Surname	Centre Number	Candidate Number
Other Names		2

AS/A LEVEL

2420U10-1

S19-2420U10-1

PHYSICS – AS unit 1
Motion, Energy and Matter

TUESDAY, 14 MAY 2019 – MORNING

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**8**	
2.	**10**	
3.	**10**	
4.	**9**	
5.	**19**	
6.	**10**	
7.	**14**	
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 pencil or gel pen. Do not use correction fluid.
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 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*(b)***.

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Answer **all** *questions.*

1. *(a)* Mesons, leptons and quarks are three groups of particles. State which of these groups are affected by:

(i) the weak nuclear force; [1]

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(ii) the strong nuclear force. [1]

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(b) The following interaction shows a β^- decay for a beryllium nucleus.

$$^{10}_{4}\text{Be} \longrightarrow {}^{10}_{5}\text{B} + e^- + \overline{\nu}_e$$

(i) State the name of the $\overline{\nu}_e$ particle. [1]

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(ii) Explain how lepton number and charge are conserved in this interaction. [2]

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(c) (i) Write down the number of neutrons in:

I. $^{10}_{4}\text{Be}$ .... II. $^{10}_{5}\text{B}$ .... [1]

(ii) On the level of baryons the interaction can be written as:

$$n \longrightarrow p + e^- + \overline{\nu}_e$$

Show clearly that there is a change in quark flavour in this interaction. [2]

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2. *(a)* State the difference between a vector and a scalar and give one example of each. [2]

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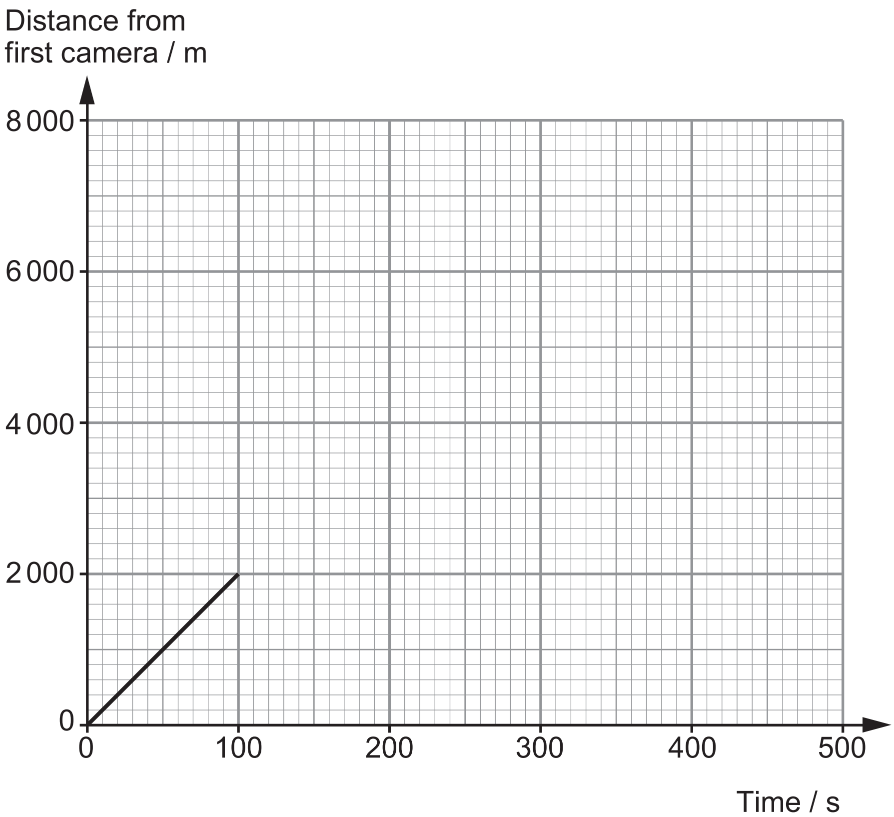
(b) Average (or mean) speed areas are now found on many motorways. A section of motorway has a mean speed of 60 km h^{-1}. The mean speed is monitored between two cameras placed 8 km apart. The graph shows the first 100 seconds of the motion of a car as it travels between the two cameras.



