GCE AS/A LEVEL

2420U10-1

THURSDAY, 18 MAY 2023 – 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.	**7**	
2.	**11**	
3.	**15**	
4.	**6**	
5.	**11**	
6.	**11**	
7.	**10**	
8.	**9**	
Total	**80**	

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.

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.

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 4.

ANSWER ALL QUESTIONS.

1. (a) Define the spring constant, k.

_____

_____

_____

[1 mark]

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

The apparatus shown in the diagram is set up to investigate moments.

A horizontal uniform metre ruler weighing 1.2 N is freely pivoted at one end.

The ruler is suspended by a spring of spring constant, $k = 20$ N m^{-1} at a point 90.0 cm from the pivot, and a load of 3.0 N is suspended at a distance x from the pivot.

continued on the next page . . .

Question 1 (b) continued

Use the following information to calculate *X*

Original (unstretched) length of spring = 10.0 cm

Stretched length of spring when the ruler is horizontal = 17.0 cm

[4 marks]

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

The diagram shows two springs of the same type used in part (b) connected in series.

Laura believes that connecting the springs in this way will result in the overall spring constant being $10\ N\ m^{-1}$

Aled believes that the overall spring constant will be $40\ N\ m^{-1}$

Explaining your answer determine who, if either, is correct.

[2 marks]

(Total for Question 1 = 7 marks)

2. Tomos and Jerry wish to determine the material from which a ball bearing is made. They both decide to determine the density of the metal of the ball bearing. However, they choose different methods.

TOMOS' METHOD:

Tomos uses digital callipers to measure the diameter of the ball bearing. He then uses a digital balance to determine the mass of the ball bearing. He obtains the following values:

Diameter of ball bearing = 18.76 $\pm$ 0.02 mm

Mass of ball bearing = 26.3 $\pm$ 0.5 g

continued on the next page . . .

Question 2 continued

JERRY'S METHOD:

Jerry measures the volume directly by submerging the ball bearing in water in a measuring cylinder. He also uses the same digital balance to determine the mass of the ball bearing and obtains the following values:

Volume of ball bearing = $3.4 \pm 0.1\ cm^3$

Mass of ball bearing = $26.3 \pm 0.5\ g$

2. (a) USING TOMOS' VALUES:

(i) Calculate the volume of the ball bearing in cm^3 and show that its PERCENTAGE uncertainty is approximately 0.3%

[3 marks]

continued on the next page . . .

Question 2 (a) continued

2. (a) (ii) Hence calculate the density of the ball bearing along with its ABSOLUTE uncertainty, giving your answer to an appropriate number of significant figures.

[4 marks]

continued on the next page . . .

Question 2 continued

2. (b) Jerry believes that, since he is measuring the volume directly, the absolute uncertainty in his value of density will be less than that found by Tomos. Determine whether or not he is correct.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 2 continued

2. (c) Look at the table for Question 2 (c) in the separate Diagram Booklet. The table gives the density of some common metals and alloys.

Tomos and Jerry use this information to determine the metal from which the ball bearing is made. Explain how Tomos' conclusion differs from Jerry's.

[2 marks]

(Total for Question 2 = 11 marks)

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

The diagram shows a demonstration that is sometimes used to explain projectile motion. In the version shown, a toy rifle is situated a horizontal distance, *D*, from an apple suspended at a large height above the ground.

Initially, the rifle is aimed horizontally at the apple. AT THE INSTANT the gun is fired an electromagnet releases the apple so that it falls vertically. The path of the pellet from the gun and the vertical fall of the apple are shown in the diagram.

continued on the next page . . .

Question 3 (a) continued

3. (a) (i) Describe and explain the motion of the pellet from the instant the gun is fired. [Ignore the effects of air resistance.]

[2 marks]

continued on the next page . . .

Question 3 (a) continued

3. (a) (ii) The distance *D* is now increased and the experiment repeated. Describe one difference AND one similarity that an observer viewing the apple would see in this case.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 3 continued

3. (b) Look at the diagram for Question 3 (b) in the separate Diagram Booklet.

The diagram shows a person 'skimming' a stone across the surface of a still pond. A magnified view of part of the stone's motion is also shown. [Ignore the effects of air resistance.]

(i) Calculate v_H, the horizontal component of the velocity, u, given that the time taken for the stone to move from A to B is 0.40 s

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 3 (b) continued

3. (b) (ii) Calculate *h*, the maximum height achieved by the stone between A and B.

[4 marks]

continued on the next page . . .

