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

M06/4/PHYSI/SP2/ENG/TZ2/XX+

22066517

PHYSICS
STANDARD LEVEL
PAPER 2

Tuesday 9 May 2006 (afternoon)

1 hour 15 minutes

Candidate session number

0	0							

INSTRUCTIONS TO CANDIDATES

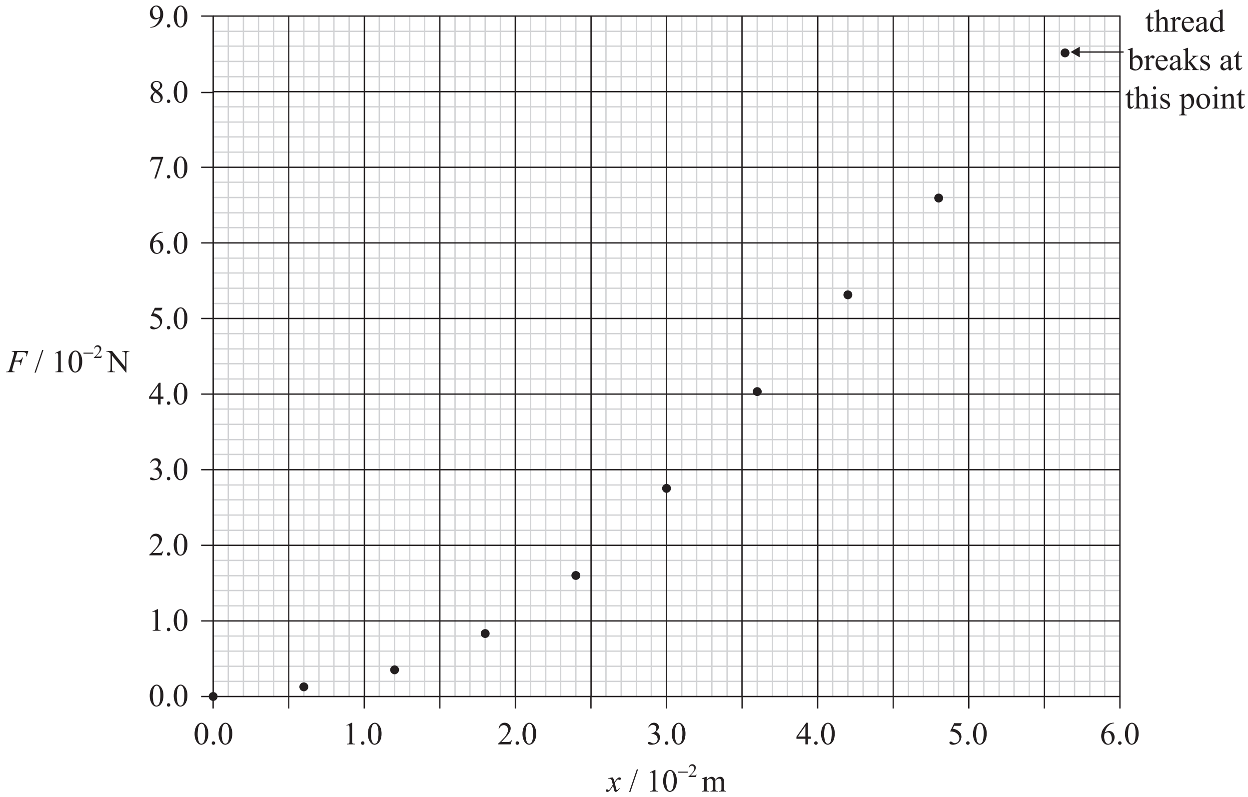
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of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

SECTION A

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

A1. This question is about a spider's web.

An experiment was carried out to measure the extension x of a thread of a spider's web when a load F is applied to it. The results of the experiment are shown plotted below. Uncertainties in the measurements are not shown.



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

(This question continues on the following page)

(Question A1 continued)

(b) When a load is applied to a material, it is said to be under "stress". The magnitude P of the stress is given by

$$P = \frac{F}{A}$$

where, A is the area of cross-section of the sample of the material.

Use the graph and the data below to deduce that the thread used in the experiment has a greater breaking stress than steel. *[3]*

Breaking stress of steel $= 1.0 \times 10^{9}\,\mathrm{N\,m^{-2}}$

Radius of spider web thread $= 4.5 \times 10^{-6}\,\mathrm{m}$

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(Question A1 continued)

(c) In a particular web, one thread has the same original length as the thread used in the experiment. In the making of this web, the original length of the thread is extended by 2.4×10^{-2} m.

