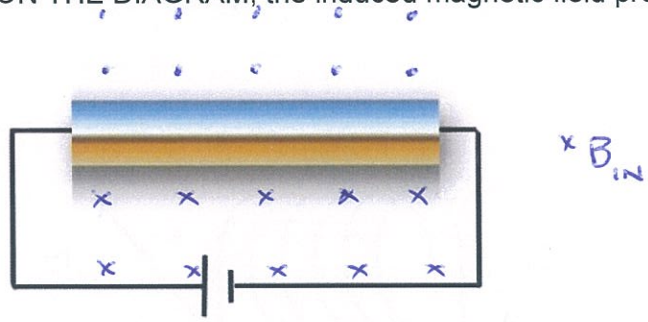
12 PHYSICS ATAR
TEST 2 - ELECTRIC FIELDS

NAME: SOLUTIONS MARK: $\frac{\phantom{00}}{68}$

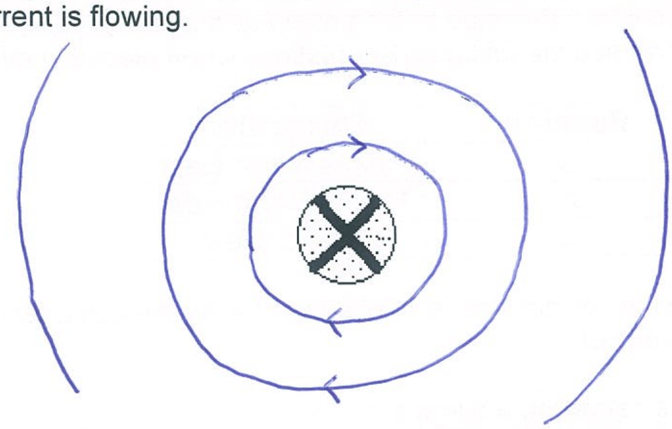
When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

1. The diagram shown represents a conductive bar connected to an external potential difference. Draw clearly ON THE DIAGRAM, the induced magnetic field produced when the circuit is closed. (1 mark)



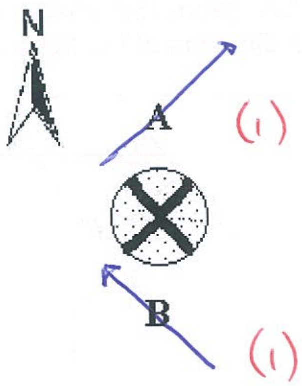

2. The diagram shown represents a current carrying conductor.

(a) Sketch clearly ON THE DIAGRAM, the magnetic field lines produced by this current when a current is flowing. (1 mark)



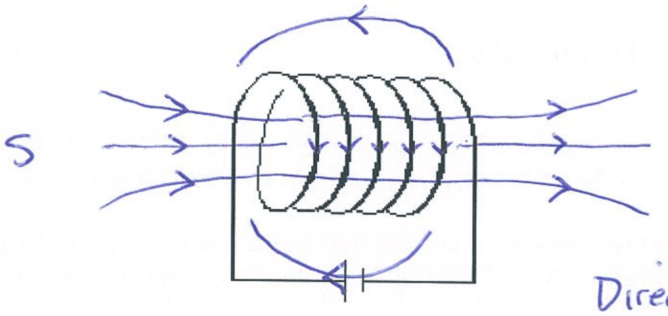
(b) The conductor is now placed into a magnetic field as shown. A pocket compass is placed at position (A) and then position (B). Sketch (below) the direction of the compass arrow for each position. (2 marks)

**(Note: $B_{earth} = B_{wire}$)**



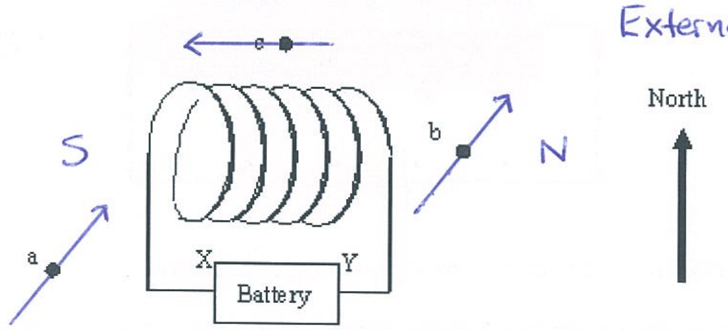

Should be 45° angle.

