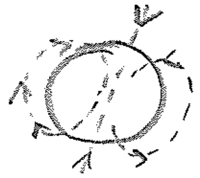
Year 12 Electromagnetism 1

revision sheet

Section 1 Short response (15 marks)

1 a) The needle of a normal mapping compass is not always balanced perfectly parallel to the Earth's surface as one end may dip down. Explain why the needle may 'dip' and identify which end would dip down here in Perth.

Magnetic field emanates from the Earth's core and "cuts" through Earth's surface at an angle to the horizontal (1)



In Perth South end dips down as field is directed North and up.

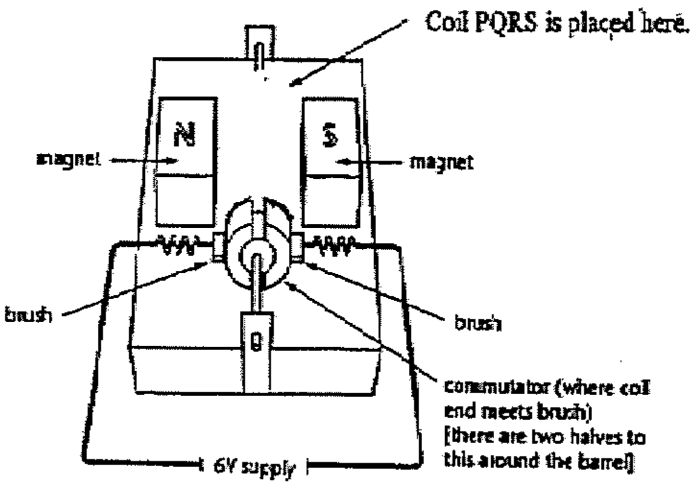
(2 marks)

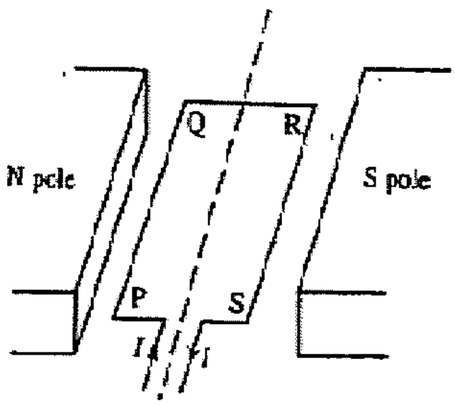
b) The Earth's North pole is a magnetic South pole. Explain the meaning of this apparent contradiction.

Magnetic North of a compass needle (magnet) points to North pole (1)
As unlike poles attract North pole of magnet must be attracted to a magnetic S. pole (1)

(2 marks)

2. A group of four students decided to make an electric motor for an assignment in which a device was to be made, its design and theory explained and the forces developed by the device calculated. The second diagram shows a rectangular coil PQRS, which can rotate about an axis, which is perpendicular to the magnetic field between two magnetic poles.





Consider the information above (text, diagrams & labelling) carefully and complete the table below with T (true) or F (false) for each statement.

Statement	T or F
The 'split' ring assembly requires a DC power supply to operate this motor.	T
As viewed from the front, the left hand brush will require a negative electrical polarity to drive current direction PQRS in the coil.	F
As viewed from the front, a current direction PQRS in the coil would cause the coil to rotate in a 'clockwise' direction.	F
If the external field magnets (N and S poles) were reversed, the coil should spin in the opposite direction.	T
If the external field magnets (N and S poles) were shifted closer to the coil PQRS the motor would develop greater torque.	T

(5 marks)

2. An electric cable carrying a direct current passes along a conduit, which lies within a factory wall running north - south. It is found that a horizontal compass needle on the east side of the wall points south instead of north.

a) Within the wall, is the conduit and cable running horizontally or vertically? Vertically

b) What is the direction of the current in the cable? Down

(2 marks)

3. The diagram below shows part of a mass spectrometer that accelerates charged ions to high velocities and propels them through a magnetic field. The ions are then deflected by the magnetic field before being detected by a movable electrometer that can be adjusted to different positions.

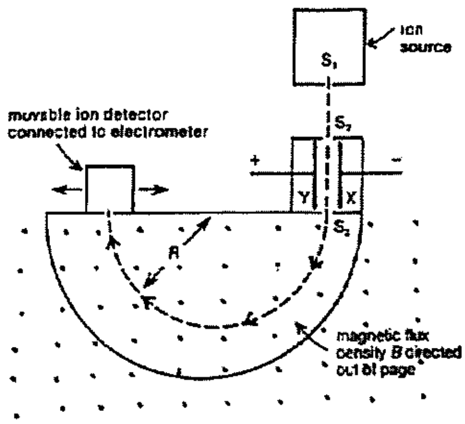
a) Is the ion source (S1) ejecting positive or negative ions through the magnetic field to produce the ion pathway (dashed line) as shown?

