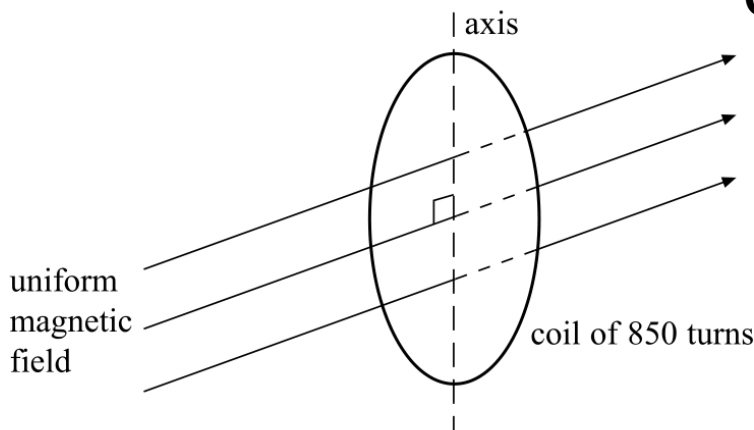


## Magnetic Fields Past Paper Questions Jan 2002—Jan 2010 (old spec)

4

**Q4 Jan 2005**



**Figure 5**

A circular coil of diameter 140 mm has 850 turns. It is placed so that its plane is perpendicular to a horizontal magnetic field of uniform flux density 45 mT, as shown in **Figure 5**.

- (a) Calculate the magnetic flux passing through the coil when in this position.

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*(2 marks)*

- (b) The coil is rotated through  $90^\circ$  about a vertical axis in a time of 120 ms.

Calculate

- (i) the change of magnetic flux linkage produced by this rotation,

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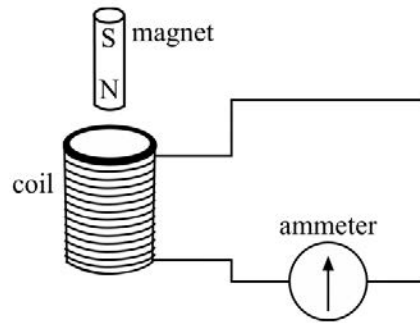
- (ii) the average emf induced in the coil when it is rotated.

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*(4 marks)*

3 A coil is connected to a centre zero ammeter, as shown. A student drops a magnet so that it falls vertically and completely through the coil.

**Q3 Jan 2004**



(a) Describe what the student would observe on the ammeter as the magnet falls through the coil.

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*(2 marks)*

(b) If the coil were not present the magnet would accelerate downwards at the acceleration due to gravity. State and explain how its acceleration in the student's experiment would be affected, if at all,

(i) as it entered the coil,

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(ii) as it left the coil.

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*(4 marks)*

(c) Suppose the student forgot to connect the ammeter to the coil, therefore leaving the circuit incomplete, before carrying out the experiment. Describe and explain what difference this would make to your conclusions in part (b).

You may be awarded marks for the quality of written communication provided in your answer.

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*(3 marks)*



- (iii) By considering the force that acts on an ion of mass  $m$  and charge  $Q$ , having velocity  $v$ , show that the diameter  $d$  of the path of the ions is given by

$$d = \frac{2mv}{BQ},$$

where  $B$  is the flux density of the magnetic field.

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(7 marks)

- (b) In an experiment using singly-ionised magnesium ions travelling at a velocity of  $7.5 \times 10^4 \text{ m s}^{-1}$ ,  $d$  was 110 mm when  $B$  was 0.34 T. Use this result to calculate the charge to mass ratio of these ions.

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(2 marks)

- (c) (i) Some ions of the same element, whilst travelling at the same velocity as each other at **P**, may arrive at a point that is close to, but slightly different from, **R**.  
 Explain why this might happen.

