Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

2420U10-1

S23-2420U10-1

THURSDAY, 18 MAY 2023 – AFTERNOON

PHYSICS – AS unit 1
Motion, Energy and Matter

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**11**	
3.	**15**	
4.	**6**	
5.	**11**	
6.	**11**	
7.	**10**	
8.	**9**	
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 **4**.

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Answer **all** questions.

1. (a) Define the spring constant, k. [1]

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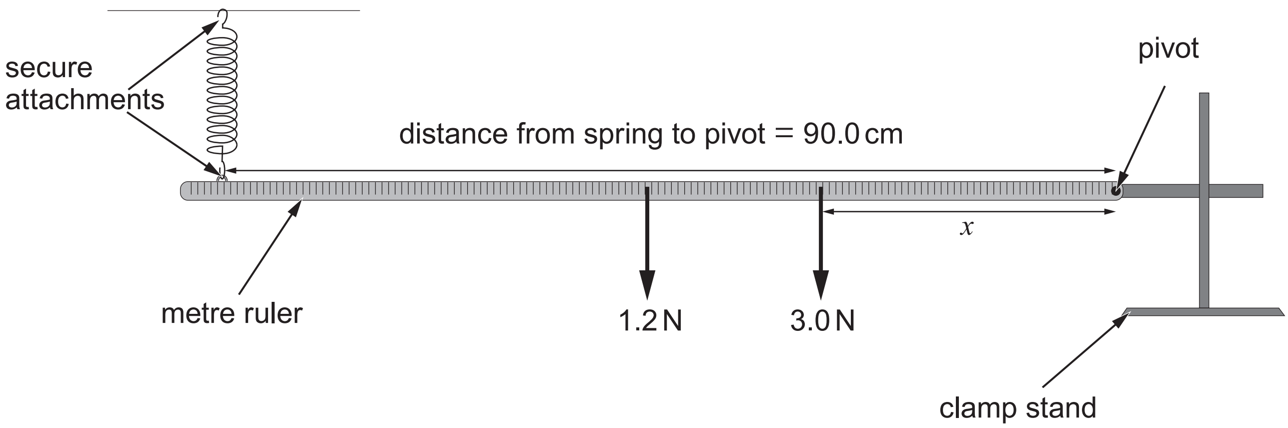
(b) The following apparatus is set up to investigate moments. A horizontal uniform metre ruler weighing 1.2 N is freely pivoted at one end. The ruler is suspended by a spring of spring constant, $k = 20\,\text{N}\,\text{m}^{-1}$, at a point 90.0 cm from the pivot, and a load of 3.0 N is suspended at a distance, x, from the pivot.



Use the following information to calculate x.

Original (unstretched) length of spring = 10.0 cm
Stretched length of spring when the ruler is horizontal = 17.0 cm [4]

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(c) Two springs of the same type used in part (b) are now connected in series as shown.

Laura believes that connecting the springs in this way will result in the overall spring constant being 10 N m^{-1}. Aled believes that the overall spring constant will be 40 N m^{-1}. Explaining your answer determine who, if either, is correct. [2]

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2. Tomos and Jerry wish to determine the material from which a ball bearing is made. They both decide to determine the density of the metal of the ball bearing. However, they choose different methods.

Tomos' method:

Tomos uses digital callipers to measure the diameter of the ball bearing. He then uses a digital balance to determine the mass of the ball bearing. He obtains the following values:

Diameter of ball bearing = $18.76 \pm 0.02\,\text{mm}$
Mass of ball bearing = $26.3 \pm 0.5\,\text{g}$

Jerry's method:

Jerry measures the volume directly by submerging the ball bearing in water in a measuring cylinder. He also uses the same digital balance to determine the mass of the ball bearing and obtains the following values:

Volume of ball bearing = $3.4 \pm 0.1\,\text{cm}^3$
Mass of ball bearing = $26.3 \pm 0.5\,\text{g}$

(a) **Using Tomos' values:**

(i) Calculate the volume of the ball bearing in **cm^3** and show that its **percentage** uncertainty is approximately 0.3 %. [3]

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(ii) Hence calculate the density of the ball bearing along with its **absolute** uncertainty, giving your answer to an appropriate number of significant figures. [4]

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(b) Jerry believes that, since he is measuring the volume directly, the absolute uncertainty in his value of density will be less than that found by Tomos. Determine whether or not he is correct. [2]

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(c) The table gives the density of some common metals and alloys.

