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	

ADDITIONAL MATERIALS

In addition to this examination 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.

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

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).

Answer ALL questions.

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

[2 marks]

(b) Natalie attempts to retrieve a hat of mass $0 \cdot 40$ kg which is resting on the surface of a frozen pond. To do this, she throws a snowball, of mass $0 \cdot 20$ kg, at a horizontal velocity of $9 \cdot 0$ m s^{-1} towards the hat. It hits the hat and rebounds at $2 \cdot 0$ m s^{-1}

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

[3 marks]

(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 . . .

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.

[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]

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.

(i) Show that the distance, x, in the diagram is approximately $5 \cdot 4$ m.

_____

_____

_____

[1 mark]

continued on the next page . . .

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.

[3 marks]

continued on the next page . . .

Question 2 (b) continued

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.

[4 marks]

(Total for Question 2 = 10 marks)

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. The following values for acceleration are determined.

Acceleration / m s^{-2}	Trial
0•76	1
0•71	2
0•79	3

continued on the next page . . .

Question 3 continued

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

[2 marks]

(ii) Calculate the PERCENTAGE uncertainty in the acceleration.

[1 mark]

continued on the next page . . .

Question 3 continued

3. (b) The 60 g mass consists of 6 slotted masses, each of 10•0 g ± 0•1 g.

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

[1 mark]

(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 marks]

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

[1 mark]

(Total for Question 3 = 10 marks)

4. (a) A lithium ATOM is denoted by $^{7}_{3}Li$.

COMPLETE the table below for the lithium atom.

One cell has already been completed for you.

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

[3 marks]

continued on the next page . . .

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]

(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.

continued on the next page . . .

Question 4 (b) continued

$\pi^0 + n \longrightarrow \Delta^0 \longrightarrow \pi^- + p$

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

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

[4 marks]

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

Production of Δ^0 :_____

_____

_____

Decay of Δ^0 : _____

_____

_____

[2 marks]

continued on the next page . . .

Question 4 continued

4. (c) Textbooks state that the mean lifetime of the Δ^0 particle is $(5 \cdot 63 \pm 0 \cdot 14) \times 10^{-24}$ s. State TWO features of the decay which suggest that it is a STRONG interaction.

[2 marks]

(Total for Question 4 = 13 marks)

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]

(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 $4 \cdot 0$ 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}

[1 mark]

continued on the next page . . .

Question 5 (b) continued

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

[2 marks]

(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 marks]

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.

[6 marks]

(Total for Question 5 = 13 marks)

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).

[6 QER marks]

continued on the next page . . .

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.

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

_____

_____

[1 mark]

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

_____

_____

_____

[1 mark]

continued on the next page . . .

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 . . .

Question 6 (b) continued

6. (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 marks]

(Total for Question 6 = 12 marks)

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

[2 marks]

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

[2 marks]

continued on the next page . . .

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]

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

[1 mark]

continued on the next page . . .

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 = $2 \cdot 78 \times 10^{10}$ m

Intensity of radiation received on Earth from Arcturus = $3 \cdot 09 \times 10^{-8}$ W m^{-2}

1 light year = $9 \cdot 46 \times 10^{15}$ m

[5 marks]

(Total for Question 7 = 12 marks)

