



GCE AS/A LEVEL

2420U10–1

THURSDAY, 16 MAY 2024 – AFTERNOON

PHYSICS – AS UNIT 1

MOTION, ENERGY AND MATTER

**1 hour 30 minutes plus your additional
time allowance**

Surname: _____

First Name(s): _____

Centre Number: _____

Candidate Number: 2 _____

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	

(Turn over)

ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a DATA BOOKLET.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

(Turn over)

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball – point pen, black felt tip or your usual method.

Write your name, centre number and candidate number in the spaces on the front cover.

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.

(Turn over)

INFORMATION FOR CANDIDATES

The total number of marks available for this task 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).

(Turn over)

Answer ALL questions.

- 1. (a) State the principle of conservation of momentum.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

- 1. (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.**

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 1 (b) continued

- 1. (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 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

- 1. (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.**

(Turn over)

[3 marks]

(Total for Question 1 = 10 marks)

- 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."

Refer to the diagram for Question 2 (a) in the separate Diagram Booklet. Five of the responses given are shown in the diagram (A to E). ONLY THREE OF THE RESPONSES ARE CORRECT.

Place a tick (✓) in the boxes next to the correct responses.

[2 marks]

(Turn over)

continued on the next page . . .

Question 2 continued

- 2. (b) Refer to the diagram for Question 2 (b) in the separate Diagram Booklet.**

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 in the diagram. The pivot point is also shown.

continued on the next page . . .

(Turn over)

Question 2 (b) continued

- 2. (b) (i) Show that the distance, x ,
in the diagram is
approximately 5.4 m.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 2 (b) continued

- 2. (b) (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.**

(Turn over)

[3 marks]

- 2. (b) (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.

continued on the next page . . . (Turn over)

Question 2 (b) (iii) continued

(Turn over)

18

[4 marks]

(Total for Question 2 = 10 marks)

(Turn over)

3. Refer to the diagram for Question 3 in the separate Diagram Booklet.

Emma uses the apparatus shown 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.

continued on the next page . . .

(Turn over)

The following values for acceleration are determined.

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

3. (a) (i) Calculate the mean acceleration along with the **ABSOLUTE** uncertainty in its value.

(Turn over)

**3. (a) (ii) Calculate the PERCENTAGE
uncertainty in the
acceleration.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 3 continued

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

**(i) Determine the PERCENTAGE
uncertainty in the 60 g mass.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 3 (b) continued

- 3. (b) (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.**

(Turn over)

[5 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (c) Suggest how Emma could reduce the uncertainty in her value for M .**

[1 mark]

(Total for Question 3 = 10 marks)

(Turn over)

4. (a) A lithium ATOM is denoted

by ${}^7_3\text{Li}$.

COMPLETE the table below for the lithium atom. One cell has already been completed for you.

Particles	Number in ${}^7_3\text{Li}$ atom
electrons	3
protons	
neutrons	
leptons	
baryons	
up quarks	
down quarks	

[3 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

- 4. (b) (i) State what a meson is,
in terms of quarks.**

[1 mark]

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

[1 mark]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

- 4. (b) (iii) The Δ^0 particle is a baryon which has a charge equal to that of a neutron.**

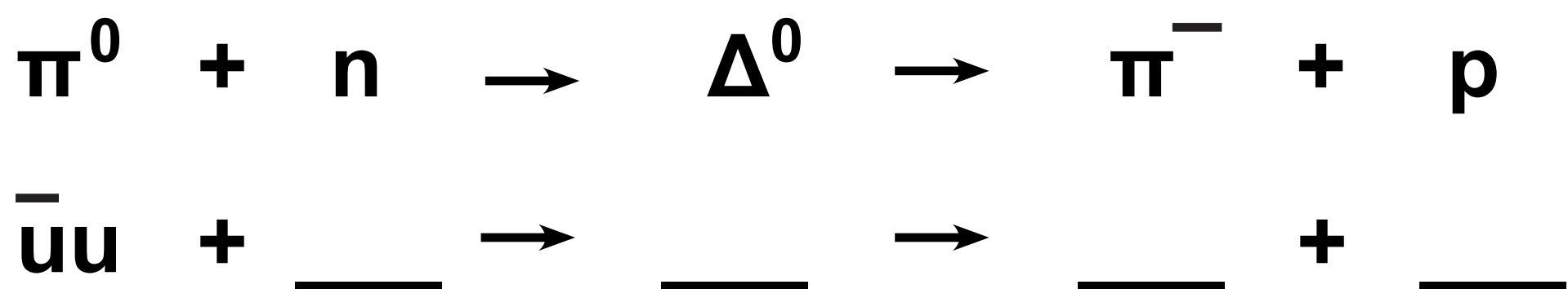
The following series shows the production and decay reactions of the Δ^0 particle.

continued on the next page . . .