Metal	Density / $g\,cm^{-3}$
tin	7.3
stainless steel	7.5
iron	7.9
brass	8.3

Tomos and Jerry use this information to determine the metal from which the ball bearing is made. Explain how Tomos' conclusion differs from Jerry's. [2]

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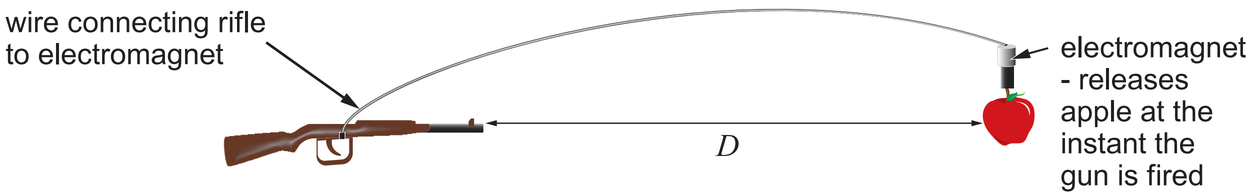
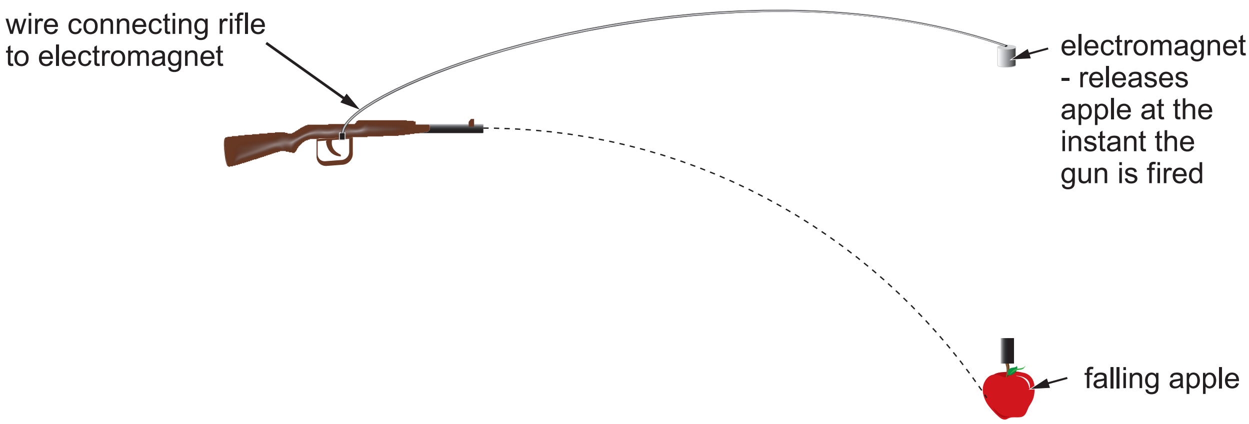
3. (a) The following demonstration is sometimes used to explain projectile motion. In the version shown, a toy rifle is situated a horizontal distance, D, from an apple suspended at a large height above the ground.

Initial set-up



Initially, the rifle is aimed horizontally at the apple. **At the instant** the gun is fired an electromagnet releases the apple so that it falls vertically. The path of the pellet from the gun is shown below.



