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

N02/430/H(2)+

PHYSICS
HIGHER LEVEL
PAPER 2

Tuesday 5 November 2002 (afternoon)

2 hours 15 minutes

Name

Number

INSTRUCTIONS TO CANDIDATES

- Write your candidate name and 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 two questions from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of the Section B questions answered in the boxes below.

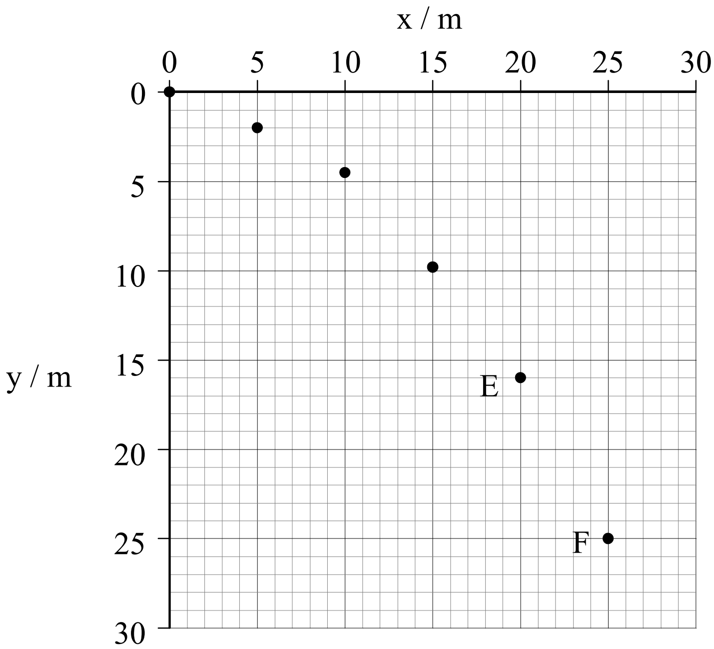
QUESTIONS ANSWERED		EXAMINER	TEAM LEADER	IBCA
SECTION A	ALL	/35	/35	/35
SECTION B QUESTION QUESTION		 /30 /30	 /30 /30	 /30 /30
		TOTAL /95	TOTAL /95	TOTAL /95

SECTION A

*Candidates must answer **all** questions in the spaces provided.*

A1. Projectile motion on a planet

A projectile is launched horizontally from a cliff on a planet in a distant solar system. The graph below plots the horizontal (x) and vertical (y) positions of the projectile **every 0.5 seconds**.



(a) Determine the initial velocity with which the projectile was launched. *[2]*

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(b) How can you tell from the plotted data that the planet's atmosphere had no significant effect on the motion of the projectile? *[2]*

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(c) State **two** reasons why the value of the acceleration due to gravity on this or any other planet is likely to be different from that on Earth. *[2]*

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(Question A1 continued)

(d) Draw a vector on the graph to represent the **displacement** of the projectile between points E and F of the motion. Then draw vectors to represent the horizontal and vertical **components** of this displacement. *[3]*

(e) Determine the **vertical** component of the average velocity of the projectile between points E and F. *[2]*

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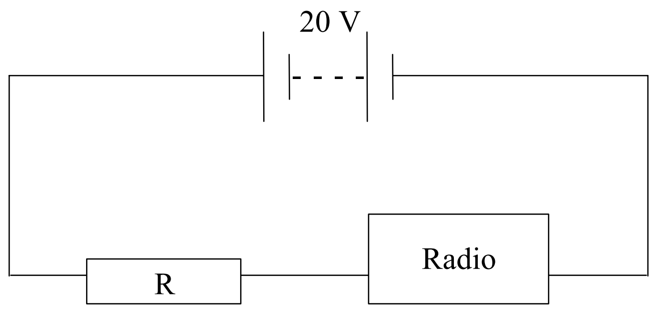
(f) Another projectile is fired at **half the speed** of the first one. On the graph opposite, plot the positions of this projectile for time intervals of 0.5 s. *[2]*

A2. Portable radio power supply

A portable radio requires a potential difference of 12 V to operate. The only supply available is a 20 V supply. In order to use the radio with this supply, a student includes a series resistor, R, as shown in the circuit below.



(a) The radio is designed to draw a current of 0.4 A with 12 V across it. The internal resistance of the 20 V supply is small. Calculate the value of the resistor, R, required for the radio to operate normally, when connected in the circuit above. *[3]*

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(b) Three resistors are available with maximum power ratings 2 W, 5 W and 10 W respectively. Explain which **one** of these resistors the student should choose for the circuit. *[2]*

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(c) Explain what would happen if a resistor with a lower power rating than that required is chosen. *[1]*