(Turn over)

Question 4 (b) (iii) continued

The reactions are also partially shown as a flow of quarks.



COMPLETE the reactions in terms of quarks. The π^0 has been done for you.

[4 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

4. (b) (iv) Explain clearly how the up quark number is conserved in both reactions.

[Consider both reactions separately.]

Production of Δ^0 : _____

continued on the next page . . .

(Turn over)

Question 4 (b) (iv) continued

Decay of Δ^0 : _____

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 continued

4. (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 marks]

(Total for Question 4 = 13 marks)

(Turn over)

5. Mean speed is defined by the equation given below:

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

- (a) State the definition of mean
VELOCITY.

[1 mark]

continued on the next page . . .

(Turn over)

Question 5 continued

- 5. (b) Refer to the diagram for Question 5 (b) in the separate Diagram Booklet. 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 in the diagram.

- (i) Show that the train's speed is approximately 1 m s^{-1}**

(Turn over)

[1 mark]

5. (b) (ii) Calculate the mean velocity of the train as it moves from A to C.

[2 marks]

continued on the next page . . .

(Turn over)

Question 5 (b) continued

- 5. (b) (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.**

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

- 5. (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 provided for

Question 5 (c) in the separate Diagram Booklet.

Space for calculations continued on the next page.

(Turn over)

Question 5 (c) continued

[6 marks]

(Total for Question 5 = 13 marks)

(Turn over)

- 6. (a) Refer to the picture for Question 6 (a) in the separate Diagram Booklet. The picture shows somebody doing a bungee jump.**
- 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).**
-
-
-
-

(Turn over)

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

[6 QER marks]

continued on the next page . . .

(Turn over)

Question 6 continued

- 6. (b) Refer to the graph for Question 6 (b) in the separate Diagram Booklet. 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.**

continued on the next page . . .

(Turn over)

Question 6 (b) continued

- 6. (b) (i) State which feature of the graph confirms that the rubber cord is elastic.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 (b) continued

6. (b) (ii) State what happens to the molecules when the elastic band is stretched.

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 (b) continued

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

[2 marks]

continued on the next page . . .

(Turn over)

Question 6 (b) continued

- 6. (b) (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.**

(Turn over)

48

[2 marks]

(Total for Question 6 = 12 marks)

(Turn over)

7. (a) Explain what is meant by the term
‘multiwavelength astronomy’.

[2 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

- 7. (b) The Stefan constant, σ , has the unit $\text{W m}^{-2} \text{K}^{-4}$**

Express this in terms of base SI units.

[2 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

7. (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 marks]

continued on the next page . . . (Turn over)

Question 7 (c) continued

**7. (c) (ii) The visible spectrum extends
from approximately
400 nm to 700 nm.**

State the colour of Arcturus.

[1 mark]

continued on the next page . . .

(Turn over)

Question 7 continued

- 7. (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.**

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

(Turn over)

55

[5 marks]

(Total for Question 7 = 12 marks)

TOTAL FOR PAPER = 80 MARKS

END OF PAPER

Turn over

[illegible]

(Turn over)

[illegible]

(Turn over)

Question Number	Additional pages, if required. Write the question number(s) in the left – hand margin.



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**The Diagram Booklet MUST be handed in
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Diagram Booklet

