IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

M05/4/PHYSI/SP2/ENG/TZ2/XX+

22056517

PHYSICS
STANDARD LEVEL
PAPER 2

Thursday 19 May 2005 (afternoon)

1 hour 15 minutes

Candidate session number

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INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet.

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SECTION A

*Answer **all** the questions in the spaces provided.*

A1. The Geiger-Nuttall theory of α-particle emission relates the half-life of the α-particle emitter to the energy E of the α-particle. One form of this relationship is

$$L = \frac{166}{E^{\frac{1}{2}}} - 53.5.$$

L is a number calculated from the half-life of the α-particle emitting nuclide and E is measured in MeV.

Values of E and L for different nuclides are given below. *(Uncertainties in the values are not shown.)*

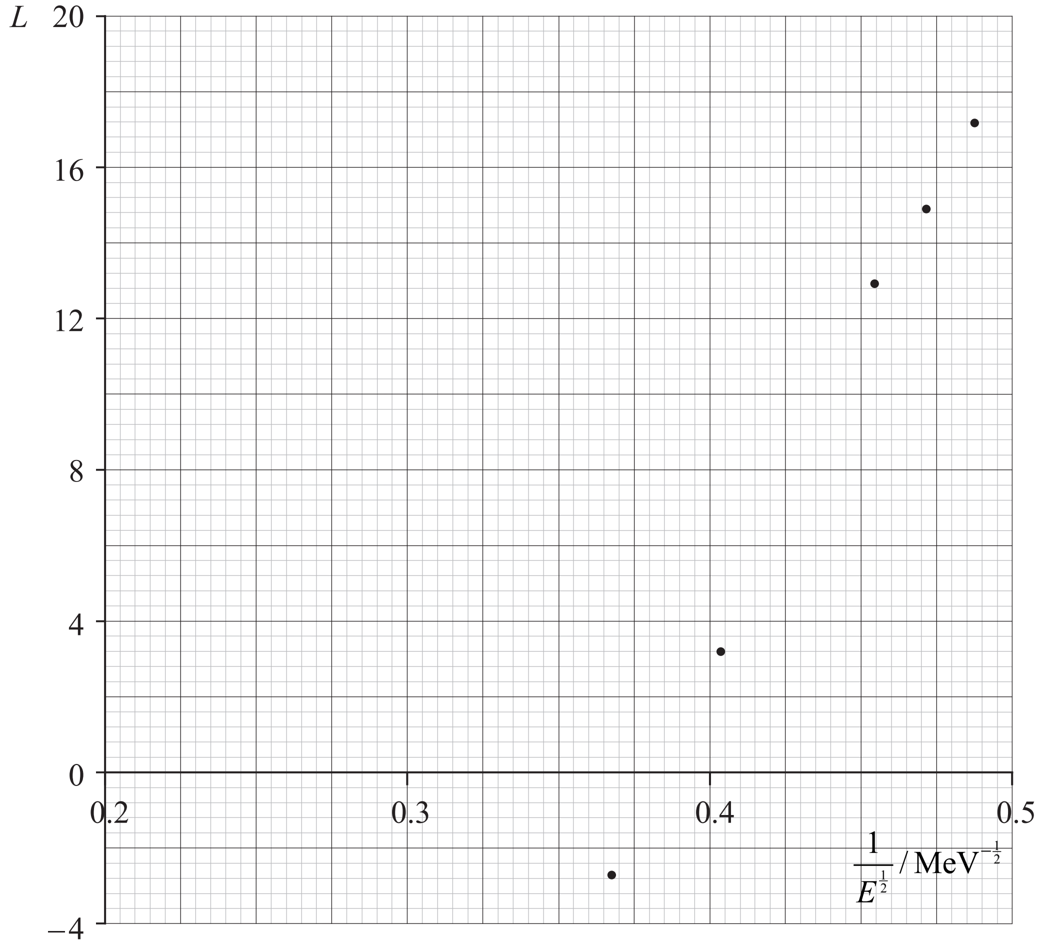
Nuclide	E **/ MeV**	L	$\frac{1}{E^{\frac{1}{2}}}$ **/ MeV**$^{-\frac{1}{2}}$
^{238}U	4.20	17.15	0.488
^{236}U	4.49	14.87	0.472
^{234}U	4.82	12.89	0.455
^{228}Th	5.42	7.78	. . . .
^{208}Rn	6.14	3.16	0.404
^{212}Po	7.39	–2.75	0.368

(a) Complete the table above by calculating, using the value of E provided, the value of $\frac{1}{E^{\frac{1}{2}}}$ for the nuclide ^{228}Th. Give your answer to three significant digits. *[1]*

(This question continues on the following page)

(Question A1 continued)

The graph below shows the variation with $\frac{1}{E^{\frac{1}{2}}}$ of the quantity L. Error bars have not been added.