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(i) Show that the instantaneous speed of the car at t = 50 s is approximately 70 km h^{-1}. [2]

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(ii) The car covers the 8 km between the two cameras at a mean speed of exactly 60 km h^{-1}. Complete the graph to show this motion. [3]
Space is provided below for your calculations.

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(c) On another stretch of motorway, the speed limit is equivalent to 30 m s^{-1}. The maximum deceleration a normal car can achieve in dry conditions is assumed to be 8 m s^{-2}. Traffic police can estimate the speed of vehicles involved in accidents using the length of the marks made by skidding tyres on the road. In one accident, the skid marks were found to be 85 m long. Investigate whether or not the car that created the skid marks was travelling below the speed limit prior to the accident. [3]

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3. *(a)* State the principle of conservation of momentum. [2]

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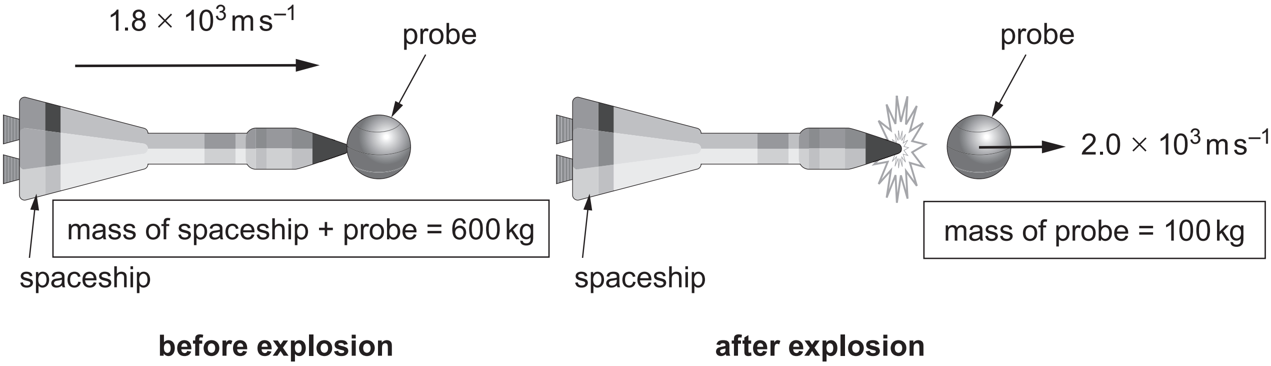
(b) A space probe is attached to a large spaceship as shown. The probe can be ejected from the space ship by an explosion. The spaceship and probe together have a mass of 600 kg and they travel in a straight line through deep space at $1.8 \times 10^3\,\mathrm{m\,s^{-1}}$. Explosives are detonated, separating the probe from the spaceship. Immediately after the explosion the probe, of mass 100 kg, continues in the original straight line at $2.0 \times 10^3\,\mathrm{m\,s^{-1}}$.



(i) Calculate the velocity of the spaceship immediately after the explosion. [2]

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(ii) Show that the kinetic energy possessed by the probe and spaceship after separation is **greater** than the kinetic energy they possessed before separation. [3]

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(iii) Account for this increase in kinetic energy. [1]

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(c) During the explosion, a mean force, F, acts on the probe for 2.0 ms. Calculate the value of F. [2]

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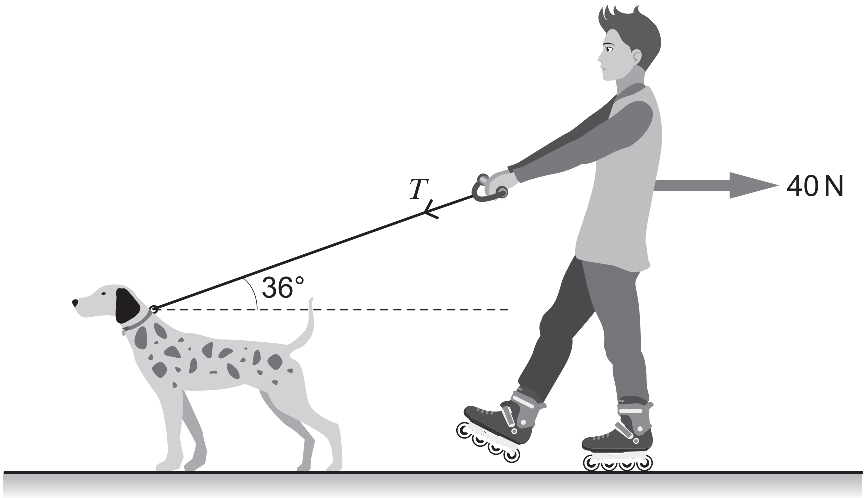
4. *(a)* The diagram shows a roller-skater being pulled along a horizontal road at **constant velocity**. The total resistive force to the skater's motion is 40 N.



