



GCE AS/A LEVEL

2420U10-1

WEDNESDAY, 18 MAY 2022 – MORNING

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.	9	
2.	10	
3.	17	
4.	14	
5.	9	
6.	12	
7.	9	
Total	80	

(Turn over)

ADDITIONAL MATERIALS

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

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

(Turn over)

INFORMATION FOR CANDIDATES

The 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 5 (a).

(Turn over)

ANSWER ALL QUESTIONS.

- 1. (a) State the conditions needed for a body to remain in equilibrium.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

- 1. (b) Look at the diagram for Question 1 (b) in the separate Diagram Booklet.**

The diagram shows a simple clothes carrier. It consists of a uniform horizontal beam (AB) of length 1.80 m resting on two vertical rods.

When the clothes carrier supports a coat weighing 11.8 N AT ITS CENTRE, a force of 8.0 N is exerted on each rod.

continued on the next page . . .

(Turn over)

Question 1 (b) continued

**Show that the weight, W ,
of the horizontal beam is
approximately 4 N.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

- 1. (c) Look at the diagram for Question 1 (c) in the separate Diagram Booklet.**

The coat is now moved to a new position and a jacket weighing 7.2 N is hung from the beam, all of which is shown in the diagram.

Calculate forces F_A and F_B .

(Turn over)

(Turn over)

10

[5 marks]

(Total for Question 1 = 9 marks)

(Turn over)

2. (a) Look at the diagram for Question 2 (a) in the separate Diagram Booklet.

The diagram is a graph.

The graph shows how the force, F , needed to stretch a simple spring varies with the extension, x , of the spring.

The spring obeys Hooke's law.

continued on the next page . . .

(Turn over)

Question 2 (a) continued

**2. (a) (i) Calculate the work done
in stretching the spring
0.4 m from its unstretched
position.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 2 (a) continued

- 2. (a) (ii) Explain why the work done to stretch the spring 0.8 m from its unstretched position is NOT TWICE your answer to part (a) (i).**

[2 marks]

(Turn over)

Question 2 continued

- 2. (b) Look at the diagram for Question 2 (b) in the separate Diagram Booklet.**

The diagram shows a toy car with a spring behind it and a track with a vertical loop in front of it.

The spring in part (a) is used to propel the toy car, of mass 30 g, along the track and around the vertical loop which has a radius 0.25 m.

continued on the next page . . .

(Turn over)

Question 2 (b) continued

- 2. (b) (i) The spring is compressed by 0.4 m. The car is placed against the end of the spring, which is then released. Assuming that all of the spring's energy is transferred to the car and that no resistive forces act on it, calculate the speed of the car at the top of the loop.**
-
-
-

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 2 (b) continued

- 2. (b) (ii) In reality resistive forces act on the car to the extent that the car loses 5% of its initial energy to frictional forces in moving from the spring to the top of the loop. Calculate the mean resistive force acting on the car during this motion.**

(Turn over)

18

[3 marks]

(Total for Question 2 = 10 marks)

(Turn over)

- 3. Drones have an increasing number of uses in society. This question considers some of the Physics associated with drones.**

Look at the photograph for Question 3 in the separate Diagram Booklet.

The photograph shows a small, square – shaped drone that is airborne. The drone has four rotors on top.

continued on the next page . . .

(Turn over)

Question 3 continued

3. (a) (i) State Newton's third law of motion.

[1 mark]

continued on the next page . . .

(Turn over)

Question 3 (a) continued

- 3. (a) (ii) The drone in the photograph has four rotors and is shown hovering stationary in the air.**

Look at the table for Question 3 (a) (ii) in the separate Diagram Booklet.

The table describes two vertical forces acting on the drone.

continued on the next page . . .

(Turn over)

Question 3 (a) (ii) continued

According to Newton's third law each of these forces is part of a pair of forces.

Identify the other force in each case on the table.

[2 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (b) The drone is able to hover when each rotor produces a downward flow of air of speed 22 m s^{-1} .**

The momentum given to the air by the 4 rotors produces an upward force which keeps the drone stationary in the air.

continued on the next page . . .

(Turn over)

Question 3 (b) continued

**3. (b) (i) State the relationship
between force and
momentum.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 3 (b) continued

- 3. (b) (ii) The rate of change of momentum of the air FROM THE 4 ROTORS can be expressed as:**

$$4\pi r^2 \rho v^2$$

where r is the radius of each of the rotor blades, v is the speed of the air which is set in motion and ρ is the density of the air.

continued on the next page . . .

(Turn over)

Question 3 (b) (ii) continued

Use the expression on the previous page to show that the weight of the drone is approximately 20 N.

$$[\rho = 1.3 \text{ kg m}^{-3}, r = 5.0 \times 10^{-2} \text{ m}]$$

(Turn over)

[2 marks]

3. (b) (iii) Calculate the vertical acceleration of the drone when v is increased to 24 m s^{-1} .

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

3. (c) (i) Define VELOCITY.

[1 mark]

continued on the next page . . .

(Turn over)

Question 3 (c) continued

3. (c) (ii) Look at the diagram for Question 3 (c) (ii) in the separate Diagram Booklet. The diagram is NOT drawn to scale. The diagram shows the view from above.

Bill flies the drone from A to B in a time of 32 s along the path shown in the diagram. The drone is kept at the same height above the ground for the entire flight.

continued on the next page . . .

(Turn over)

Question 3 (c) (ii) continued

Bill's friend Ted believes that, in flying this path (from A to B), the mean speed of the drone is more than twice the magnitude of its mean velocity. Bill disagrees.

Use the information given to determine who is correct.

(Turn over)

32

[illegible]

[4 marks]
(Turn over)

Question 3 continued

3. (d) Drones have many applications in today's society.

Give ONE benefit and ONE risk of drone technology.