Question 3 (b) continued

3. (b) (iii) Calculate the TOTAL energy of the stone at height, *h*, given that it has a mass of 0.10 kg.

[3 marks]

continued on the next page . . .

Question 3 continued

3. (c) The thrower believes that the stone loses 20 % of its energy every time it impacts with the water.

Investigate whether or not this is true FOR THE IMPACT AT B, given the fact that the stone's velocity just before impacting the water AT C is 3.3 m s^{-1}

[3 marks]

(Total for Question 3 = 15 marks)

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

The diagram shows a stress against strain graph for a ductile metal.

Identify and describe the key features SHOWN BY THIS GRAPH. Reference to atoms, ions or molecules is NOT REQUIRED.

[6 marks QER]

(Total for Question 4 = 6 marks)

5. (a) Newton's second law of motion is sometimes expressed as $\sum F = ma$

Explain the term $\sum F$ giving an example to illustrate your answer.

[2 marks]

continued on the next page . . .

Question 5 continued

5. (b) Look at the diagram for Question 5 (b) in the separate Diagram Booklet.
The diagram shows a crane lifting a concrete block.

The crane uses a steel cable to lift heavy objects on a building site.
The crane operator is told that the maximum safe lifting force of the crane is 16 000 N.

continued on the next page . . .

Question 5 (b) continued

5. (b) (i) A concrete block of mass 1 500 kg is attached to the crane. Calculate the maximum safe upward acceleration of the block.

[3 marks]

continued on the next page . . .

Question 5 (b) continued

5. (b) (ii) The crane operator assumes that the crane is safe to lift any load up to 16 000 N.

Discuss whether or not he is correct.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 5 continued

5. (c) The steel cable has a cross – sectional area of $2.0 \times 10^{-3}\ m^2$ and a Young modulus of $2.0 \times 10^{11}\ N\ m^{-2}$

As the concrete block moves UPWARDS the tension in the cable changes depending on whether the block is accelerating, decelerating or moving at constant speed. At one point in its motion the strain in the cable is 3.2×10^{-5}

Describe the motion of the block at this point. Explain your answer.

[4 marks]

(Total for Question 5 = 11 marks)

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

The diagram shows a toy train carriage, A, being accelerated from rest by an applied force in a straight line on a smooth track towards a stationary carriage, B.
A graph of momentum against time for carriage A is also shown.

(a) Estimate, from the graph, the resultant accelerating FORCE acting on carriage A at a time of 1.0 s.

[3 marks]

continued on the next page . . .

Question 6 continued

6. (b) Impact between carriage A and carriage B occurs between 2.8 s and 3.0 s.

Just before impact the applied force is removed. State how the graph confirms that the applied force is removed, and explain why its removal enables you to calculate the momentum given to carriage B.

[3 marks]

continued on the next page . . .

Question 6 continued

6. (c) (i) DRAW, ON THE GRAPH, a line showing the momentum of CARRIAGE B between 0 s and 4 s.

[3 marks]

(ii) Hence calculate the speed of CARRIAGE B after impact given that its mass is 0.16 kg.

[2 marks]

(Total for Question 6 = 11 marks)

7. (a) Look at the table for Question 7 (a) in the separate Diagram Booklet.
In the table, statements are given which describe different particles or interactions.

COMPLETE THE TABLE by naming the particle or interaction described.

[4 marks]

(b) An antiparticle has a quark composition of $\bar{u}\,\bar{d}\,\bar{d}$.

Determine its charge and identify the particle. Show your working clearly.

[2 marks]

continued on the next page . . .

Question 7 continued

7. (c) (i) Consider the following hypothetical interaction.

$$p + n \longrightarrow p + \bar{p} + p + \nu_e$$

The reaction is NOT POSSIBLE because it does not obey one or more of the conservation laws.
By considering baryon number, lepton number and charge, show which law(s) are obeyed and which are not.

[3 marks]

7. (c) (ii) Jon suggests that replacing the electron neutrino (ν_e) with a pi – zero pion (π^0) would allow the reaction to occur. Explain whether or not he is correct.

[1 mark]

(Total for Question 7 = 10 marks)

8. (a) The solar spectrum includes an absorption spectrum. Describe the appearance of this spectrum AND state where in the Sun the absorption occurs.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 8 continued

8. (b) Look at the diagram for question 8 (b) in the separate Diagram Booklet.
The diagram is a graph.

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

Use information from the graph to determine the total power emitted by the Sun.

[3 marks]

Question 8 continued

8. (c) Look at the diagram for Question 8 (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.