Show that the tension, T, in the dog lead is approximately 50 N. [2]

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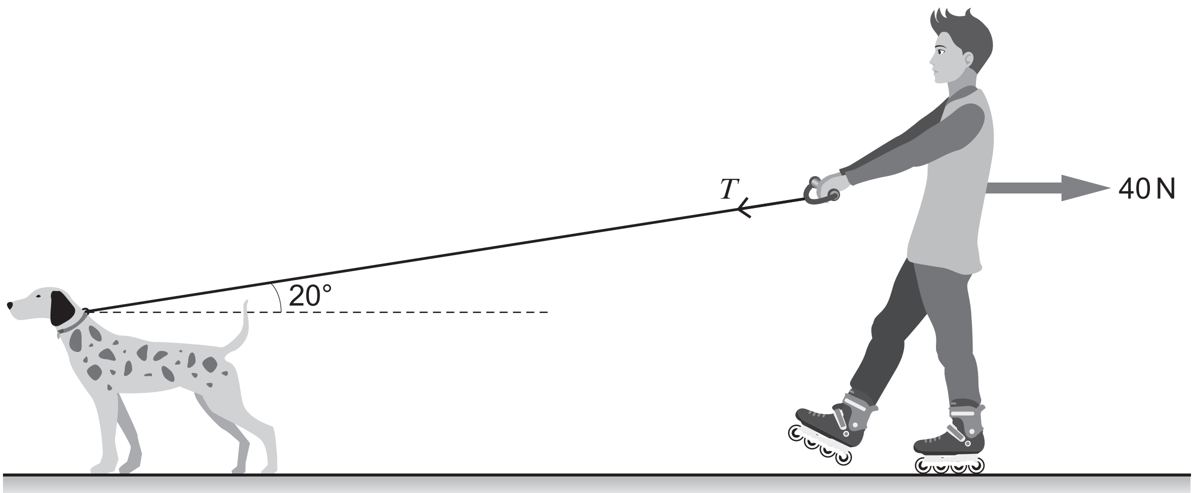
(b) Later, the roller-skater, moving at the same velocity as in part *(a)*, extends the dog lead as shown in the diagram below.



(i) Assuming that the tension, T, is the same as in part *(a)*, explain why the roller-skater initially accelerates. [1]

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(ii) Calculate this initial acceleration, given that the mass of the roller-skater is 35 kg. [3]

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(c) The roller-skater believes that the dog's rate of doing work is the same, regardless of the length of the dog lead. Use information from *(a)* and *(b)* to investigate whether or not this claim is correct. [3]

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5. Sam carries out an experiment to determine the mass of a metal block using the principle of moments.

(a) State the principle of moments. [2]

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(b) The metal block is in the form of a cuboid as shown in **Diagram 1**. When setting up the experiment Sam accidentally knocks the metal block so that it tilts to the position shown in **Diagram 2**. The block then returns to the upright position as in **Diagram 1**.