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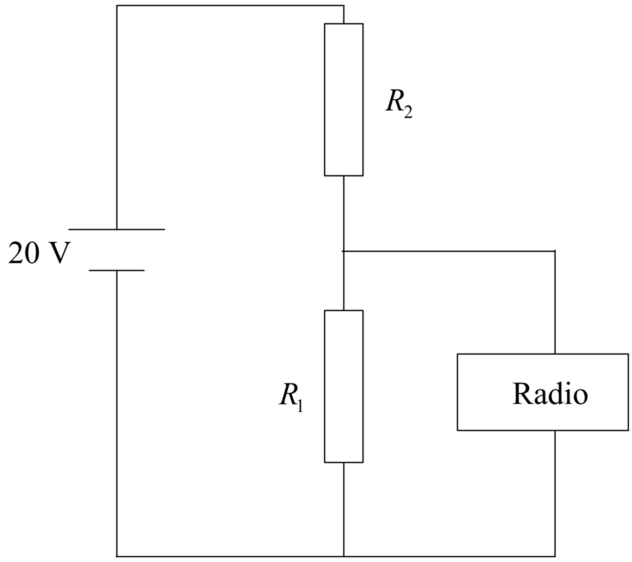
(Question A2 continued)

(d) An alternative circuit for producing the required working voltage for the radio is shown below.



The resistances R_1 and R_2 are very much less than the resistance of the radio.

Calculate the ratio of R_1 to R_2 in order for the operating voltage of the radio to be equal to 12 V. *[3]*

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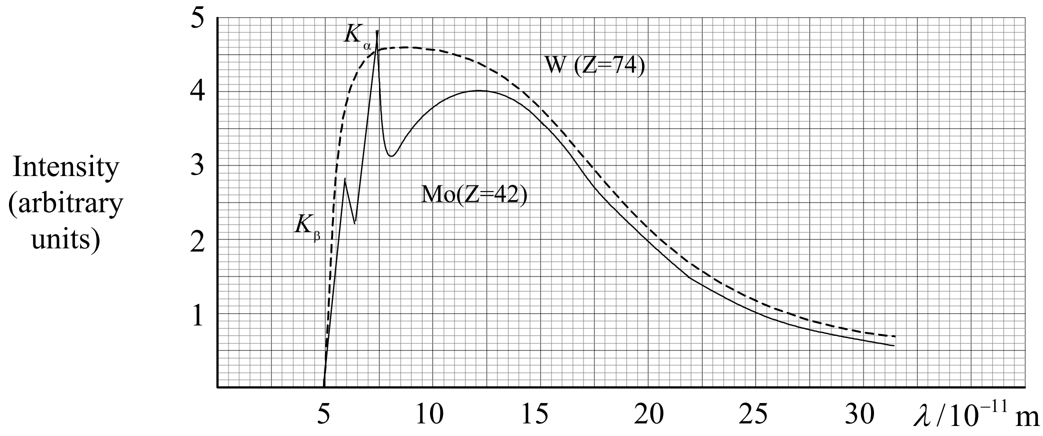
A3. X-Ray spectra

A particular X-ray tube uses molybdenum (Mo) as the target element and another uses tungsten (W). The atomic number Z of molybdenum is 42 while that of tungsten is 74.

The graph below shows the X-ray spectra produced by the two tubes when the accelerating potential is the same for both tubes.



(a) Explain, with reference to the mechanism of X-ray production, why the minimum wavelength produced is the same for both target elements. *[3]*

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(b) Use data from the graph to calculate the accelerating potential used in the X-ray tubes. *[4]*

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(Question A3 continued)

(c) The graph shows that characteristic peaks K_α and K_β occur for molybdenum, but not for tungsten. In order to obtain characteristic spectra for tungsten, the accelerating potential has to be increased beyond a certain value.

(i) Explain why characteristic tungsten spectra only appear when the accelerating potential is greater than that necessary to produce molybdenum characteristic spectra. *[2]*

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(ii) Sketch on the graph a possible spectrum for tungsten that shows both the characteristic and continuous spectra. Numerical values are not required. *[2]*

(iii) Explain the relative position of the tungsten characteristic spectra with respect to the position of the molybdenum characteristic spectra. *[2]*

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SECTION B

This section consists of four questions: B1, B2, B3 and B4. Answer any ***two*** *questions in this section.*

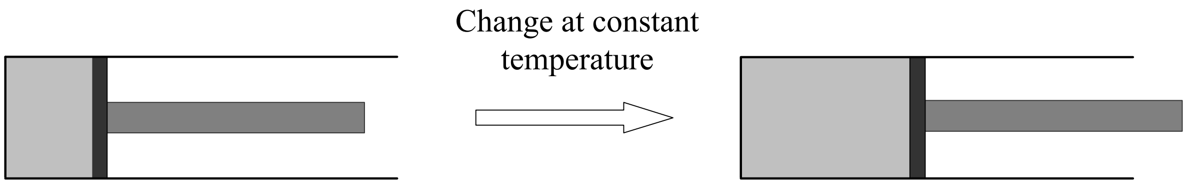
B1. This question consists of **two** parts. Part 1 is about thermodynamics and Part 2 is about a collision between hanging masses.

Part 1 Thermodynamics of two-stage gas process

This question is about pressure, volume and temperature changes of an ideal gas.