TOTAL FOR PAPER = 80 MARKS

END OF PAPER

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

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MOTION, ENERGY AND MATTER

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

Diagram Booklet

Surname: _____

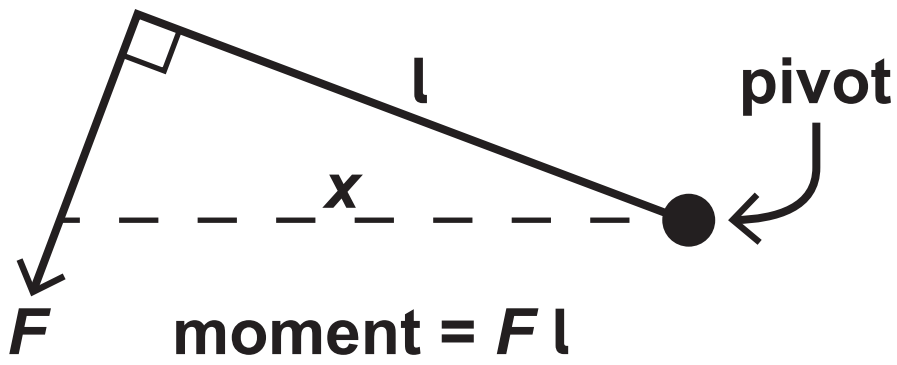
First name(s): _____

Centre Number: _____

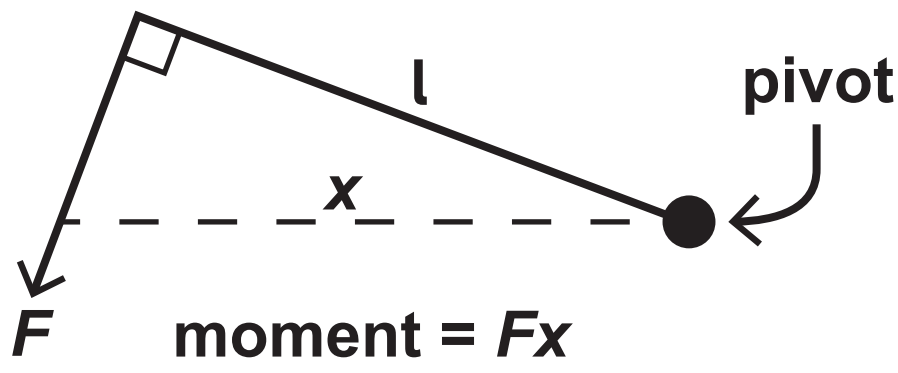
Candidate Number: 2 _____

Question 2 (a)