(b) (i) Identify the data point for the nuclide ^{208}Rn. Label this point R. *[1]*

(ii) On the graph, mark the point for the nuclide ^{228}Th. Label this point T. *[1]*

(iii) Draw the best-fit straight-line for all the data points. *[1]*

(This question continues on the following page)

(Question A1 continued)

(c) (i) Determine the gradient of the line you have drawn in (b) (iii). *[2]*

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(ii) Without taking into consideration any uncertainty in the values for the gradient and for the intercept on the x-axis, suggest why the graph does **not** agree with the stated relationship for the Geiger-Nuttall theory. *[2]*

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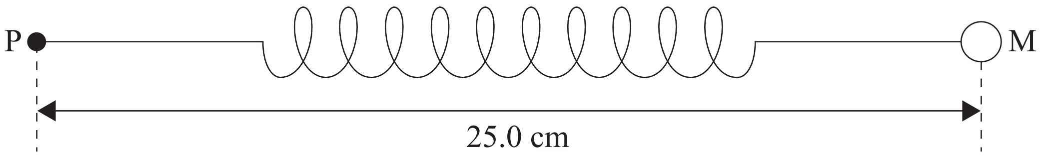
(d) On the graph opposite, draw the line that would be expected if the relationship for the Geiger-Nuttall theory were correct. No further calculation is required. *[2]*

A2. This question is about circular motion.

A linear spring of negligible mass requires a force of 18.0 N to cause its length to increase by 1.0 cm.

A sphere of mass 75.0 g is attached to one end of the spring. The distance between the centre of the sphere M and the other end P of the unstretched spring is 25.0 cm, as shown below.



The sphere is rotated at constant speed in a horizontal circle with centre P. The distance PM increases to 26.5 cm.

(a) Explain why the spring increases in length when the sphere is moving in a circle. *[2]*

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(b) Determine the speed of the sphere. *[4]*

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A3. This question is about thermal physics.

(a) Explain why, when a liquid evaporates, the liquid cools unless thermal energy is supplied to it. *[3]*

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(b) State **two** factors that cause an increase in the rate of evaporation of a liquid. *[2]*

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2. . . . .

(c) Some data for ice and for water are given below.

Specific heat capacity of ice $= 2.1 \times 10^3\ \text{J kg}^{-1}\ \text{K}^{-1}$

Specific heat capacity of water $= 4.2 \times 10^3\ \text{J kg}^{-1}\ \text{K}^{-1}$

Specific latent heat of fusion of ice $= 3.3 \times 10^5\ \text{J kg}^{-1}$

A mass of 350 g of water at a temperature of 25°C is placed in a refrigerator that extracts thermal energy from the water at a rate of 86 W.

Calculate the time taken for the water to become ice at -5.0°C. *[4]*

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SECTION B

This section consists of three questions: B1, B2 and B3. Answer ***one*** *question.*

B1. This question is about collisions and radioactive decay.

(a) (i) Define *linear momentum* and *impulse*. *[2]*

Linear momentum: . . . .

. . . .

Impulse: . . . .

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(ii) State the law of conservation of momentum. *[2]*

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(iii) Using your definitions in (a) (i), deduce that linear momentum is constant for an object in equilibrium. *[2]*

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(This question continues on the following page)

(Question B1 continued)

A stationary radon-220 ($^{220}_{86}\text{Rn}$) nucleus undergoes α-decay to form a nucleus of polonium (Po). The α-particle has kinetic energy of 6.29 MeV.

(b) (i) Complete the nuclear equation for this decay. *[2]*

$$^{220}_{86}\text{Rn} \rightarrow \text{Po} +$$

(ii) Calculate the kinetic energy, in joules, of the α-particle. *[2]*

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(iii) Deduce that the speed of the α-particle is $1.74 \times 10^{7}\ \text{m s}^{-1}$. *[1]*

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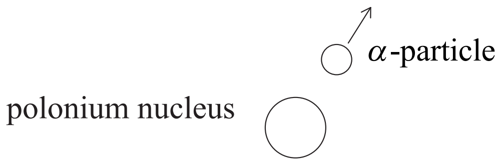
(Question B1 continued)

The diagram below shows the α-particle and the polonium nucleus immediately after the decay. The direction of the velocity of the α-particle is indicated.