Surname: _____

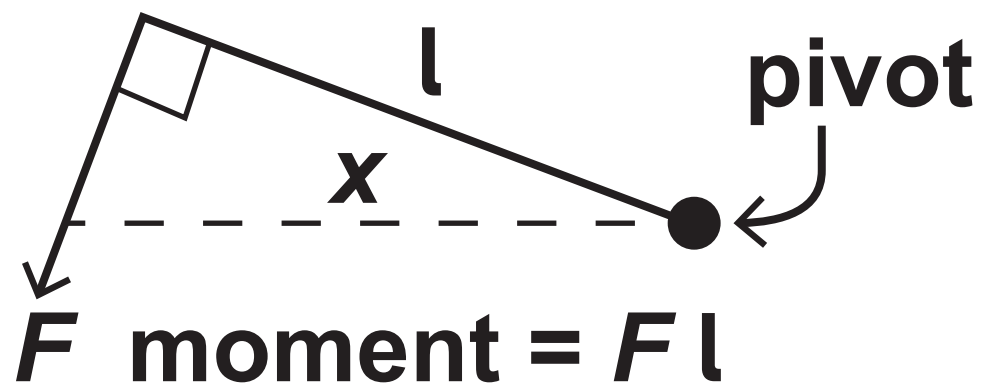
First Name(s): _____

Centre Number: _____

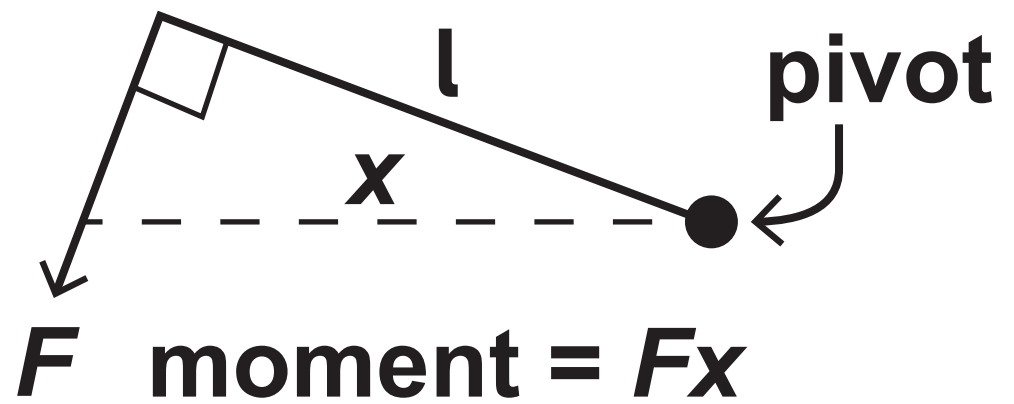
Candidate Number: 2 _____

Question 2 (a)

