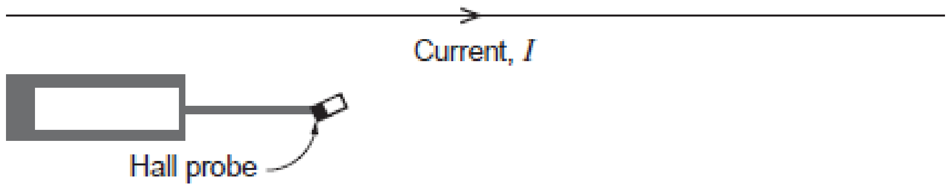
#1

4. *(a)* The current in a long wire is 290 A and is too great to be measured by an ammeter. Explain how you could use a Hall probe, calibrated in tesla (T), to determine this current. [3]



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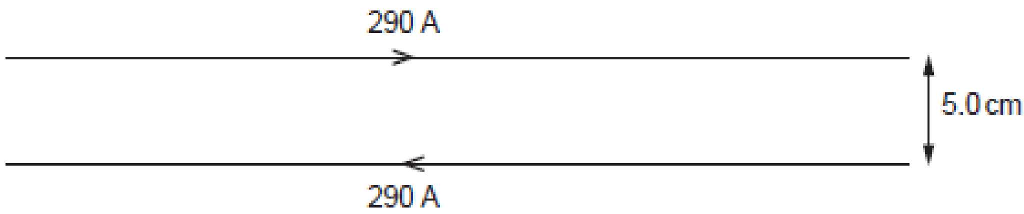
(b) Another long wire carrying the same large current is placed parallel to the original wire as shown. Calculate the force per unit length on each wire also stating the direction of the force on each wire. [4]



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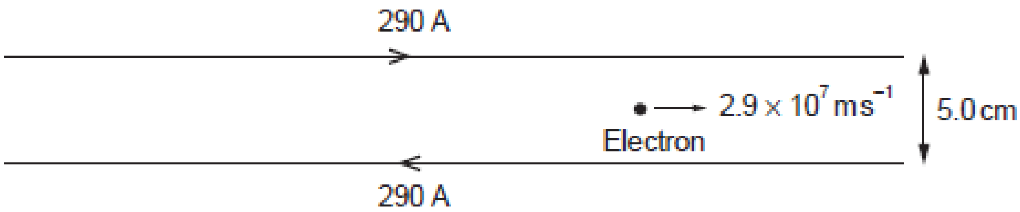
(c) (i) Tirion claims that an electron halfway between the wires, travelling at a speed of $2.9 \times 10^7\,\mathrm{m\,s^{-1}}$ parallel to the wires will perform perfect circular motion between the wires. Determine, using a suitable calculation, whether or not Tirion's claim is correct. The magnetic flux density halfway between the wires is 4.64 mT. [4]



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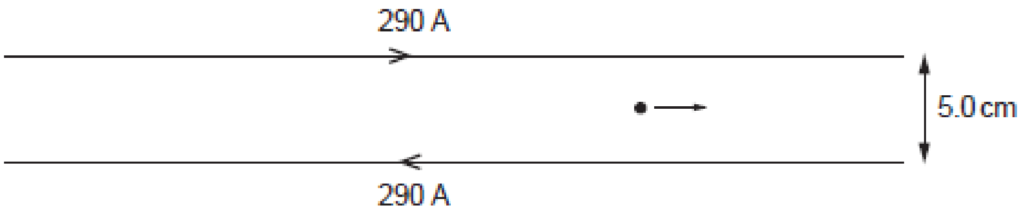
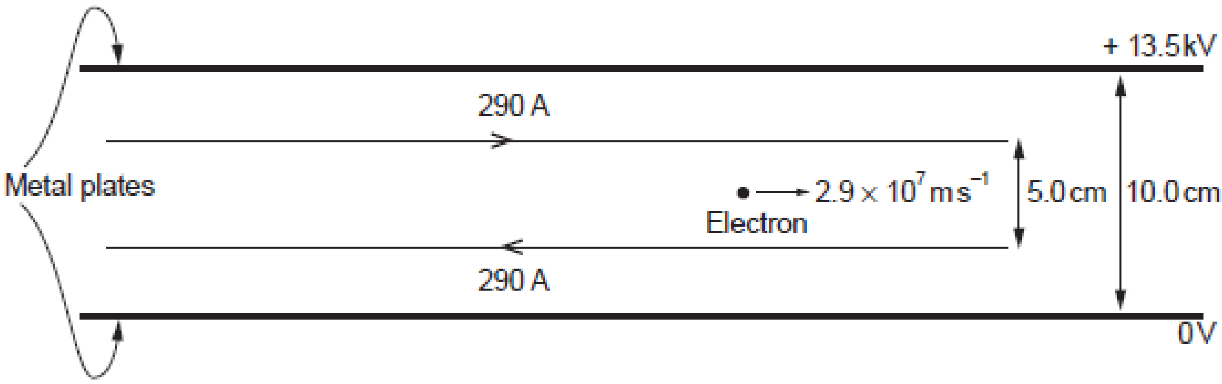
(ii) Sketch the motion of the electron. [2]