(c) (i) On the diagram above, draw an arrow to show the initial direction of motion of the polonium nucleus immediately after the decay. *[1]*

(ii) Determine the speed of the polonium nucleus immediately after the decay. *[3]*

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(iii) In the decay of another radon nucleus, the nucleus is moving before the decay. Without any further calculation, suggest the effect, if any, of this initial speed on the paths shown in (c) (i). *[2]*

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(This question continues on the following page)

(Question B1 continued)

The half-life of the decay of radon-220 is 55 s.

(d) (i) Explain why it is not possible to state a time for the life of a radon-220 nucleus. *[2]*

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(ii) Define *half-life*. *[2]*

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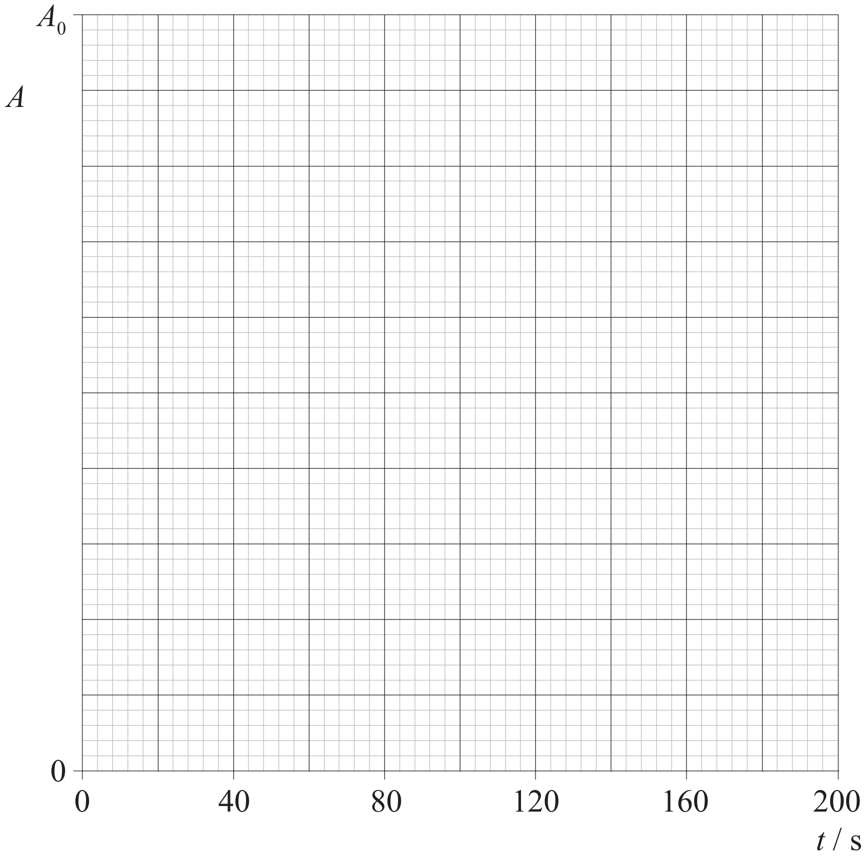
A sample of radon-220 has an initial activity A_0.

(iii) On the axes below, draw a graph to show the variation with time t of the activity A for time $t = 0$ to time $t = 180$ s. *[2]*



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(Question B1 continued)

(iv) Use your graph to determine the activity, in terms of A_0, of the sample of radon at time $t = 120$ s. Also, estimate the activity, in terms of A_0, at time $t = 330$ s. *[2]*

Activity at time $t = 120$ s : . . . .

Activity at time $t = 330$ s : . . . .

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B2. This question is about travelling waves and stationary waves.

(a) (i) Describe what is meant by a *continuous travelling wave*. *[2]*

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(ii) With reference to your answer in (a) (i), state what is meant by the speed of a travelling wave. *[1]*

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(b) A travelling wave has speed v, frequency f and wavelength λ.

(i) Define *frequency* and *wavelength*. *[2]*

Frequency: . . . .

. . . .

Wavelength: . . . .