Determine whether or not the answer you obtained in part (b) and information which can be obtained from the above spectrum are consistent with each other.

[Surface area of the Sun = 6.2×10^{18} m^2]

[4 marks]

(Total for Question 8 = 9 marks)

END OF PAPER

TOTAL 80 MARKS

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

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 to the invigilators and sent for marking.

Diagram Booklet

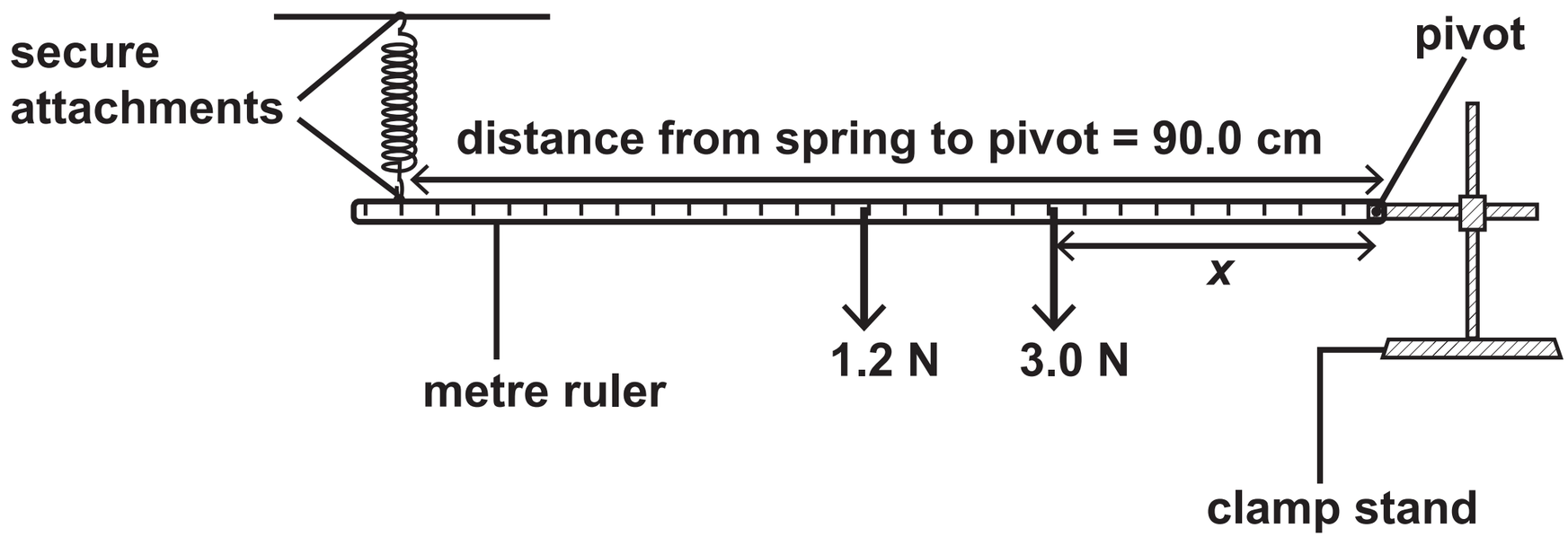
Surname: _____

First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

Question 1 (b)


secure
attachments
pivot
distance from spring to pivot = 90.0 cm
x
1.2 N
3.0 N
metre ruler
clamp stand

Question 1 (c)