(d) Suppose that an electron travels in a region with a magnetic field and an electric field due to two parallel metal plates as shown below. Deduce whether or not the electron continues with constant velocity ($B = 4.64\,\text{mT}$). [5]



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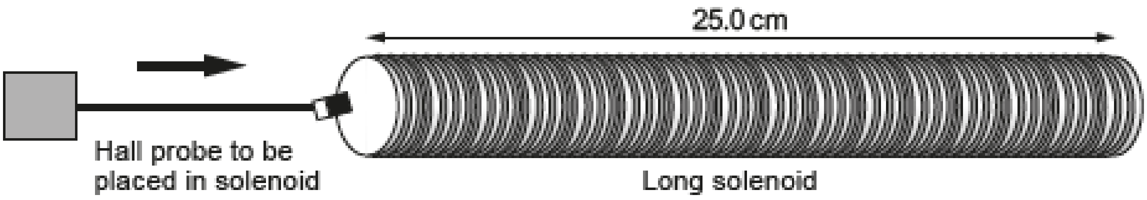
Question taken from WJEC examination paper 242801, June 2019

#2

4. An experiment is carried out to measure the magnetic field in a long solenoid as the current in the solenoid is varied.

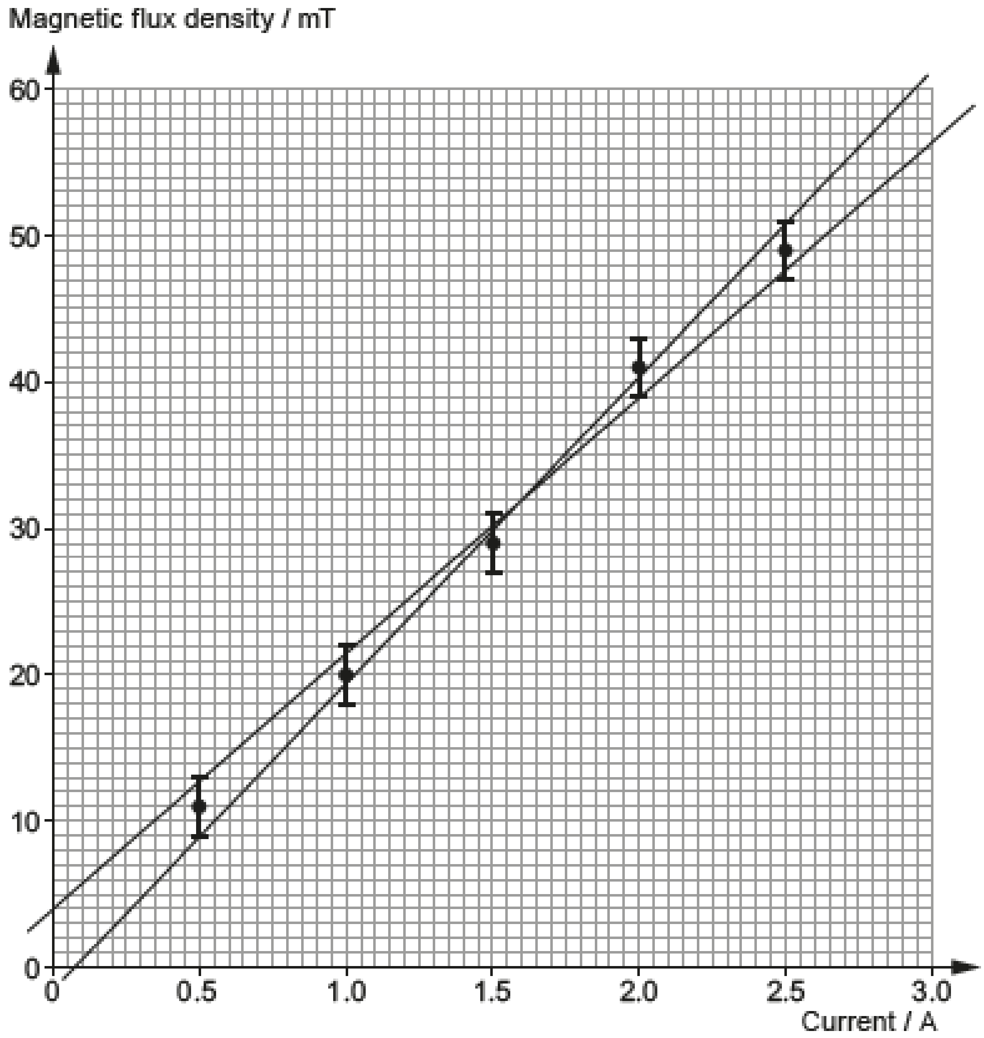


Theory states that the relationship between magnetic flux density, B, at the centre of the solenoid and current, I, is given by the equation:

$$B = \mu_0 n I$$

The results obtained are shown in the table and plotted on the grid opposite along with error bars and lines of maximum and minimum gradient.

Current / A ±0.01 A	Magnetic flux density / mT ±2 mT
0.50	11
1.00	20
1.50	29
2.00	41
2.50	49



(a) Calculate the mean value of the gradient along with its **percentage** uncertainty. [4]

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(b) Calculate the number of turns in the solenoid along with its **absolute** uncertainty. The percentage uncertainty in the length of the solenoid is 0.4 %. [3]

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(c) (i) The solenoid manufacturer states that there are exactly 5 000 turns in the solenoid. Evaluate the accuracy of your value obtained in part *(b)* and whether or not the graph is in agreement with the equation: $B = \mu_0 nI$. [4]

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(ii) Suggest a reason for the disagreement between the manufacturer's stated value (5 000 turns) and your value calculated in part *(b)*. Suggest how the experimental technique might be improved for better agreement. [2]

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Question taken from WJEC examination paper 242801, June 2018

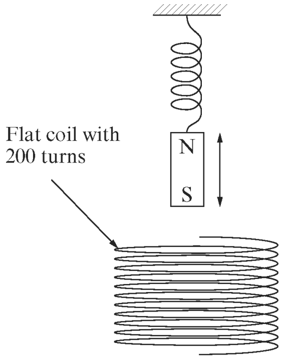
#3 ///image1 large left///

///image2 large left///

Question taken from WJEC examination paper 132501, June 2012

#4

A strong magnet is held on a spring and performs simple harmonic motion near a flat coil as shown.