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(ii) Derive an expression relating v, f and λ. *[2]*

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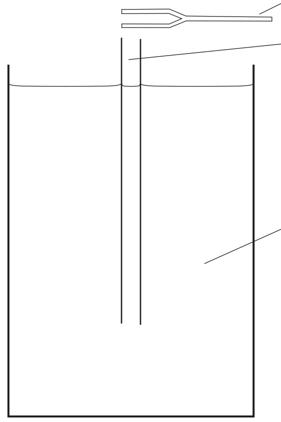
(Question B2 continued)

A tube that is open at both ends is placed in a deep tank of water, as shown below.



A tuning fork of frequency 256 Hz is sounded continuously above the tube. The tube is slowly raised out of the water and, at one position of the tube, a maximum loudness of sound is heard.

(c) (i) Explain the formation of a standing wave in the tube. *[2]*

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(ii) The tube is raised a further small distance. Explain, by reference to resonance, why the loudness of the sound changes. *[4]*

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(This question continues on the following page)

(Question B2 continued)

(iii) The tube is gradually raised from a position of maximum loudness until the next position of maximum loudness is reached. The length of the tube above the water surface is increased by 65.0 cm. Calculate the speed of sound in the tube. *[2]*

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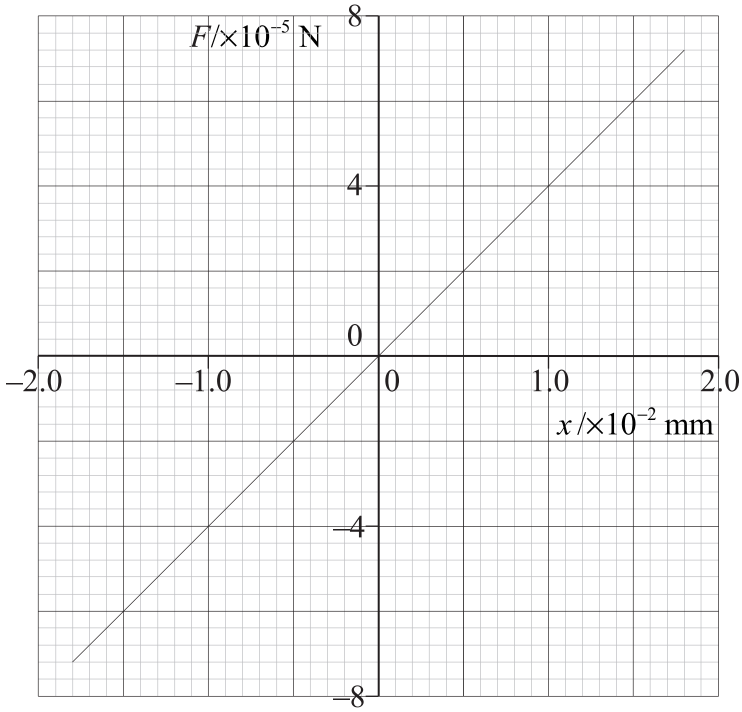
(Question B2 continued)

A sound wave is incident on the ear of a person. The pressure variation of the sound wave causes a force F to be exerted on a moveable part of the ear called the eardrum. The variation of the displacement x of the eardrum caused by the force F is shown below.



(d) The eardrum has an area of $30\,\text{mm}^2$. Calculate the pressure, in pascal, exerted on the eardrum for a displacement x of 1.0×10^{-2} mm. *[2]*

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(This question continues on the following page)

(Question B2 continued)

(e) (i) Calculate the energy required to cause the displacement to change from $x = 0$ to $x = +1.5\times10^{-2}$ mm. *[3]*

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The sound wave causing a maximum displacement of the eardrum of 1.5×10^{-2} mm has frequency 1000 Hz.

(ii) Deduce that the energy causing the displacement in (e) (i) is delivered in a time of 0.25 ms. Also, determine the mean power of the sound wave to cause this displacement. *[4]*

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(iii) Suggest the form of energy into which the energy of the sound wave has been transformed at the eardrum. *[1]*

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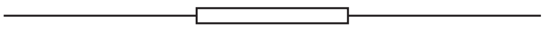
B3. This question is in **two** parts. **Part 1** is about electrical components. **Part 2** is about magnetic forces.