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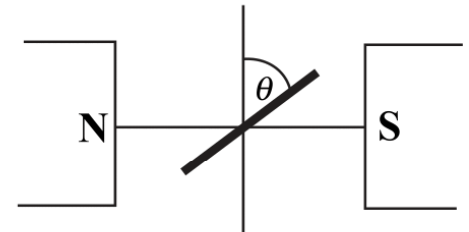
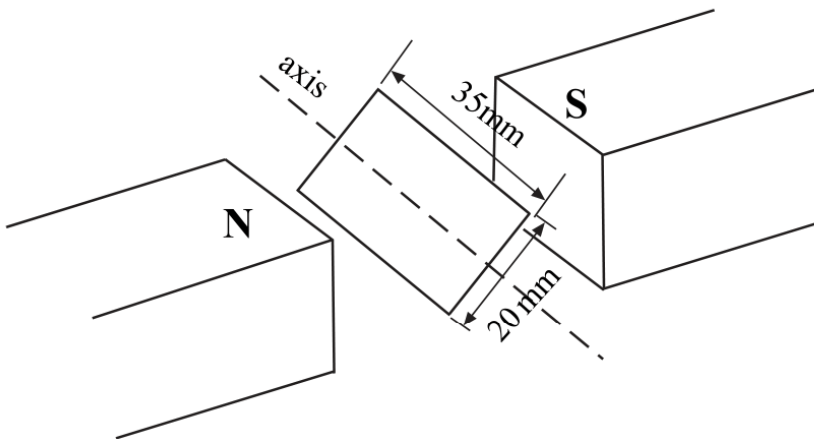
- (ii) Other ions of the same element, also travelling at the same velocity at **P** as all of the others, may travel in a path whose diameter is half that of the others.  
 Explain why this might happen.

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(3 marks)

- 3 A rectangular coil measuring 20 mm by 35 mm and having 650 turns is rotating about a horizontal axis which is at right angles to a uniform magnetic field of flux density  $2.5 \times 10^{-3}$  T. The plane of the coil makes an angle  $\theta$  with the vertical, as shown in the diagrams.

**Q3 Jun 2002**



front view

- (a) State the value of  $\theta$  when the magnetic flux through the coil is a minimum.

.....  
 (1 mark)

- (b) Calculate the magnetic flux passing through the coil when  $\theta$  is  $30^\circ$ .

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 .....  
 (2 marks)

- (c) What is the maximum flux linkage through the coil as it rotates?

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 (2 marks)

- 3 (a) The equation  $F = BIl$ , where the symbols have their usual meanings, gives the magnetic force that acts on a conductor in a magnetic field.

Give the unit of each of the quantities in the equation.

**Q3 Jun 2003**

$F$  .....

$B$  .....

$I$  .....

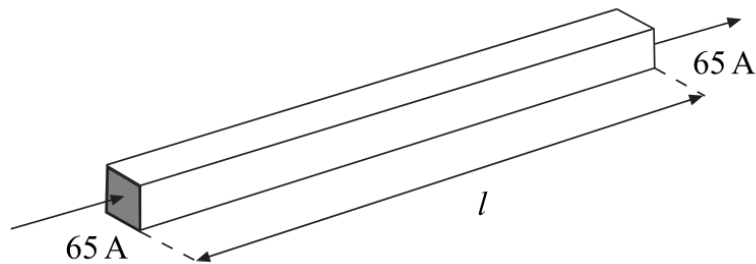
$l$  .....

State the condition under which the equation applies.

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(2 marks)

- (b) The diagram shows a horizontal copper bar of  $25 \text{ mm} \times 25 \text{ mm}$  square cross-section and length  $l$  carrying a current of  $65 \text{ A}$ .



- (i) Calculate the minimum value of the flux density of the magnetic field in which it should be placed if its weight is to be supported by the magnetic force that acts on it.