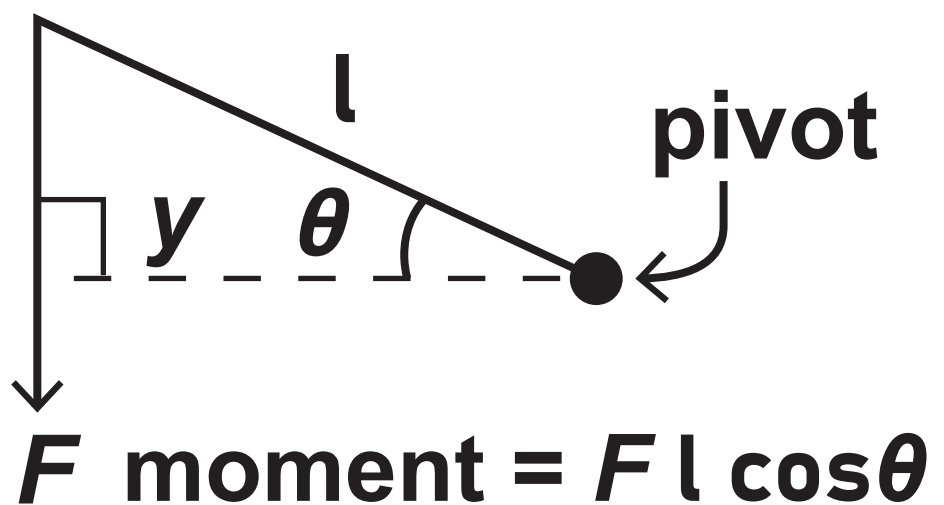
Response A

☐

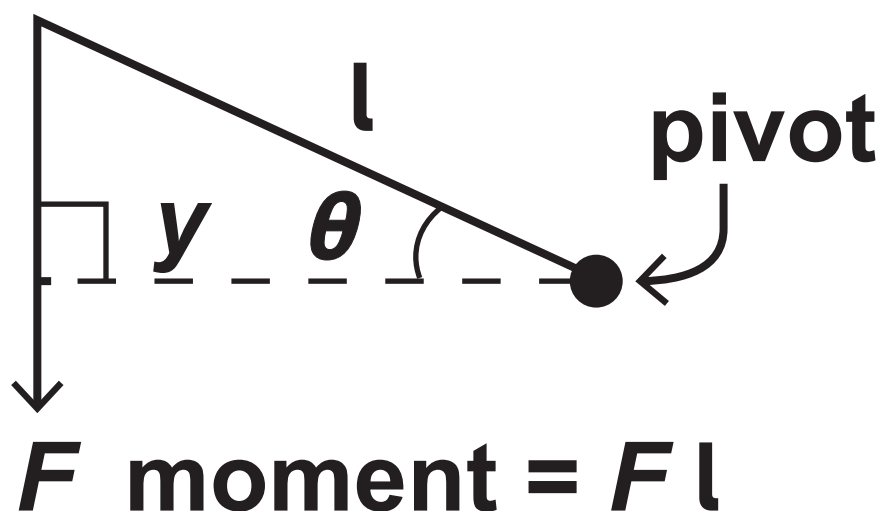
Response B

☐

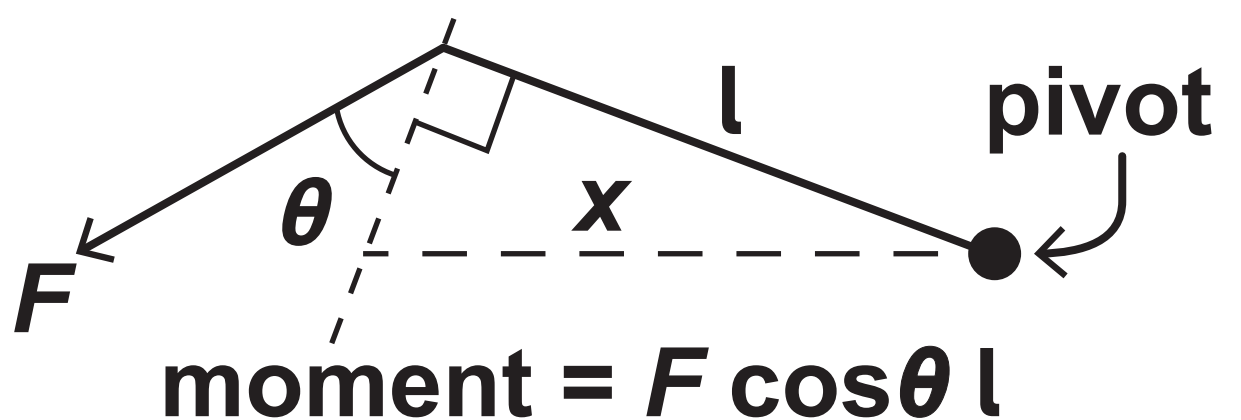
Response C

