_W \tan 60°$

$= (4.0\times10^{-5}T)\tan 60°$

$B_E = 6.9\times10^{-5}T$

A3. This question is about motion of a charged particle in a magnetic field.

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]*

negative by right-hand rule

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

$W = F\Delta d\cos\theta$, since $\theta = 90°$, $W = 0$ J

no work is done.

(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]*

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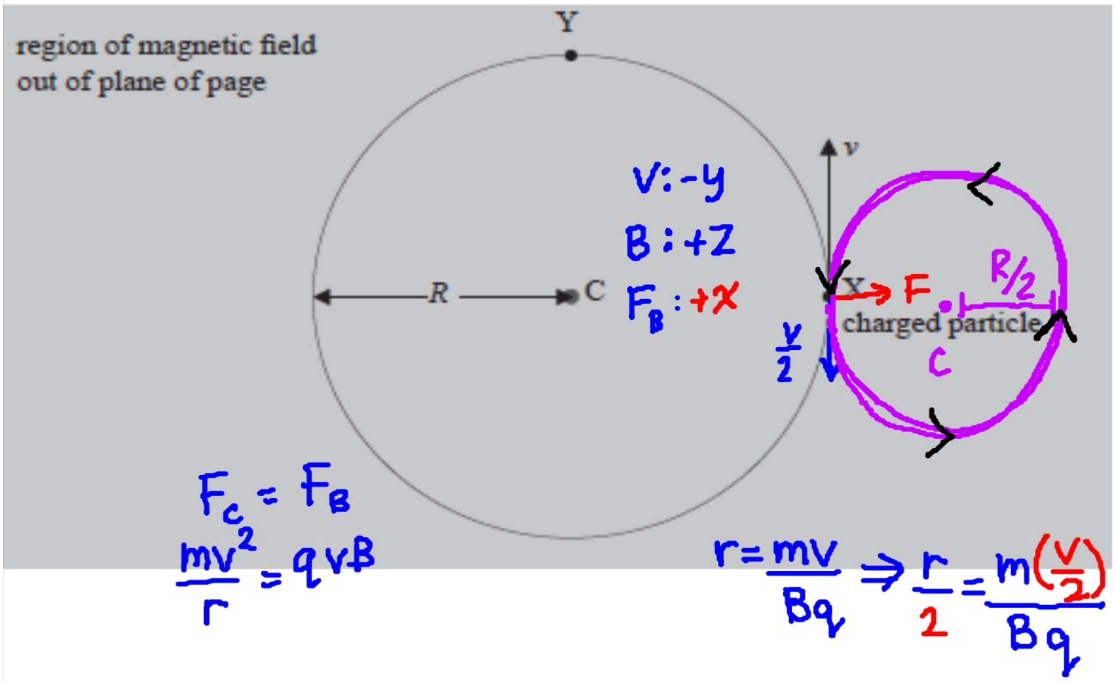
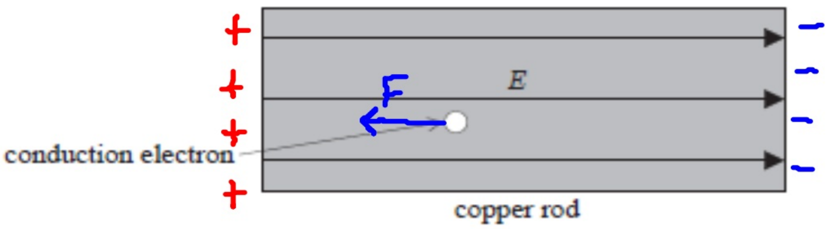
(Question B3 continued)

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.)



(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]

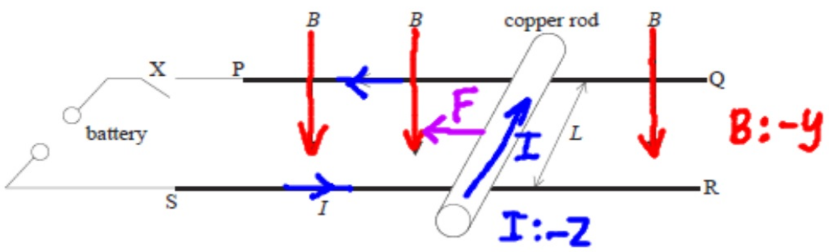
(ii) Describe how the electric field enables the conduction electrons to have a drift velocity in a direction along the copper rod. [3]

• If $F_E = F_{net}$ then $Eq = ma \Rightarrow a = \frac{Eq}{m}$, electric field causes electrons to accelerate;

• electrons will collide with one another causing changes in direction and velocity;

(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]

F:-x

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

$F_B = F_{net} \Rightarrow \frac{BIL}{M} = \frac{Ma}{M} \Rightarrow \therefore a = \frac{BIL}{M}$

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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]

$P = \frac{W}{t}$ and $W = F\Delta d$

$\therefore P = \frac{F\Delta d}{t} = F \cdot \frac{\Delta d}{t} = Fv$

(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

$P = Fv$

$\therefore v = \frac{P}{F} = \frac{I\Delta V}{BIL} = \frac{\Delta V}{BL} = \frac{(.80V)}{(.25T)(.60m)}$

$v = 5.3\ ms^{-1}$