3. A single piece of copper wire is wound into a coil as shown. Draw clearly ON THE DIAGRAM, the magnetic field produced when a current (I) is passed through this coil. (3 marks)




Direction - 1 mark
Shape - 1 mark
External field - 1 mark.

4.




The coil shown above is connected to the battery terminals X and Y. A compass needle that normally points north has the following orientations when placed in different positions:

| Position | Orientation |
|---|---|
| a | Points North East |
| b | Points North East |
| c | Points West |

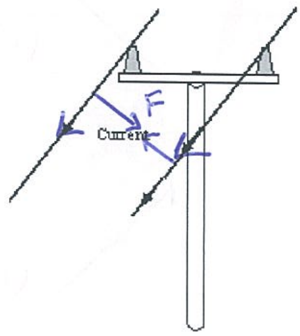
Which of the following conclusions is NOT supported by the observations? (2 marks)
***(Circle your answer(s).)***

(2)

(a) The battery is delivering a current.
(b) X is negative and Y is positive.
(c) The end of the coil near point b is a north pole.
(d) Y is negative and X is positive.

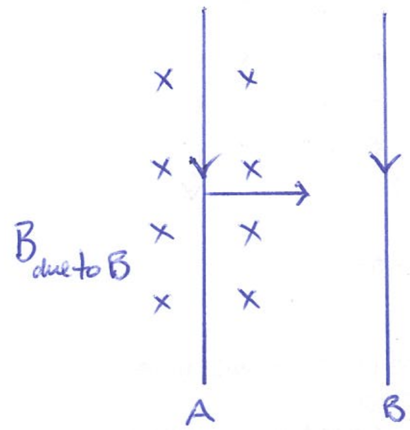
5. Power cables run on a pole to a farm in the NE (north-east) direction.

(a) Consider the magnetic field produced when a current flows in the wires. Show clearly ON THE DIAGRAM, the direction of the force acting each wire. (2 marks)




Ignoring $B_{Earth}$.

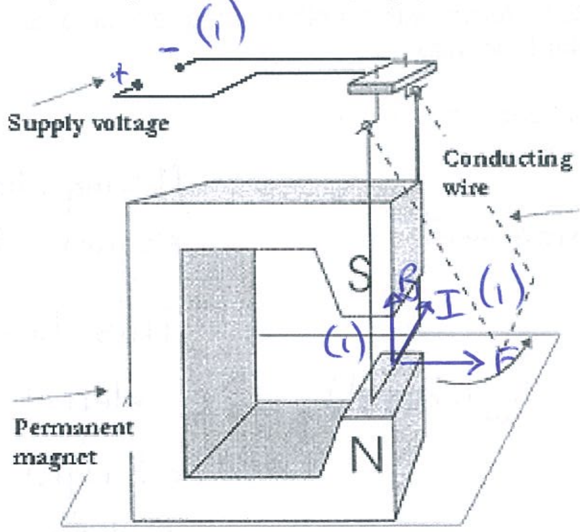
(b) Explain your answer to part (a). A full explanation will include a diagram and description making use of the right- hand rules that apply. (4 marks)



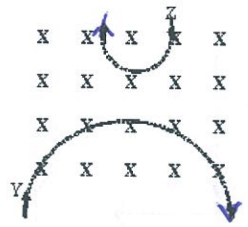

- Field due to current B is into the page at A. (1)
- The current A produces a magnetic field. (1)
- The two field interact, causing a force towards B. (1)
- Wire B is in the field of A and experiences a force towards A. (1)

6. (a) When the apparatus shown below is connected to a power supply the conducting wire swings out as shown.