(i) Use the graph to deduce that the amount of work required to further extend the thread to the length at which it just breaks, is about 1.6×10^{-3} J. Explain your working. *[3]*

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(ii) If the thread is not to break due to the impact of a flying insect, then the thread must be capable of absorbing all the kinetic energy of the insect as it is brought to rest by the impact. Determine the impact speed that an insect of mass 0.15 g must have in order that it just breaks the thread. *[3]*

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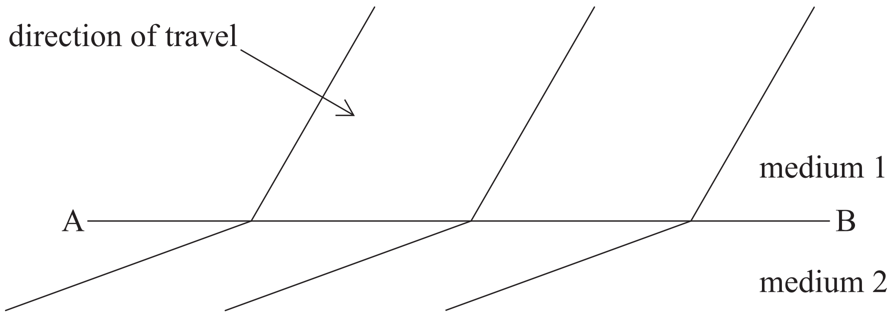
A2. This question is about waves.

(a) In the scale diagram below, plane wavefronts travel from medium 1 to medium 2 across the boundary AB.



State and explain in which medium the wavefronts have the greater speed. *[3]*

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(b) By taking measurements from the diagram, determine the ratio

$$\frac{\text{speed of wave in medium 1}}{\text{speed of wave in medium 2}}.$$ *[3]*

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A3. This question is about magnetic fields.

(a) Using the diagram below, draw the magnetic field pattern of the Earth. *[2]*

(b) State what other object produces a magnetic field pattern similar to that of the Earth. *[1]*

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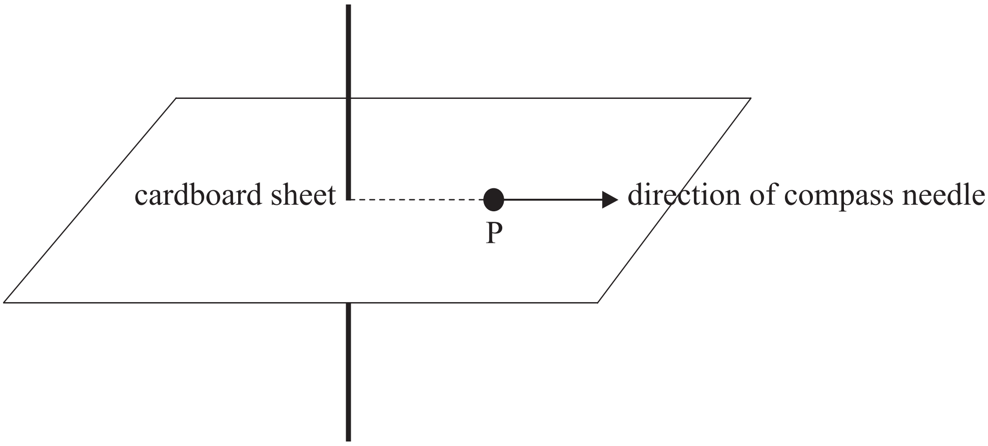
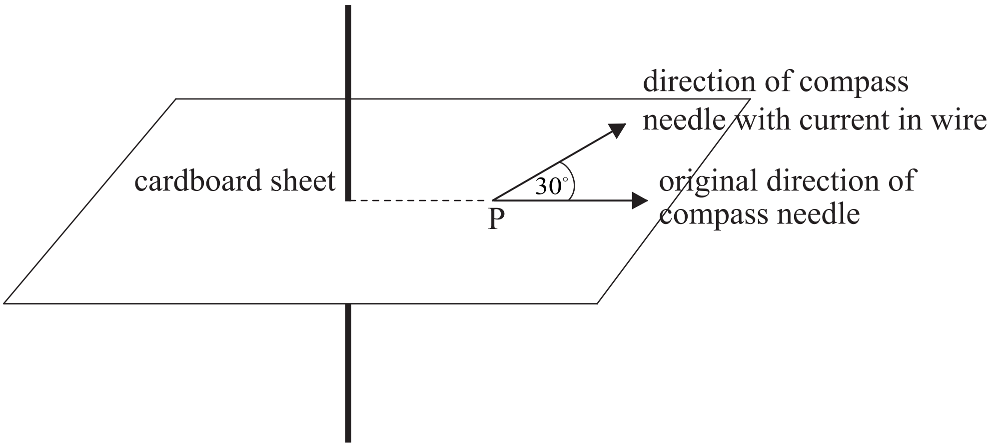
(Question A3 continued)