(Turn over)

34

[2 marks]

(Total for Question 3 = 17 marks)

(Turn over)

- 4. Look at the diagram for Question 4 in the separate Diagram Booklet.**

Karen is an A level Physics student who has been absent for some of her Physics practical lessons.

During her absence, the other students in the class have been using the apparatus to identify the metal in a wire by finding the Young modulus of the metal and comparing it with known values.

continued on the next page . . .

(Turn over)

Question 4 continued

In order to catch up with the other students, Karen decides to use the same apparatus to carry out a quick experiment to find the Young modulus.

Look at the information provided for Question 4 in the separate Diagram Booklet. Her notes are shown.

continued on the next page . . .

(Turn over)

Question 4 continued

4. (a) Use Karen's notes to answer the following questions.

(i) Calculate the cross – sectional area of the wire IN m^2 and show that the PERCENTAGE uncertainty in its value is approximately 11%.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 (a) continued

- 4. (a) (ii) Show, with an appropriate calculation, that the uncertainty in the length reading can be considered negligible.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 4 continued

4. (b) (i) Determine the Young modulus of the metal.

[2 marks]

(Turn over)

Question 4 (b) continued

- 4. (b) (ii) Karen is told by her teacher that the percentage uncertainty in the load is 5%. Use this information along with Karen's notes and your answers to part (a) to calculate the ABSOLUTE uncertainty in the Young modulus. Give your answer in GPa and to an appropriate number of significant figures.**
-
-

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

Question 4 continued

- 4. (c) Look at the table for Question 4 (c) in the separate Diagram Booklet.**

The table shows Young modulus values of the wires available to the students.

Karen's friend Jack determined the Young modulus of the metal to be 126 ± 20 GPa.

continued on the next page . . .

(Turn over)

Question 4 (c) continued

They both use the table to determine the metal in their wires. Discuss how Jack's conclusions differ from Karen's.

[2 marks]

(Turn over)

Question 4 continued

4. (d) Jack had more time to carry out this experiment than Karen.

Suggest differences in the way Jack carried out the experiment (i.e. procedure) AND in the way that he analysed his results which led to him reaching a different conclusion to Karen.

(Turn over)

(Turn over)

[3 marks]

(Total for Question 4 = 14 marks)

(Turn over)

- 5. (a) HADRONS are a group of particles. Write a detailed account of hadrons, including how they may be subdivided into other groups of particles, giving examples.**

(Turn over)

[illegible]

(Turn over)

[6 marks QER]

continued on the next page . . .

(Turn over)

Question 5 continued

- 5. (b) A high energy interaction between a proton and a pion is shown below.**



Use conservation laws to show that the interaction is possible.

(Turn over)

[3 marks]

(Total for Question 5 = 9 marks)

(Turn over)

6. (a) Look at the diagram for Question 6 (a) in the separate Diagram Booklet.

This diagram shows a velocity – time graph for a body which is accelerating uniformly for a time, t .

Using the graph, show clearly that:

$$x = ut + \frac{1}{2} at^2$$

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

- 6. (b) The shot put is an event in athletics. The shot (a heavy metal ball) is thrown from a standing position so that it lands on the ground a horizontal distance, R , from the thrower.**

Look at the diagram for Question 6 (b) in the separate Diagram Booklet. The diagram shows the path of the shot after it leaves Steve's hand.

continued on the next page . . .

(Turn over)

Question 6 (b) continued

Steve is a shot putter. He throws a shot with a velocity of 11.0 m s^{-1} in a direction 50° to the horizontal. The shot takes 1.95 s to reach the ground.

continued on the next page . . .

(Turn over)

Question 6 (b) continued

- 6. (b) (i) Show that the vertical component of the initial velocity is approximately 8 m s^{-1} .**

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 (b) continued

6. (b) (ii) Hence calculate, H ,
the vertical distance above
the ground from which the
shot was thrown.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 6 (b) continued

6. (b) (iii) Calculate the horizontal distance, R , for this throw.

[2 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

- 6. (c) Steve makes the following comment to Bryn, a fellow competitor.**

“Throwing the shot at an angle even greater than 50° to the horizontal will increase the horizontal distance travelled by the shot because the time of flight will increase.”

continued on the next page . . .

(Turn over)

Question 6 (c) continued

Consider whether or not it would be a good idea for Bryn to follow Steve's advice. Justify your answer.

(Turn over)

[3 marks]

(Total for Question 6 = 12 marks)

(Turn over)

7. (a) Stars are very good approximations of BLACK BODIES. Explain what is meant by the term BLACK BODY.

[1 mark]

continued on the next page . . .

(Turn over)

Question 7 continued

- 7. (b) Look at the diagram for Question 7 (b) in the separate Diagram Booklet.**

The diagram is a graph.

The graph shows how the intensity of electromagnetic radiation, I , from the Sun varies with the distance from its centre, d .

continued on the next page . . .

(Turn over)

Question 7 (b) continued

- 7. (b) (i) Confirm that the graph shows an inverse square relationship between I and d .**

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 7 (b) continued

**7. (b) (ii) Show that the Sun's
luminosity is approximately
 4×10^{26} W.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

- 7. (c) Look at the diagram for Question 7 (c) in the separate Diagram Booklet.**

The diagram is a graph.

The graph shows how the intensity of the radiation incident on the Earth from the Sun is distributed across the spectrum.

continued on the next page . . .

(Turn over)

Question 7 (c) continued

Use information from this graph, along with your answer to part (b) (ii), to calculate the radius of the Sun.