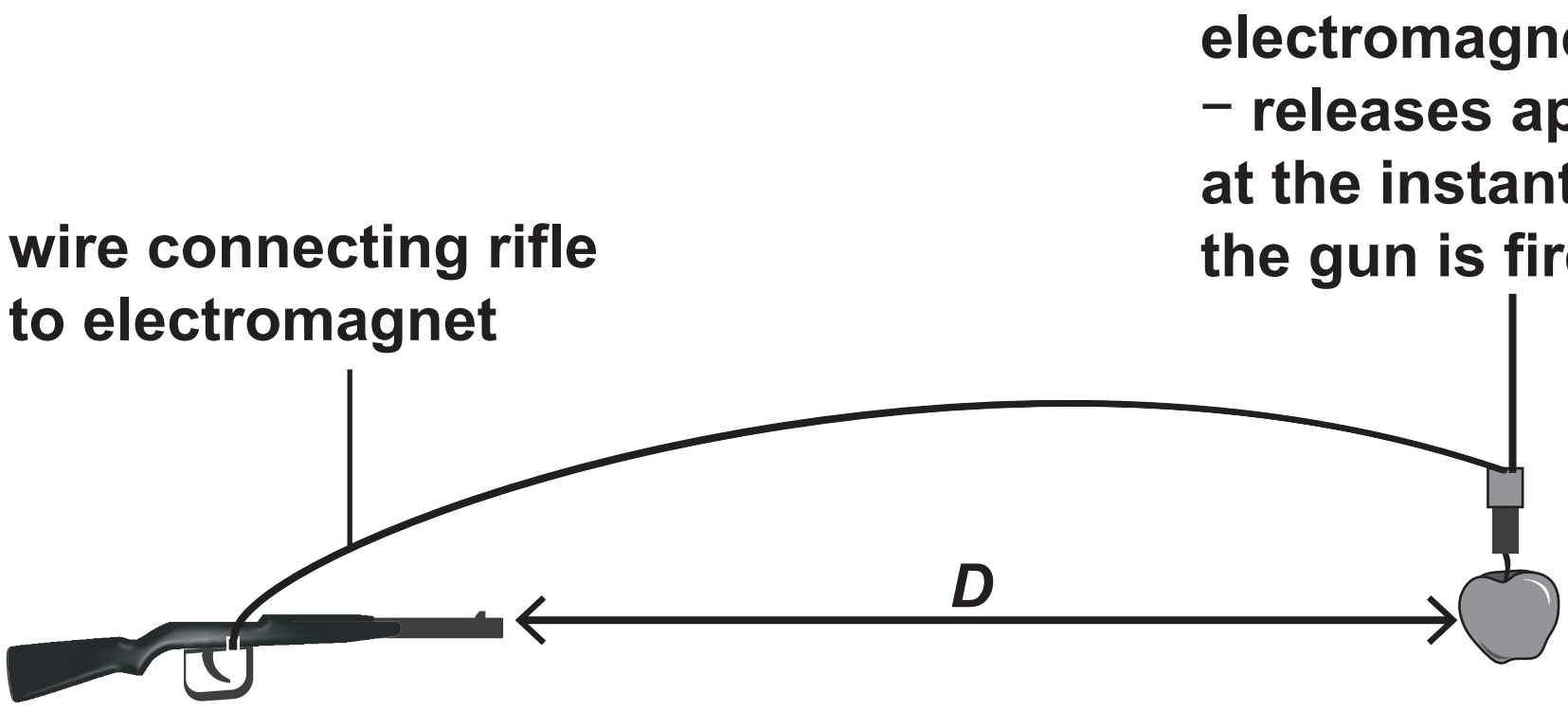
Question 2 (c)