Part 1 Electrical components

(a) In the space below, draw a circuit diagram that could be used to determine the current-voltage *(I-V)* characteristics of an electrical component X. *[2]*

component X



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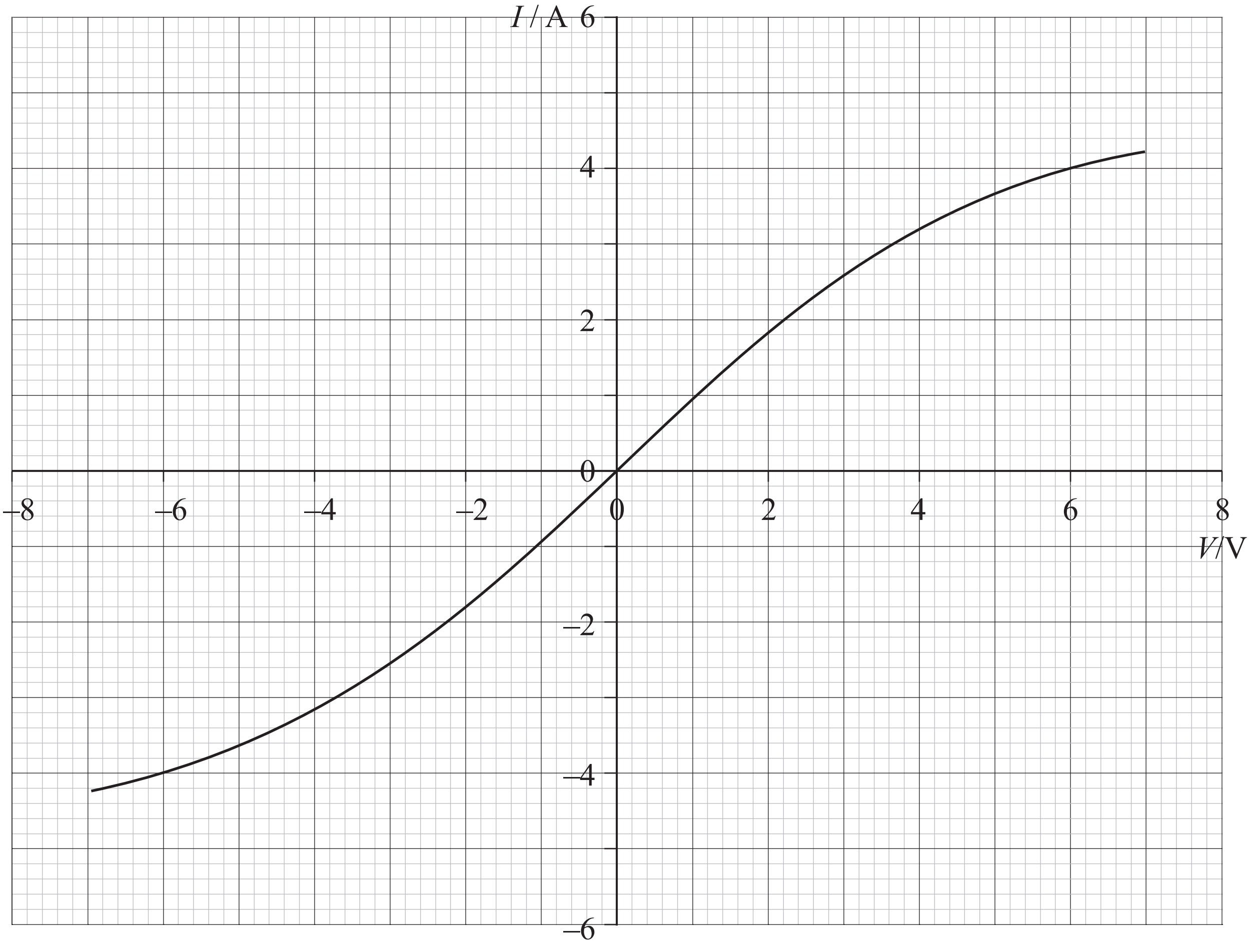
(Question B3, part 1 continued)

The graph below shows the *I-V* characteristics for the component X.



The component X is now connected across the terminals of a battery of e.m.f. 6.0 V and negligible internal resistance.