(Turn over)

[4 marks]

(Total for Question 7 = 9 marks)

END OF PAPER

TOTAL 80 MARKS

(Turn over)

[illegible]

(Turn over)

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

[illegible]

(Turn over)

[illegible]



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and sent for marking.**

Diagram Booklet

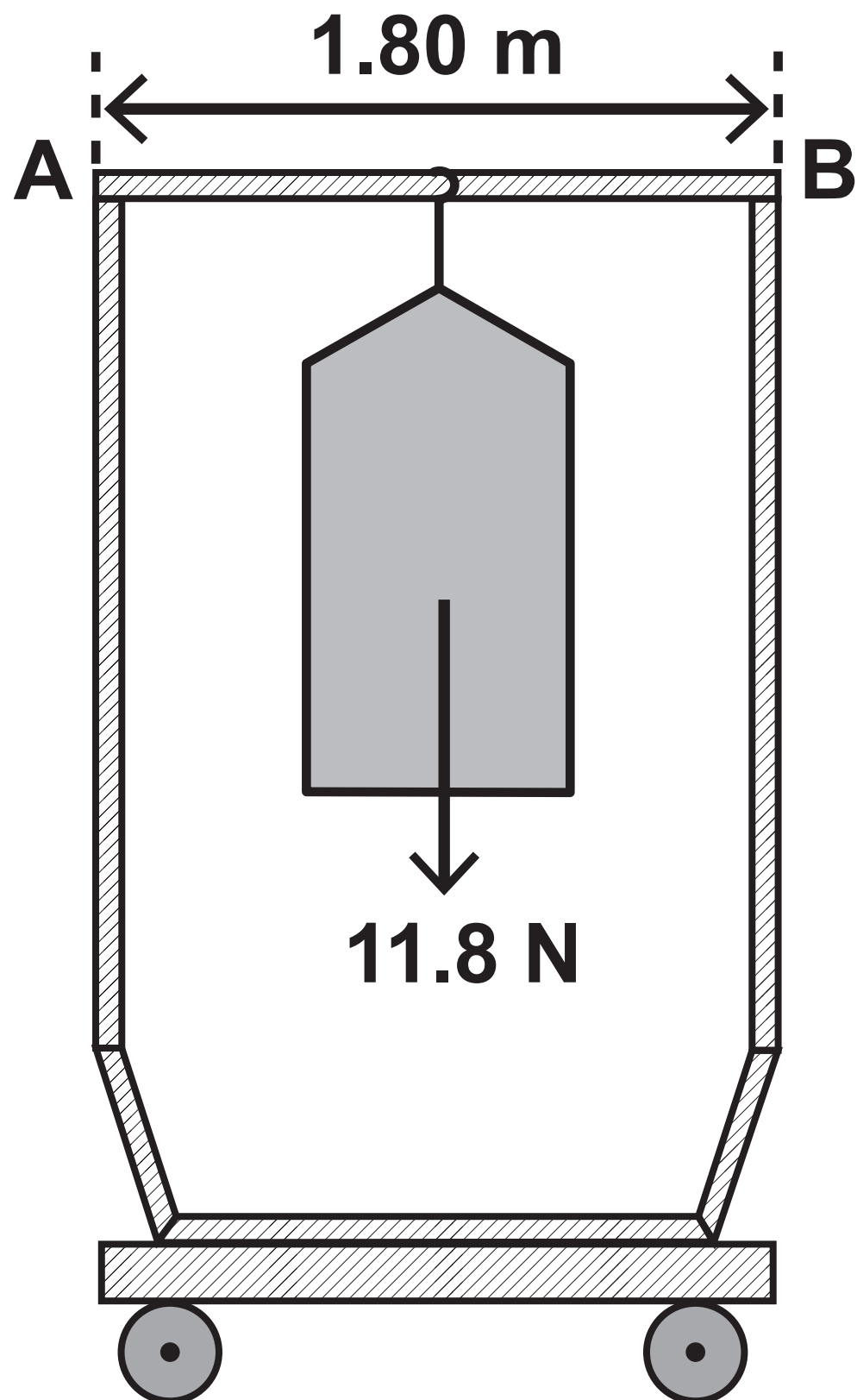
Surname: _____

First name(s): _____

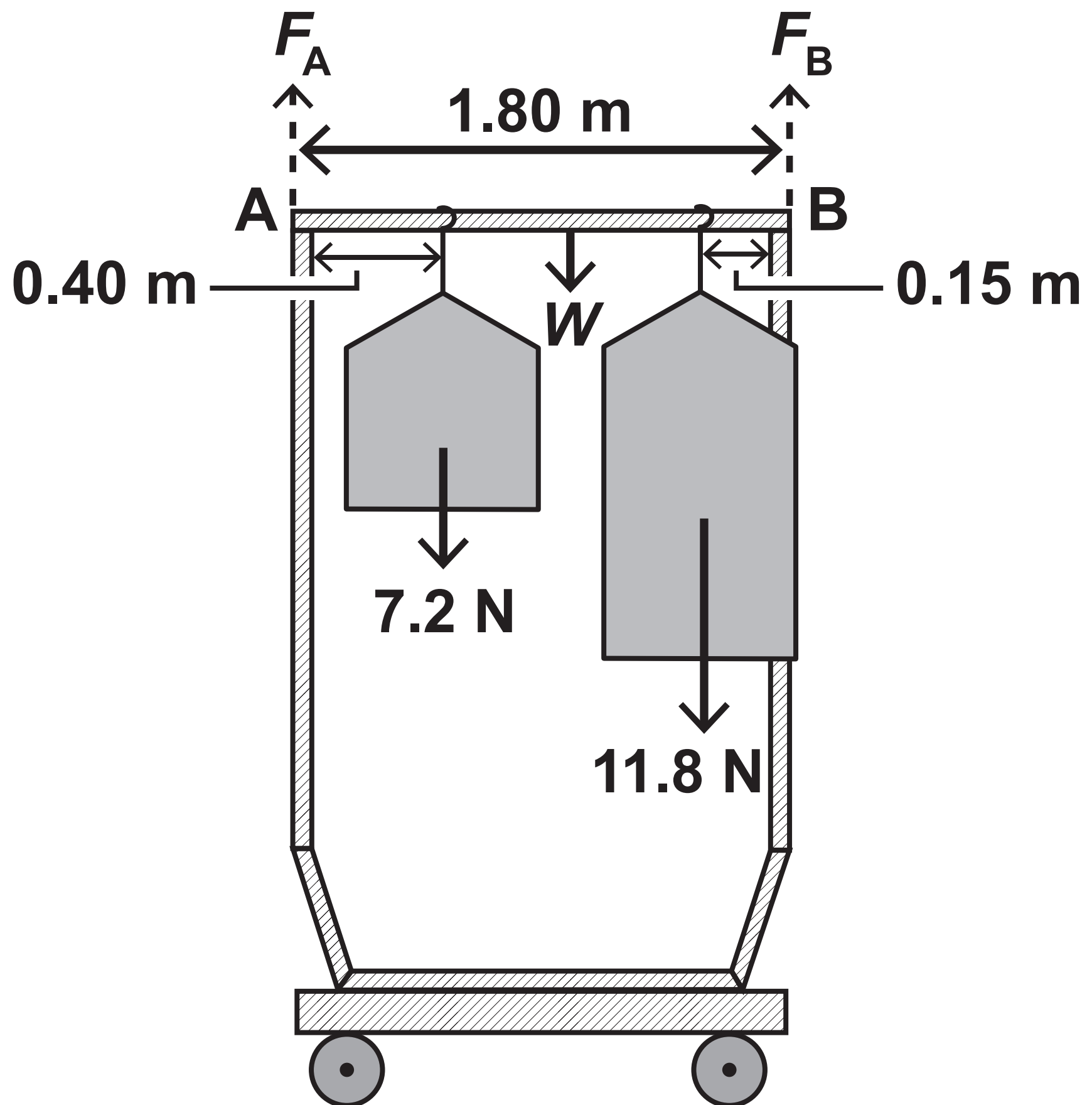
Centre Number: _____

Candidate Number: 2 _____

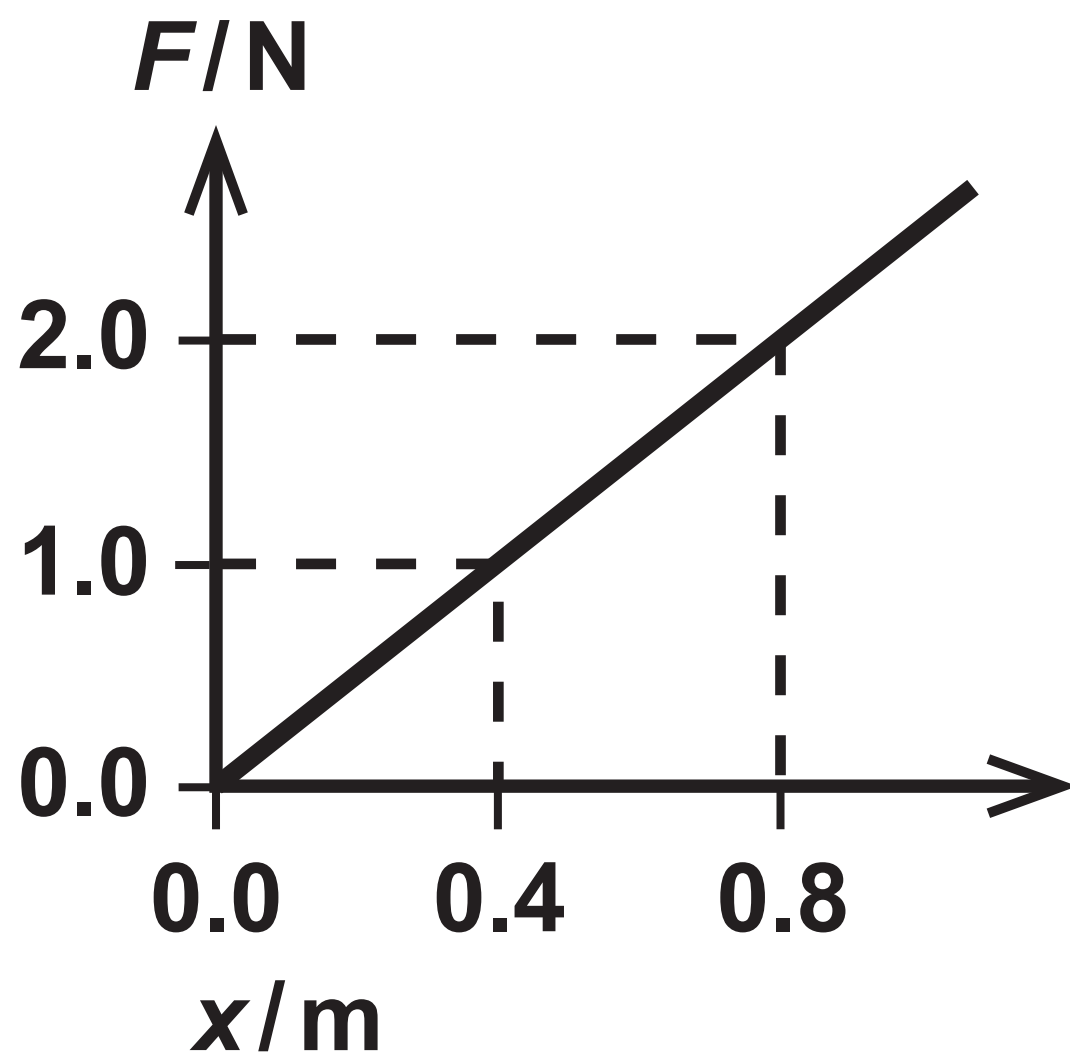
Question 1 (b)