An ideal gas is enclosed in a cylinder fitted with a moveable piston. The gas undergoes two processes, as follows:

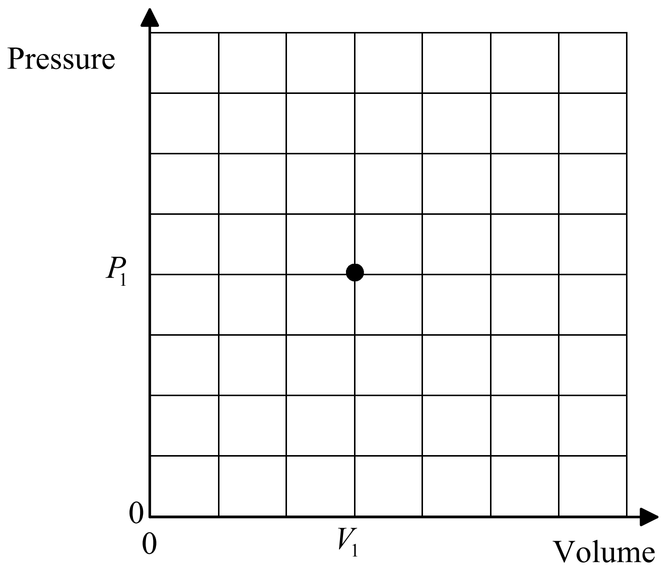
First process:
The gas, initially in state 1, is **expanded at constant temperature** T_1 until its volume is doubled. This is state 2. The two states are represented in the diagram below.



State 1
Pressure: P_1
Volume: V_1
Temperature: T_1

State 2
Pressure: $P_2 = ?$
Volume: $V_2 = 2V_1$
Temperature: $T_2 = T_1$

(a) Using the axes below, sketch a graph to show how **pressure** and **volume** are related for this process. The data point for state 1 is shown plotted. Label the state reached as state 2. *[2]*



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(Question B1 part 1 continued)

(b) Explain in terms of motions of the gas molecules, why the pressure decreases when the volume increases. *[2]*

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(c) Explain whether or not in this process

(i) work is done by **or** on the gas. *[2]*

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(ii) the internal energy of the gas changes. *[1]*

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(iii) thermal energy flows into **or** out from the gas. *[2]*

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(d) Explain how the work done, if any, is related to the thermal energy transfer. *[2]*

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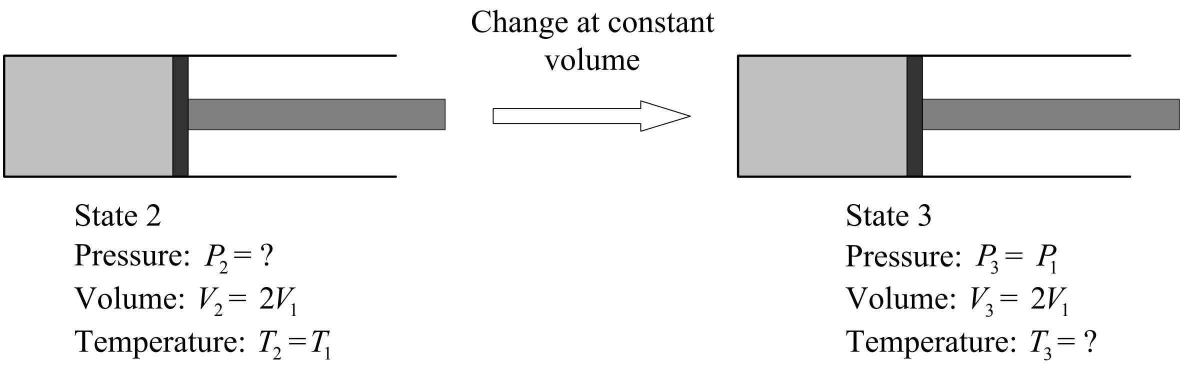
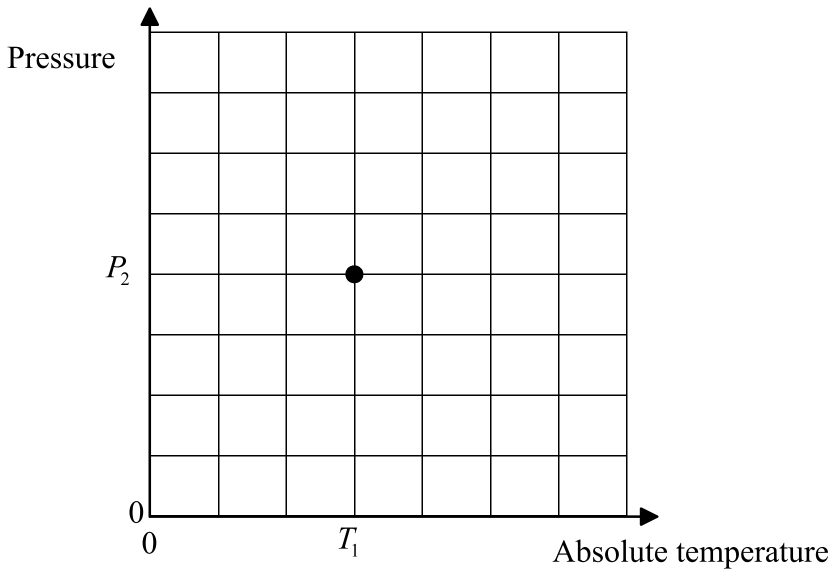
(Question B1 part 1 continued)

Second process:
The piston is now kept fixed, and the gas is heated until the pressure returns to its original value P_1. This is state 3 and is represented in the diagram below.



