Circle your teacher:

Surname	Mr Webber	Mr Kampas
First name(s)	Ms Holvey	

Your group:

S24-2420U10-1

GCE AS/A LEVEL

2420U10-1

THURSDAY, 10 April 2025 – MORNING

PHYSICS – AS unit 1
Motion, Energy and Matter

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**10**	
2.	**10**	
3.	**10**	
4.	**13**	
5.	**13**	
6.	**12**	
7.	**12**	
Total	**80**	

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01

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) State the principle of conservation of momentum. [2]

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(b) Natalie attempts to retrieve a hat of mass 0.40 kg which is resting on the surface of a frozen pond. To do this, she throws a snowball, of mass 0.20 kg, at a horizontal velocity of 9.0 m s^{-1} towards the hat. It hits the hat and rebounds at 2.0 m s^{-1}.

(i) Calculate the magnitude of the velocity of the hat after the collision. [3]

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(ii) The snowball is in contact with the hat for 0.14 s. Calculate the mean force experienced by the hat in this time. [2]

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(c) Natalie believes that, if the snowball stuck to the hat, the velocity of the hat would be greater than the velocity calculated in (b)(i). **Without further calculation**, discuss whether or not Natalie is correct. [3]

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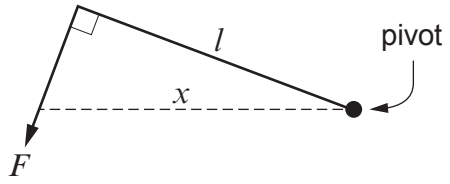
2. (a) The following question has been set in a previous Physics exam:

Explain what is meant by the moment of a force about a pivot.

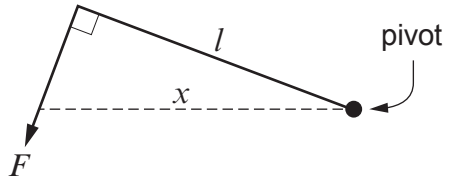
Five of the responses given are shown below (**A** to **E**). **Only three of the responses are correct**. Place a tick (✓) in the boxes next to the correct responses. [2]

A.



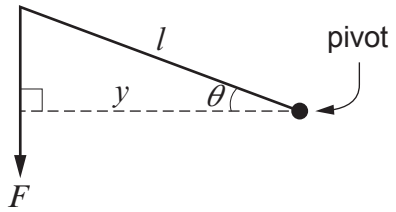
moment = Fl ☐

B.



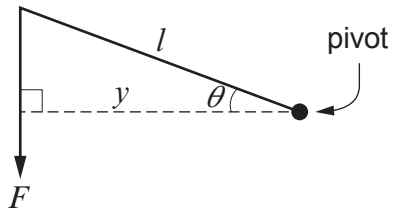
moment = Fx ☐

C.



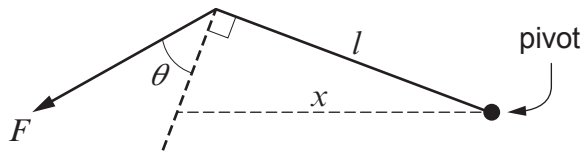
moment = $Fl\cos\theta$ ☐

D.



moment = Fl ☐

E.