Question 1 (c)

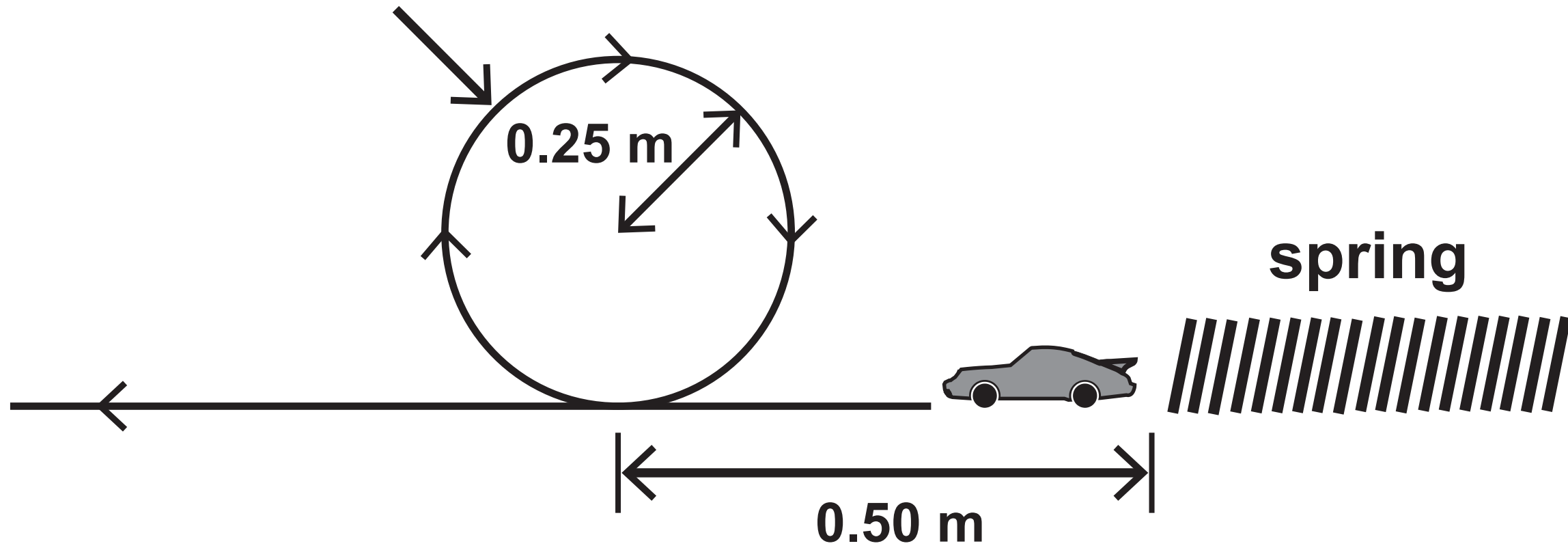


Question 2 (a)



Question 2 (b)

vertical loop



Question 3

Photograph



Question 3 (a) (ii)