Table

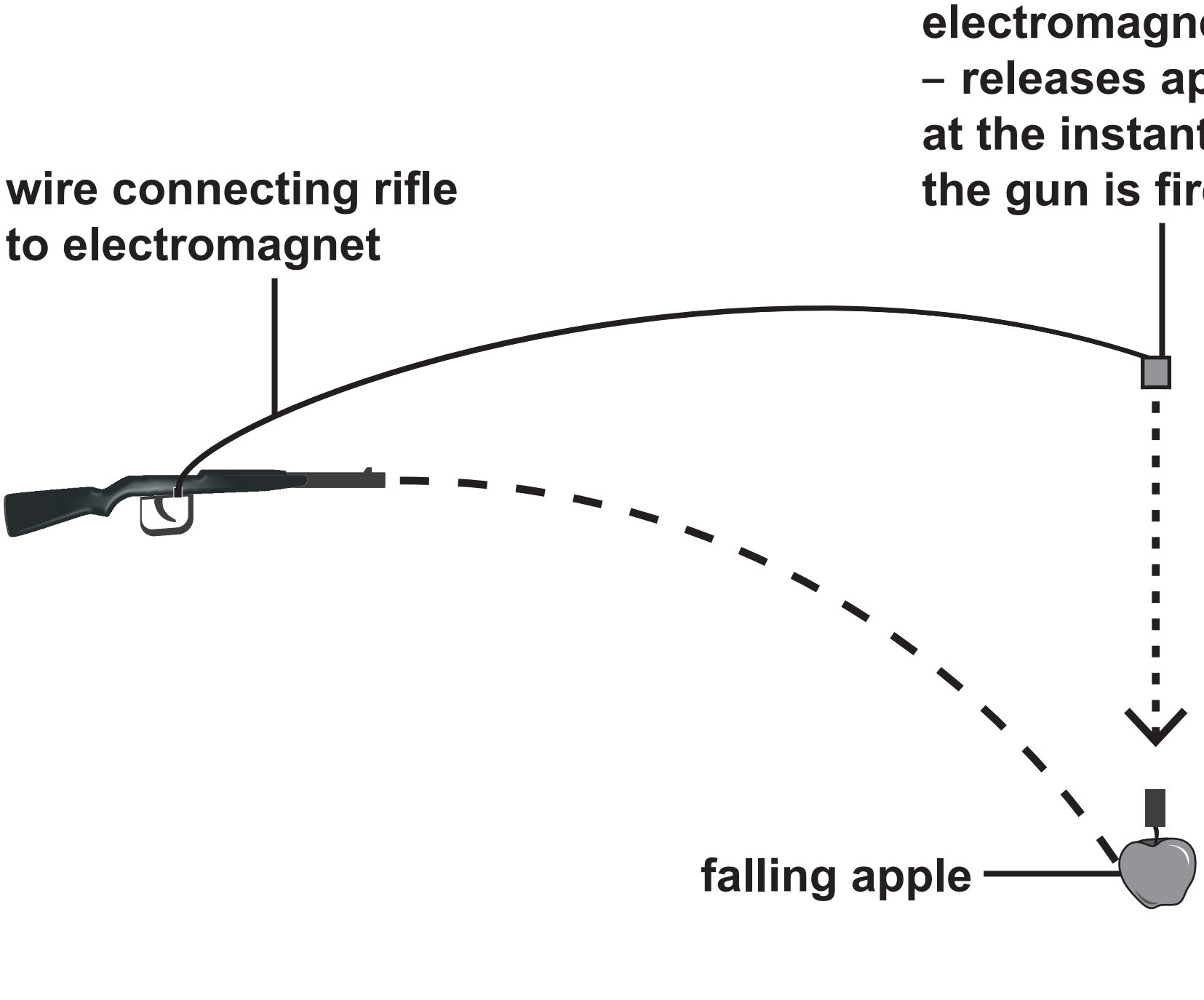
Metal	Density / g cm^{-3}
tin	7.3
stainless steel	7.5
iron	7.9
brass	8.3

Question 3 (a)