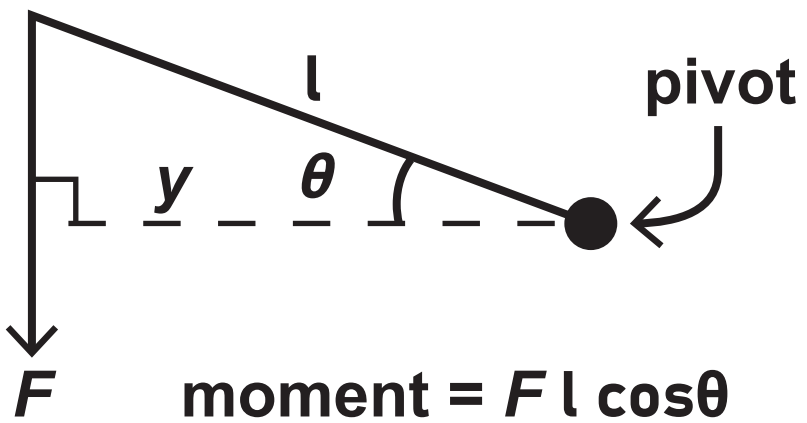
Response A ☐



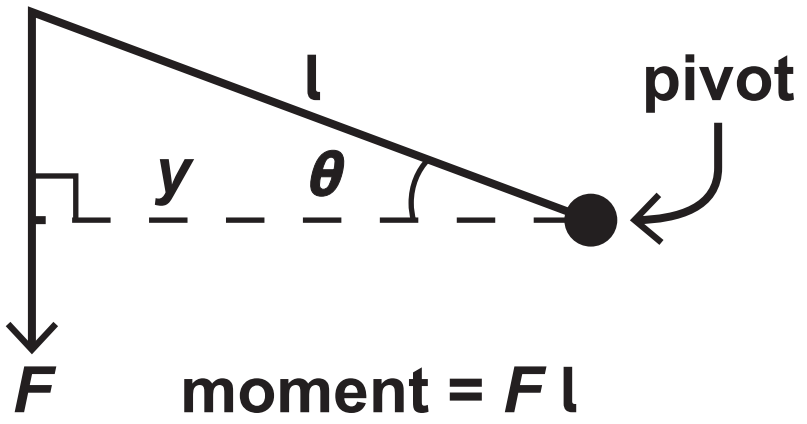
Response B ☐



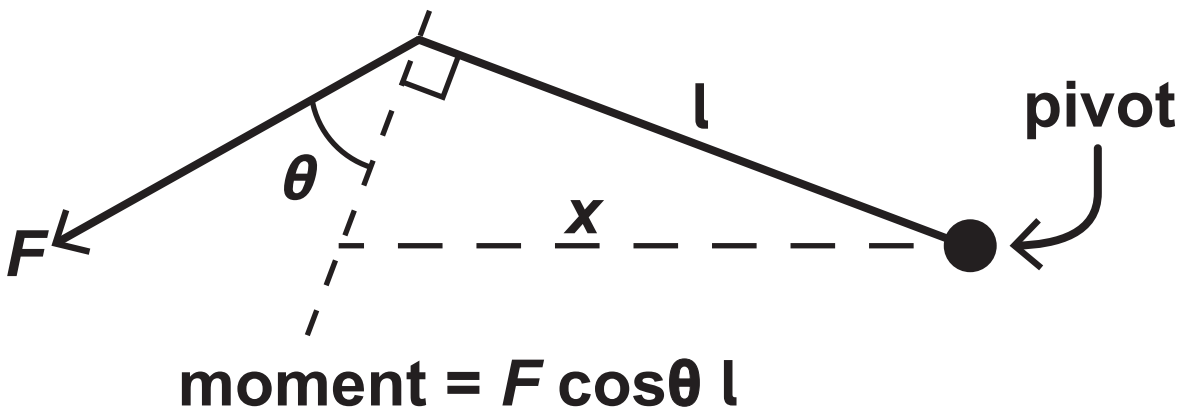
Response C ☐