(i) Describe and explain the motion of the pellet from the instant the gun is fired. [Ignore the effects of air resistance.] [2]

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(ii) The distance D is now increased and the experiment repeated. Describe one difference **and** one similarity that an observer viewing the apple would see in this case. [2]

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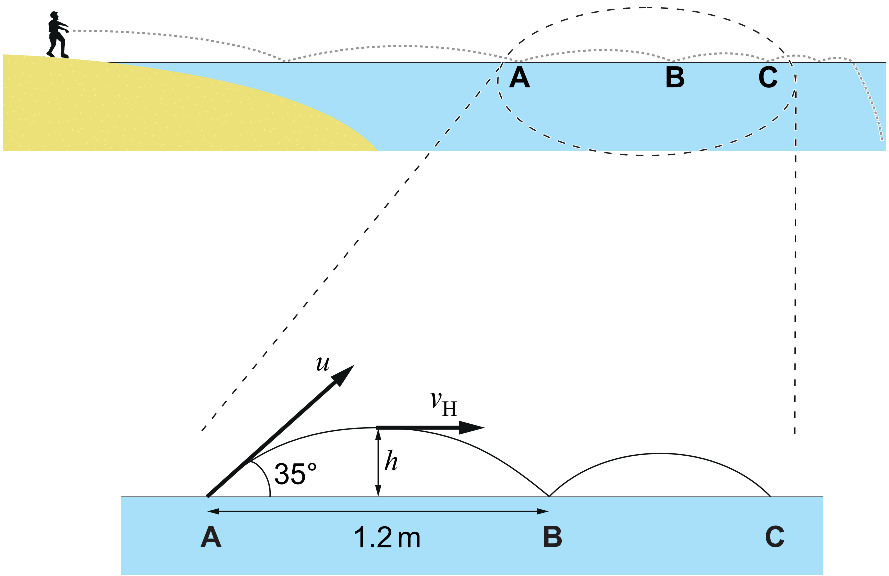
(b) The diagram shows a person 'skimming' a stone across the surface of a still pond. A magnified view of part of the stone's motion is also shown. [Ignore the effects of air resistance.]



(i) Calculate v_H, the horizontal component of the velocity, u, given that the time taken for the stone to move from **A** to **B** is 0.40 s. [1]

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(ii) Calculate h, the maximum height achieved by the stone between **A** and **B**. [4]

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(iii) Calculate the **total** energy of the stone at height, h, given that it has a mass of 0.10 kg. [3]

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(c) The thrower believes that the stone loses 20 % of its energy every time it impacts with the water. Investigate whether or not this is true **for the impact at B**, given the fact that the stone's velocity just before impacting the water **at C** is $3.3\,m\,s^{-1}$. [3]

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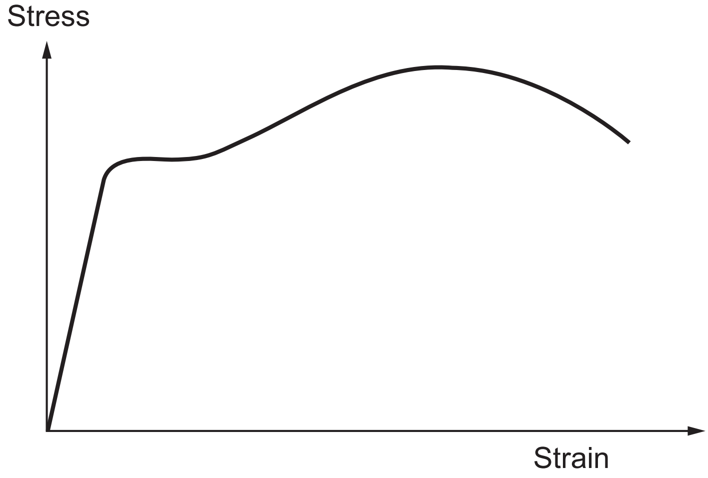
4. A stress against strain graph for a ductile metal is shown.



