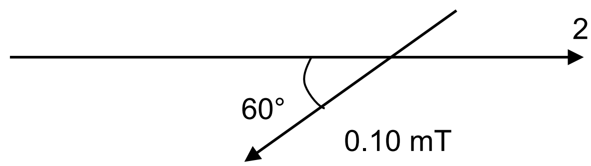
1

The magnetic field by wire X will cut wire Y at an angle of 60°.



$F = BIL\sin 60°$

$\frac{F}{L} = BI = (0.10 \times 10^{-3})(2.5)\sin 60° = 2.17 \times 10^{-4}$ N m^{-1}

Using Fleming's left hand rule, force will be perpendicularly into the page.

2 **B**

As long as P and R have current in the same direction, they will exert force on T in opposite directions and the same goes for Q and S.

3 W and X has current flowing into the page and Y and Z has current flowing out of the page.

Can visualize the side view of a coil, with WX representing the cross section of wires in the upper end and ZY representing the cross section of wires in the lower end. Using right hand grip rule, to form B-field in the coil, pointing to the left, current must flow as indicated above.

4 **B**

Direction OX must be perpendicular to a line drawn from centre of wire because the magnetic field is perpendicular to the current and not cutting the current.. Hence, current must be flowing in P.

Using right hand grip rule, current must be flowing out of the plane of the diagram.

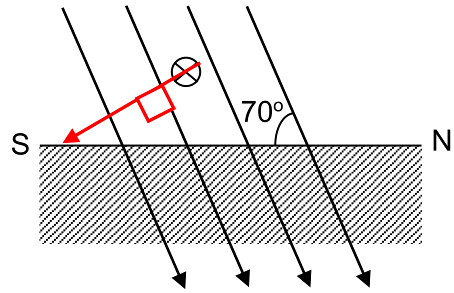
5 **B**

6 $F = BIL = (0.040)(5.0)(0.030) = 6.0 \times 10^{-3}$ N

(Note that the angle between I and L is 90°.

7 Earth's magnetic field is perpendicular to the current in this case.

Applying FLHR,



8

(a) By FLHR, current flows from A to B.

(b)

$$|mg| = |BIL|$$

$$mg = B(\frac{V}{R})L$$

$$V = \frac{mgR}{BL} = \frac{0.0045(9.81)(0.050)}{1.8\times10^{-3}(0.57)} = 2.15 \text{ V}$$

(c) To lift a wire of a mere 4.5 g will require a voltage of 861 V when flux density is 1.8 x 10^{-3} T. With a magnetic field strength a hundred times weaker, the expected voltage will be a hundred times larger and hence, is not common.

9 The current in XY is flowing up while that of YZ is flowing downwards, hence, the currents in opposite directions will repel each other and causes the two sections to move away from each other.

10

(a) Gain in KE = Loss in EPE

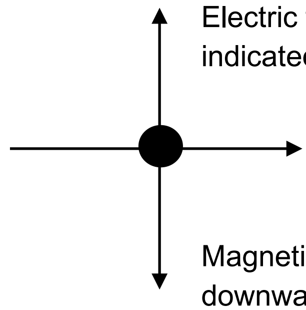
Assuming the ions starts from rest at S,

$$\frac{1}{2}mv^2 - 0 = qV$$

$$\frac{1}{2}(2.84\times10^{-26})v^2 - 0 = 1.6\times10^{-19}(3000)$$

$$v = 1.84\times10^5 \text{ m s}^{-1}$$

(b) The electric forces acting on the negative ions are acting along the same vertical line in opposite directions as shown in the diagram below.



Hence, when the two forces are equal in magnitude, and the vertical resultant force is zero, the ions will move through without deflection.

(c)

$$|F_e| = |F_B|$$
$$qE = Bqv$$
$$E = Bv = 0.83(1.84\times10^5) = 1.53\times10^5 \text{ N C}^{-1}$$

(d) Without the electric field between the plates, the electric force no longer exists. Hence, there will only be magnetic force downwards, which will cause the ions to be deflected downwards in a circular path, since the magnetic force is always perpendicular to the direction of the velocity.

11(a) For definition of magnetic flux density, refer to notes.

(b) $B = \dfrac{F}{IL}$

Both section TU and WV experience forces that causes coil to turn about axis PQ.

Force experienced by each section $F = NBIL$

The two forces from a couple.

Torque created by couple about axis PQ $= FL$

At balance, by Principle of moments,

$$Mgx = FL$$
$$Mgx = NBIL(L)$$
$$B = \frac{Mgx}{IL^2N}$$

(c)(i) As seen from calculation in part **(b)**, when *N* is doubled, *x* will double as well if all other factors are held constant. However, as current is supplied by a battery of constant e.m.f., the current will be affected by the resistance of the wire making up the coil. Since $R = \rho \frac{l}{A}$, when *N* is doubled, the length of wire doubles and hence, *R* doubles, leading to I being halved. Therefore, there will be no net effect on *x*.