(e) Using the axes below sketch a graph to show how **pressure** varies with **absolute temperature** for this process. The data point for state 2 is shown plotted. Label the state reached as state 3. *[2]*



(f) Explain in terms of the motions of the gas molecules, why the pressure increases when the gas is heated. *[3]*

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(Question B1 part 1 continued)

(g) Explain whether or not for this process

(i) work is done. *[2]*

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(ii) the internal energy of the gas changes. *[1]*

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(h) If the initial temperature of the gas in state 1 is $20\,^{\circ}\mathrm{C}$, determine the final temperature of the gas in state 3, after both processes. *[3]*

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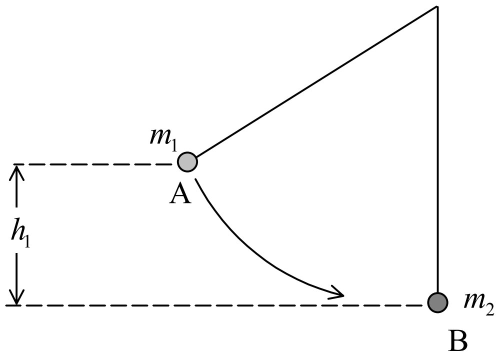
(Question B1 continued)

Part 2 Pendulum collision

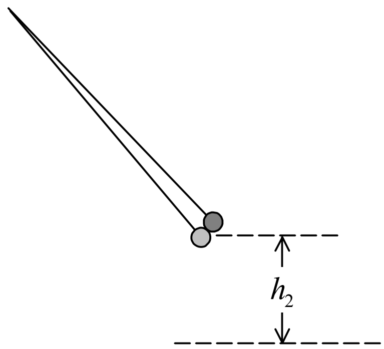
Two balls A and B, of masses m_1 and m_2 respectively, are suspended from a common point by strings of equal length. Ball A is pulled aside to the left, rising a height h_1, as shown in diagram 1 and is then released.

Diagram 1



Ball A swings down, **sticks** to ball B, and the two balls **together** swing up to the right to a height h_2 as shown in diagram 2.

Diagram 2



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(Question B1 part 2 continued)

(a) Deduce an expression for

(i) the speed of m_1 immediately before it collides with m_2. *[2]*

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(ii) the speed of m_1 and m_2 immediately after collision. *[4]*

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(b) If the expression for the speed of m_1 and m_2 immediately after collision is known, state the name of the principle (law) of physics that enables an expression for the height h_2 to be found in terms of h_1, m_1, m_2 and g. *[1]*

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(c) Explain why the height h_2 will always be less than the height h_1. *[1]*

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B2. This question consists of **two** parts. Part 1 is about an electric generator and Part 2 is about circular waves.

Part 1 An electric generator

The diagrams below show a simple electric generator which can convert mechanical energy into electrical energy. A light metal rod, CD, is loaded with a mass *M* (diagram 1) and is able to slide downward while making contact with two long vertical metal rails PQ and RS. The rods are connected at the bottom by a resistor R, and the whole device is in a uniform magnetic field *B* perpendicular to the page.

When the loaded rod is released from rest, it falls downwards and as a result an electric current, *I*, flows around the circuit CDSQC. The rod speeds up initially before reaching a constant downward speed. (Diagram 2)

Diagram 1

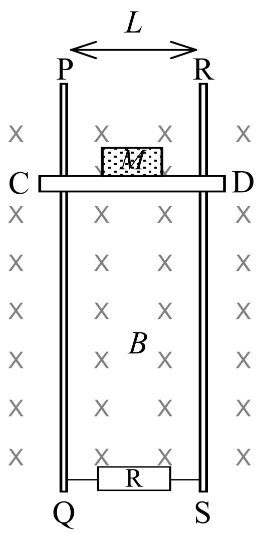
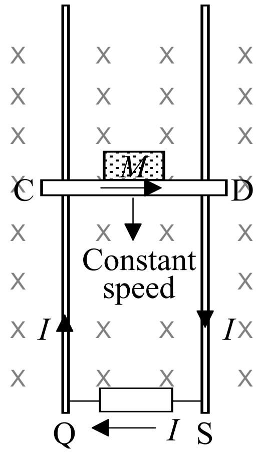
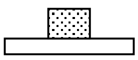


Diagram 2

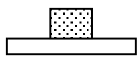


(a) Draw diagrams showing the forces acting on the loaded rod in the two cases below. Show and **label** the force(s) acting on the rod in each case. *[3]*

