Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

S25-2420U10-1

2420U10-1

THURSDAY, 15 MAY 2025 – AFTERNOON

PHYSICS – AS unit 1
Motion, Energy and Matter

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**8**	
2.	**8**	
3.	**13**	
4.	**15**	
5.	**16**	
6.	**9**	
7.	**11**	
Total	**80**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **6(a)**.

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Answer **all** questions.

1. (a) Explain what is meant by the centre of gravity of a body. [1]

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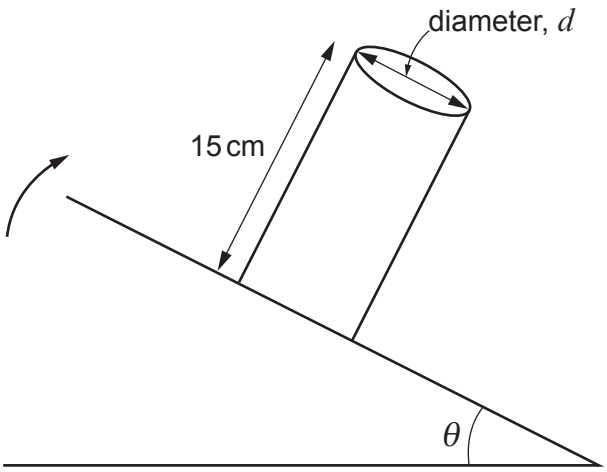
(b) The diagram shows a uniform cylinder of length 15 cm and diameter, d, placed on a rough surface that is gradually tilted. No sliding occurs.



(i) The cylinder is shown when it is about to topple. **Indicate on the diagram** the line of action of the cylinder's weight. [1]

(ii) When the cylinder is about to topple, θ is 18.7°. Show that the diameter of the cylinder is approximately 5 cm. [2]

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(iii) Use the following information to determine the metal from which the cylinder is made, given that it has a mass of 2400 g. [3]

Metal	Density / g cm^{-3}
copper	9.0
brass	8.6
iron	7.9

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(c) Aluminium has a density of 2.7 g cm^{-3}. A student believes that a cylinder made from aluminium, but with the **same length and diameter** as the cylinder in part (b), would topple when θ is less than 18.7°. Discuss whether the student is correct. [1]

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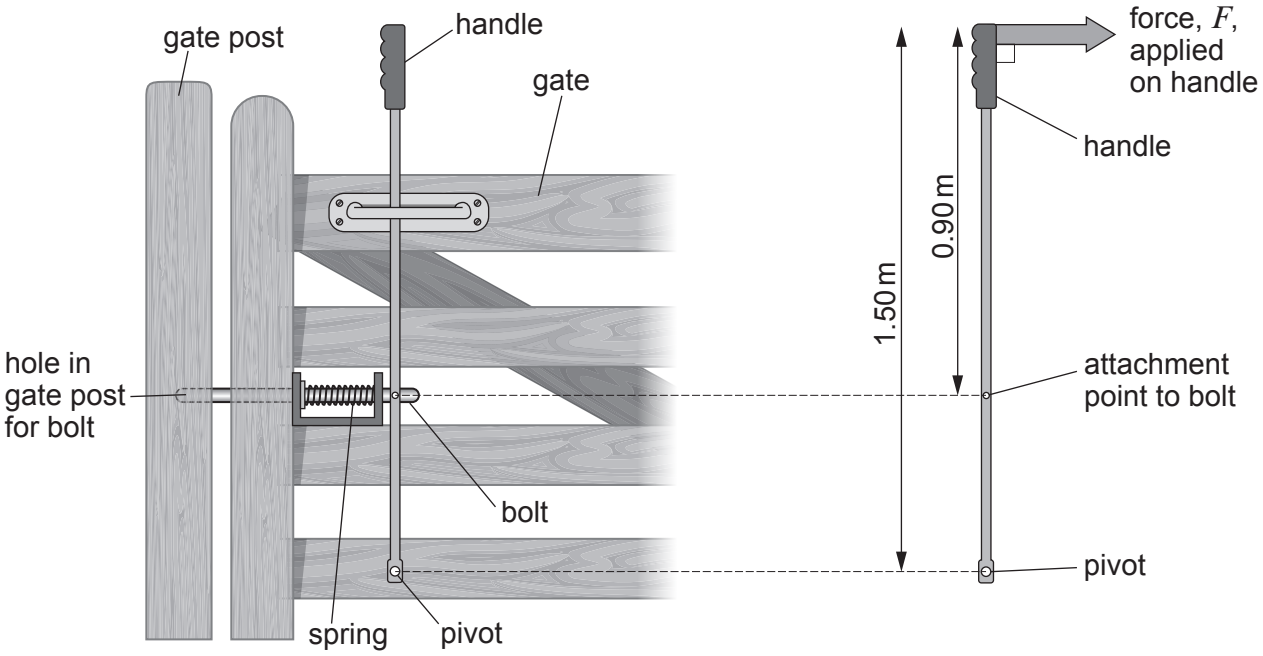
2. The picture shows a gate on a public footpath. The accompanying diagram gives details of the mechanism for opening the gate. The gate is opened by applying a force to the handle as shown. This moves the bolt to the right, compressing the spring. When the handle is released, the spring pushes the bolt back to its original position.