(a) Explain briefly why an alternating emf is induced in the coil. [3]

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(b) (i) The induced emf varies in magnitude sinusoidally with a peak value of ±0.707 V. Calculate the rms value of the induced emf. [1]

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(ii) State the value of the rate of change of flux through each turn of the coil when the peak value of 0.707 V is obtained and explain how you obtained your answer. [3]

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(c) One end of the coil is connected with the other so that there is an induced current. Explain why the magnet's motion is now damped. [3]

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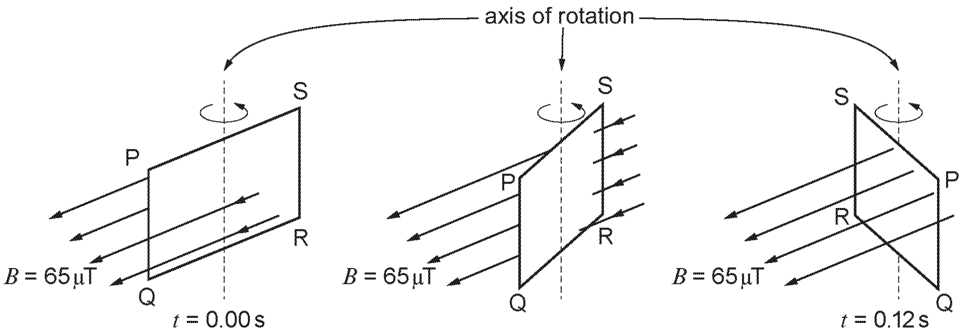
Question taken from WJEC examination paper 132501, June 2011

#5

A large square loop has sides of length 0.815 m and is rotated through 90° in a uniform magnetic field of 65 μT. The diagrams show the same square loop at different times.



(a) Determine the magnetic flux through the square loop: [3]

(i) when t = 0.00 s (sides QR and SP are parallel to the B-field);

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(ii) and when t = 0.12 s (PQ, QR, RS and SP are perpendicular to the B-field).

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(b) The square loop is made of copper. Explain why there is a current in the loop as it is rotated. [2]

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(c) Explain how Lenz's law will give the direction of the forces acting on the sides PQ and RS as the square loop is rotated. [2]

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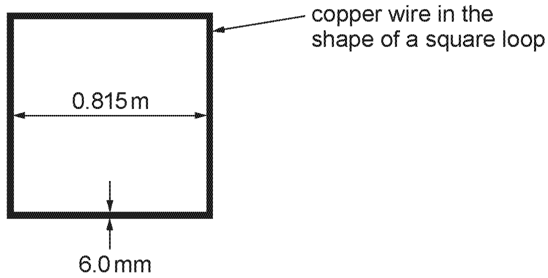
(d) The copper wire from which the square loop is made has a circular cross-section of diameter 6.0 mm. The resistivity of copper is $1.67 \times 10^{-8}\,\Omega\,\text{m}$. Calculate the **mean** current flowing through the square loop as it is rotated between $t = 0.00\,\text{s}$ and $t = 0.12\,\text{s}$. [5]



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Question taken from WJEC examination paper 132501, June 2015

#6

(a) State the **two** laws of electromagnetic induction (Faraday's law and Lenz's law). [3]

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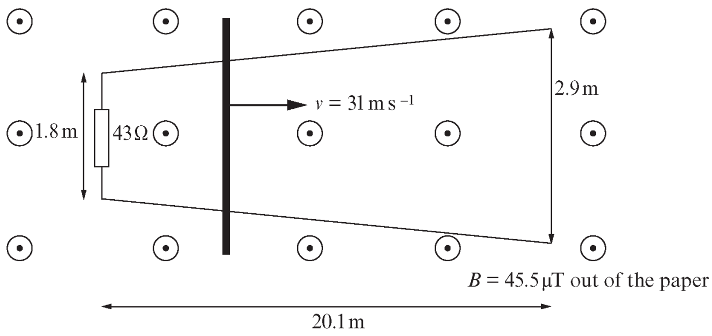
(b) A thick conducting bar is moved with constant speed over non-parallel conducting rails as shown below. The rails have negligible resistance and the B-field is uniform.