Identify and describe the key features **shown by this graph**. Reference to atoms, ions or molecules is **not required**. [6 QER]

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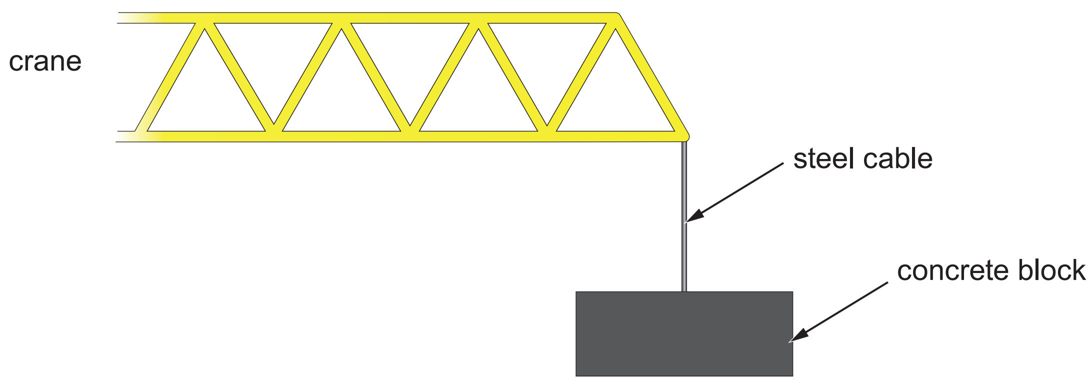
5. (a) Newton's second law of motion is sometimes expressed as $\sum F = ma$.
Explain the term $\sum F$, giving an example to illustrate your answer. [2]

(b) A crane uses a steel cable to lift heavy objects on a building site. The crane operator is told that the maximum safe lifting force of the crane is 16 000 N.



(i) A concrete block of mass 1 500 kg is attached to the crane. Calculate the maximum safe upward acceleration of the block. [3]

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(ii) The crane operator assumes that the crane is safe to lift any load up to 16 000 N. Discuss whether or not he is correct. [2]

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(c) The steel cable has a cross-sectional area of $2.0 \times 10^{-3}\,m^2$ and a Young modulus of $2.0 \times 10^{11}\,N\,m^{-2}$. As the concrete block moves **upwards** the tension in the cable changes depending on whether the block is accelerating, decelerating or moving at constant speed. At one point in its motion the strain in the cable is 3.2×10^{-5}. Describe the motion of the block at this point. Explain your answer. [4]

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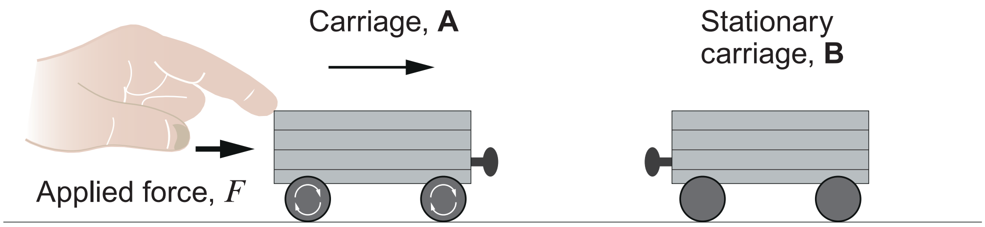
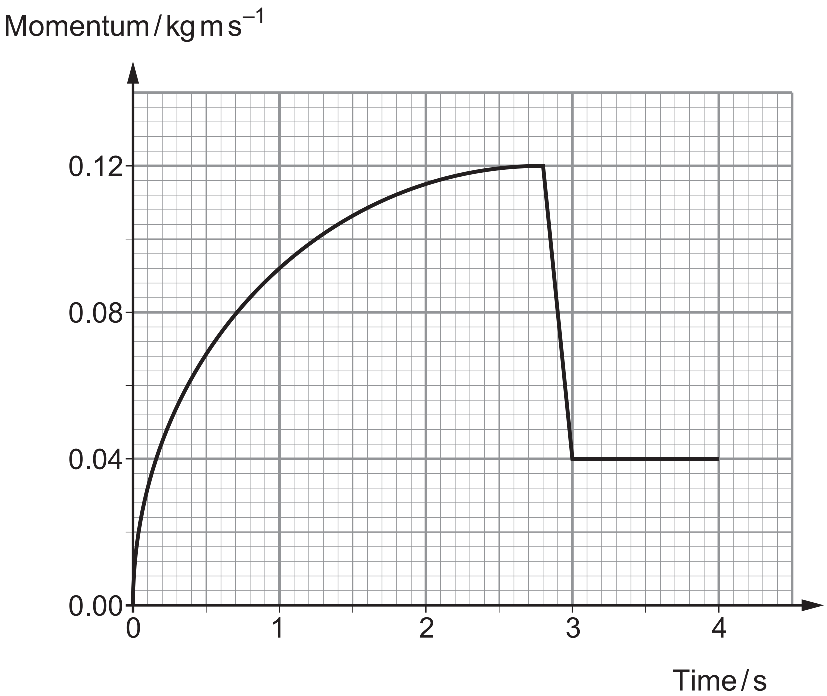
6. A toy train carriage, **A**, is accelerated from rest by an applied force in a straight line on a smooth track towards a stationary carriage, **B**. A graph of momentum against time for carriage **A** is shown below.