(i) Just as it is released



(ii) During fall at constant speed



(b) Explain why the rod accelerates initially, but then reaches a steady (terminal) speed. *[3]*

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(Question B2 part 1 continued)

(c) When the rod is moving steadily downward at terminal speed v_T, show that the current I induced is given by

$$I = \frac{Mg}{BL}$$

where M is the mass of the load, L is the length of the rod between the rails and B is the magnetic field strength. *[3]*

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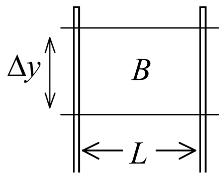
(d) The diagram below shows the rod descending a distance Δy in a time Δt, at constant speed v_T.



(i) Write an expression for the change of magnetic flux $\Delta\phi$ through the circuit during this time. *[1]*

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(ii) Hence show from Faraday's law that the induced e.m.f. E is given by $E = BLv_T$. *[2]*

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(e) Show that the terminal velocity of the rod is given by the expression

$$v_T = \frac{MgR}{B^2L^2}$$

where R is the resistance of the resistor R. *[4]*

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(Question B2 part 1 continued)

(f) State a disadvantage of this type of generator compared to a conventional rotating generator. *[1]*

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Part 2 Properties of circular waves on water

(a) Ripples on water can essentially be considered as transverse waves. Explain what is meant by a *transverse wave.* *[2]*

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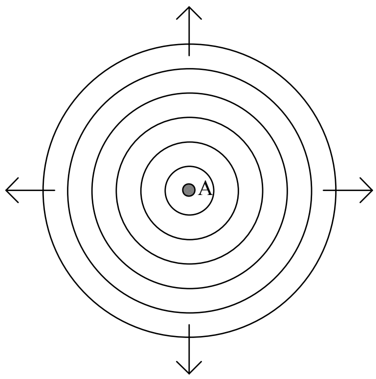
(b) An oscillator with a frequency 3.0 Hz generates ripples on the surface of water. The ripples spread in circles from the point A as shown in the diagram, viewed from the top. The distance between wavefronts is 5.0 cm.



(i) Calculate the speed of the ripples. *[2]*

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(ii) The amplitude of a wave is a measure of the energy carried by the wave. Explain what you think happens to the amplitude of the ripples as they spread out in expanding circles from the point A. *[2]*

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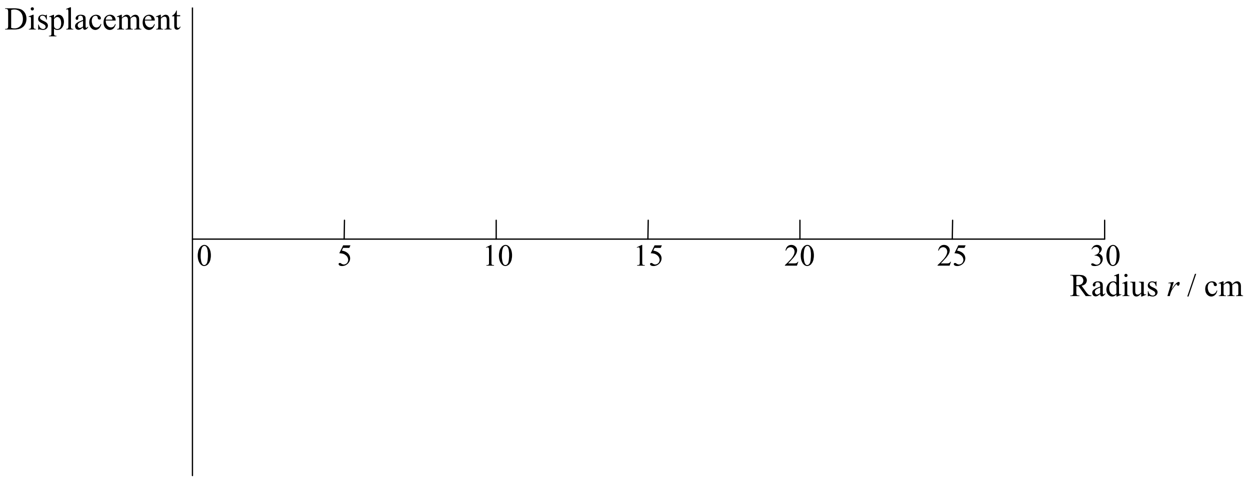
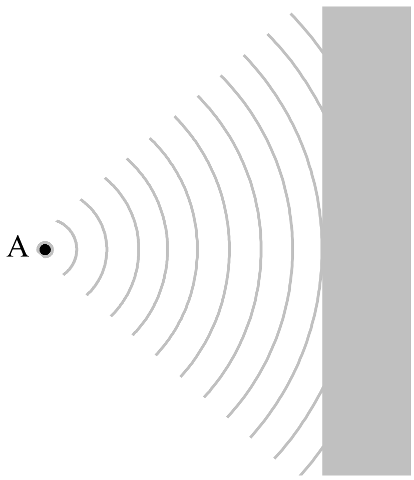
(Question B2 part 2(b) continued)

(iii) On the axes below, sketch a graph of the water displacement along a straight-line from A at a particular instant of time. *(Note: This is a sketch graph; you do not need to add values to the displacement axis.)* *[3]*



(c) The diagram below shows the circular ripples incident on a plane barrier.