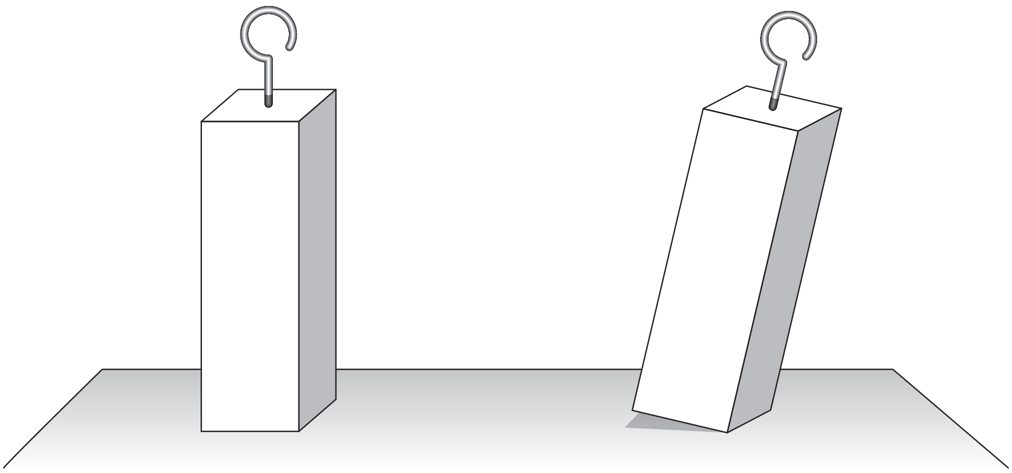

Diagram 1 **Diagram 2**

Explain, in terms of centre of gravity, why the block returns to the upright position. [2]

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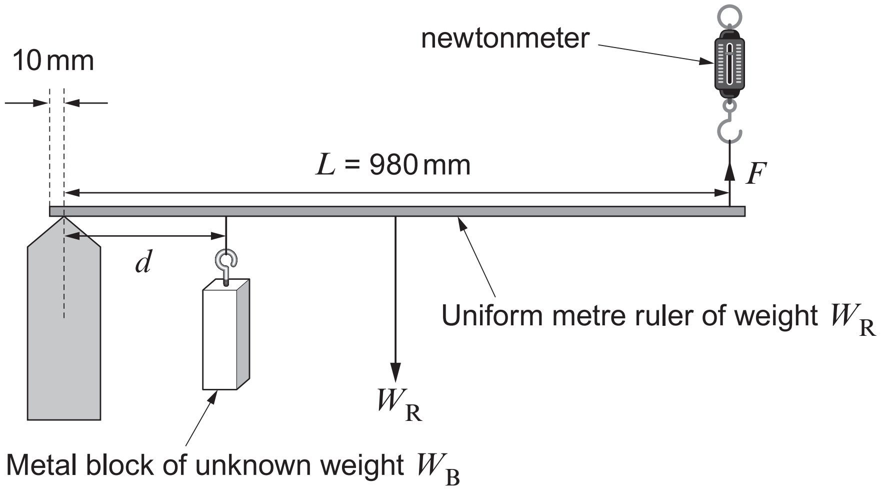
(c) Sam sets up the experiment as shown using a metre ruler.



Sam uses the newtonmeter to measure the force, F, needed to make the metre ruler horizontal for varying values of d. He carries out the experiment twice and determines a mean value for F for each of the distances d. Sam judges that the ruler is horizontal by eye before taking readings for F. The measurements are recorded in the table below.

Distance, d / mm	Force, F / N		
	Trial 1	Trial 2	Mean
100	2.8	2.6	
250	5.2	5.7	
400	8.8	8.5	
550	11.2	11.6	
700	14.6	14.5	
850	17.2	17.6	

(i) Complete the table. [1]

(ii) The following relationship is used to find the weight, W_B, of the block:

$$F = \frac{W_B d}{L} + \frac{W_R}{2}$$

By taking moments about the pivot, show how this relationship is obtained. [2]

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(iii) Use the grid to plot a graph of mean F (vertical axis) against d (in mm, on the horizontal axis) and draw a line of best fit. **Error bars should not be included.** [4]

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(iv) Use your graph to determine:

I. W_B, the weight of the metal block; [2]

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II. W_R, the weight of the ruler. [2]

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(d) The distances, d, were measured to a resolution of ±1 mm. Use data from the table of results to show that the percentage uncertainty in mean F is greater than the percentage uncertainty in d, when d = **100 mm**. [3]

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(e) Suggest **one** change to his method which would improve the quality of Sam's measurements. [1]

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6. *(a)* Materials can be classified as *crystalline*, *amorphous* or *polymeric*. Explain the meaning of **two** of the terms in italics in terms of microscopic structure. Give **one** example of each of your chosen materials. [4]

