Magnetic Fields

Multiple choice questions

Question 1

The electron will experience a force in the same direction as the current experiences a force, because it is the same force acting.

With the right hand thumb pointing to the right (in the direction of the current) the fingers point into the page (the direction of the field), then the force is projecting upwards from the palm of your hand.

∴ A (ANS)

Question 2

The flow of electrons is down the conductor, so the conventional current is 'up'. The direction of the field is to the North. If your right hand thumb points up, your fingers are in the direction of the field, (North), then the force must be in a "Westerly" direction, coming straight out of your palm. Refer back to the notes on Magnetic Fields, if you need further clarification.

∴ D (ANS)

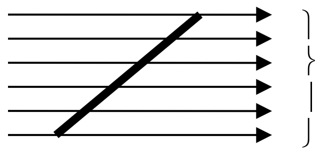
Question 3

Use $F = nBIL$
$= 1 \times 2 \times 10^{-5} \times 2 \times 10^{5} \times 2.5$
$= 10$ N

∴ A (ANS)

Question 4

Because the conductor is now bent over at an angle of 30^0, the effective length of the conductor perpendicular to the field is less.



this is now the effective length.

So the new force will be less than before, but not zero.

∴ C (ANS)

Question 5

The expression *one or more* means exactly that, there may be 1, 2, 3 or 4 correct answers. If it does not say *one or more* then there is only one 'best' answer.
If the wire is being pushed then F = nBIL, implies that n, B, I, L are all non-zero, ∴ they exist.

Answer C is correct because it is the definition, the force acts on the moving charges, which in this case are the electrons that are constrained to move inside the wire.

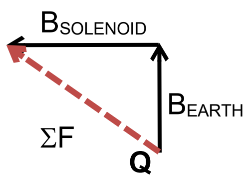
∴ A C (ANS)

Question 6

Magnetic fields are vectors, so the two fields due to the individual bar magnets will cancel each other out. There is still the magnetic field due to the Earth at this point, so the best answer is D. C is also correct but D is much better.

∴ D (ANS)

Question 7 (2012 Question 17, 1m, 40%)



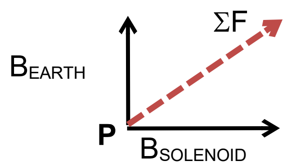
The arrow had to **originate at Q**, and point approximately 45^0 up to the left.

The direction of the field is the direction that the North end of the compass will point to.

∴ B (ANS)

Question 8 (2012 Question 17, 2m, 47%)

The small magnet free to rotate about its centre is a compass needle. This points in the direction of the magnetic field.



The arrow had to **originate at P**, and point approximately 45^0 up to the right.

∴ D (ANS)

Question 9

Use your right hand with your fingers in the direction of the field, from N to S. The thumb is in the direction of the current, (from K to L) so the force (direction of palm) must be down.

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Use your right hand with your fingers in the direction of the field, from N to S. The thumb is in the direction of the current, (from K to L) so the force (direction of palm) must be down.

∴ **B (ANS)**

The other way of looking at this question is: Did anything change between orientations 1 to 3, other than the angle. The direction of the force is given by the relationship between the field (which didn't change) and the direction of the current (that didn't change), so the direction of the force shouldn't change.

Question 10

Use your right hand with your fingers in the direction of the field, from N to S. The thumb is in the direction of the current, (from M to L) so the force (direction of palm) must be forwards to the centre of the loop.

Use your right hand with your fingers in the direction of the field, from N to S. The thumb is in the direction of the current, (from M to L) so the force (direction of palm) must be forwards to the centre of the loop.

Now the wire is parallel to the direction of the field so the force acting must be zero.

∴ **D (ANS)**

Question 11 (2014 Question 12a, 1m, 50%)

The current is going up the front in the wire at the left hand end. This will give a field to the left.

∴ **A (ANS)**

Question 12 (2014 Question 12b, 1m, 50%)

With the field to the left, the current up the page, then from the right hand slap rule, the force is out of the page.

∴ **C (ANS)**

Question 13 (2017 Question 1, 1m, 65%)

At this point in time it is not known how to create a magnetic monopole.

Extended questions

Question 14

Use $F = Bqv$, and $F = \frac{mv^2}{r}$

$$\therefore Bqv = \frac{mv^2}{r}$$

$$\therefore B = \frac{mv}{rq}$$

$$\therefore B = \frac{9.1\times10^{-31}\times1.5\times10^{7}}{0.25\times1.6\times10^{-19}}$$

$\therefore$ **B = 3.4 × 10^{-4} T (ANS)**

Question 15

Use $F = nBIl$

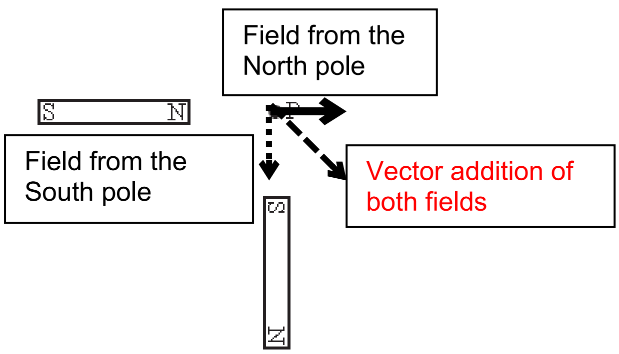
Where n = 1, l = 2, B = 0.15 and F = 3

$\therefore 3 = 1 \times 0.15 \times i \times 2$

$\therefore$ **i = 10 A (ANS)**

Question 16 (2011 Question 2, 2m, 37%)

The combined field will be the field created by vector addition of the two fields.