On the diagram,

(i) sketch a wavefront that has been **reflected** from the barrier. *[1]*

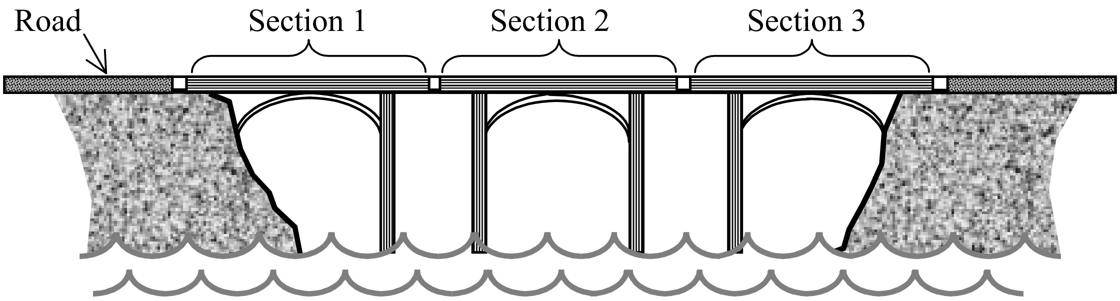
(ii) draw **two** rays originating from point A that correspond to the **incident** wavefronts. *[1]*

(iii) locate the position from where the reflected waves **appear** to originate. *[2]*

B3. This question consists of **three** parts. Part 1 is about the expansion of iron, Part 2 is about radioactive decay and Part 3 is about the Doppler effect.

Part 1 Iron bridge

An iron bridge is built in three sections, each section is 25 m long. Since the temperature varies during the day and from day to day, gaps are left between sections and at the ends, as shown in the diagram below.



(a) Explain why gaps are provided in the bridge and describe what could happen if there were no gaps. *[2]*

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(b) The road at each end of the bridge is fixed. If the coefficient of linear expansion of iron is $1.31\times10^{-5}\ ^{\circ}\text{C}^{-1}$, calculate the size that each gap would need to be at $-10\ ^{\circ}\text{C}$ to allow for a temperature range of $-10\ ^{\circ}\text{C}$ to $+50\ ^{\circ}\text{C}$. *[5]*

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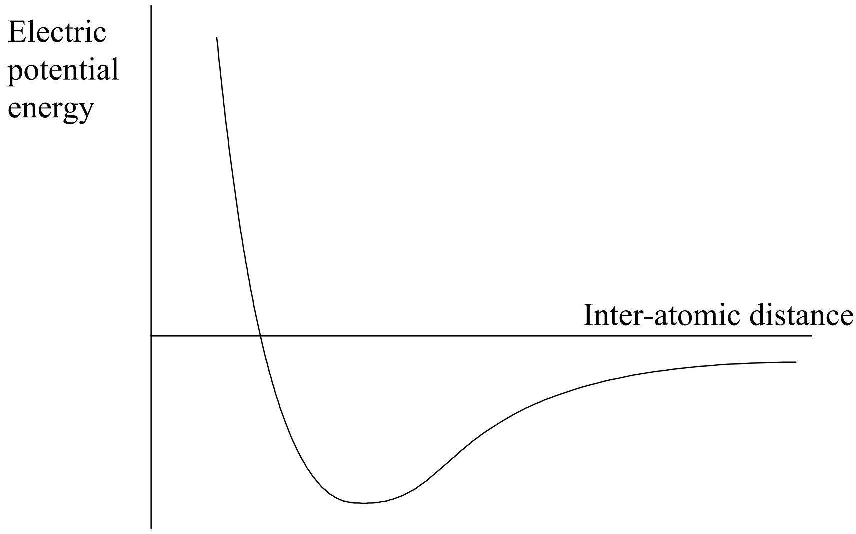
(Question B3 part 1 continued)

(c) The graph below shows the inter-atomic electric potential energy versus distance between iron atoms.