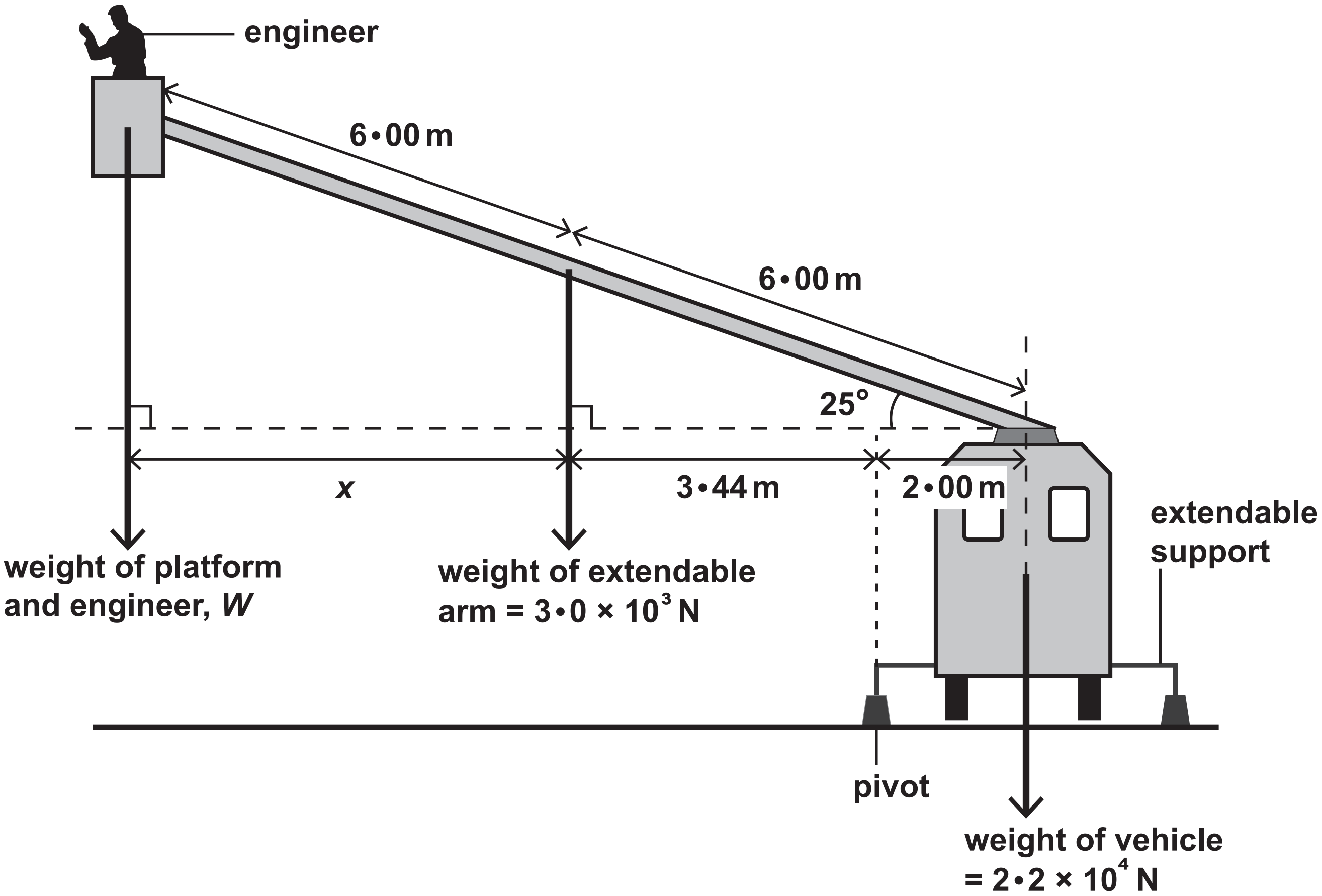
Response D ☐



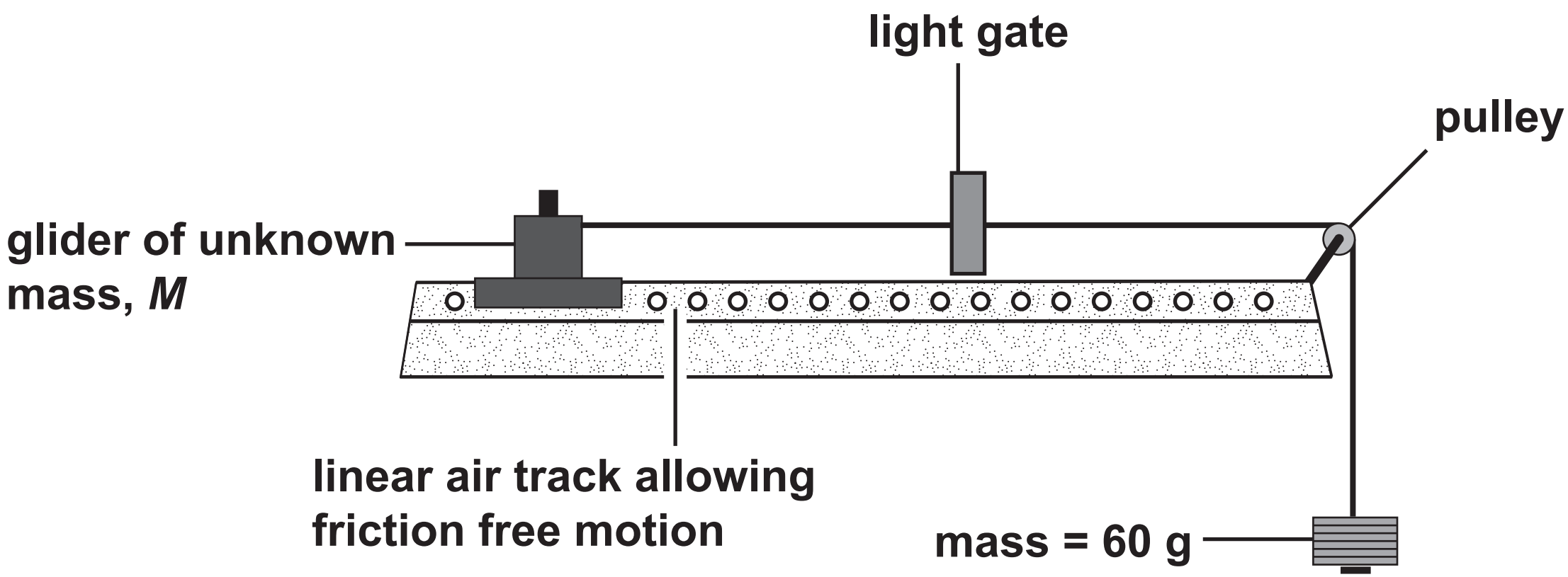
Response E ☐



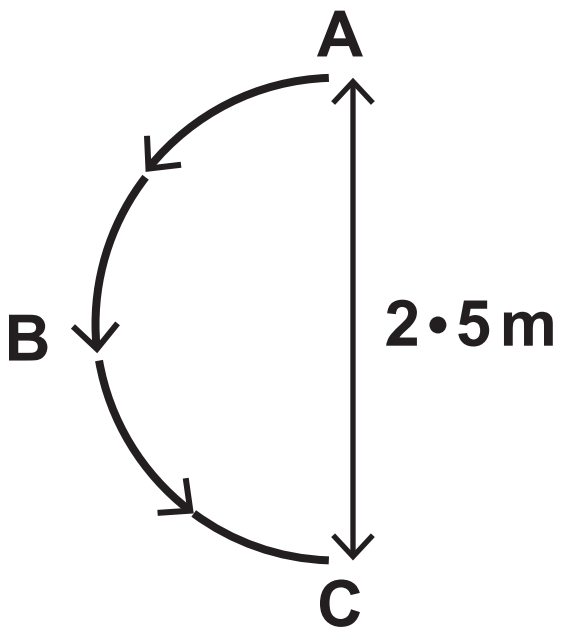
Question 2 (b)

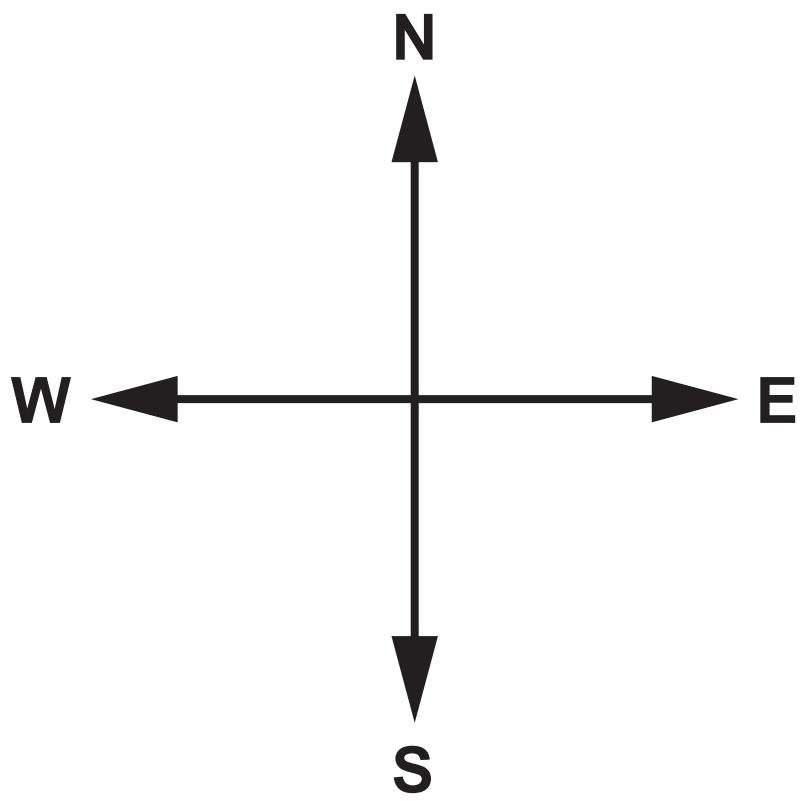

engineer
6•00 m
6•00 m
25°
x
3•44 m
2•00 m
extendable support
weight of platform and engineer, W
weight of extendable arm = 3•0 × 10^3 N
pivot
weight of vehicle = 2•2 × 10^4 N