density of copper =  $8.9 \times 10^3 \text{ kg m}^{-3}$

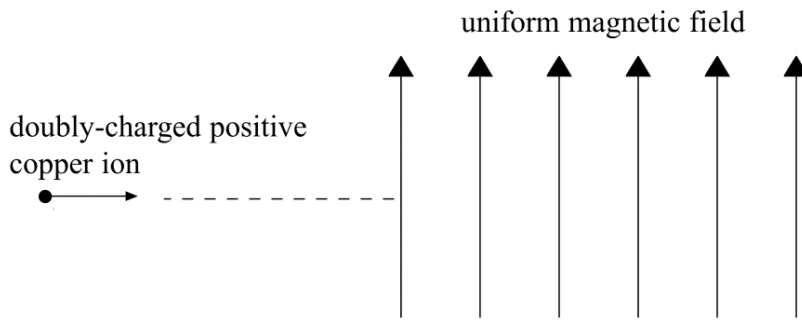
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- (ii) Draw an arrow on the diagram above to show the direction in which the magnetic field should be applied if your calculation in part (i) is to be valid. Label this arrow M.

(5 marks)

2 (a)

**Q2 Jun 2004**



**Figure 2**

**Figure 2** shows a doubly-charged positive ion of the copper isotope  ${}^{63}_{29}\text{Cu}$  that is projected into a vertical magnetic field of flux density 0.28 T, with the field directed upwards. The ion enters the field at a speed of  $7.8 \times 10^5 \text{ m s}^{-1}$ .

- (i) State the initial direction of the magnetic force that acts on the ion.

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- (ii) Describe the subsequent path of the ion as fully as you can. Your answer should include both a qualitative description and a calculation.

mass of  ${}^{63}_{29}\text{Cu}$  ion =  $1.05 \times 10^{-25} \text{ kg}$

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(5 marks)

- (b) State the effect on the path in part (a) if the following changes are made separately.

- (i) The strength of the magnetic field is doubled.

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- (ii) A singly-charged positive  ${}^{63}_{29}\text{Cu}$  ion replaces the original one.

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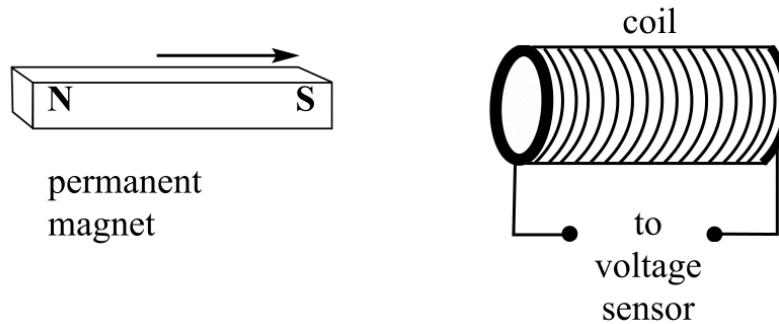
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(3 marks)

- 4 (a) In an experiment to illustrate electromagnetic induction, a permanent magnet is moved towards a coil, as shown in **Figure 3**, causing an emf to be induced across the coil.

**Figure 3**

**Q4 Jun 2006**



Using Faraday's law, explain why a larger emf would be induced in this experiment if a stronger magnet were moved at the same speed.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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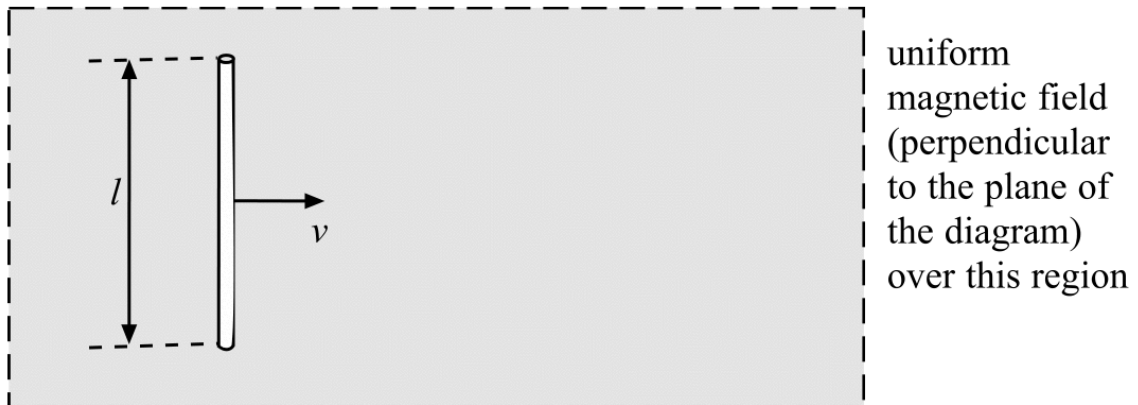
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*(3 marks)*



- (b) A conductor of length  $l$  is moved at a constant speed  $v$  so that it passes perpendicularly through a uniform magnetic field of flux density  $B$ , as shown in **Figure 4**.