To open the gate, a force, F, is applied at right angles to the handle as shown.

(a) The spring used in the gate has a spring constant, k, of 160 N m^{-1}. To open the gate, the bolt must be moved 8.0 cm. This compresses the spring by the same distance. Assuming Hooke's law applies, calculate the force applied directly to the spring. [2]

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(b) In designing the gate, the manufacturer requires that the force, F, is of a reasonable value to allow nearly all users to open the gate. They believe that this value should be approximately 5 N. Determine whether the arrangement opposite meets this requirement. [3]

(c) After using the gate, a user suddenly releases the handle. Calculate the speed with which the bolt returns to its original position. Assume the mass of the bolt is 0.3 kg and that only 20% of the energy stored in the spring is transferred to the bolt. [3]

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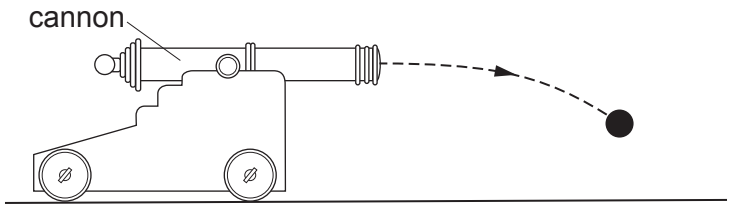
3. (a) A cannonball is fired in a horizontal direction, as shown.



The following table refers to the flight of the cannonball after it has left the barrel of the cannon. Complete the table by inserting **one** of the following words or phrases into each of the empty boxes. Words or phrases may be used once, more than once or not at all. **Ignore the effects of air resistance.** [2]

- increases
- decreases
- constant, but not zero
- is zero

	In the **horizontal** direction	In the **vertical** direction
Velocity of cannonball	.....	.....
Acceleration of cannonball	.....	.....