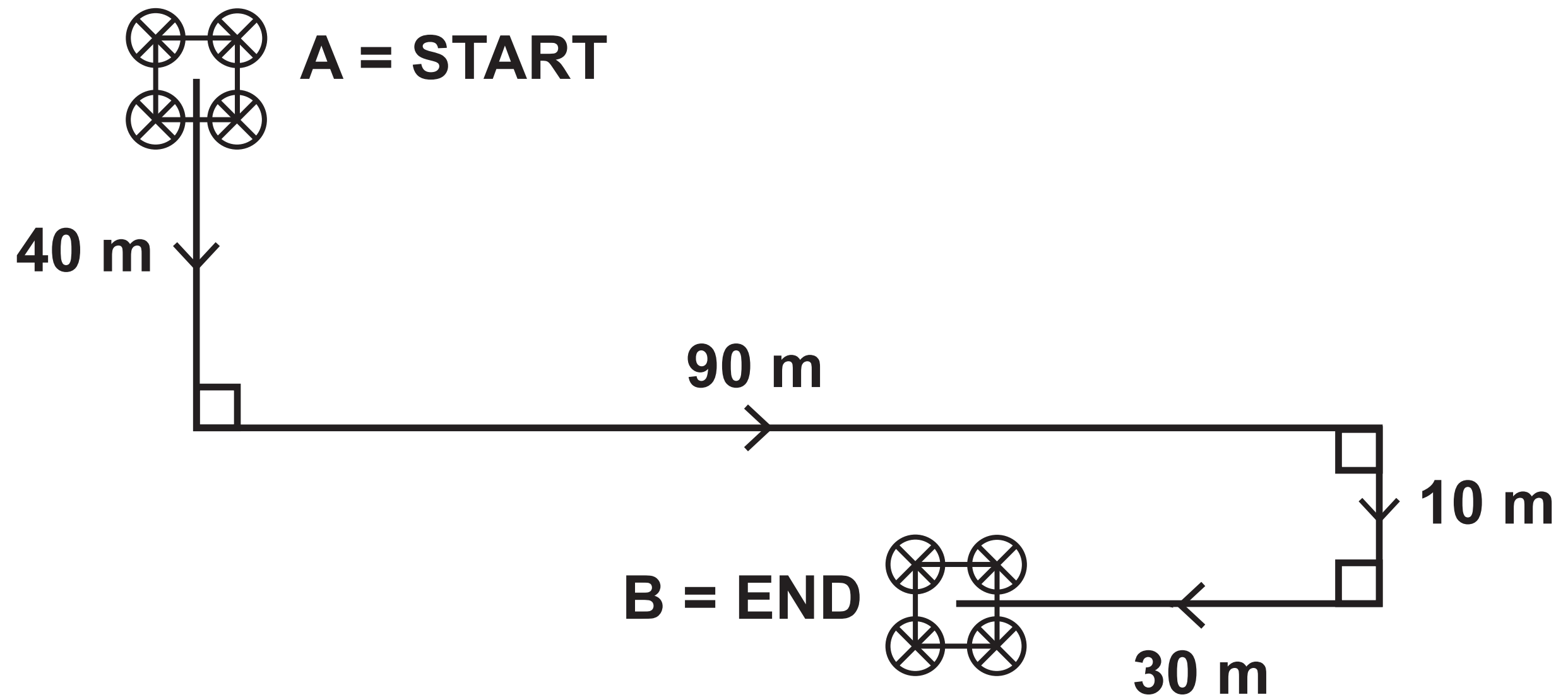
Table

Forces acting vertically downwards	Forces acting vertically upwards
Gravitational force of Earth on drone	
	Force of air on rotors

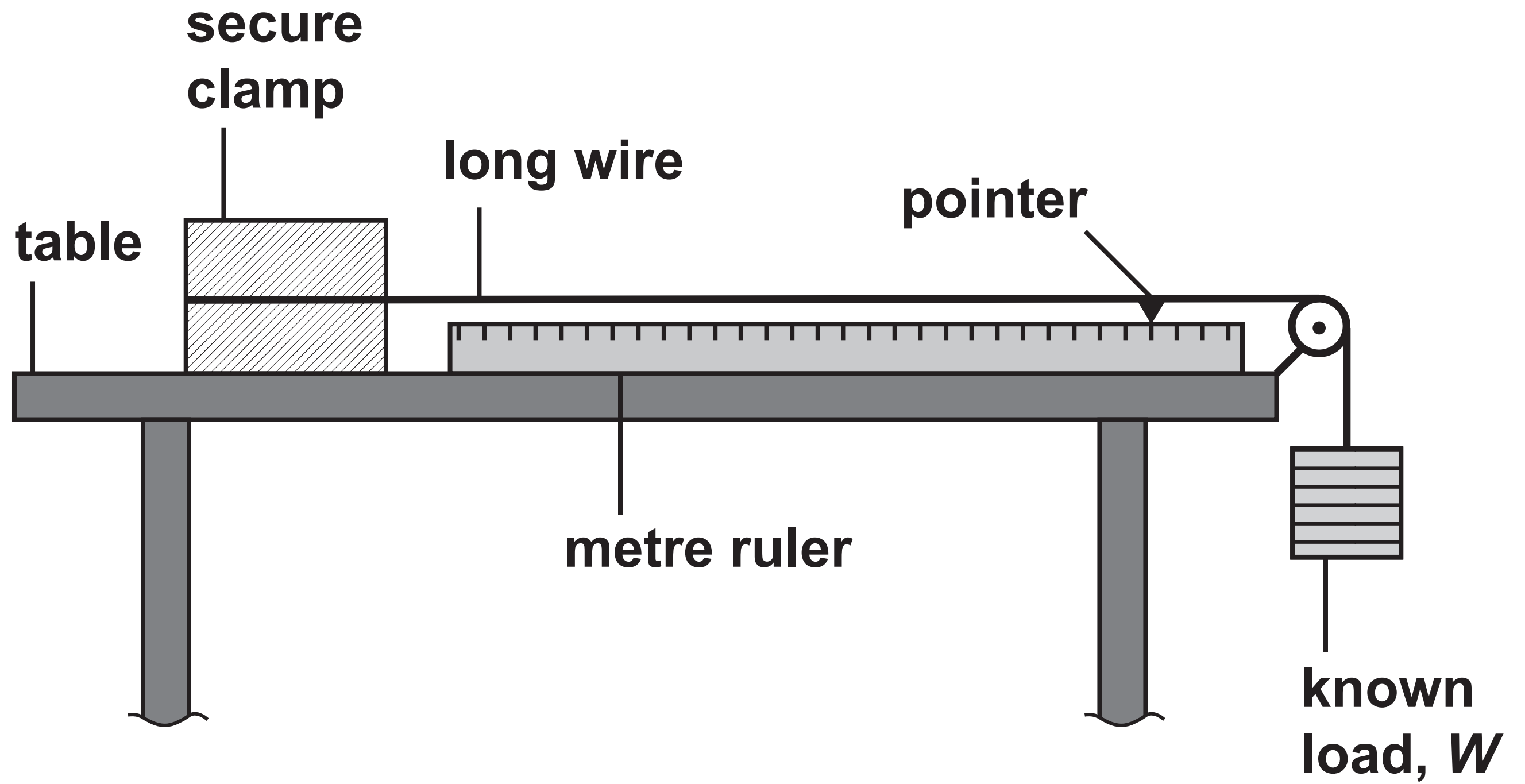
Question 3 (c) (ii)

Diagram NOT drawn to scale

View from above



Question 4



Question 4

Information

- **Take single reading of diameter using a micrometer of resolution 0.01 mm.**

DIAMETER = 0.18 mm

- **Use a metre ruler of resolution 1 mm to measure the initial length of the wire.**

INITIAL LENGTH = 1.940 m

- **Set up the apparatus and add a MASS OF 1.0 kg to the end of the wire. Measure extension.**