Question 3


light gate
pulley
glider of unknown mass, *M*
linear air track allowing friction free motion
mass = 60 g

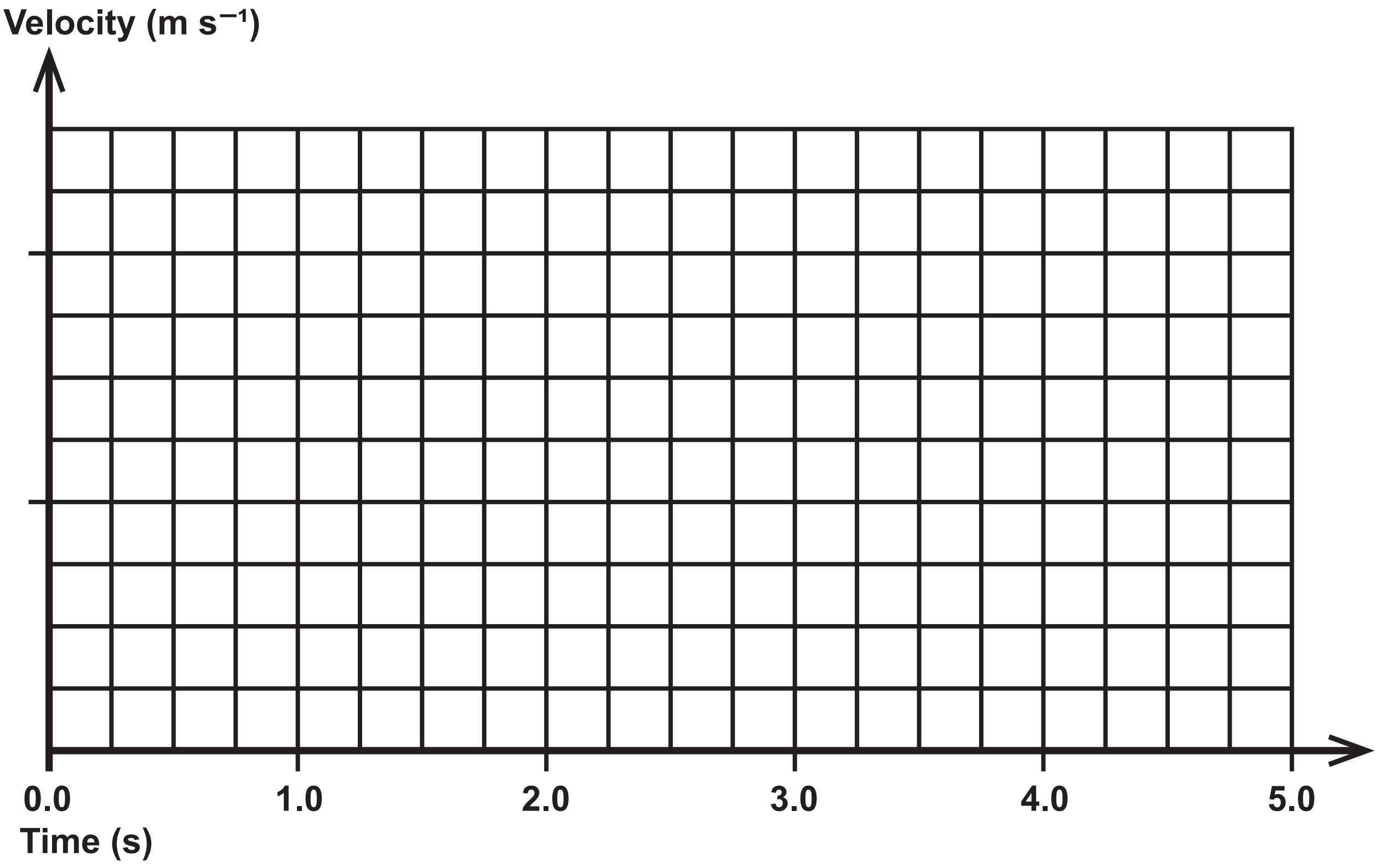
Question 5 (b)