(c) A long vertical wire passes through a sheet of cardboard that is held horizontal. A small compass is placed at the point P and the needle points in the direction shown.



A current is passed through the wire and the compass needle now points in a direction that makes an angle of 30° to its original direction as shown below.



(i) Draw an arrow on the wire to show the direction of current in the wire. Explain why it is in the direction that you have drawn. *[2]*

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(Question A3 continued)

(ii) The magnetic field strength at point P due to the current in the wire is B_W and the strength of the horizontal component of the Earth's magnetic field is B_E.

Deduce, by drawing a suitable vector diagram, that

$$B_E = B_W \tan 60^\circ.$$ *[2]*

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(iii) The point P is 2.0 cm from the wire and the current in the wire is 4.0 A. Calculate the strength of the horizontal component of the Earth's magnetic field at point P. *[2]*

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SECTION B

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

B1. This question is in **two** parts. **Part 1** is about travelling and standing waves and **Part 2** is about mechanical power.

Part 1 Travelling and standing (stationary) waves

(a) State **two** differences between a travelling wave and a standing (stationary) wave. *[2]*

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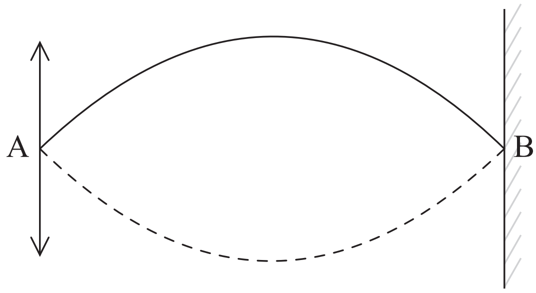
(b) To demonstrate the production of a standing wave, Samantha attaches the end B of a length AB of rubber tubing to a rigid support. She holds the other end A of the tubing, pulls on it slightly and then shakes the end A in a direction at right angles to AB. At a certain frequency of shaking, the tubing is seen to form the standing wave pattern shown below.



Explain how this pattern is formed. *[5]*

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(Question B1, part 1 continued)

(c) The speed v with which energy is propagated in the tubing by a travelling wave depends on the tension T in the tubing. The relationship between these quantities is

$$v = k\sqrt{T}$$

where k is a constant.

In an experiment to verify this relationship, the fundamental (first harmonic) frequency f was measured for different values of tension T.

(i) Explain how the results of this experiment, represented graphically, can be used to verify the relationship $v = k\sqrt{T}$. *[4]*

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(ii) In the experiment, the length of the tubing was kept constant at 2.4 m. The fundamental frequency for a tension of 9.0 N in the tubing was 1.8 Hz. Calculate the numerical value of the constant k. *[3]*

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(Question B1 continued)

Part 2 Mechanical power

(a) Define *power*. *[1]*

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(b) A car is travelling with constant speed v along a horizontal straight road. There is a total resistive force F acting on the car.

Deduce that the power P to overcome the force F is

$$P = Fv.$$ *[2]*

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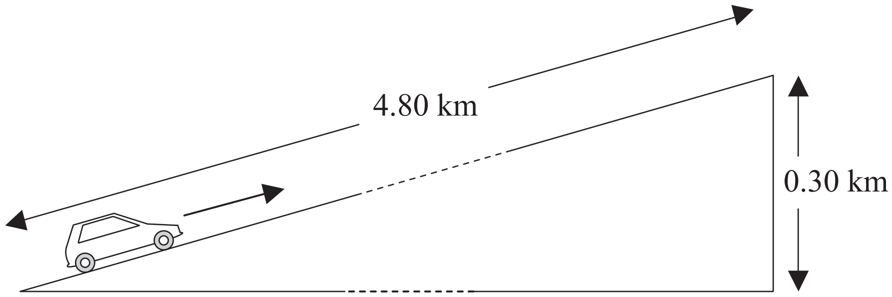
(Question B1, part 2 continued)

(c) A car drives up a straight incline that is 4.80 km long. The total height of the incline is 0.30 km.