(i) Indicate the direction of the induced current on the diagram and explain how you arrived at your answer. [2]

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(ii) The conductor moves at a constant speed of $31\ \text{m s}^{-1}$. Use Faraday's law to explain why the induced emf increases. [2]

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(iii) The conductor starts moving from the end near the $43\ \Omega$ resistor. Calculate the mean current in the resistor when the conducting bar has travelled the full 20.1 m length of the track. [4]

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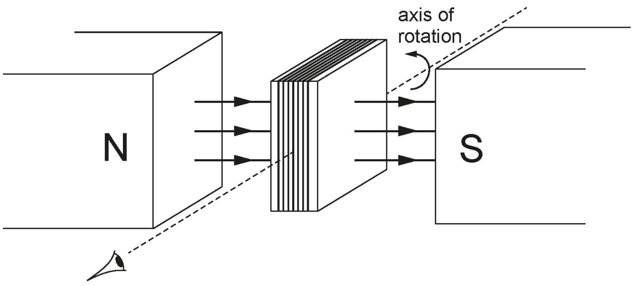
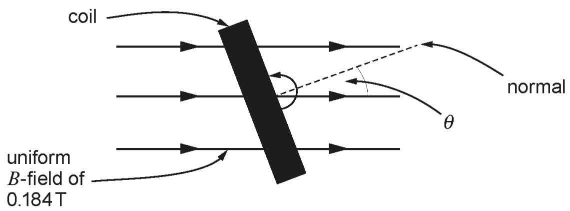
Question taken from WJEC examination paper 132501, June 2013

#7

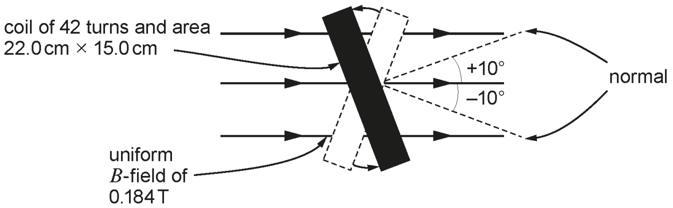
A rectangular coil rotates at a constant angular velocity within a uniform magnetic field. The coil has 42 turns and area 22.0 cm × 15.0 cm. The diagram below is a simplified 3D diagram of the coil when the magnetic field is perpendicular to the coil.



The second diagram is a 2D representation of the coil looking along the axis of rotation.



(a) (i) Calculate the flux **linkage** of the coil for the angles θ = –10° and θ = +10°. [2]



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(ii) Explain why the mean induced emf is zero as the coil moves between $\theta = -10°$ and $\theta = +10°$. [1]

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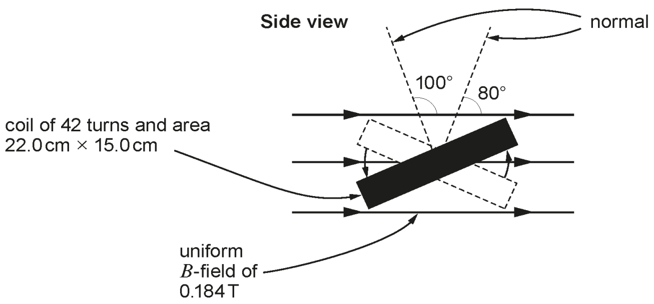
(b) Calculate the mean induced emf in the coil when the angle θ changes from 80° to 100° if the period of rotation of the coil is 0.100 s. [4]



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(c) An oscilloscope is used to display the sinusoidal emf in a different coil rotating at a frequency of 12.5 Hz and producing an **rms** pd of 12.0 V. The oscilloscope settings are 5 V per division (vertically) and 20 ms per division (horizontally). Sketch a trace that might be seen on the oscilloscope. (Space is provided for your workings.) [3]