☐

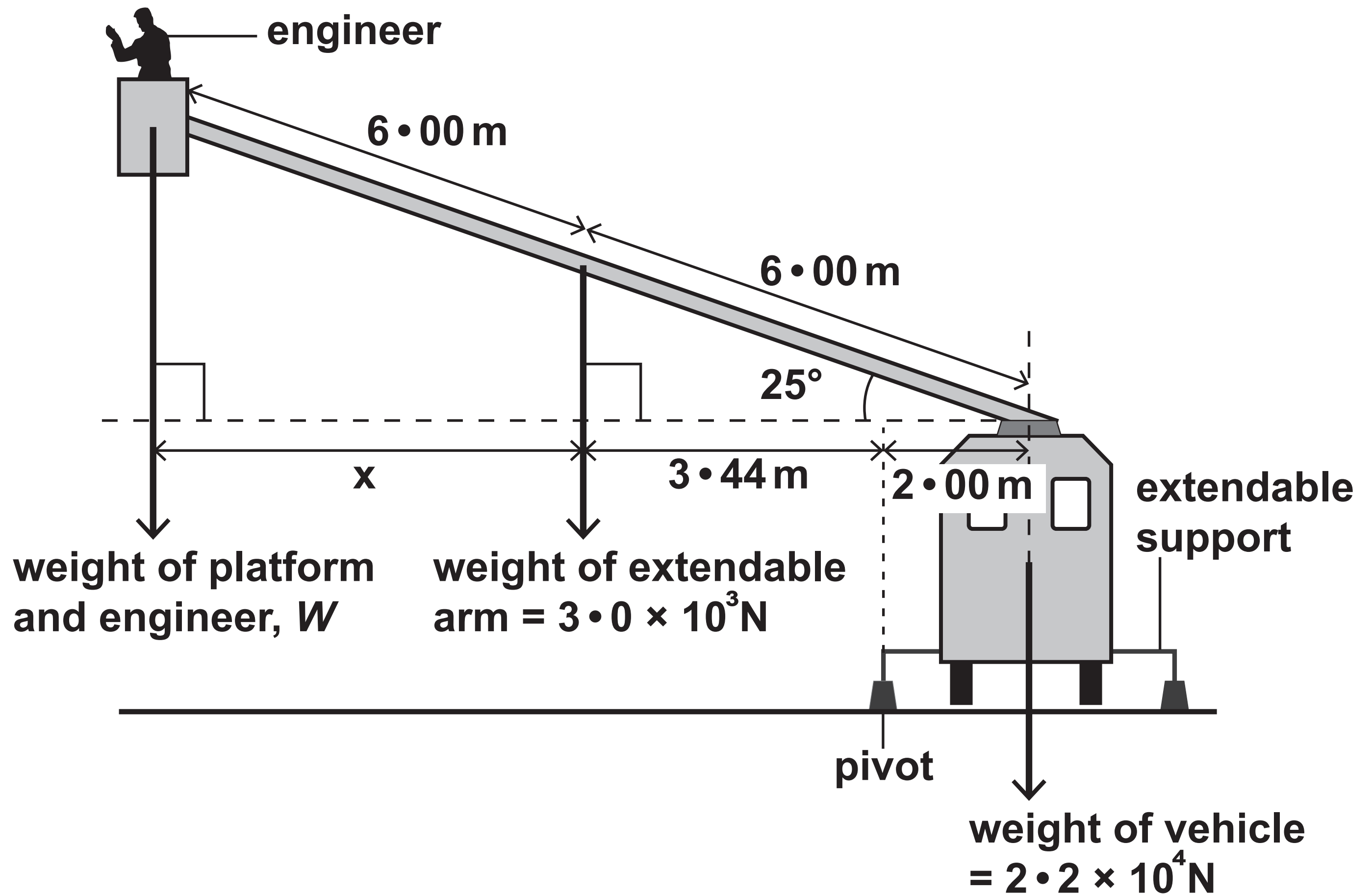
Response D

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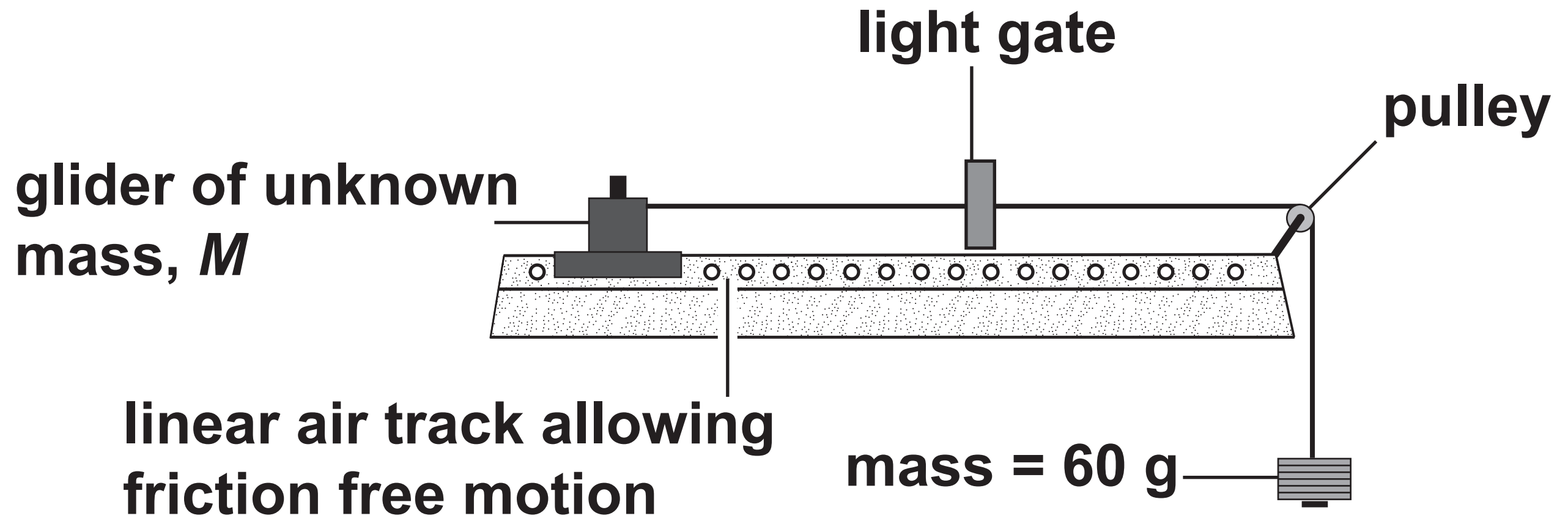
Response E