Positive

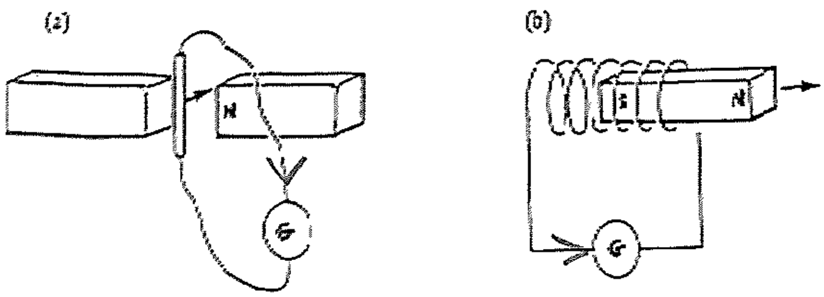
b) Which direction, left or right, should the electrometer be moved to detect the same ions if the magnetic flux density was increased?

Right

(2 marks)



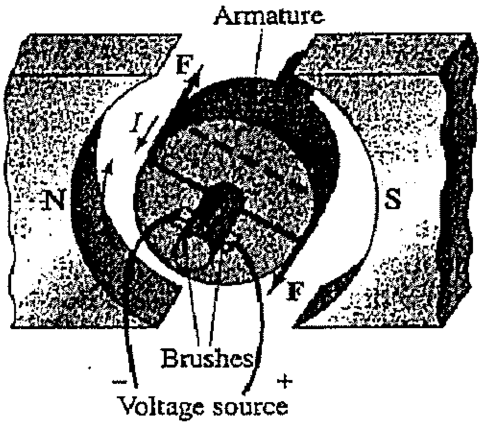
4. In each case below, an external force is applied in the direction of the arrow inducing an emf in the external circuit, and current flow is detected by the galanometer. Indicate the direction of induced current in each of these cases. Draw an arrow on the wire next to the galvanometer.



(2 marks)

Section 2 Problem solving (25 marks)

1. The simple motor shown has windings of 3.50 cm length and 2.40 cm width and rotates in a uniform magnetic field of 7.50 x 10^{-3} T. When 200 mA of current passes through the coil it develops a maximum torque of 1.89 x 10^{-4} Nm.



   a) Calculate the number of windings on the armature.

$\tau = 2 \times BIl \times r \times n$ (1)

$n = \frac{\tau}{2BIlr} = \frac{1.89 \times 10^{-4}}{2 \times 7.5 \times 10^{-3} \times 0.2 \times 0.035 \times 0.012}$ (2)

$= 150$ (1)

(4 marks)

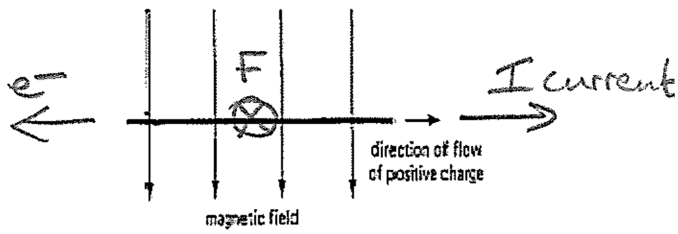
   b) If a greater torque were required, state 3 ways this could be achieved in the design of the motor.

More windings on armature
Stronger magnetic field
Larger current

(3 marks)

2. The current carrying conductor pictured below has a total force of 5.00 x 10^{-3} N exerted on its 2.50 m length when conducting current at right angles to a magnetic field of 3.25 x 10^{-4} T as shown.

   a) On the diagram above, show clearly
      i) The direction of current
      ii) The direction of electron flow (e-)
      iii) The direction of the force (F)



(3marks)

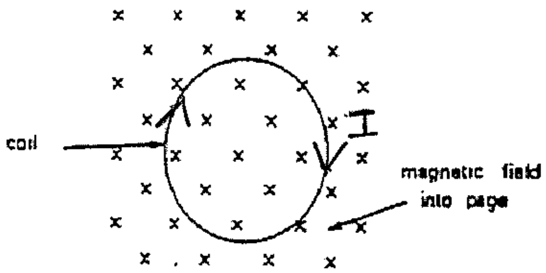
   b) Calculate the amount of current that must flow.