Show clearly ON THE DIAGRAM, the direct of the permanent magnetic field (B), the current (I) and the polarity of the power supply (+/-). (3 marks)



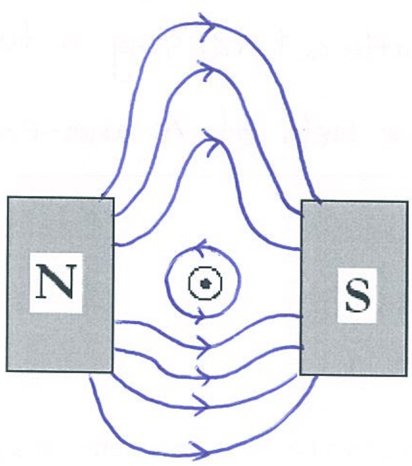
7. Two ions Y and Z of the same velocity are fired into a magnetic field shown going into the page.




Which of the following statements is ***true***? (1 mark)
***(Circle your answer(s).)***

(a) The magnetic field (B) must be changing with time.
(b) Y and Z are both positively charged.
(c) Y is negatively charged and Z is positively charged.
(d) The magnetic field (B) does no work on Y and Z.

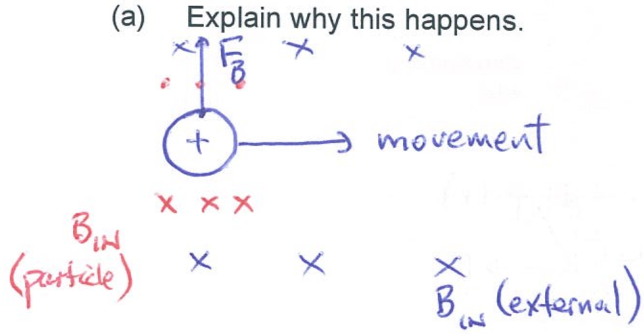
8. When a current-carrying wire is placed in a magnetic field, the two fields interact to form a newly-shaped resultant field. ON THE DIAGRAM, carefully draw the resultant magnetic field. (2 marks)




Shape - 1 mark
Direction - 1 mark.

9. When charged particles interact with a uniform magnetic field (B), the resulting path shows particle taking a circular trajectory.

(a) Explain why this happens. (2 marks)




- Moving charge generates a magnetic field. (1)
- This field interacts with the external field, causing a force at right angles to the movement and the external field. (1)
- This force changes the trajectory.

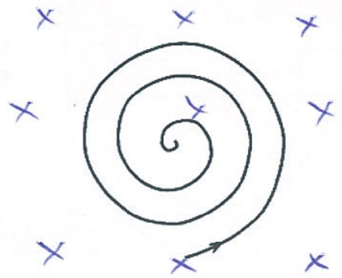
(b) Show that for a charged particle (q) entering a magnetic field (B) with initial velocity (v), the radius of the orbit of rotation inside the field is directly proportional to the initial velocity (v). (3 marks)

$$F_B = F_c \quad (1)$$

$$\Rightarrow \quad q\cancel{v}B = \frac{mv^{\cancel{2}}}{r} \quad (1)$$

$$\Rightarrow \quad r = \frac{mv}{qB} \quad (1)$$

(c) When a proton enters a region of uniform magnetic field its path is recorded on the surface of a photographic plate and displayed as the diagram shown here.



$B_{IN}$ (1)

(i) Indicate the direction of the magnetic field that the proton passes through. (1 mark)

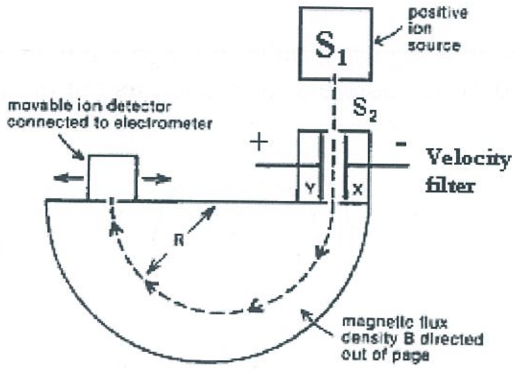
(ii) Explain why the path of the particle does not remain a circle of constant radius? (2 marks)