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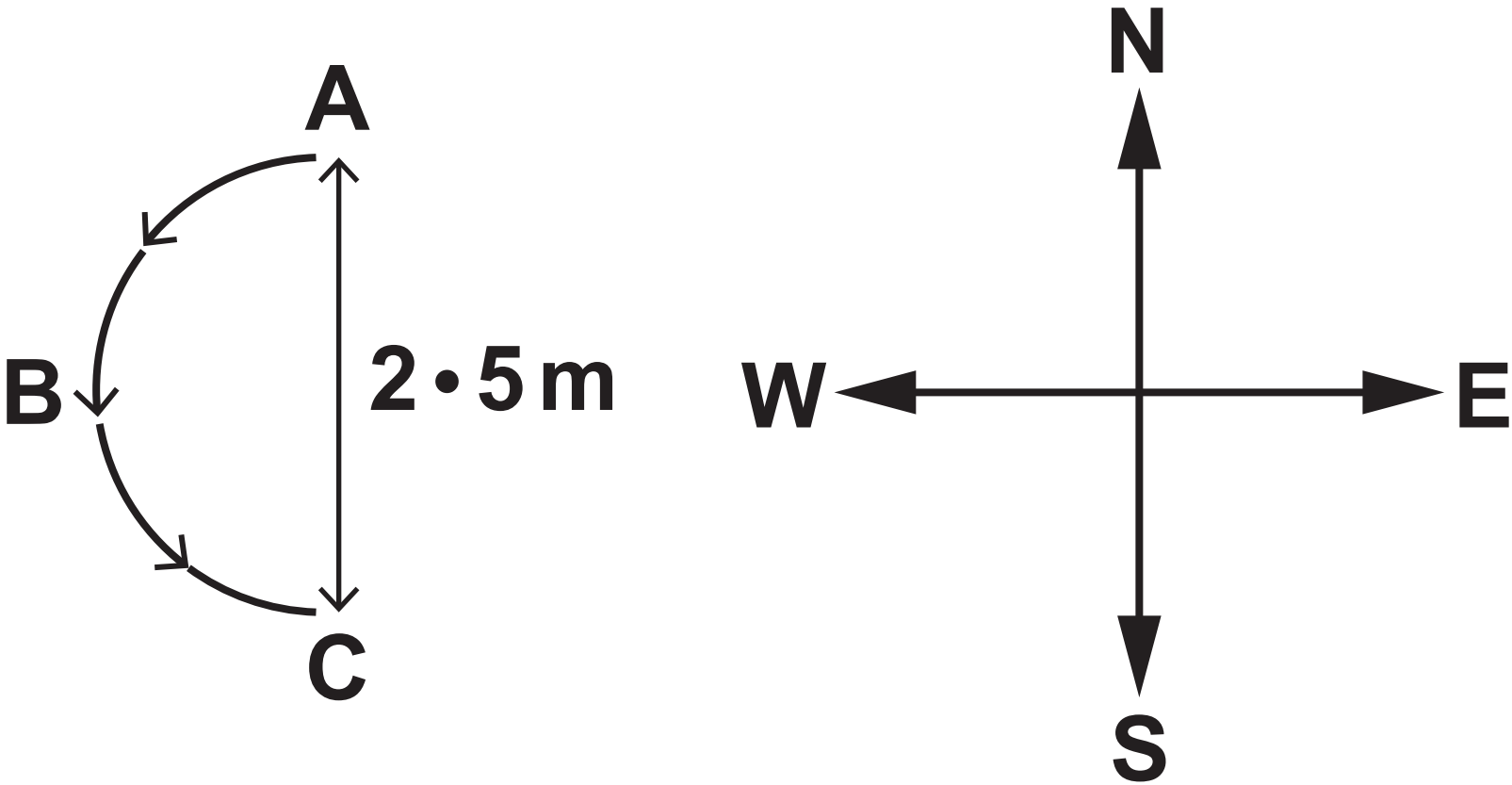
Question 2 (b)