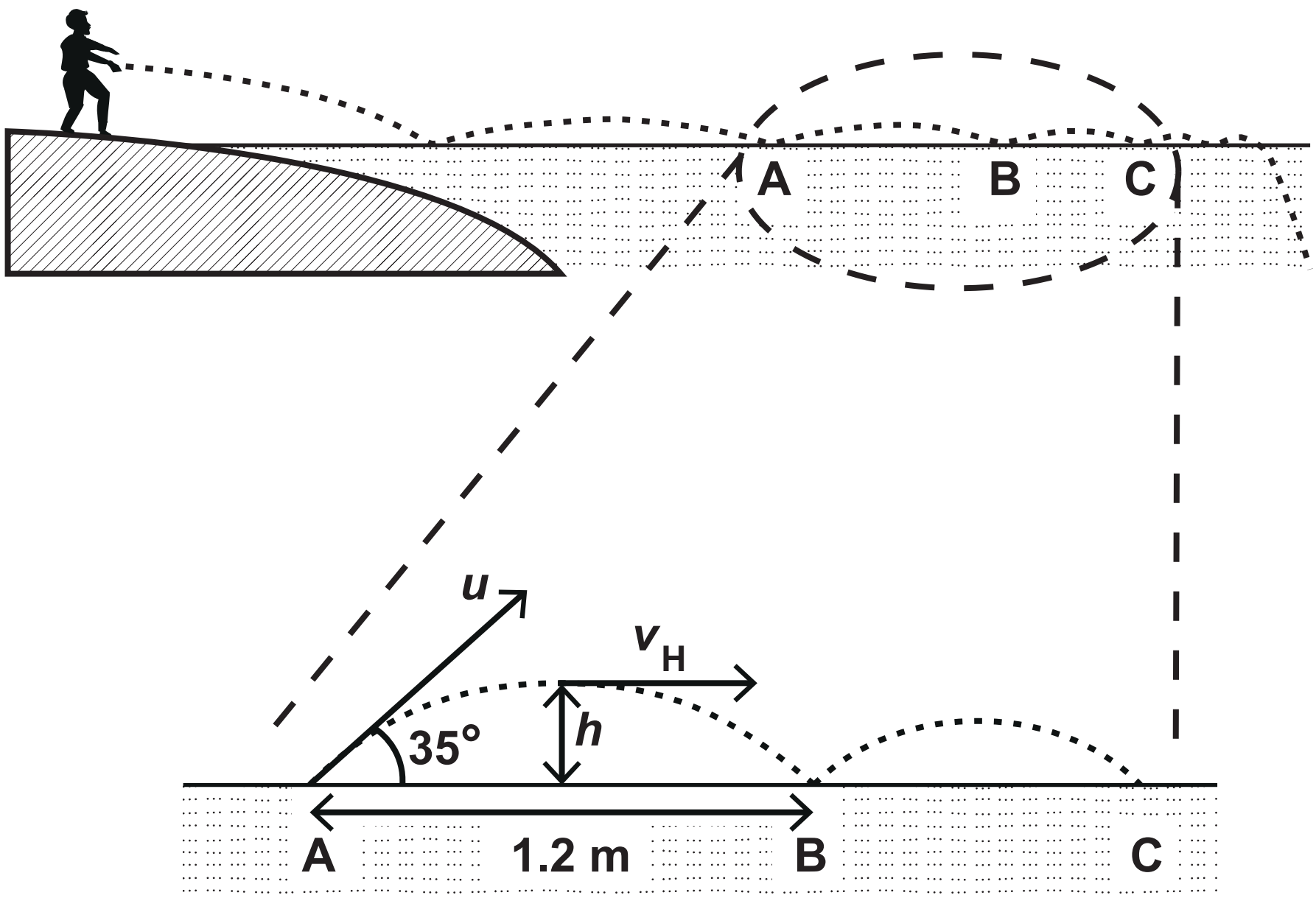
INITIAL SET-UP



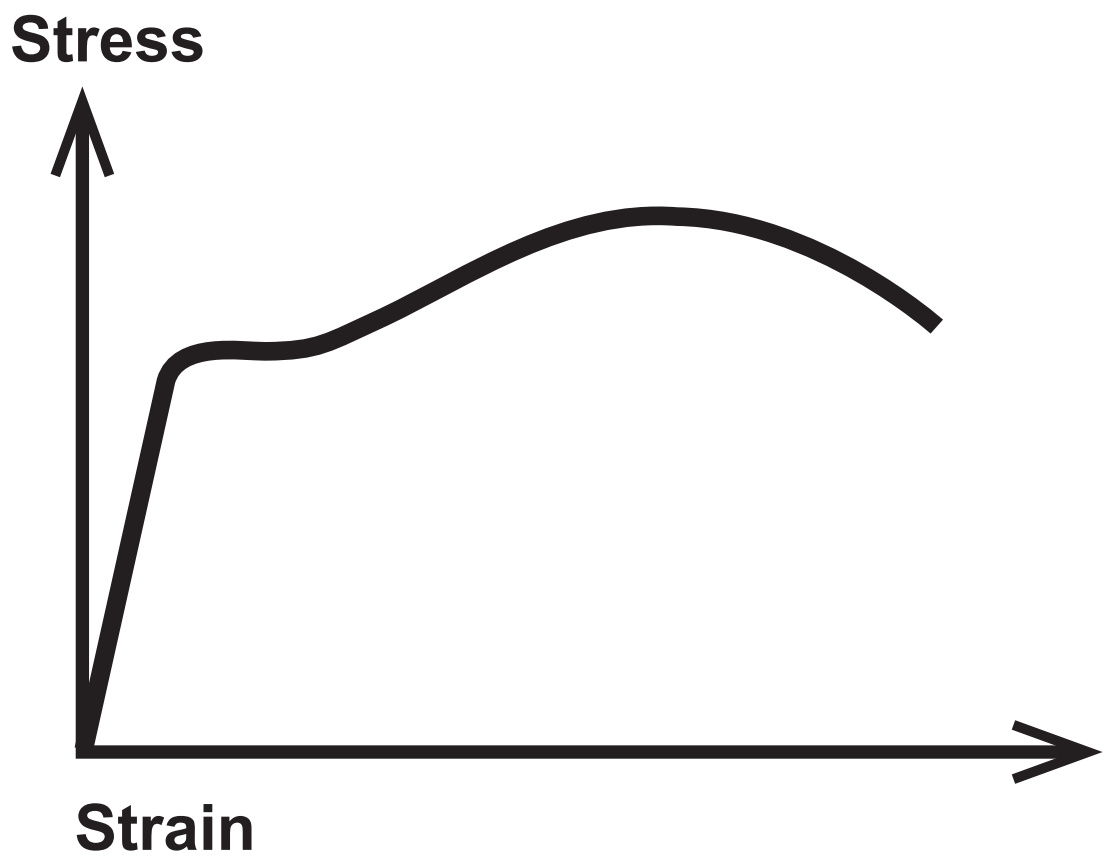