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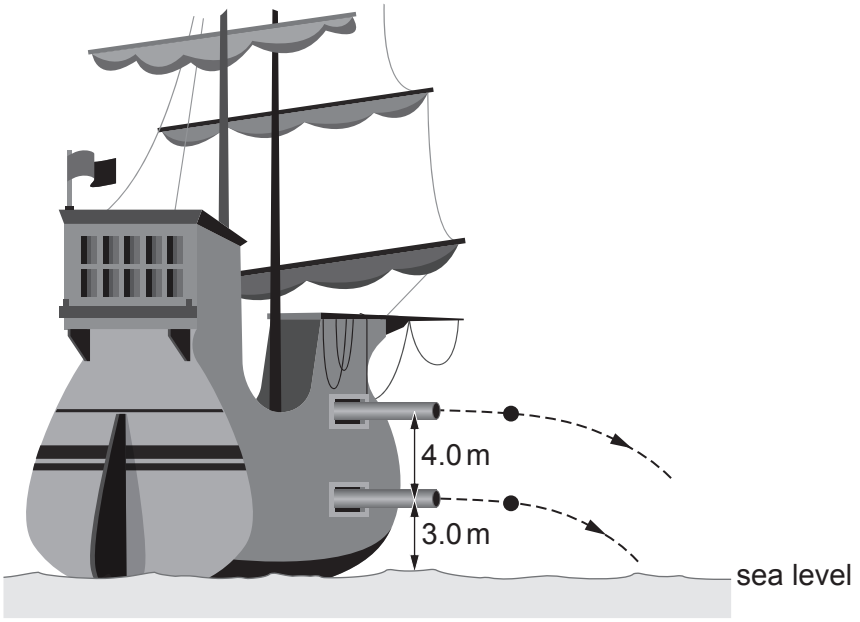
(b) Two cannons are positioned, one directly above the other, on a pirate ship, as shown.



Both cannons are fired at the **same instant** and the initial horizontal velocity of both cannonballs **is the same**. Assume that air resistance has no effect on the cannonballs.

(i) The height of the **lower** cannon above the sea is 3.0 m. Show that the time of flight through the air for this cannonball is approximately 0.8 s. [3]

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(ii) Calculate the vertical velocity of the cannonball fired from the **upper** cannon just before it strikes the sea. [2]

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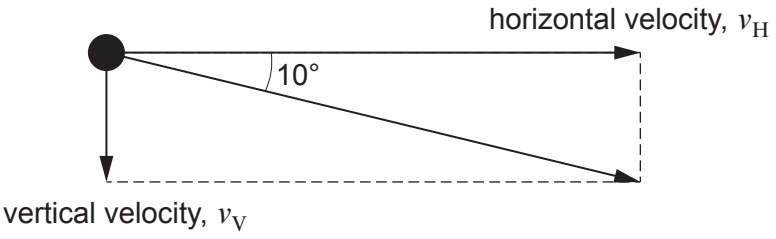
(iii) The cannonball fired from the **upper** cannon strikes the sea at an angle of 10° below the horizontal, as shown below.



Use the information in the diagram and your answer to (b)(ii) to calculate the horizontal velocity of the cannonball. [2]

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(iv) Hence, calculate the horizontal distance travelled by the cannonball fired from the **lower** cannon before it strikes the sea. [2]

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(c) Without further calculation, explain whether the cannonball fired from the **lower** cannon would strike the water at an angle greater than, equal to or less than 10° below the horizontal. [2]

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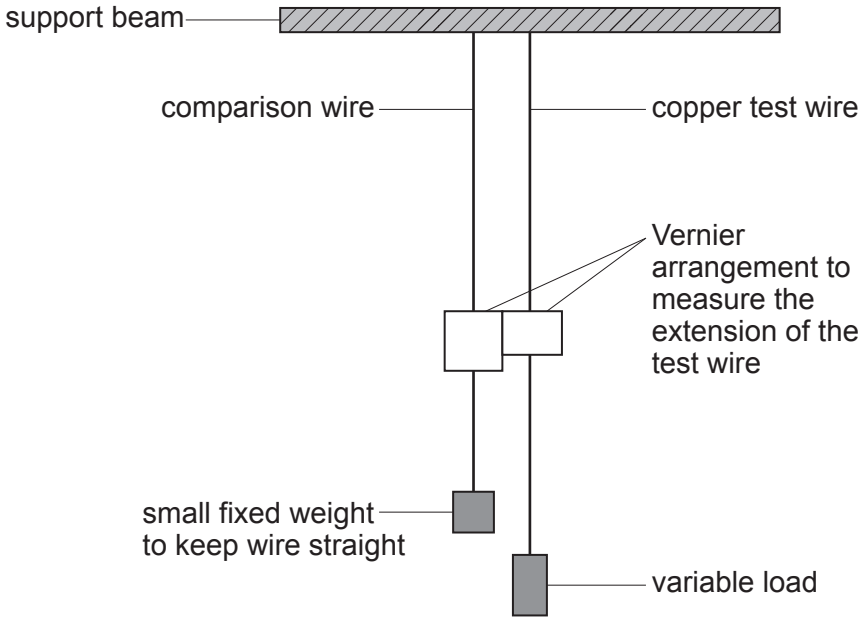
4. Alana uses the following apparatus to determine the Young modulus of copper in the form of a wire, labelled copper test wire in the diagram.