The car moves up the incline at a steady speed of $16\,m\,s^{-1}$. During the climb, the average resistive force acting on the car is 5.0×10^2 N. The total weight of the car and the driver is 1.2×10^4 N.

(i) Determine the time it takes the car to travel from the bottom to the top of the incline. *[2]*

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(ii) Determine the work done against the gravitational force in travelling from the bottom to the top of the incline. *[1]*

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(iii) Using your answers to (i) and (ii), calculate a value for the minimum power output of the car engine needed to move the car from the bottom to the top of the incline. *[4]*

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(iv) State **one** reason why your answer to (iii) is only an estimate. *[1]*

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B2. This question is about nuclear energy.

(a) Define *nuclear binding energy*. *[2]*

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(b) A neutron collides with a nucleus of uranium-235 and the following reaction takes place.

$${}^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{96}_{37}\text{Rb} + {}^{138}_{55}\text{Cs} + 2\,{}^{1}_{0}\text{n}$$

State the name of this type of reaction. *[1]*

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(c) The mass of nuclei can be expressed in terms of unified mass units (u).

(i) Define the term *unified mass unit*. *[1]*

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(ii) Using the data below, calculate the energy, in MeV, that is released in the reaction. *[4]*

$$\text{mass of } {}^{235}_{92}\text{U} = 235.0439\,u$$
$$\text{mass of } {}^{96}_{37}\text{Rb} = 95.9342\,u$$
$$\text{mass of } {}^{138}_{55}\text{Cs} = 137.9112\,u$$
$$\text{mass of } {}^{1}_{0}\text{n} = 1.0087\,u$$

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(Question B2 continued)

(d) Explain the importance of the two neutrons produced in the reaction. *[2]*

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(e) Each neutron accounts for about 2 MeV of the energy released in the reaction. Suggest what accounts for the rest of the energy released. *[2]*

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(f) The reaction in (b) is more likely to take place if the colliding neutron has an energy of about 0.1 eV. In certain types of nuclear reactors in which this reaction might take place, the neutrons produced have their energy reduced by collisions with nuclei of graphite (^{12}C). The law of conservation of momentum can be used to estimate the number of collisions required to reduce the energy of the neutrons to 0.1 eV.

State the law of conservation of momentum. *[2]*

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(g) A neutron has a kinetic energy of 2.00 MeV. Deduce that the speed of the neutron is $1.95 \times 10^{7}\,\mathrm{m\,s^{-1}}$. *[2]*

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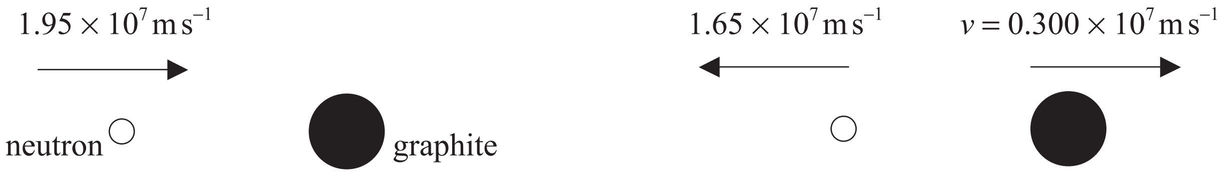
(Question B2 continued)

(h) You may assume that the mass of a nucleus of graphite is twelve times the mass of a neutron. In a certain collision between a neutron and a stationary graphite nucleus, the neutron of kinetic energy 2.00 MeV, rebounds from the graphite nucleus in a direction along a line joining the centres of the nucleus and neutron.



before collision after collision

The rebound speed of the neutron is $1.65 \times 10^7\,\text{m s}^{-1}$.