- The proton encounters friction with the air and/or photographic plate. (1)
- Since $r = \frac{mV}{qB} \Rightarrow r \propto V$, if $v$ decreases, $r$ decreases. (1)

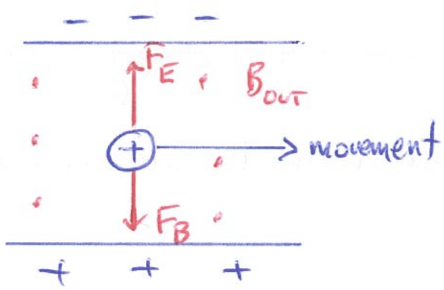
(d) How would the path of the particle differ if the particle were an electron with the same speed instead of a proton? (3 marks)

- From $r = \frac{mv}{qB} \Rightarrow r \propto m$. (1)
- Since $m_{electron}$ is much smaller than $m_{proton}$, $r$ would be much smaller. (1)
- Spiral is in the opposite direction - now a negative charge. (1)

10. In a mass spectrometer, charged particles of varying masses and velocity are accelerated across a potential difference as shown in the diagram ($S_1$). They then pass through a combination of an electric field and magnetic field to filter their velocities ($S_2$).




(a) Explain how the velocity filter works; use equations in your answer. (3 marks)




- Electric and magnetic fields are at right angles to each other. (1)

$\Rightarrow F_E = F_B$ (1)

$\Rightarrow Eq = qvB$

$\Rightarrow v = \frac{E}{B}$ (1)

(b) The two isotopes of bromine have relative atomic masses of 79.918 and 80.916. If, after passing through a mass spectrometer like the one above, the lighter isotope has a radius of curvature of 55.5 mm, find the distance that the detector would have to be moved in order to detect the other ion? (Assume that the ion has the same velocity and charge). (5 marks)

$$r_1 = \frac{m_1 v}{qB} = 55.5 \text{ mm.} \quad (1)$$

$$r_2 = \frac{\left(\frac{80.916}{79.918}\right) m_1 v}{qB} \quad (1)$$

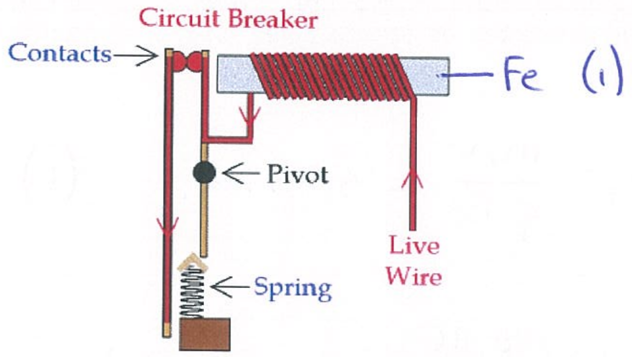
$$= \left(\frac{80.916}{79.918}\right) 55.5 \quad (1)$$

$$= 56.2 \text{ mm.} \quad (1)$$

Distance moved (d) = $2 \times (56.2 - 55.5)$

$= \underline{1.4 \text{ mm}}$ (1)

11. The diagram shown below gives the general layout of a common circuit breaker.




(a) On the diagram, identify the soft iron core. (1 mark)

(b) Explain the purpose and physics of the soft iron core (4 marks)

- Fe is ferromagnetic. (1)
- It concentrates the magnetic field of the coil. (1)
- Fe attracts the contact and breaks the circuit (1)
- It breaks the circuit when the current reaches a particular value. (1)

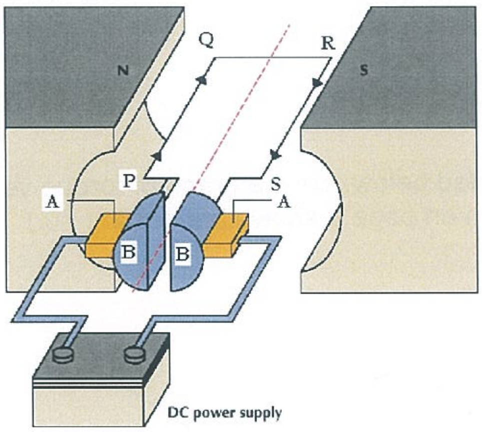
(c) A student remarks that using a stainless steel core instead of a soft iron core might actually prolong the life of the circuit breaker, as it would reduce failure due to corrosion. Comment on this statement. (2 marks)

- Stainless steel will not corrode as easily.
- It is still ferromagnetic and able to concentrate the magnetic field.