(c)(ii) As seen from calculation in part **(b)**, when *L* is halved, *x* will reduce to $\frac{1}{4}x$ if all other factors are held constant. However, as current is supplied by a battery of constant e.m.f., the current will be affected by the resistance of the wire making up the coil. Since $R = \rho \frac{l}{A}$, when *L* is halved, the length of wire is halved and hence, *R* is halved, leading to I being doubled. Therefore, net effect on *x* is that it will be reduced to $\frac{1}{2}x$.

12 (a) Note that in this case "specific" refers to per unit mass.

Magnetic force provides centripetal force

$$F_B = F_C$$
$$Bqv = mr\omega^2$$
$$Bqr\omega = mr\omega^2$$
$$Bq = m\omega$$
$$Bq = m(\frac{2\pi}{T})$$
$$T = \frac{2m\pi}{Bq} = \frac{2\pi}{B\frac{q}{m}} = \frac{2\pi}{10^{-2}(1.76\times10^{11})} = 3.57\times10^{-9} \text{ s}$$

(b) Note that in this case the electron possess only kinetic energy and no electric potential energy as it is not orbiting about other charged particles.

Hence, since $KE = \frac{1}{2}mv^2$, when energy is halved, the speed is reduced to $\frac{1}{\sqrt{2}}v$.

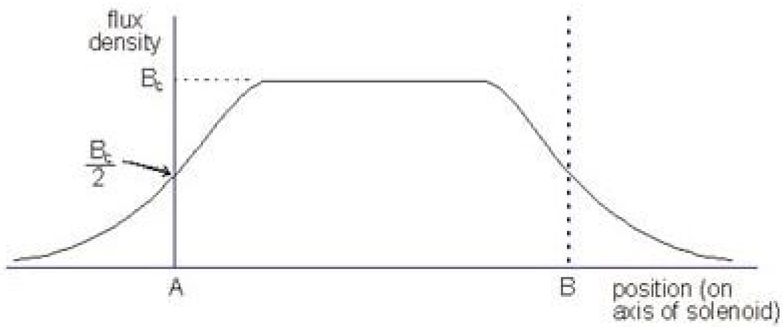
However, as can be seen from above, period is not affected at all by the speed.

13 The electron will continue undeflected along its path because the magnetic field in the solenoid is parallel to the axis and hence the current created by the coil. Therefore, there will be no resultant magnetic force acting on the electron to deflect it.

14 The flux density will be 2*B*. This is because the magnetic flux density at the centre of the solenoid is twice that at the end.

Note: A mathematical derivation will require Biot-Savart's Law that is not in syllabus.

In general, this graph is a representation of the law applied in this case.



Alternatively, you can also visualize along this line:

The magnetic field at any point in space can be computed by summing over the magnetic fields produced by each turn of wire in your solenoid. It turns out that for an infinitely long solenoid, with the same number of turns per unit length of the solenoid, the magnetic field is constant in strength everywhere inside. If your solenoid has ends, then you can think of it as an infinitely long solenoid minus the end parts that stretch off to infinity. The magnetic field strength on the axis going right through the solenoid, in the place on the end of the solenoid is then the field of an infinitely long solenoid minus half of it because half is missing, and so the field strength is half as big on the ends (but right in the middle).

15(a)

Assuming effect of current in GF on the magnet is negligible (since distance from GF to magnet is unknown) and that magnet is placed at mid-point between FE and GH,

Vertical magnetic field created by FE at magnet position

= Vertical magnetic field created by GH at magnet position

$$= \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7}(3.0)}{2\pi(0.25)} = 2.4 \times 10^{-6} \text{ T}$$

Hence, the vector sum of the two magnetic fields = 4.8 x 10^{-6} T

(b)(i) The magnetic field created by the current will be much stronger than that of Earth's and hence, caused the magnet to be pointing almost vertically upwards. (Almost and not completely vertically upwards is because the horizontal component caused by Earth is not affected by magnetic field created by coil.

(b)(ii) As above, but, with the current direction reversed, the magnetic field created by the coil will now be pointing downwards, in the same direction as that of Earth's and hence, caused the magnet to be pointing almost vertically downwards.

16 There is no force acting on the wire Q due to the current in wire P because the magnetic field created by P is parallel to the direction of current flow in Q.

17

$$F = BIL$$

$$\frac{F}{L} = BI = \frac{\mu_0 I}{2\pi r}(I) = \frac{\mu_0 I^2}{2\pi r}$$

Hence,

$$\frac{F}{L} = \propto \frac{I^2}{r}$$

Therefore,

$$\frac{F_{YZ}}{L} = 4(2\times10^{-6}) = 8\times10^{-6}\ \text{N m}^{-1}\ \text{upwards}$$

$$\frac{F_{YZ}}{L} = \frac{(2\times10^{-6})}{2} = 1\times10^{-6}\ \text{N m}^{-1}\ \text{upwards}$$

Resultant force acting on Z per unit length $= (1+8)\times10^{-6} = 9\times10^{-6}\ \text{N m}^{-1}$