Question 3

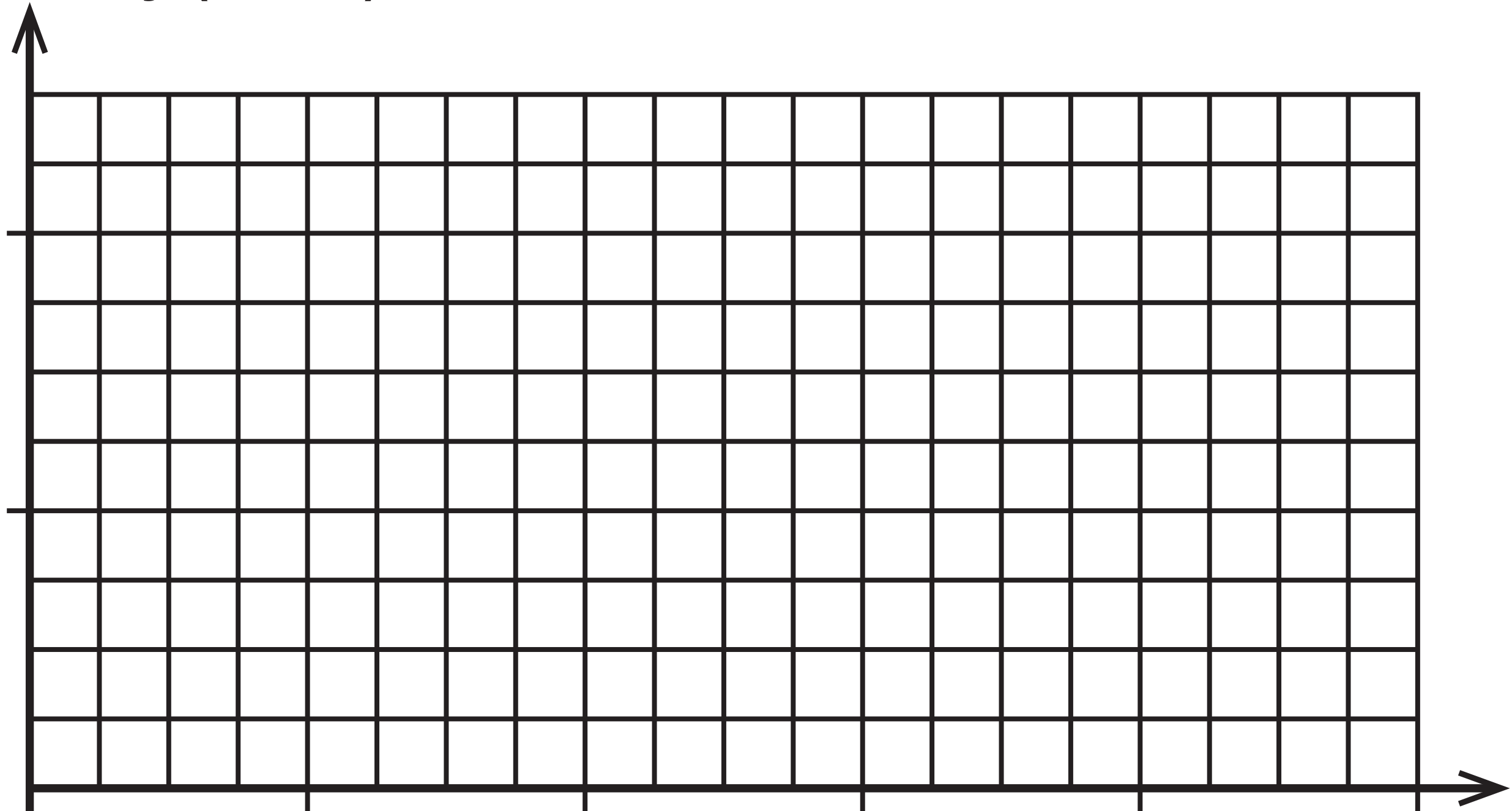


Question 5 (b)