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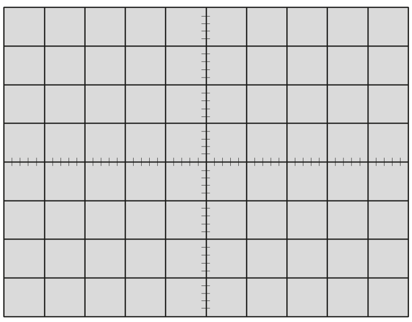
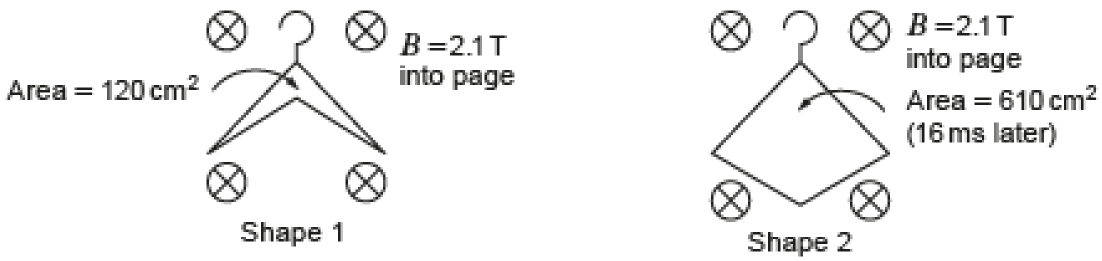


#8

5. An experiment is carried out in a very strong uniform magnetic field in order to confirm Faraday's Law under extreme conditions. A coat hanger made of aluminium wire is bent from Shape 1 to Shape 2 in a time of 16 ms.



(a) (i) Show that a mean emf of 6.4 V is induced in the coat hanger. [2]

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(ii) Show on the diagram of Shape 2 the direction of the induced current and state very briefly how you determined this direction. [2]

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(b) The aluminium wire has a circular cross-section of diameter 3.0 mm and the length of the wire through which the current flows is 91 cm. Show that the mean current in the wire is approximately 1 900 A (resistivity of aluminium = $2.65 \times 10^{-8}\,\Omega\,m$). [3]

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(c) Iestyn claims that changing the shape of the coat hanger from Shape 1 to Shape 2 in 16 ms in the magnetic field will increase its temperature by less than 1 °C.
Determine, using appropriate calculations, whether or not Iestyn is correct. (Density of aluminium = $2\,700\ \mathrm{kg\,m^{-3}}$, specific heat capacity of aluminium = $897\ \mathrm{J\,kg^{-1}\,K^{-1}}$.) [5]

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(d) For medical research, it is decided to investigate the effect of this strong magnetic field (2.1 T) on patients with metal replacement joints to see if the metal joints become hot or undergo large forces (during MRI scans). Discuss the ethics of such an experiment. [3]

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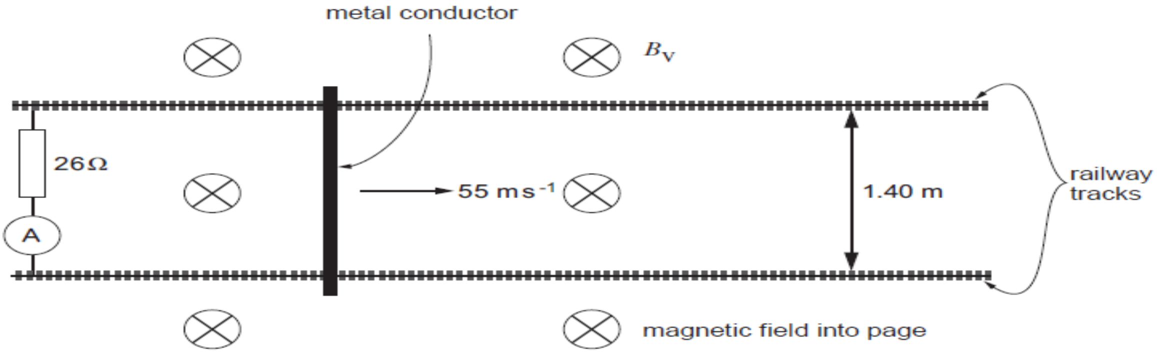
#9

A metal conductor is placed across horizontal railway tracks and moved quickly in the direction shown. This set up is designed to measure the vertical component (B_V) of the Earth's magnetic field.