Question 17

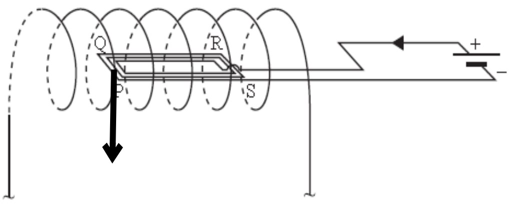
The current flowing in coil 2 is creating a North pole to the right hand end. In coil 2 the current is flowing from the right hand side of the cell (battery). This is produces a field directed to the right. Therefore the left hand end of coil 2 is acting as a South pole.

The current in coil 1 is in the opposite direction, this produces a field to the left. These fields are in the opposite directions, like two South poles, so they will repel each other.

So the force on coil 1 (from coil 2) is a repulsive force, acting to the left.

Question 18a (2010 Question 2, 2m, 45%)

Inside the loop the magnetic field is parallel to the loop and is acting to the left. The current is going from Q to P.
Using the right hand rule, the force will be downwards.



Question 18b (2010 Question 4, 2m, 70%)

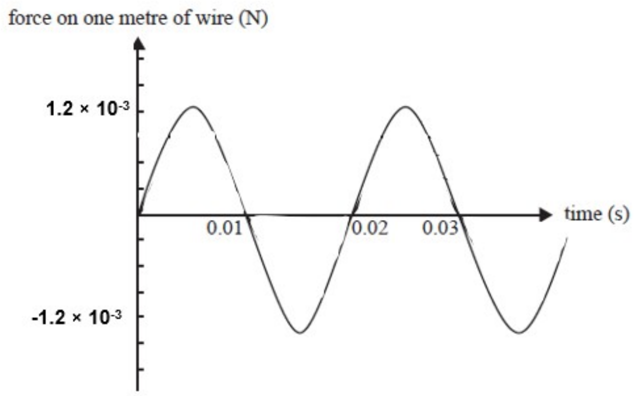
Using F = nBiL gives
F = 3 × 5.0 × 10^{-2} × 4.0 × 4.0 × 10^{-2}
∴ F = 240 × 10^{-4}
∴ F = 0.024 N (ANS)

Question 18c (2010 Question 5, 2m, 70%)

The current in QR is parallel to the field of the solenoid, therefore the force will be zero.
∴ 0 N (ANS)

Question 19 (2011 Question 17, 2m, 20%)

The current in the transmission line is 30 A_{RMS}, this means that it is $30\sqrt{2}$ A_{Peak}.
Since the current varies sinusoidally, so will the force.
Where n, B and L are constants, so
F = nBIL becomes
= 1 × 3.0 × 10^{-5} × $30\sqrt{2}$ × 1
= 1.2 × 10^{-3} N (Peak).



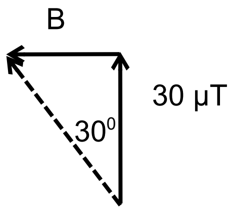
The question actually asks you to label the voltage and time axes, it meant for you to label the **force** and time axes. I also think that it is better to stick to MKSA units on the axes.

Question 20a

When the current flows in the solenoid, it produces a field to the left. The compass will turn 30^0 in an anticlockwise direction due to the vector addition of the two fields.

Question 20b

The field (B) is due to the solenoid.



Use $\tan 30 = \frac{B}{30 \times 10^{-6}}$
∴ B = (30 × 10^{-6}) × tan 30
∴ B = 17.3 × 10^{-6} T
∴ 17 μT (ANS)

Question 21a

Use F = Bqv
∴ F = 5.0 × 10^{-5} × 1.6 × 10^{-19} × 40 × 10^{3}
∴ F = 3.2 × 10^{-19} N (ANS)

Question 21b

Use F = Bqv, and $F = \frac{mv^2}{r}$
∴ $Bqv = \frac{mv^2}{r}$
∴ $r = \frac{mv}{Bq}$
∴ $r = \frac{1.7 \times 10^{-27} \times 40 \times 10^3}{5 \times 10^{-5} \times 1.6 \times 10^{-19}}$
∴ r = 8.5 m (ANS)

Question 22a

The magnetic field is into the page (X), so the force on the moving charge is down (current is to the left).
This means that the electric field needs to produce an upward force. This will happen when the top plate attracts the electron.
Therefore, the top plate (plate A) needs to be positive.