(a) Explain why the comparison wire is also made of copper. [2]

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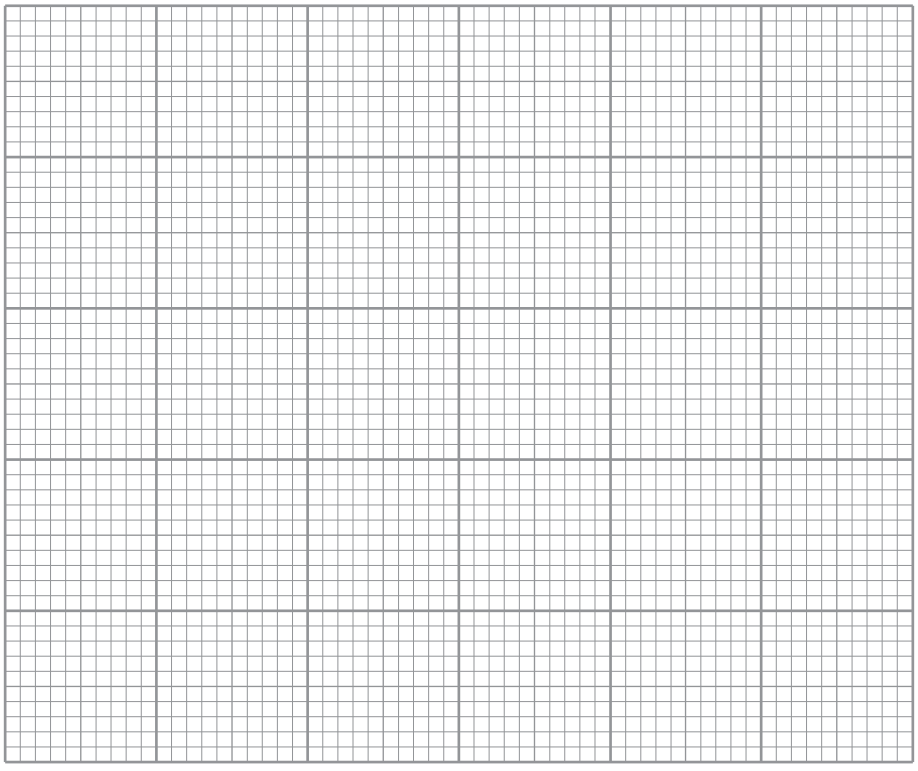
(b) Alana carefully increases the load on the copper test wire and records the extension (**in mm**) for each load. Her results are shown in the table below.

Load, F/N	Extension, x/mm
0.0	0.00
4.9	1.06
9.8	2.25
14.7	3.19
19.6	4.15
24.5	5.32

(i) On the grid, plot a graph of load (y-axis) against extension (x-axis) and draw a line of best fit. [4]



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(ii) I. Alana uses a digital micrometer to determine the mean diameter of the wire to be 0.36 mm. Write down the resolution of the micrometer she used. [1]

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II. Determine the cross-sectional area of the wire in m^2. [2]

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(iii) By calculating the gradient of the graph, determine the Young modulus of copper. The original length of the wire was 2.88 m. Give your answer in GPa and to an appropriate number of significant figures. [4]

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(c) As part of her experimental procedure, Alana removes the load after taking each reading of extension and notes the reading on the vernier. Explain why she does this. [2]