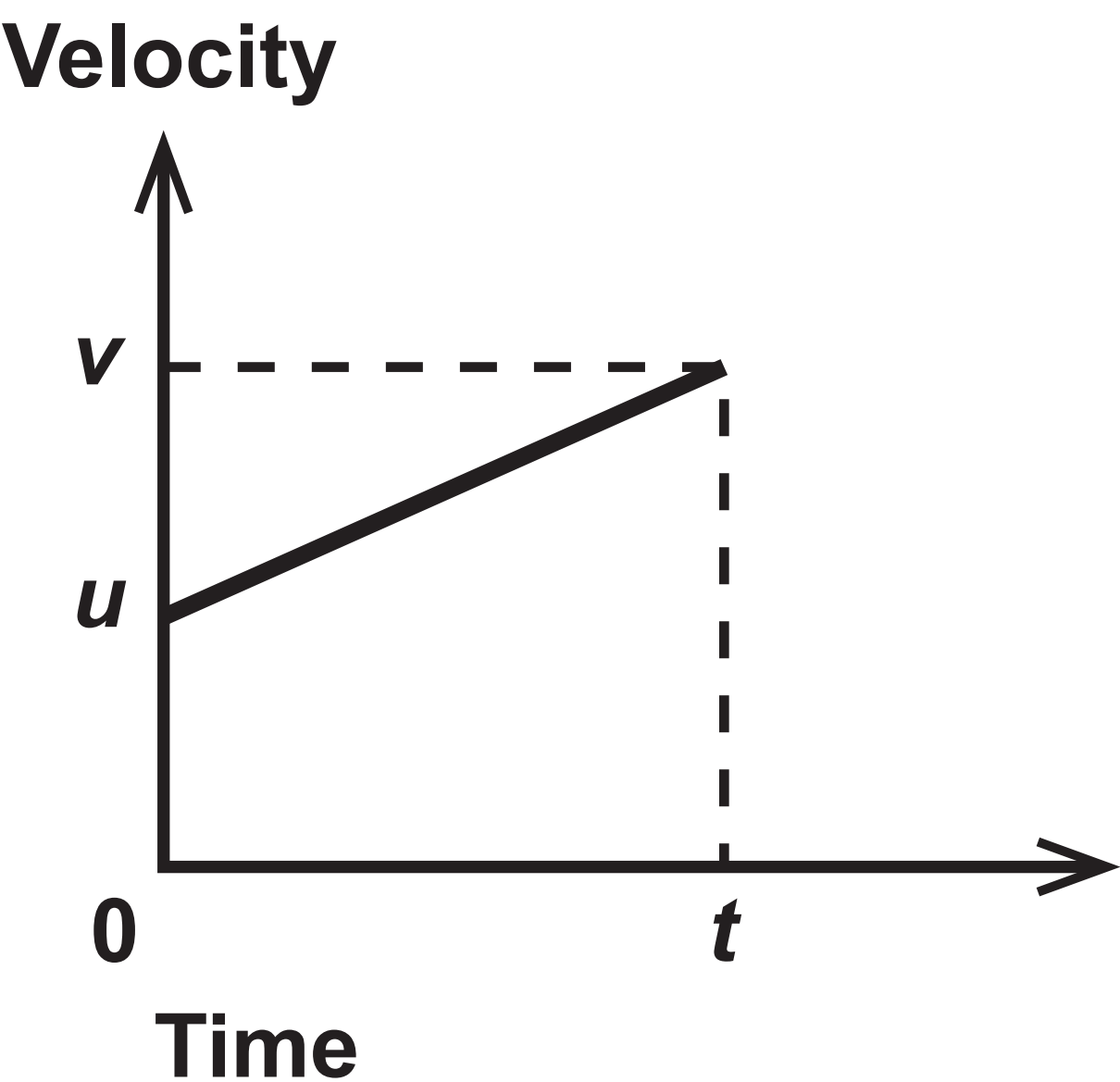
EXTENSION = 6.0 ± 0.5 mm

Question 4 (c)