moment = $F\cos\theta\, l$ ☐

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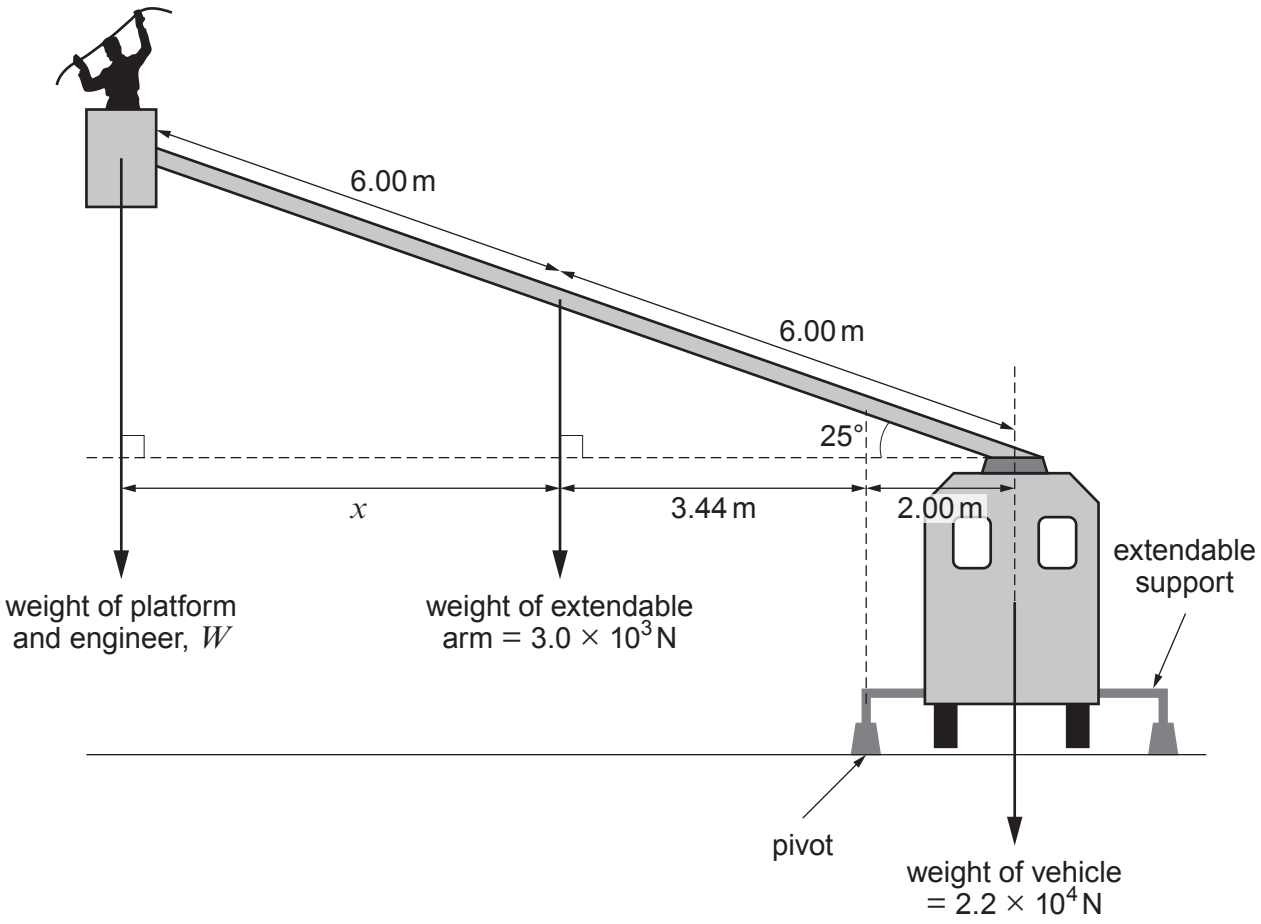
(b) Telephone engineers sometimes use an extendable arm to repair telephone lines. The arm is able to extend from the top of a specially modified vehicle. When the arm is in use extendable supports are used as shown. The pivot point is also shown.



(i) Show that the distance, x, in the diagram is approximately 5.4 m. [1]

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(ii) Determine the maximum possible weight of the platform and engineer, W, in the situation shown in the diagram, so that the system does not topple. [3]

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(iii) A sign placed on the platform gives the following warning:

Maximum 2 persons or 200 kg

Consider whether or not this is a reasonable warning to give. Assume the arm is at its maximum extension in the diagram and the angle shown (25°) is the lowest possible. The weight of the platform is 1700 N. [4]

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Turn over.