**Figure 4**



- (i) Give an expression for the area of the magnetic field swept out by the conductor in time  $\Delta t$ .

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- (ii) Show that the induced emf,  $\epsilon$ , across the ends of the conductor is given by  $\epsilon = Blv$ .

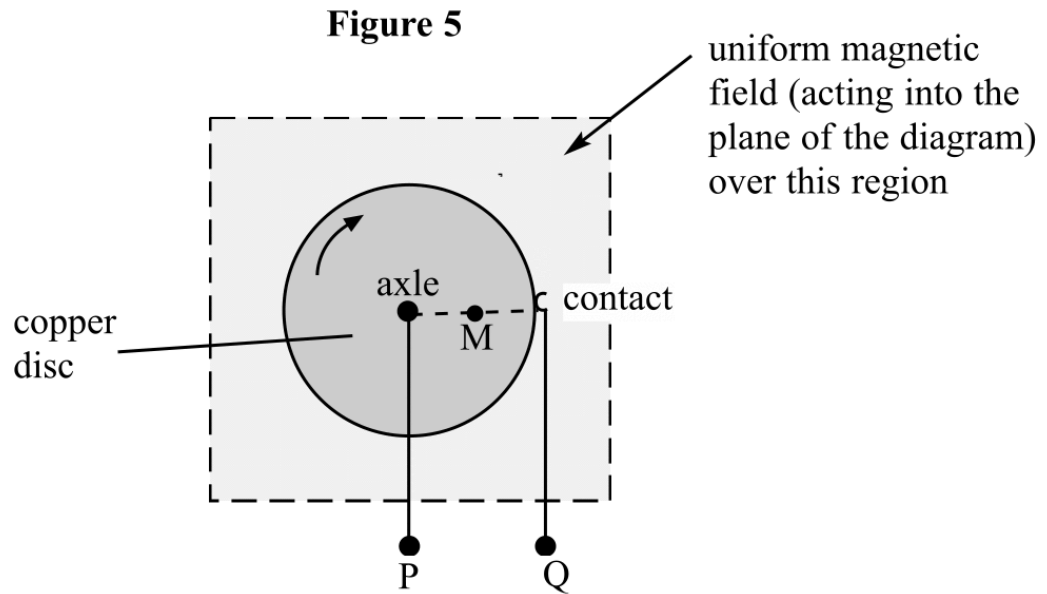
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(3 marks)

- (c) A simple electrical generator can be made from a copper disc, which is rotated at right angles to a uniform magnetic field, directed into the plane of the diagram (**Figure 5**). An emf is developed across terminals P (connected to the axle) and Q (connected to a contact on the edge of the disc).



The radius of the disc is 64 mm and it is rotated at 16 revolutions per second in a uniform magnetic field of flux density 28 mT.

- (i) Calculate the angular speed of the disc.

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- (ii) Calculate the linear speed of the mid-point M of a radius of the disc.

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- (iii) Hence, or otherwise, calculate the emf induced across terminals P and Q.