Question 22b

Equate F = Bqv with F = Eq

$\therefore$ Bv = E

$\therefore$ E = 0.2 × 200 000

$\therefore$ E = 40 000 N C^{-1} (ANS)

Question 22c

Use $E = \frac{V}{d}$

$\therefore 40\,000 = \frac{1000}{d}$

$\therefore d = \frac{1000}{40000}$

$\therefore$ d = 0.025 m (ANS)

This is different to the answer in the back of the book.

Question 22d

Since the alpha particle has the opposite charge sign, the direction of the magnetic force will change, but the electric force will also change. These will cancel each other out.
Equating F = Bqv with F = Eq shows that the mass of the particle is irrelevant.
The change in charge affects both the magnetic force and electric force proportionally, and hence the effects cancels out.
Therefore no changes are required.

Question 23a

If the ion is accelerated, it is attracted to the cathode (which is connected to the negative side of the battery), therefore it must be positive.

Question 23b

The magnetic field exerts a constant force on the moving ion perpendicular to its motion. This is the condition for circular motion to occur, as the speed of the ion does not change.

Question 23c

The positive ion experiences a force that is radially inwards. Initially the "current" is to the right, therefore the magnetic field is out of the page. (Use the right-hand rule to ascertain)

Question 23d

WD = ΔKE

$\therefore qV = \frac{1}{2} mv^2$

$\therefore 1.6 \times 10^{-19} \times 4000 = \frac{1}{2} \times 11.6 \times 10^{-27} \times v^2$

$\therefore v^2 = 110{,}344{,}827{,}586.2$

$\therefore$ v = 332 182

$\therefore$ v = 3.32 × 10^5 m s^{-1} (ANS)

Question 23e

Use F = Bqv, and $F = \frac{mv^2}{r}$

$\therefore Bqv = \frac{mv^2}{r}$

$\therefore B = \frac{mv}{rq}$

$\therefore B = \frac{11.6 \times 10^{-27} \times 3.32 \times 10^5}{6.4 \times 10^{-2} \times 1.6 \times 10^{-19}}$

$\therefore$ B = 0.38 T (ANS)

Question 23f

From F = Bqv, and $F = \frac{mv^2}{r}$

$\therefore Bqv = \frac{mv^2}{r}$

$\therefore r = \frac{mv}{Bq}$

If B and v remain the same, then the ratio $\frac{m}{q}$ must halve.
This means that Student A and Student B could be correct, as both of their suggestions would halve the ratio.
Student C response would reduce D by a factor of 4.

Question 24a

With a current flowing through the copper bar, when the magnetic field is on, the moving charges (electrons) will experience a force, (F = Bqv) This will move the electrons down (conventional current is to the left), field into the page.
This will make the bottom of the bar more negative in comparison to the top.

Question 24b

The top, point A, will be at a higher potential. (See above)

Question 24c

Use $E = \frac{V}{d}$

$\therefore E = \frac{0.75 \times 10^{-6}}{5.0 \times 10^{-2}}$

$\therefore$ E = 1.5 × 10^{-5} V m^{-1} (ANS)

Question 24d

Use Bqv = Eq, as the force due to the electric field is equal and opposite to the force of the magnetic field.

Use $E = \frac{V}{d}$, to get

$Bqv = \frac{Vq}{d}$

$\therefore Bv = \frac{V}{d}$

$\therefore$ V = Bvd.

Question 24e

Use V = Bvd, to get

0.75 × 10^{-6} = 0.75 × v × 5.0 × 10^{-2}

$\therefore$ v = 2.0 × 10^{-5} m s^{-1} (ANS)

Question 25a

If the particle loses some energy going through the piece of lead, it will be travelling slower after going through the lead.
The particle will not lose charge, or mass, and the field is constant in the detector.

From F = Bqv, and $F = \frac{mv^2}{r}$

$\therefore Bqv = \frac{mv^2}{r}$

$\therefore r = \frac{mv}{Bq}$

If the radius of curvature of the particle is smaller, it is travelling slower.
Therefore the particle is travelling upwards.

Question 25b

The direction of the force acting on the particle is radially inwards to the left.
From the right-hand rule, with the field into the page, the particle moving up the page, the conventional current must be up the page.
Therefore the particle carries a positive charge.

Question 25c

From F = Bqv, and $F = \frac{mv^2}{r}$

$\therefore Bqv = \frac{mv^2}{r}$

$\therefore r = \frac{mv}{Bq}$

$\therefore$ mv = Bqr

$\therefore$ p = Bqr (ANS)

Question 26a (2016 Question 13a, 2m, 85%)

Use F = nBiL

0.32 = 1 × B × 2 000 × 3

$\therefore B = \frac{0.32}{2000 \times 3}$

$\therefore$ B = 5.3 × 10^{-5} Tesla (ANS)

Question 26b (2016 Question 13b, 2m, 55%)

The field is to the North, the current is down, therefore, the force is EAST.
This is from the right hand rule, where the finger face North, the thumb is down, so the palm is facing east.