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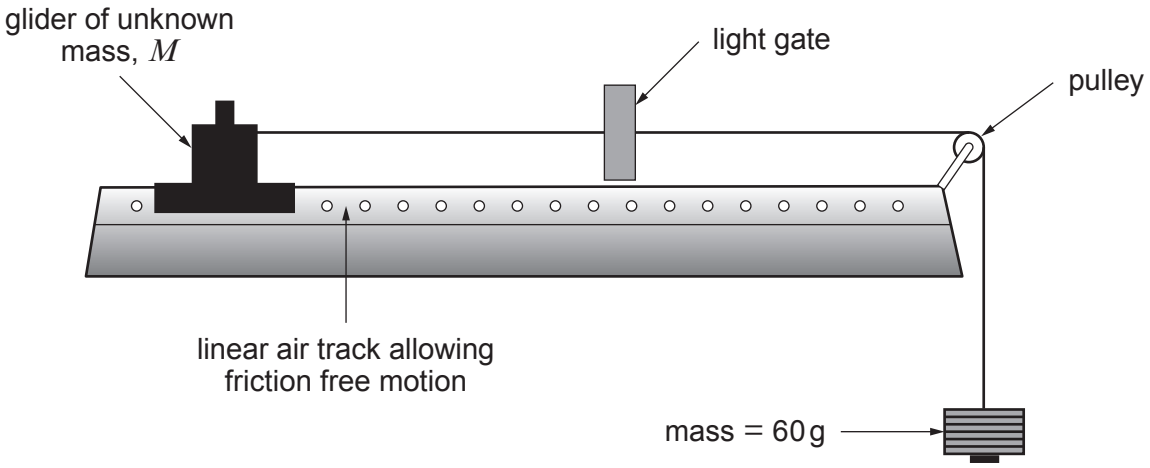
3. Emma uses the following apparatus to determine the unknown mass, M, of a glider.



Emma takes three readings of acceleration using a mass of 60 g. She does this by attempting to hold the glider and releasing it from rest. The following values for acceleration are determined.

Trial	1	2	3
Acceleration / m s^{-2}	0.76	0.71	0.79

(a) (i) Calculate the mean acceleration along with the **absolute** uncertainty in its value. [2]

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(ii) Calculate the **percentage** uncertainty in the acceleration. [1]

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(b) The 60 g mass consists of 6 slotted masses, each of 10.0 g $\pm$ 0.1 g.

(i) Determine the **percentage** uncertainty in the 60 g mass. [1]

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(ii) Hence determine the unknown mass, M, of the glider along with the **absolute** uncertainty in its value. Give both values to an appropriate number of significant figures. [5]

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(c) Suggest how Emma could reduce the uncertainty in her value for M. [1]

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Turn over.

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4. (a) A lithium **atom** is denoted by $^{7}_{3}\mathrm{Li}$.

Complete the table for the lithium atom. One cell has already been completed for you. [3]

Particles	Number in $^{7}_{3}\mathrm{Li}$ atom
electrons	3
protons	
neutrons	
leptons	
baryons	
up quarks	
down quarks	

(b) (i) State what a meson is, in terms of quarks. [1]

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(ii) Explain why the quark make-up of a π^0 meson must be either $u\bar{u}$ or $d\bar{d}$. [1]

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(iii) The Δ^0 particle is a baryon which has a charge equal to that of a neutron. The following series shows the production **and** decay reactions of the Δ^0 particle. The reactions are also partially shown as a flow of quarks.

π^0 + n $\longrightarrow$ Δ^0 $\longrightarrow$ π^- + p

$\bar{u}u$ + ... $\longrightarrow$ ..... $\longrightarrow$ ..... + ...

Complete the reactions in terms of quarks. The π^0 has been done for you. [4]

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(iv) Explain clearly how the up quark number is conserved in both reactions.
[Consider both reactions separately.] [2]

Production of Δ^0 : .....

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Decay of Δ^0 : .....

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(c) Textbooks state that the mean lifetime of the Δ^0 particle is $(5.63 \pm 0.14) \times 10^{-24}$ s.
State **two** features of the decay which suggest that it is a **strong** interaction. [2]

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5. Mean speed is defined by the equation:

$$\text{mean speed} = \frac{\text{total distance}}{\text{total time}}$$

(a) State the definition of mean **velocity**. [1]

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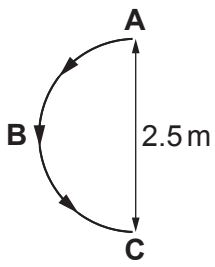
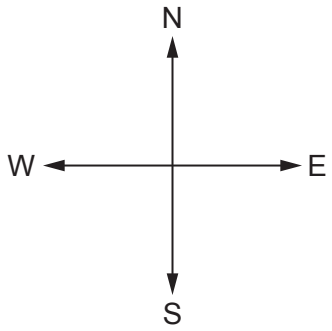
(b) Ieuan and Seren play with their toy train. A train takes 4.0 s to travel at constant speed in a semicircle **ABC** as shown.