AFTER GUN IS FIRED



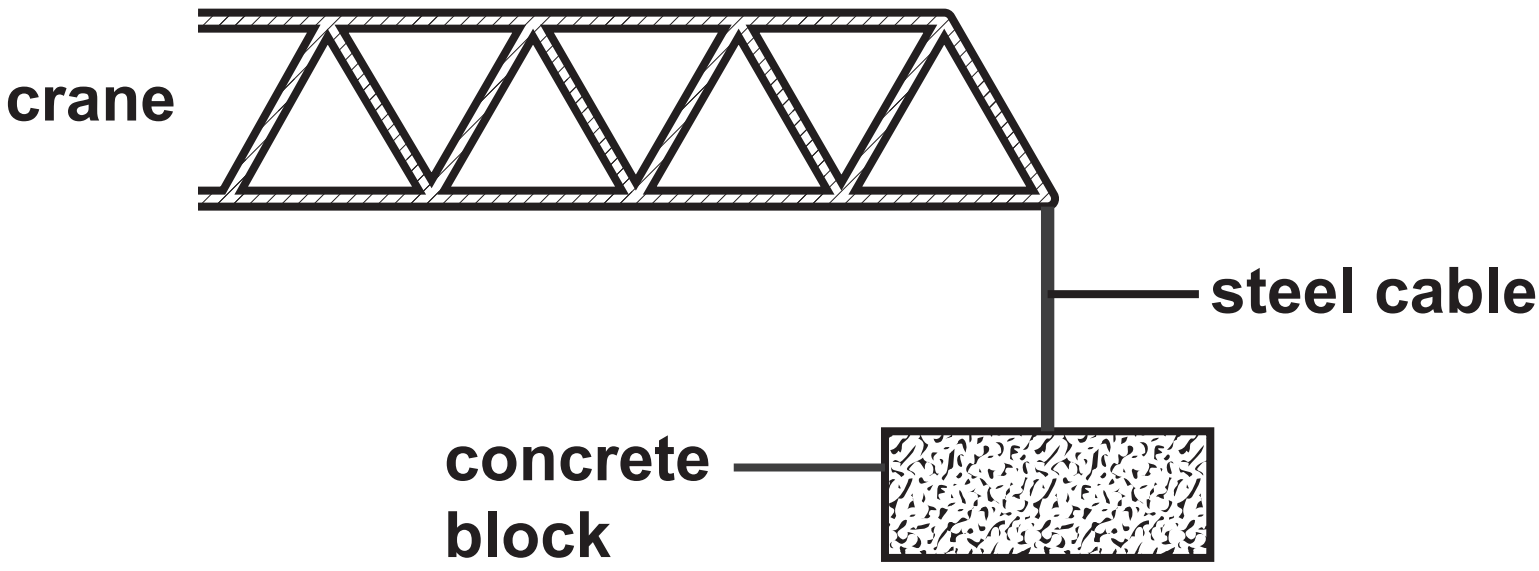
Question 3 (b)