(i) Deduce that the speed v of the graphite nucleus after collision is $0.300 \times 10^7\,\text{m s}^{-1}$. *[3]*

(ii) Using your answer in (i), deduce whether the collision is elastic or inelastic. *[3]*

(iii) Use your answer to (ii) to deduce that each time a neutron collides in this manner with a graphite nucleus it loses about 30 % of its kinetic energy. *[2]*

(iv) State the fraction of the total initial energy lost by a neutron in its second collision with a graphite nucleus. *[1]*

B3. This question is in **two** parts. **Part 1** is about ideal gas behaviour and **Part 2** is about electrical circuits.

Part 1 Ideal gas behaviour

(a) Explain, in terms of the behaviour of the molecules of an ideal gas, why the pressure of the gas rises when it is heated at constant volume. *[3]*

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(b) The pressure P of a fixed mass of an ideal gas is directly proportional to the kelvin temperature T of the gas. That is,

$$P \propto T.$$

State

(i) the relation between the pressure P and the volume V for a change at constant temperature. *[1]*

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(ii) the relation between the volume V and kelvin temperature T for a change at a constant pressure. *[1]*

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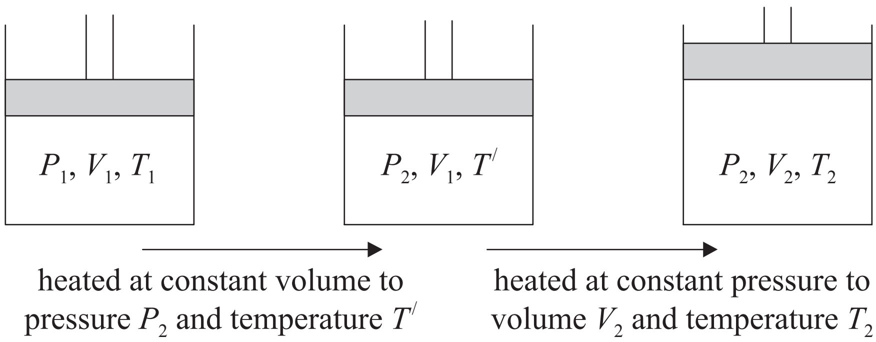
(Question B3, part 1 continued)

(c) The ideal gas is held in a cylinder by a moveable piston. The pressure of the gas is P_1, its volume is V_1 and its kelvin temperature is T_1.

The pressure, volume and temperature are changed to P_2, V_2 and T_2 respectively. The change is brought about as illustrated below.



State the relation between

(i) P_1, P_2, T_1 and $T^{/}$. *[1]*

(ii) V_1, V_2, $T^{/}$ and T_2. *[1]*

(d) Use your answers to (c) to deduce, that for an ideal gas

$$PV = KT$$

where K is a constant. *[4]*

(This question continues on the following page)

(Question B3, part 1 continued)

(e) The gas in (c) is argon-40 ($^{40}_{18}Ar$) and $P_1 = 2.00 \times 10^5$ Pa, $V_1 = 2.49 \times 10^{-2}\,m^3$, $T_1 = 300$ K.

Calculate the mass of the gas. *[4]*

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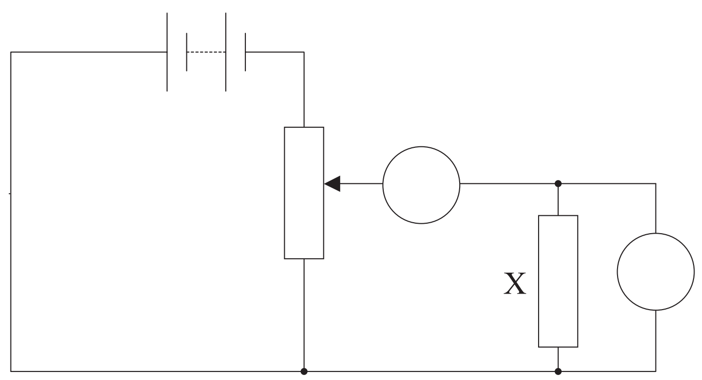
Part 2 Electric circuits

(a) The diagram below shows the circuit used to measure the current-voltage (*I-V*) characteristic of an electrical component X.