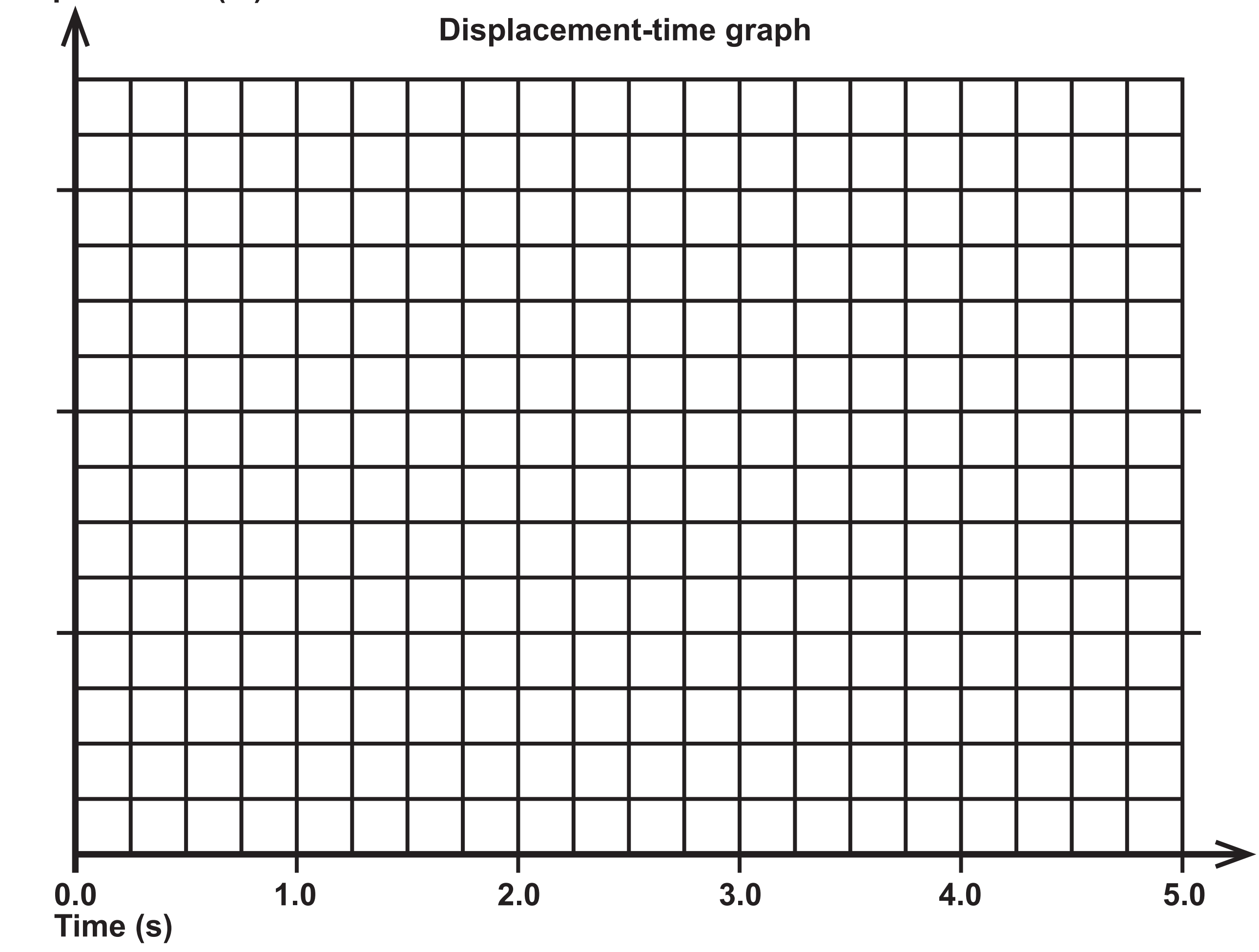
Question 5 (c)

Velocity-time graph



Question 5 (c)

Displacement-time graph



Question 6 (a)

A bungee jumper

Question 6 (b)