(a) (i) Explain why a current is detected by the ammeter. [2]

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(ii) State why the current is independent of the horizontal component of the Earth's magnetic field. [1]

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(b) Calculate a value for the vertical component of the Earth's magnetic field given that the reading on the ammeter is 184 µA. [3]

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(c) State the direction of the current in the resistor and how you obtained this direction. [2]

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(d) A student suggests that the opposing force due to the magnetic field on the moving conductor is negligible compared with other resistive forces. Is the student correct? Justify your answer with a calculation. [4]

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Question taken from WJEC examination paper 242801, June 2017

#10

5. *(a)* State the laws of Faraday and Lenz for electromagnetic induction. [2]

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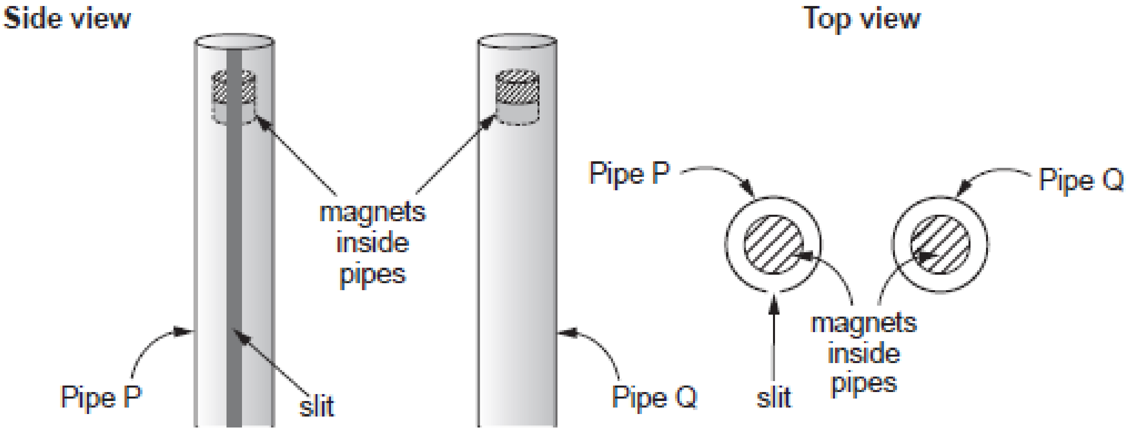
(b) Two strong bar magnets are dropped through two copper pipes (P and Q). Pipe P has a slit running along its length but Q is complete. When the magnet is dropped through pipe P it accelerates almost uniformly but the magnet dropped through pipe Q quickly reaches a very low terminal velocity. Explain these observations. [6 QER]



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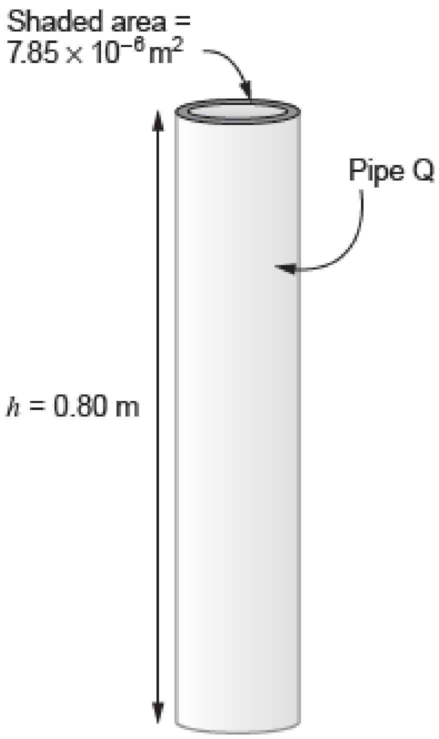
(c) By applying the principle of conservation of energy, calculate the temperature increase of pipe Q after the magnet has fallen at constant speed. [4]

Data:

- mass of magnet = 0.300 kg,
- cross-sectional area of the copper walls of pipe Q = $7.85 \times 10^{-6}\,m^2$ (see diagram)
- density of copper = $8960\,kg\,m^{-3}$
- specific heat capacity of copper = $385\,J\,K^{-1}\,kg^{-1}$.



Question taken from WJEC examination paper 242801, June 2019