(d) Explain how the circuit breaker works. (4 marks)

See previous question.

12. The diagram shown here represents the basic parts of a DC motor.




(a) In which direction will the motor rotate when the current is allowed to flow in the loop PQRS? (1 mark)

anticlockwise (1)

(b) Two of the key components are labelled A and B; name these parts. (2 marks)

A: brushes/contacts (1) B: split-ring commutator. (1)

(c) In practice, suggest ONE way this motor could be made to spin faster? (1 mark)

- More current
- Stronger magnets.
- More coils

(1)

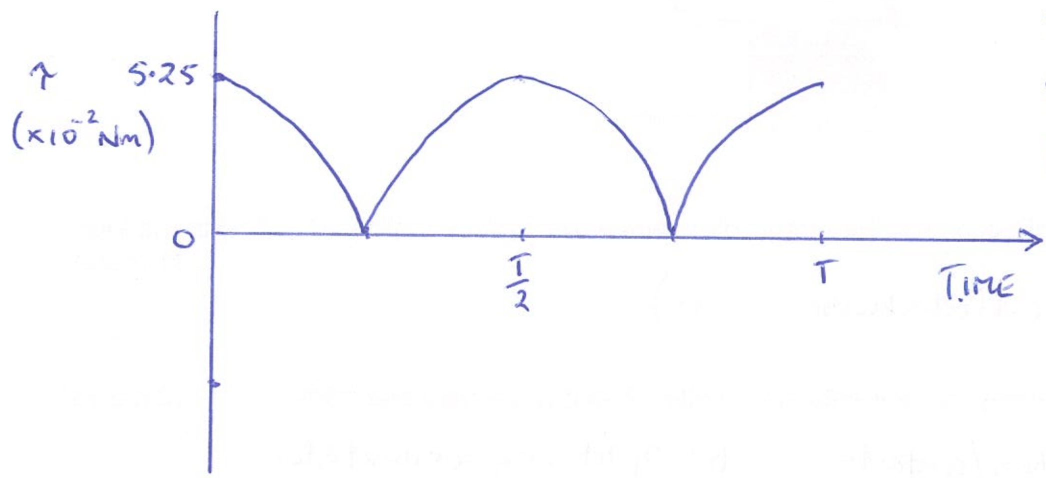
(d) How could this motor be made to spin more consistently? (1 mark)

- Have several coils at a 30° angle to each other. (1)

(e) Given that length PQ is 50.0 cm, length QR is 40.0 cm, the magnetic field is 0.350 T and the current flowing is 0.750 amps, what would the maximum torque that could be provided by this motor? (4 marks)

$$\tau = 2 \times N \times I\ell B \times r \quad (2)$$
$$= 2(1)(0{\cdot}750)(0{\cdot}500)(0{\cdot}350)(0{\cdot}200) \quad (1)$$
$$= \underline{5{\cdot}25 \times 10^{-2} \text{ Nm}} \quad (1)$$

(f) In the space provided below, draw a graph of torque versus period for the arm RS. (Note: The diagram on page 8 shows the coil at t =0.) (3 marks)




Scales - 1 mark
Shape - 1 mark
Positive only - 1 mark.

(g) In detailed steps, explain the physics of the operation of this DC motor. (5 marks)

- DC current flows in one direction (1)
- Current generates a magnetic field that interacts with the external field. (1)
- A force causes a torque to rotate the coil. (1)
- The split-ring commutator reverses the current flow in the coil every 180° of rotation so that the torque remains in the same direction. (2)