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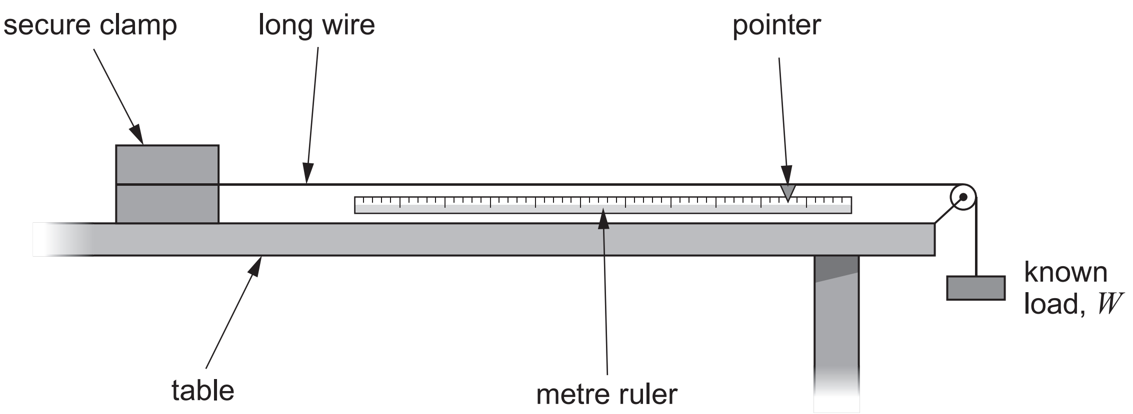
(b) The diagram shows apparatus that can be used to determine the Young modulus of a metal in the form of a wire. Describe the measurements which must be made, how they should be used to determine the Young modulus **and** precautions to minimise uncertainties. [6 QER]



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7. *(a)* Describe the main features of the spectrum of a star and state where in the star they arise. [2]

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(b) The table gives some information about two stars.

Star	Luminosity / W	Distance from Earth / m
Sirius	9.7×10^{27}	8.1×10^{16}
Vega	1.5×10^{28}	2.4×10^{17}

(i) Determine the ratio:

$$\frac{\text{Intensity of radiation reaching Earth from Sirius}}{\text{Intensity of radiation reaching Earth from Vega}}$$ [3]

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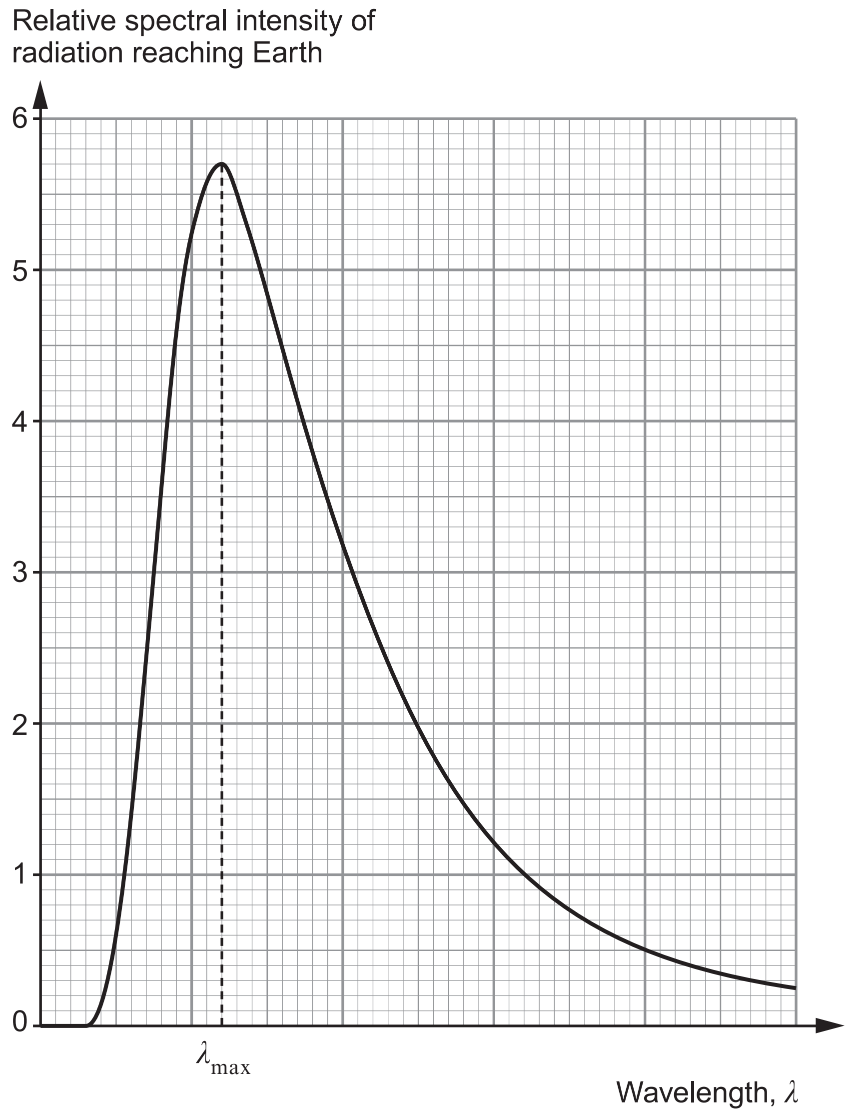
(ii) The two stars have similar surface temperatures. Below is a black body radiation curve for Sirius. Using your answer to *(b)*(i), sketch the expected black body curve for Vega on the same axes. [2]