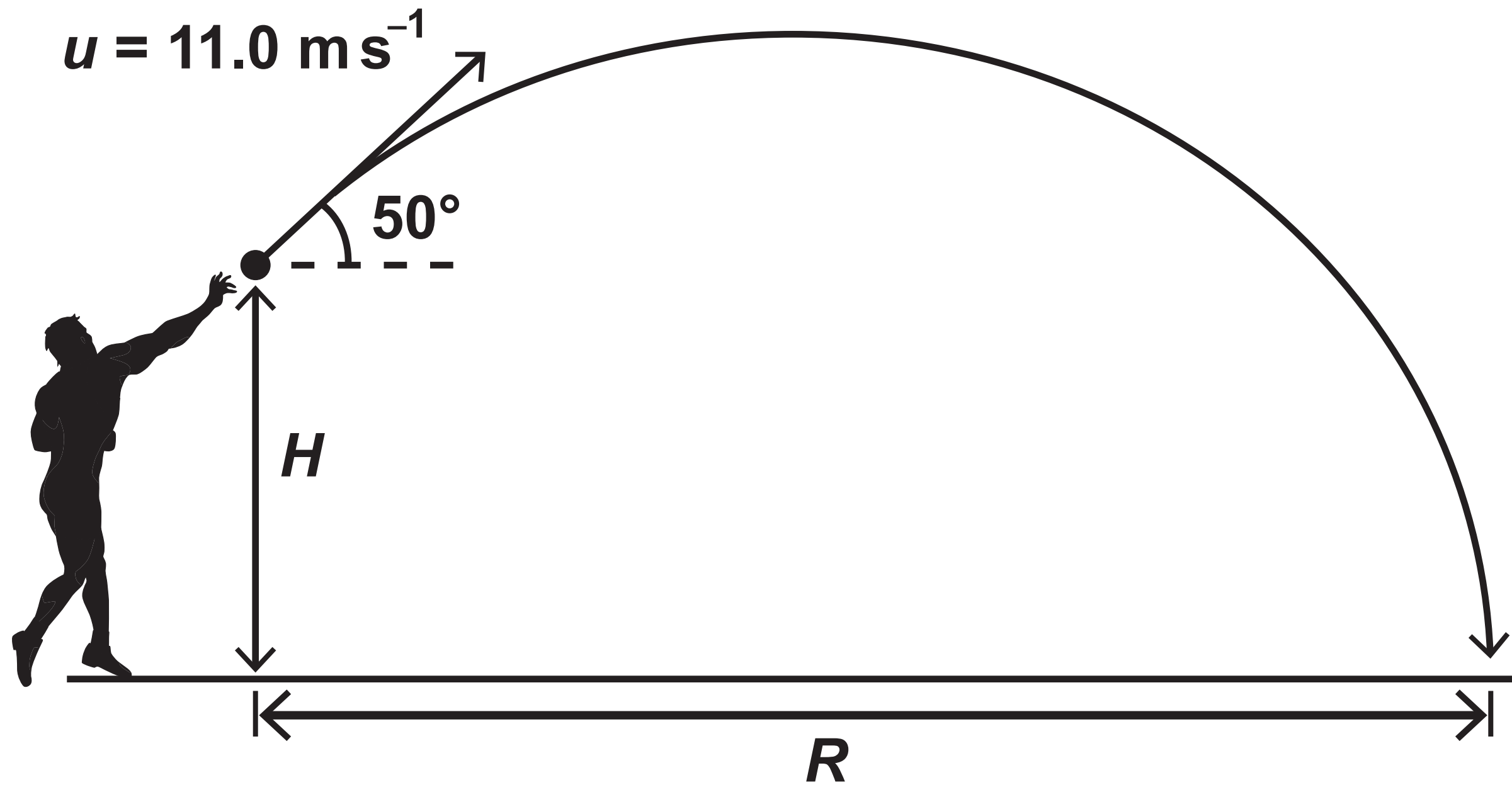
Table

Metal	Young modulus / GPa
aluminium	70
zinc	100
bronze	103
copper	117
nickel	166

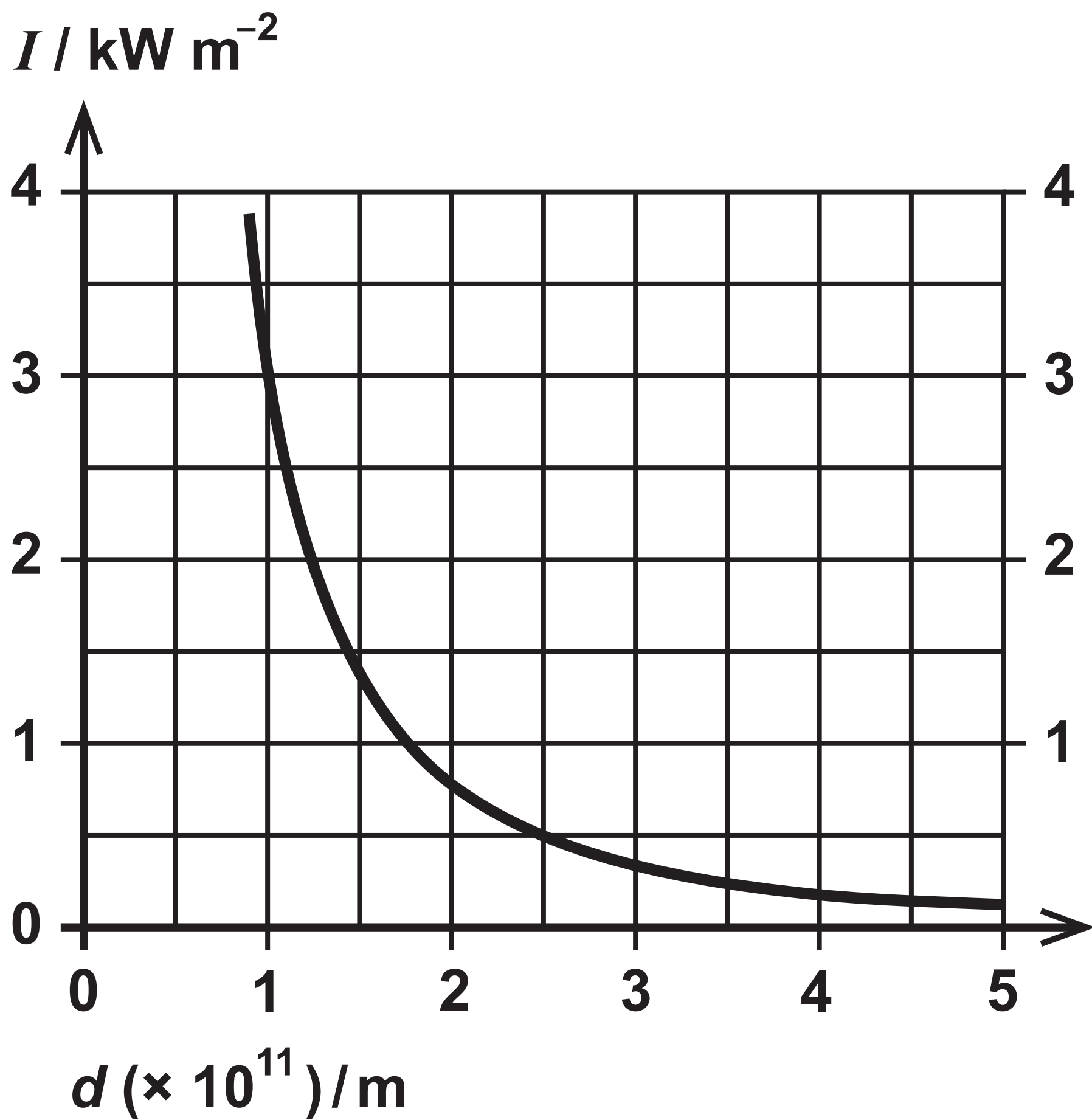
Question 6 (a)



Question 6 (b)



Question 7 (b)



Question 7 (c)

Spectral
intensity