$F = BIl$ (1)

$I = \frac{F}{Bl} = \frac{5 \times 10^{-3}}{3.25 \times 10^{-4} \times 2.5} = 6.15\ A$ (1) (1)

(3 marks)

3. The diagram shows a coil consisting of 20 turns of conducting wire each with a cross-sectional area of 3.00×10^{-2} m^2. It is held at right angles to a magnetic field of intensity 6.00×10^{-4} T.



a) As the magnetic field is steadily reduced to zero over a period of 1.00×10^{-2} s, calculate the emf generated in the coil.

$$V_{emf} = -n\frac{\Delta\phi}{t} = -\frac{nBA}{t} \quad (1)$$

$$= \frac{20 \times 6 \times 10^{-4} \times 3 \times 10^{-2}}{1 \times 10^{-2}} \quad (1)$$

$$= 3.60 \times 10^{-2} V \quad (1)$$

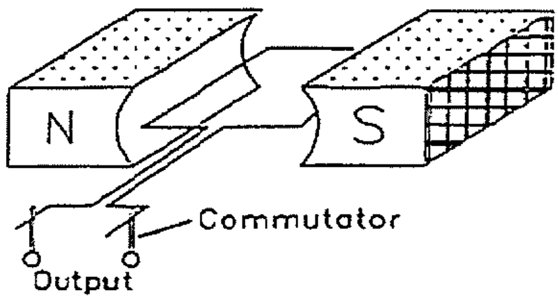
(3 marks)

b) Show the direction of induced current in the coil).

clockwise as shown

(1 mark)

4. The diagram to the right represents a simple electric generator. The coil consists of 200 turns of copper wire wound in a square of side 40 mm. The coil is rotated between the poles of a permanent magnet where the flux density is 5.00×10^{-2} T at 250 r.p.m. (revolutions per minute).



a) What average emf would be generated?

$$V_{emf} = -n\frac{\Delta\phi}{t} = -n.\frac{4BA}{T} \quad (1) \quad = \frac{200 \times 4 \times 5 \times 10^{-2} \times (40 \times 40 \times 10^{-6})}{60/250} \quad (1)$$

$$f = \frac{250}{60}$$

$$T = \frac{60}{250} \quad (1)$$

$$= 0.267V \quad (1)$$

b) What maximum emf would be generated?

$$V_{max} = -B\ell v \quad (1) \quad = 5 \times 10^{-2} \times (2 \times 40 \times 10^{-3} \times 200) \quad (1) \times \frac{2\pi \times 20 \times 10^{-3}}{60/250} \quad (1)$$

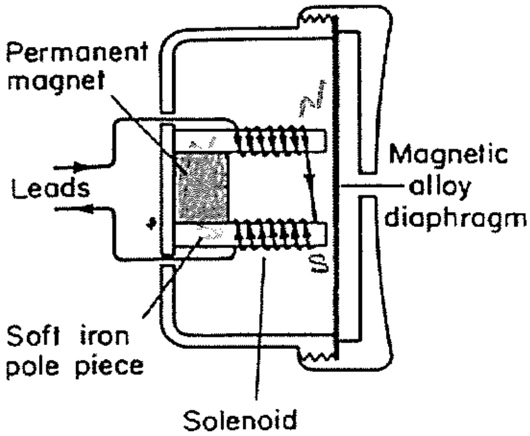
$$v = \frac{2\pi r}{T}$$

$$= 0.419V \quad (1)$$

(8 marks)

Section 3 Comprehension (10 marks)

The telephone receiver (earpiece).



The telephone receiver contains a U-shaped magnet formed by placing a short permanent bar magnet across the ends of two soft-iron bars (Fig. 36.14). This is placed so that it exerts a pull on a springy magnetic alloy diaphragm. Two solenoids are wound in opposite directions on the soft-iron bars.

When a person speaks into the microphone at the other end of the line a varying electric current is set up having the same frequency as the sound waves. A similar electric current is caused to pass through the solenoids in the earpiece. This alters the strength of the magnetic flux in the U-shaped magnet and produces a corresponding variation in the pull of the diaphragm. The latter therefore vibrates and reproduces a copy of the sound waves which entered the microphone.

1. Part of the first sentence " ... formed by placing a short permanent bar magnet across the ends ..... " refers to a permanent bar magnet that is labelled and shaded in the diagram. On this diagram place an N and S to clearly indicate the magnetic polarity of the bar magnet.

(1 mark)

2. Explain why "soft iron" is a suitable core material for the solenoid windings.

Soft iron undergoes rapid changes in domain alignment (1)
So the magnetic strength of the fields in the solenoids is very responsive to changing currents (1)

(2 marks)

3. The microphone and earpiece are functionally similar to motors and generators. Complete the statements.
   a) The microphone is most similar to a ......Generator...... .
   b) The earpiece is most similar to a ......Motor...... .

(2 marks)

4. If the *frequency* of variation in the electric current controls the *pitch* of the resulting sound, then the *magnitude* of the electric current controls the ......Loudness...... of the resulting sound.

(1 mark)

5. The alloy diaphragm is a magnetic material, but not a magnet. Describe how it can be attracted to the" V-shaped magnet" and name this property of the magnetic alloy material.

Solenoid fields induce magnetism in the (1) diaphragm by causing domain alignment in (1) the material with opposite polarity to the (1) solenoids resulting in attraction.

(3 marks)