Explain, with the aid of the graph, why iron expands slightly as its temperature increases. *[5]*

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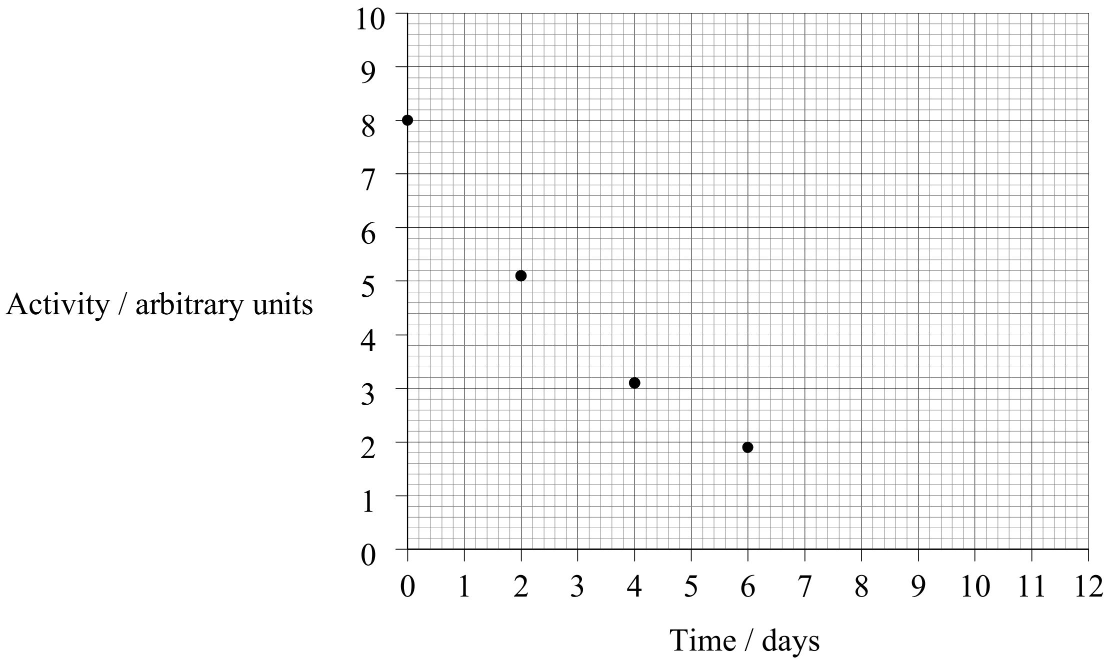
(Question B3 continued)

Part 2 Radioactive decay

The activity of a radioactive sample is shown plotted against time over 6 days, on the graph below.



(a) Draw a best fit curve to the data between 0 and 6 days. *[1]*

(b) Using the graph

(i) estimate the activity after 5 days. *[1]*

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(ii) determine the half-life of the sample and explain your method. *[2]*

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(c) Extend the best fit curve to show the expected activity for times up until 12 days. *[2]*

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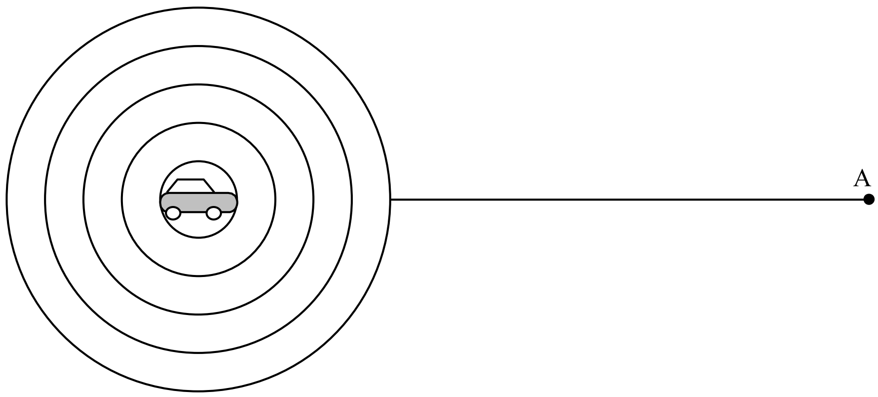
(Question B3 continued)

Part 3 The Doppler effect

(a) A car is initially **at rest**, with its radio playing music. The diagram below (not drawn to scale) represents the sound wavefronts arising from a musical note of frequency 440 Hz, spreading out from the car. The speed of sound in air is $330\ \text{m s}^{-1}$.



Calculate the

(i) distance between the wavefronts. *[2]*

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(ii) frequency of the note as heard by an observer at point A. *[1]*

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(Question B3 part 3 continued)

(b) The car now moves at constant speed, v, toward the observer at point A with the radio still playing.

(i) On the diagram below sketch the wavefronts from the musical note of frequency 440 Hz. *[3]*

(ii) At what speed are the wavefronts progressing toward the observer? *[1]*

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(c) If the speed of the car is $8.0\ \text{m s}^{-1}$, calculate the

(i) distance between the wavefronts that approach the observer at point A. *[3]*

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(ii) frequency of the note as heard by the observer at point A. *[2]*

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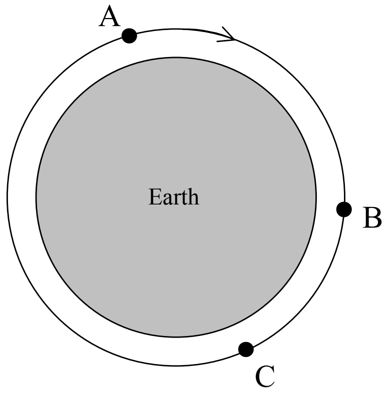
B4. This question is in **two** parts. Part 1 deals with satellite orbits and Part 2 is about the oscillations of an object suspended from a spring.