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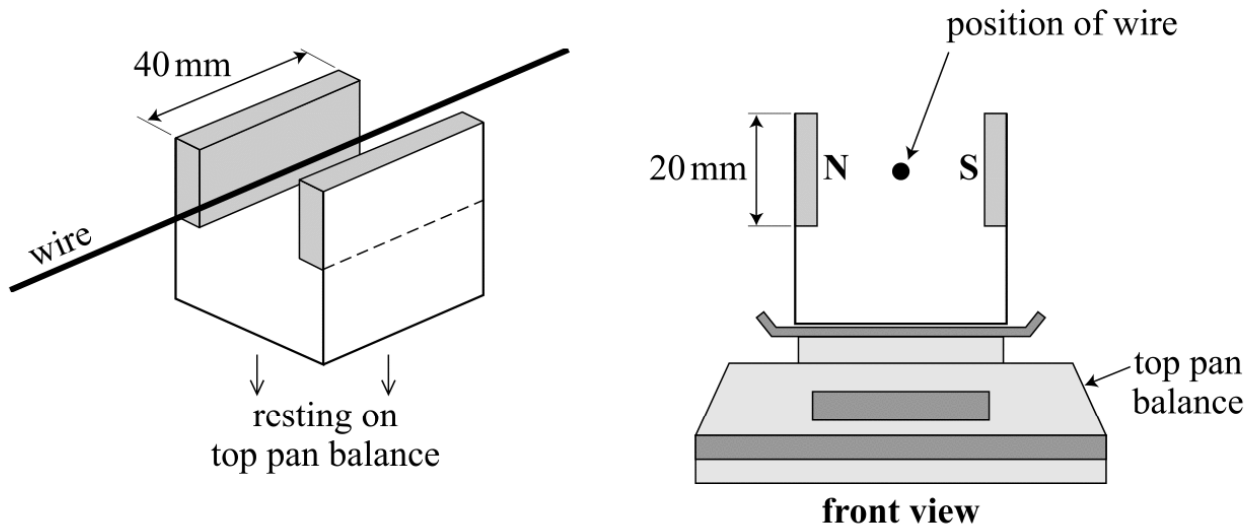
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(5 marks)

- 4 A uniform magnetic field is produced by mounting two flat magnets on a U-shaped iron frame, so that the north and south poles are facing, as shown in **Figure 3**. The flux density of the magnetic field is 45 mT and may be assumed to act only over the area of the pole faces, which measure 40 mm by 20 mm. This magnet arrangement rests on the pan of a top pan balance.

**Q4 Jun 2008**

**Figure 3**



- 4 (a) A horizontal wire is placed in the centre of the magnetic field and aligned to make it perpendicular to the flux lines. When a current is passed through the wire, the balance reading increases by  $1.4 \times 10^{-3}$  kg.

Calculate the current in the wire.

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(2 marks)

- 4 (b) The wire is disconnected from the current source and its ends are connected to a sensitive voltmeter. When the wire is moved rapidly, vertically upwards across the whole magnetic field, cutting all of the flux lines perpendicularly, the voltmeter gives a reading.

Calculate

- 4 (b) (i) the magnetic flux change experienced by the wire during its movement completely across the magnetic field,

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- 4 (b) (ii) the time taken for the wire to pass completely across the magnetic field, assuming it is moved at constant speed, if the voltmeter reads 0.15 mV.

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(5 marks)

- 4 (a) Experiments are carried out to measure the electromotive force induced in coils when they are removed quickly from magnetic fields.

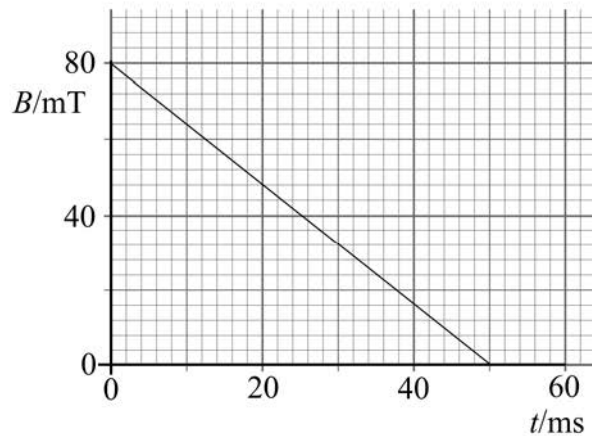
**Q4 Jan 2009**

State **four** factors which, if increased, would increase the magnitude of the induced electromotive force in these experiments.

- 1.....
- 2.....
- 3.....
- 4.....