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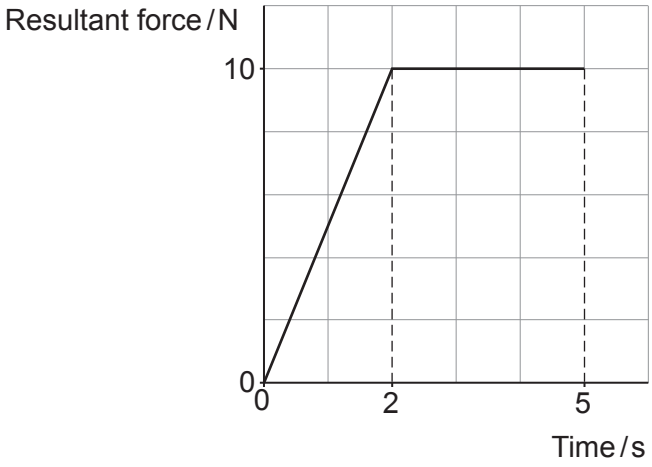
5. Curling is an Olympic sport where players slide heavy polished stones on ice towards a target area.

(a) A player pushes a stone of mass 19.0 kg from **rest** for 5 seconds before releasing it with velocity, v. The resultant force applied to the stone as it is pushed is shown by the graph.



Use the graph to show that, when the stone is released at 5 seconds, its release velocity, v, is approximately 2 m s^{-1}. [3]

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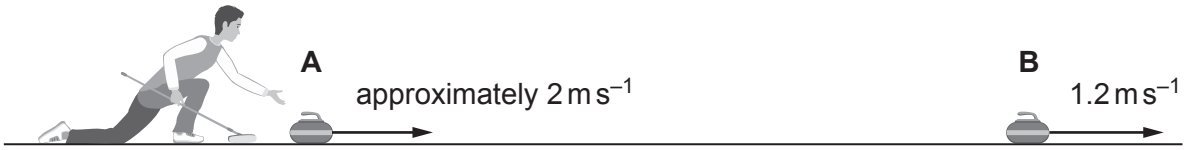
(b) As the stone slides across the ice, frictional forces slow it down. The diagram shows the point at which the stone is released (labelled **A**) and a distant point when the stone's velocity has reduced to $1.2\,m\,s^{-1}$ (labelled **B**).



(i) Determine the work done against frictional forces between **A** and **B**. [3]

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(ii) Calculate the mean resistive force between **A** and **B**, given that the distance **AB** is 8.0 m. [2]

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(iii) Determine the mean rate of energy transfer between **A** and **B**. [4]

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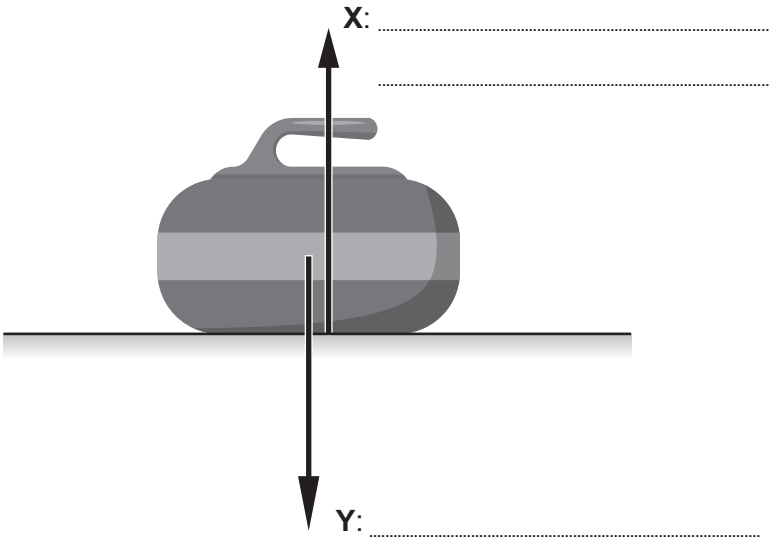
(c) The stone eventually comes to rest on the ice.