(i) Show that the train's speed is approximately $1\,m\,s^{-1}$. [1]

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(ii) Calculate the mean velocity of the train as it moves from **A** to **C**. [2]

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(iii) Ieuan believes that, since the speed between **A** and **C** is constant, the train is not accelerating. Seren disagrees. Explain who is correct, justifying your answer. [3]

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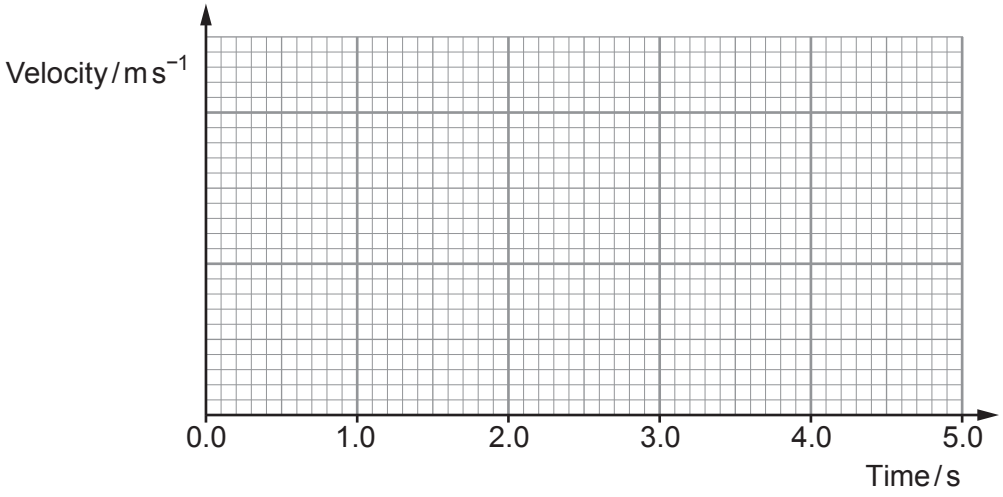
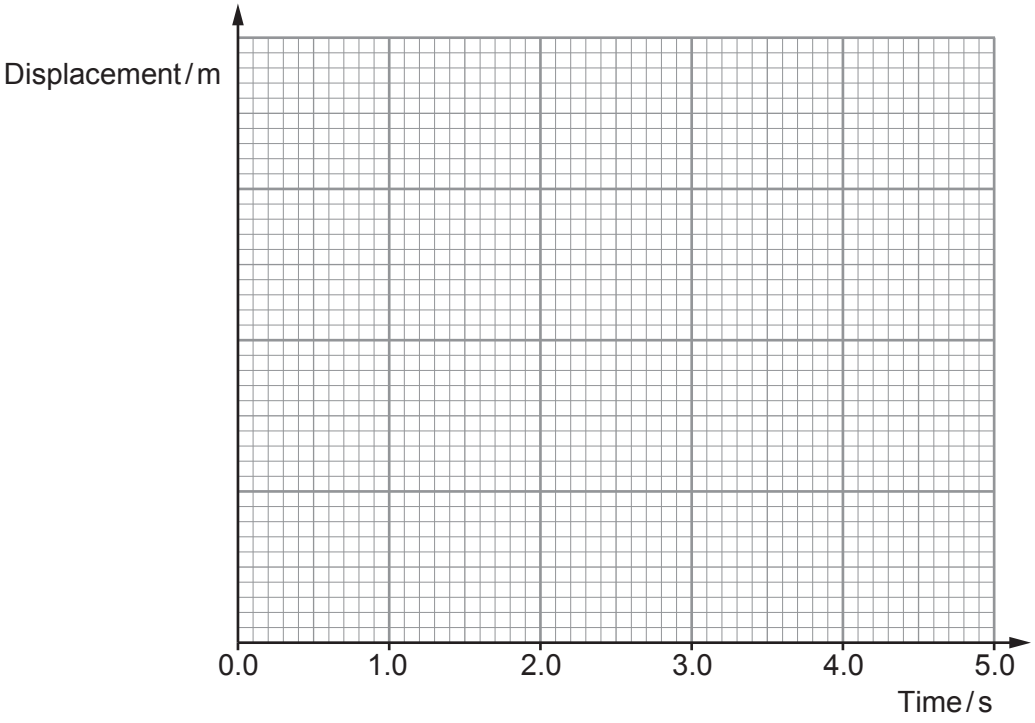
(c) **From C**, the train continues in a straight line with a speed of $1.0\,m\,s^{-1}$ for 2.0 s. It then decelerates uniformly to rest in a distance of 1.2 m. Complete the velocity-time graph and the displacement-time graph **for the motion from C** on the grids below.
Space for calculations. [6]