(2 marks)

- 4 (b) A rectangular coil of dimensions 60 mm × 35 mm and having 48 turns is placed with its plane perpendicular to the magnetic field of an electromagnet. The current in the electromagnet is reduced to zero, causing the flux density,  $B$ , of the magnetic field it produces to decrease with time,  $t$ , as shown.



Calculate

- 4 (b) (i) the rate of change of magnetic flux through the coil,

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- 4 (b) (ii) the emf induced in the coil.

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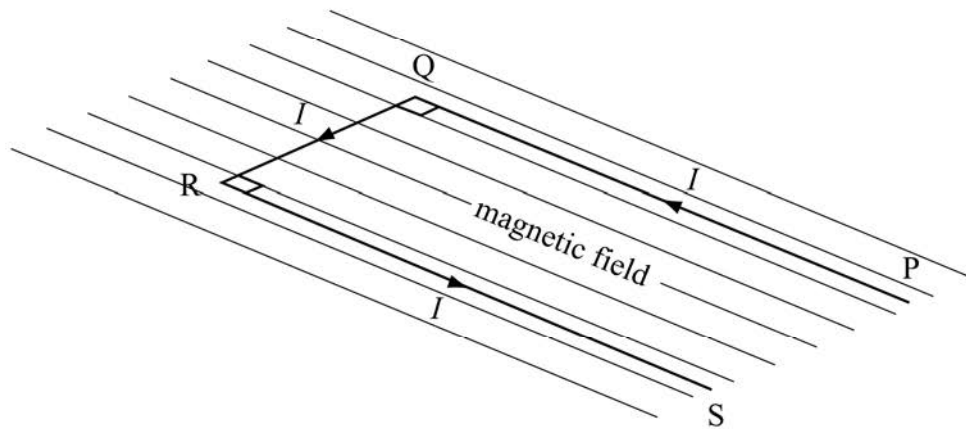
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(6 marks)

- 6 **Figure 7** shows a section of a circuit, PQRS, with right-angled corners at Q and at R. It is mounted so that it lies in the same horizontal plane as a uniform magnetic field of flux density  $B$ , which is parallel to the sides PQ and RS. When a current,  $I$ , flows in the direction shown in the diagram, the wire QR experiences a force which acts vertically upwards.

Figure 7

**Q6 Jan 2010**



- 6 (a) (i) Draw an arrow on **Figure 7** to show the direction of the magnetic field. Label your arrow **M**.
- 6 (a) (ii) If the length of QR is 0.12 m, and  $B$  is 0.25 T, the force on QR is 0.16 N. Calculate  $I$ .
- 6 (a) (iii) Explain why the magnetic forces on sides PQ and RS need not be considered when investigating the equilibrium of PQRS.

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(3 marks)

**Question 6 continues on the next page**

- 6 (b) An experiment based on the arrangement described on **page 11** may be used to determine the magnitude of the flux density of a magnetic field. A current is passed through PQRS, which is a wire frame pivoted about a horizontal axis through PS. The upwards magnetic force on QR is balanced by the weight of a length of ticker tape placed over it. The experiment is repeated for other lengths of tape.

The following results were obtained in such an experiment.

|                         |      |      |      |      |      |      |
|-------------------------|------|------|------|------|------|------|
| length of tape $x$ / mm | 49   | 100  | 144  | 194  | 250  | 299  |
| current $I$ / A         | 0.61 | 1.18 | 1.84 | 2.42 | 3.06 | 3.66 |

The mass of a 2.00 m length of the uniform ticker tape was  $1.30 \times 10^{-3}$  kg.

- 6 (b) (i) On the graph paper opposite plot a graph of  $I$  against  $x$ .
- 6 (b) (ii) Show that  $I$  and  $x$  are related by the equation

$$I = \left( \frac{\mu g}{Bl} \right) x$$

where  $\mu$  is the mass per unit length of the tape,  $l$  is the length of QR and  $g$  is the gravitational field strength.

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**Originally, graph paper (next page) was here between the 2 question parts**

- 6 (b) (iii) Calculate the magnitude of  $B$  from the gradient of the graph.

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(7 marks)