(a) Estimate, from the graph, the resultant accelerating **force** acting on carriage A at a time of 1.0 s. [3]

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(b) Impact between carriage A and carriage B occurs between 2.8 s and 3.0 s. Just before impact the applied force is removed. State how the graph confirms that the applied force is removed, and explain why its removal enables you to calculate the momentum given to carriage B. [3]

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(c) (i) **Draw, on the graph opposite**, a line showing the momentum of **carriage B** between 0 s and 4 s. [3]

(ii) Hence calculate the speed of **carriage B** after impact given that its mass is 0.16 kg. [2]

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7. (a) In the table below, statements are given which describe different particles or interactions.
Complete the table by naming the particle or interaction described. [4]

Description of particle or type of interaction	Name of particle or interaction
The quark combination of this particle is u u d.	....
The electron and electron neutrino are examples of this group of particles.	....
Antibaryons are a combination of three of these.	....
Neutrino involvement and quark flavour changes are exclusive to this type of interaction.	....

(b) An antiparticle has a quark composition of $\bar{u}\,\bar{d}\,\bar{d}$. Determine its charge and identify the particle. Show your working clearly. [2]

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(c) (i) Consider the following hypothetical interaction.

$$p + n \longrightarrow p + \bar{p} + p + \nu_e$$

The reaction is **not possible** because it does not obey one or more of the conservation laws. By considering baryon number, lepton number and charge, show which law(s) are obeyed and which are not. [3]

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(ii) Jon suggests that replacing the electron neutrino (ν_e) with a pi-zero pion (π^0) would allow the reaction to occur. Explain whether or not he is correct. [1]

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8. (a) The solar spectrum includes an absorption spectrum. Describe the appearance of this spectrum **and** state where in the Sun the absorption occurs. [2]