Part 1 Satellite orbits

A satellite of mass m is in a circular orbit about the Earth. The satellite is at a height of a few hundred kilometres above the surface of the Earth and the radius of the Earth is 6.4×10^3 km.



(a) On the diagram above, draw vectors representing the force(s) acting on the satellite when it is at the points A, B and C of its orbit. *[2]*

(b) Explain why, provided that the satellite is only a few hundred kilometres above the surface of the Earth, the gravitational force acting on the satellite can be estimated as mg, where g is the gravitational field strength at the surface of the Earth. *[3]*

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(c) Show that the orbital period of the satellite is about 84 min. *[6]*

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(Question B4 part 1 continued)

(d) Show that for any satellite in an orbit of radius R measured from the centre of the Earth

$$\frac{R^3}{T^2} = \text{constant}$$

where T is the orbital period of the satellite. *[5]*

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(e) A geostationary satellite is one that orbits the Earth with a period equal to the period of rotation of the Earth about its axis. Calculate the orbital radius of such a satellite in terms of R_E, the radius of the Earth. *[3]*

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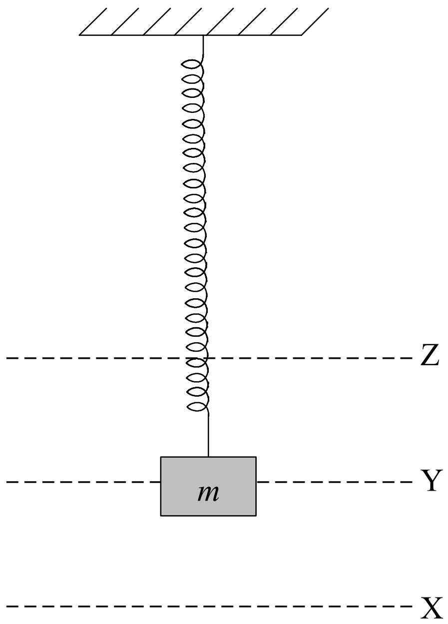
(Question B4 continued)

Part 2 Oscillations of an object suspended from a spring

An object of mass m is suspended from a vertically supported spring.



The object is pulled down to the position marked X and then released such that the object oscillates between the positions X and Z with simple harmonic motion.

(a) Explain what is meant by the term *simple harmonic motion*. *[2]*

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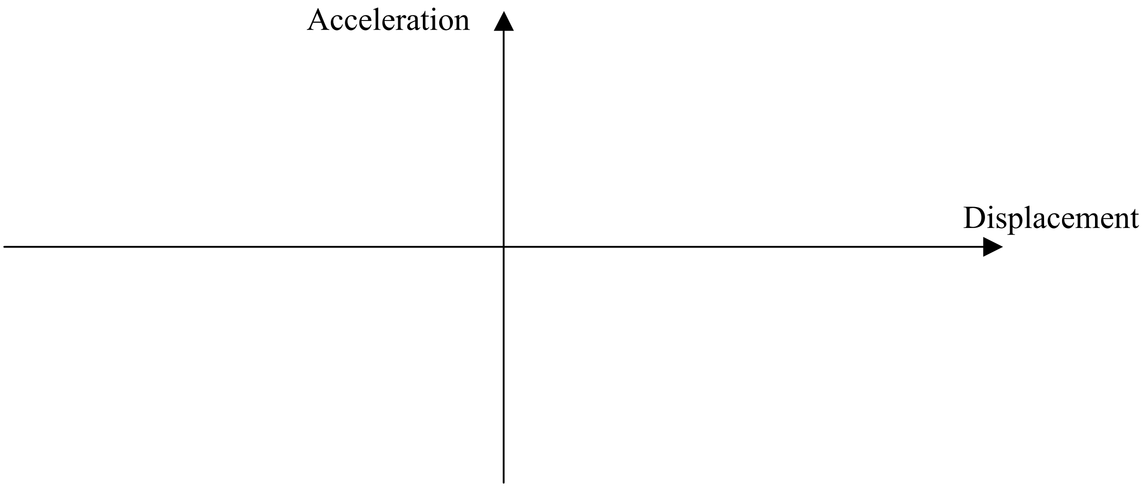
(Question B4 part 2 continued)

(b) On the axes below sketch a graph to show how the **acceleration** of the object varies with its **displacement** from the position marked Y. *[3]*



(c) Indicate on the above graph the points that correspond to the positions X, Y and Z. *[1]*

(d) On the axes below sketch a graph to show how the **acceleration** varies with **time** from the moment that it is released to the moment that it returns for the first time to position X. *[2]*

(e) Indicate on the above graph the points that correspond to the positions X, Y and Z. *[1]*

(f) The mass of the object is 0.050 kg and the spring constant for the spring is $2.0\ \text{N m}^{-1}$. If the distance between X and Y is 0.12 m, determine the maximum acceleration of the object. *[2]*

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