(i) Identify the forces **X** and **Y** acting on the stone. [2]



(ii) Give **two** reasons why the forces shown **do not** form a Newton 3rd law pair. [2]

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6. (a) The following decay occurs in a time of approximately 10^{-8} s.

$$\pi^+ \longrightarrow e^+ + \upsilon_e$$

Give a detailed description of the process, including how conservation laws apply.
[6 QER]

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(b) (i) Rhian believes that the only possible combination of u and d quarks for a proton is uud. Justify Rhian's opinion. [2]

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(ii) Circle the term(s) that can be used to describe a proton. [1]

baryon lepton meson hadron anti-particle charged-pion

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7. (a) The Sun's surface temperature is 5800 K. Calculate the wavelength of peak spectral intensity for the Sun. [2]

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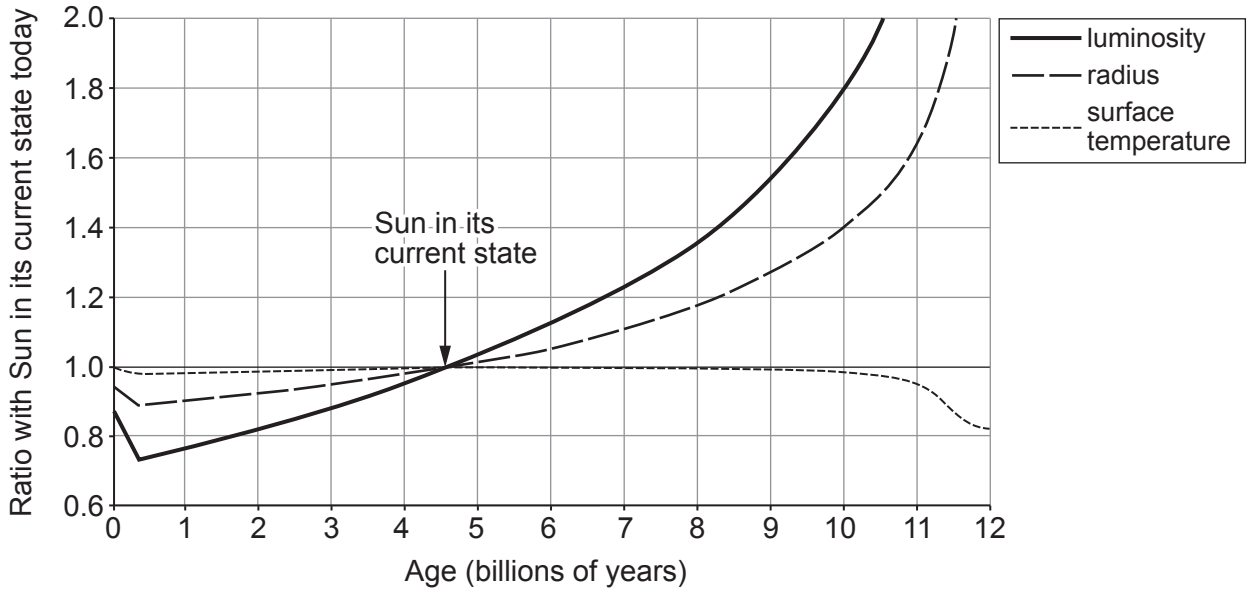
(b) The graph shows how the Sun's power output (luminosity), P, radius, R, and surface temperature, T, change over many billions of years when compared to the Sun in its current state. See below the graph for data about the Sun as it is today.



Data for the Sun in its current state:
Luminosity, $P = 3.9 \times 10^{26}$ W
Radius, $R = 7.0 \times 10^{8}$ m
Surface temperature, $T = 5800$ K

(i) Determine the luminosity of the Sun at 10 billion years of age. [1]

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(ii) Calculate the surface area of the Sun at 10 billion years of age. [2]

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(iii) The graph indicates that the surface temperature at 10 billion years of age will only be slightly less than its current value. Using a suitable calculation, show that the decrease will be approximately 100 K. [3]

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(c) The answer to (b)(iii) indicates that there will be little change to the colour of the Sun until it is about 10 billion years old. An astronomer makes the following comment:

"Between 11 and 12 billion years of age the colour of the Sun will change dramatically."

Justify this comment. [3]

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END OF PAPER

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