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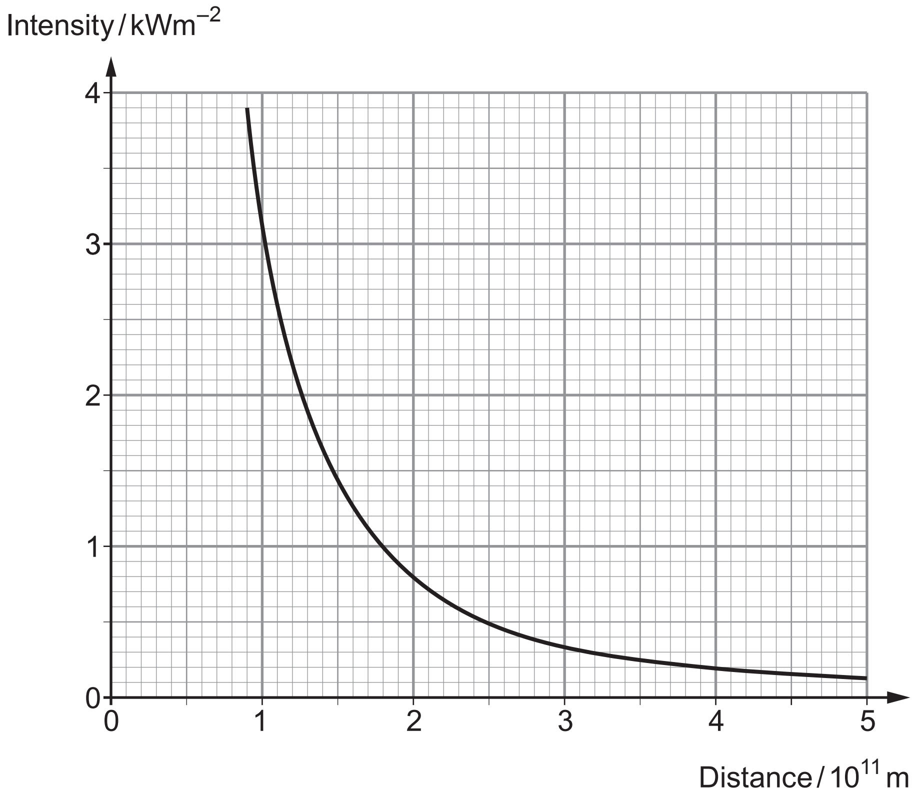
(b) The graph shows how, outside the Sun, the intensity of electromagnetic radiation from the Sun varies with the distance from its centre.



Use information from the graph to determine the total power emitted by the Sun. [3]

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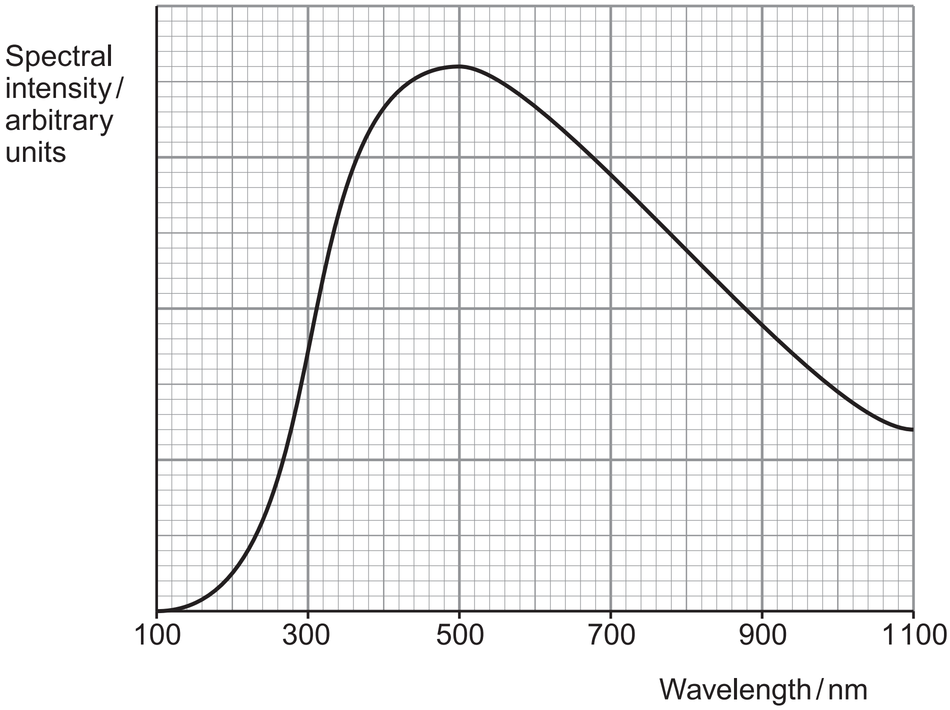
(c) The diagram below shows how the intensity of the radiation incident on the Earth from the Sun is distributed across the spectrum.



Determine whether or not the answer you obtained in part (b) and information which can be obtained from the above spectrum are consistent with each other.
[Surface area of the Sun = $6.2 \times 10^{18}\,m^2$] [4]

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END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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