Question 5 (c)
Velocity – time graph

Velocity (m s^{-1})



0.0

1.0

2.0

3.0

4.0

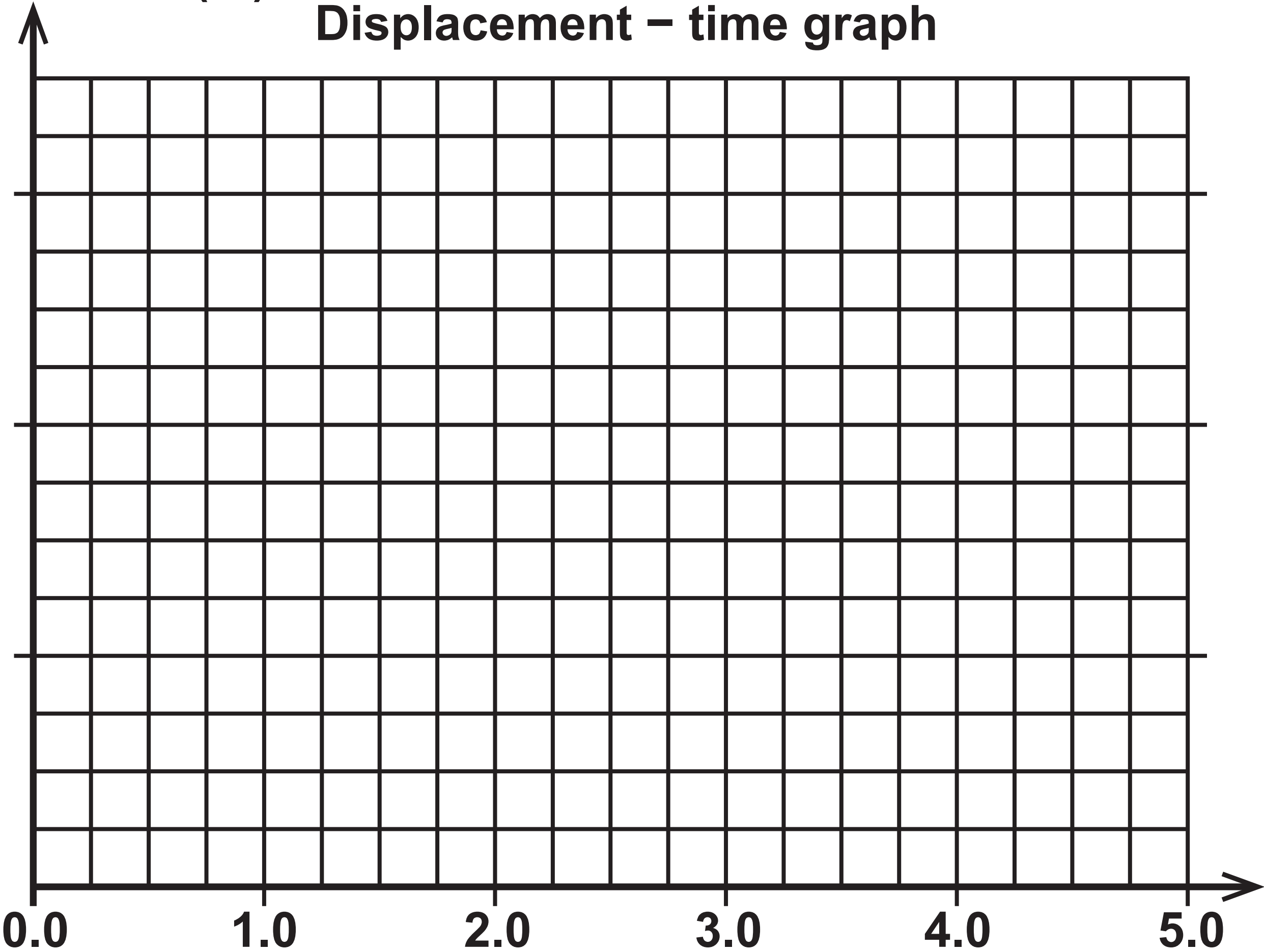
5.0

Time (s)

Question 5 (c)

Displacement – time graph

Displacement (m)



Time (s)

Question 6 (a)

A bungee jumper



Question 6 (b)