(iii) Determine λ_{max}, given that the surface area of Sirius is $1.8 \times 10^{19}\,m^2$. [4]

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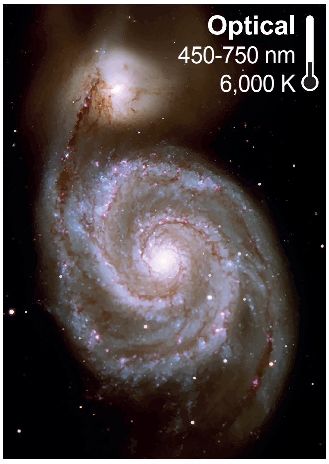
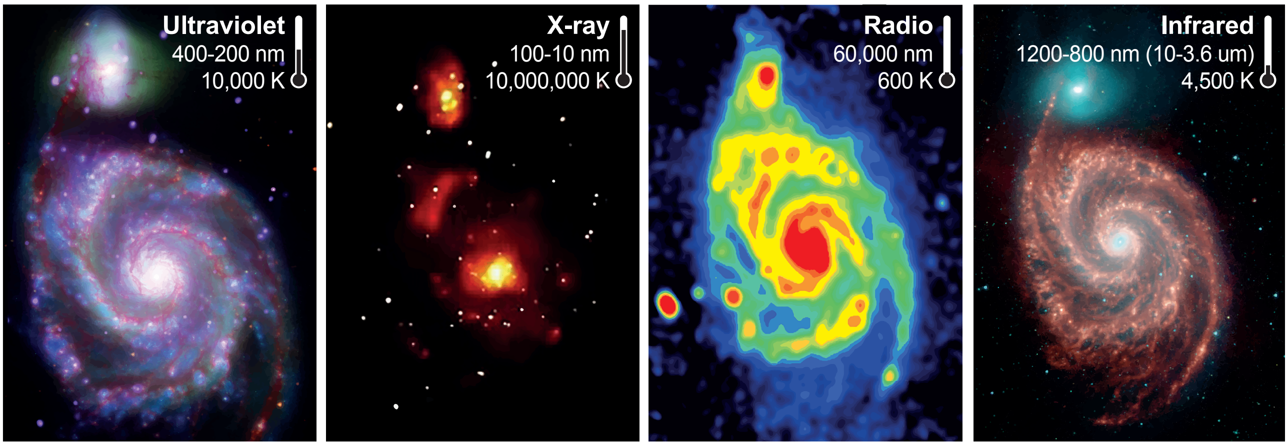
(c) The image below is of the whirlpool galaxy, M51 (or NGC 5194). This is one of the first galaxies to be photographed by astronomers.



Subsequent images of the **same galaxy** are shown below.



Describe how these developments in observational astronomy have advanced the study of the whirlpool galaxy. [3]

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END OF PAPER

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

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