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6. (a) Discuss the energy changes involved in a bungee jump over one complete jump (i.e. from the initial jump height to the bottom of the jump and back up again). [6 QER]

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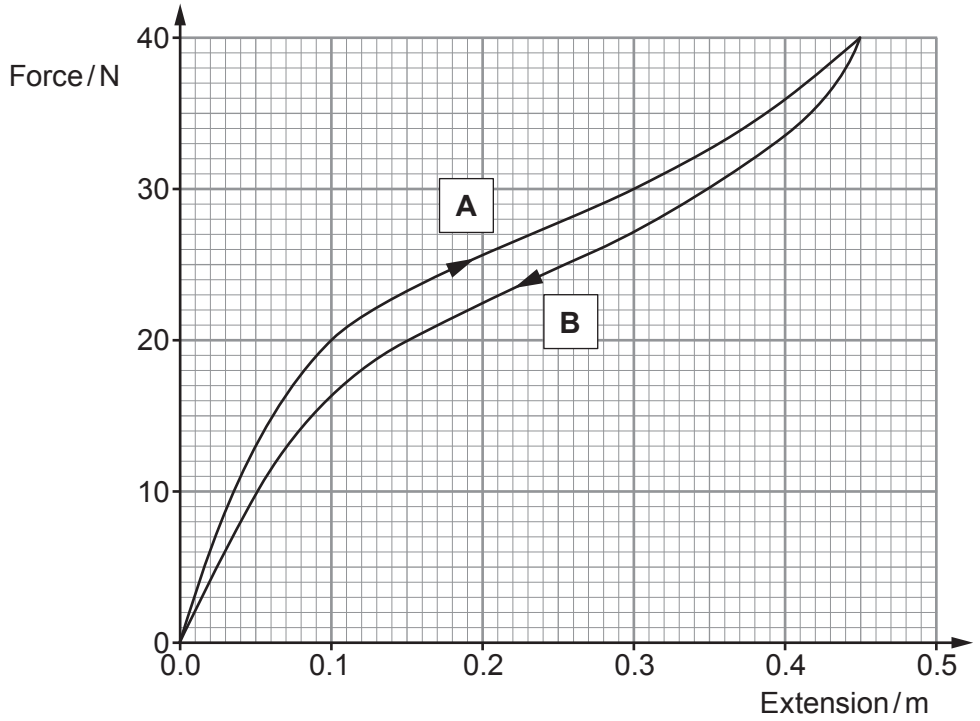
(b) Experiments are carried out on the rubber used in the bungee cord. The graph of load against extension is shown for a short piece of the cord. Curve **A** shows loading, and curve **B** shows unloading of the cord.



(i) State which feature of the graph confirms that the rubber cord is elastic. [1]

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(ii) State what happens to the molecules when the elastic band is stretched. [1]

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(iii) Showing your method, use curve **A** to estimate the work done in producing an extension of 0.3 m. [2]

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(iv) When the specimen is gradually unloaded, it is noted that the curve for unloading, **B**, is different from the curve for loading, **A**. Name this phenomenon **and** account for it in terms of energy. [2]

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7. (a) Explain what is meant by the term 'multiwavelength astronomy'. [2]

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(b) The Stefan constant, σ, has the unit $W\,m^{-2}\,K^{-4}$. Express this in terms of base SI units. [2]

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(c) The wavelength of the peak emission of the bright star Arcturus is measured to be 674 nm.

(i) Calculate the star's temperature. [2]

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(ii) The visible spectrum extends from approximately 400 nm to 700 nm. State the colour of Arcturus. [1]

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(d) A website claims that Arcturus is about 37 light years from the Sun. Use the following information and your answer to (c)(i) to justify this claim. [5]

Diameter of Arcturus = 2.78×10^{10} m
Intensity of radiation received on Earth from Arcturus = 3.09×10^{-8} W m^{-2}
1 light year = 9.46×10^{15} m

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