On the diagram above,

(i) label the ammeter A and the voltmeter V. *[1]*

(ii) mark the position of the contact of the potentiometer that will produce a reading of zero on the voltmeter. Label this position P. *[1]*

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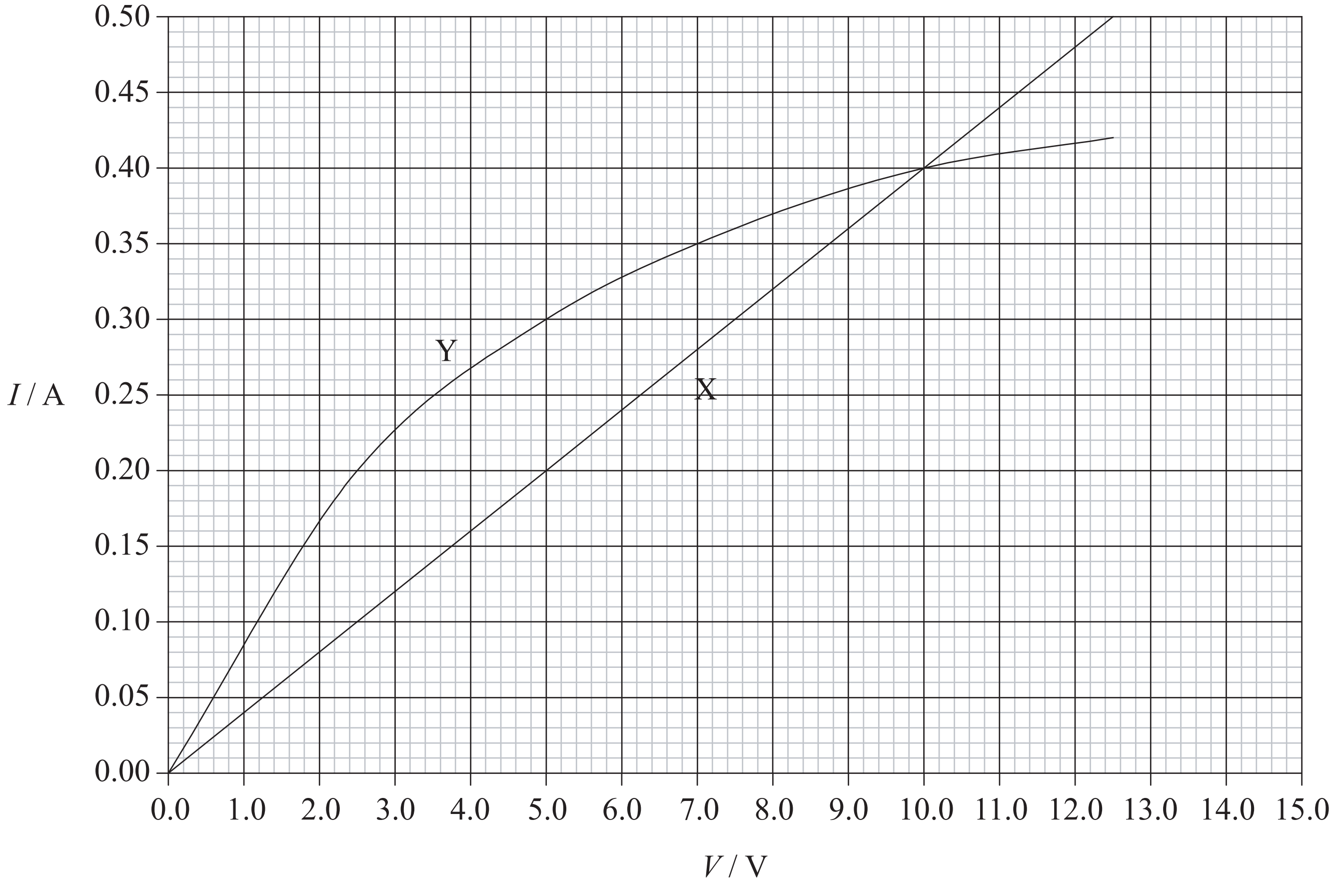
(Question B3, part 2 continued)

(b) The graph below shows the current-voltage (*I-V*) characteristics of two different conductors X and Y.



(i) State the value of the current for which the resistance of X is the same as the resistance of Y and determine the value of this resistance. *[2]*

Current: . . . .

Resistance: . . . .

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(ii) Describe and suggest an explanation for the *I-V* characteristic of conductor Y. *[3]*

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(Question B3, part 2 continued)

(c) The two conductors X and Y are connected in series with a cell of negligible internal resistance. The current in the conductors is 0.20 A.

Use the graph in (b) to determine

(i) the resistance of Y for this value of current. *[1]*

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(ii) the e.m.f. of the cell. *[2]*

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