(b) Use the graph to determine

(i) the current in component X. *[1]*

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(ii) the resistance of component X. *[2]*

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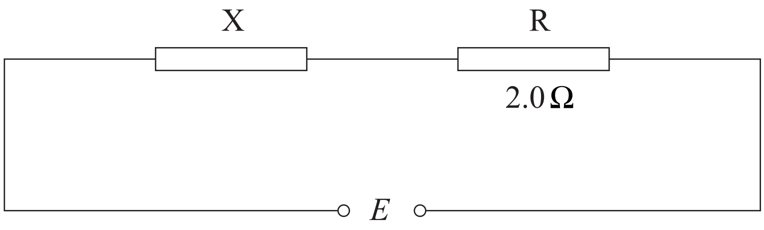
(Question B3, part 1 continued)

A resistor R of constant resistance 2.0 Ω is now connected in series with component X as shown below.



(c) (i) On the graph opposite, draw the *I*-*V* characteristics for the resistor R. *[2]*

(ii) Determine the total potential difference *E* that must be applied across component X and across resistor R such that the current through X and R is 3.0 A. *[2]*

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(d) (i) A resistor is to be used as a temperature-measuring device. List **two** desirable properties of such a device. *[2]*

1. . . . .

2. . . . .

(ii) Explain how a temperature scale could be constructed for this resistance thermometer. *[3]*

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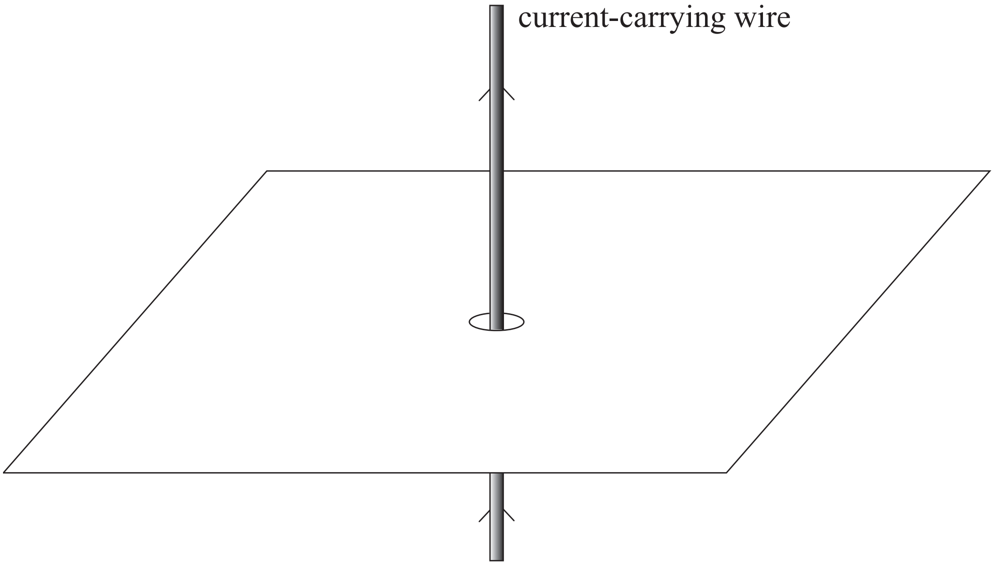
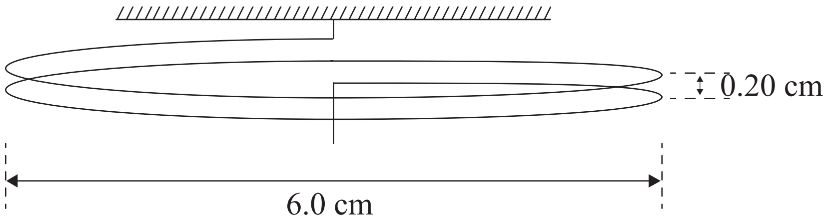
(Question B3 continued)

Part 2 Magnetic forces

(a) On the diagram below, draw the magnetic field pattern around a long straight current-carrying conductor. *[3]*



The diagram below shows a coil consisting of two loops of wire. The coil is suspended vertically.



Each loop has a diameter of 6.0 cm and the separation of the loops is 0.20 cm. The coil forms part of an electrical circuit so that a current may be passed through the coil.

(b) (i) State and explain why, when the current is switched on in the coil, the distance between the two loops changes. *[3]*

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(This question continues on the following page)

(Question B3, part 2 continued)

When there is a current I in the coil, a mass of 0.10 g hung from the free end of the coil returns the separation of the loops to the original value of 0.20 cm.

The circumference C of a circle of radius r is given by the expression

$$C = 2\pi r.$$

(ii) Calculate the current I in the coil. You may assume that each loop behaves as a long straight current-carrying wire. *[5]*

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