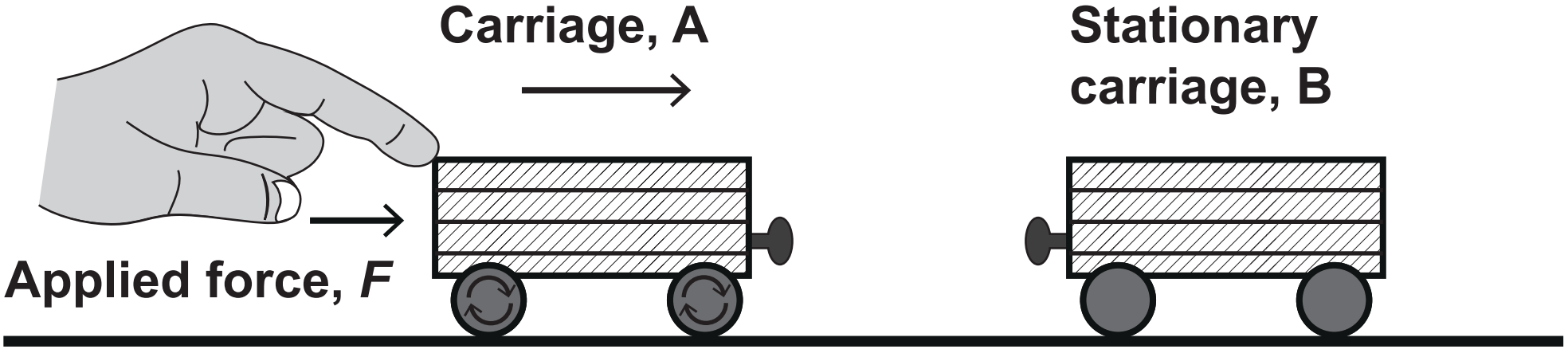
Question 4

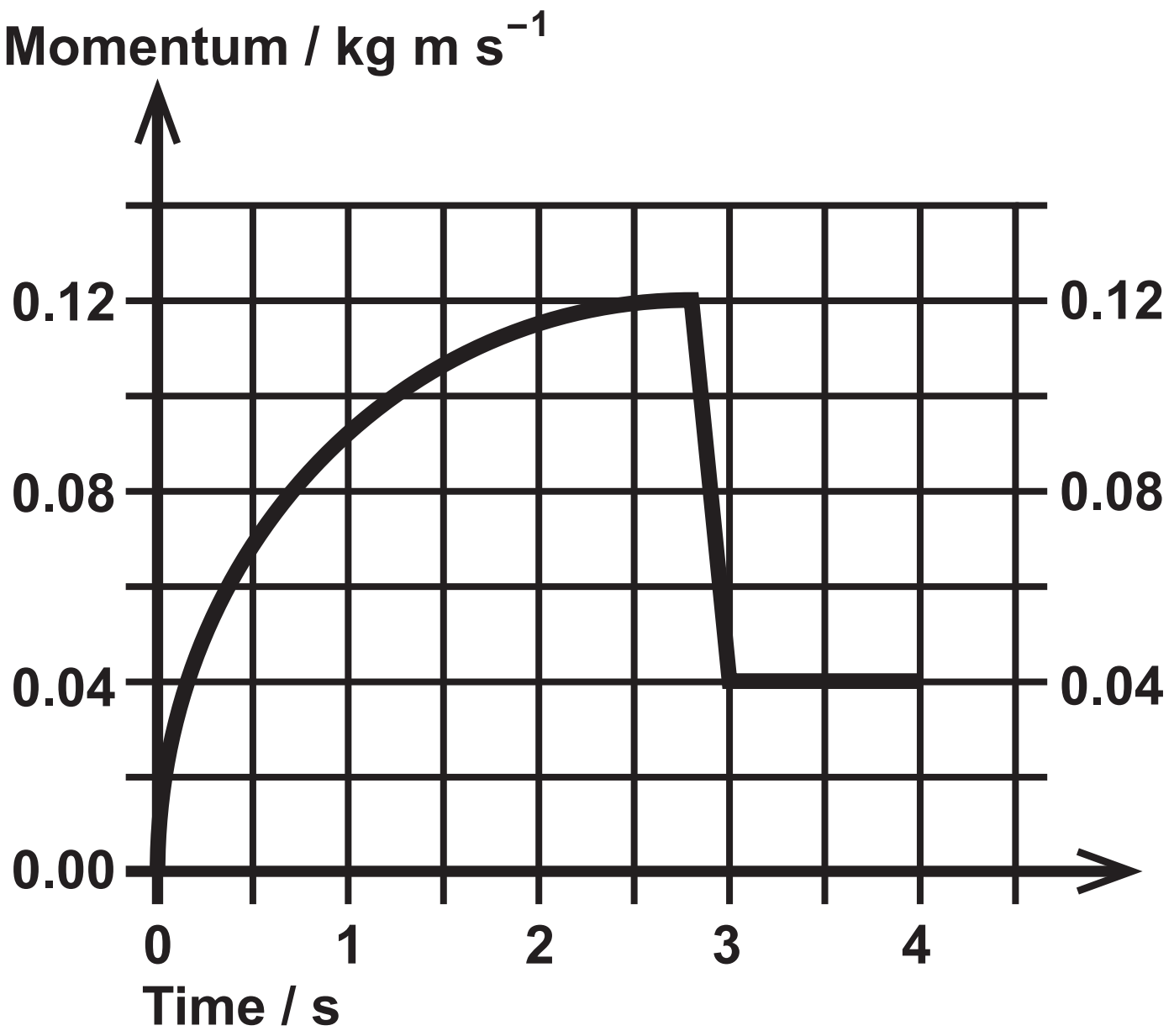


Question 5 (b)



Question 6


Carriage, A
Stationary carriage, B
Applied force, F

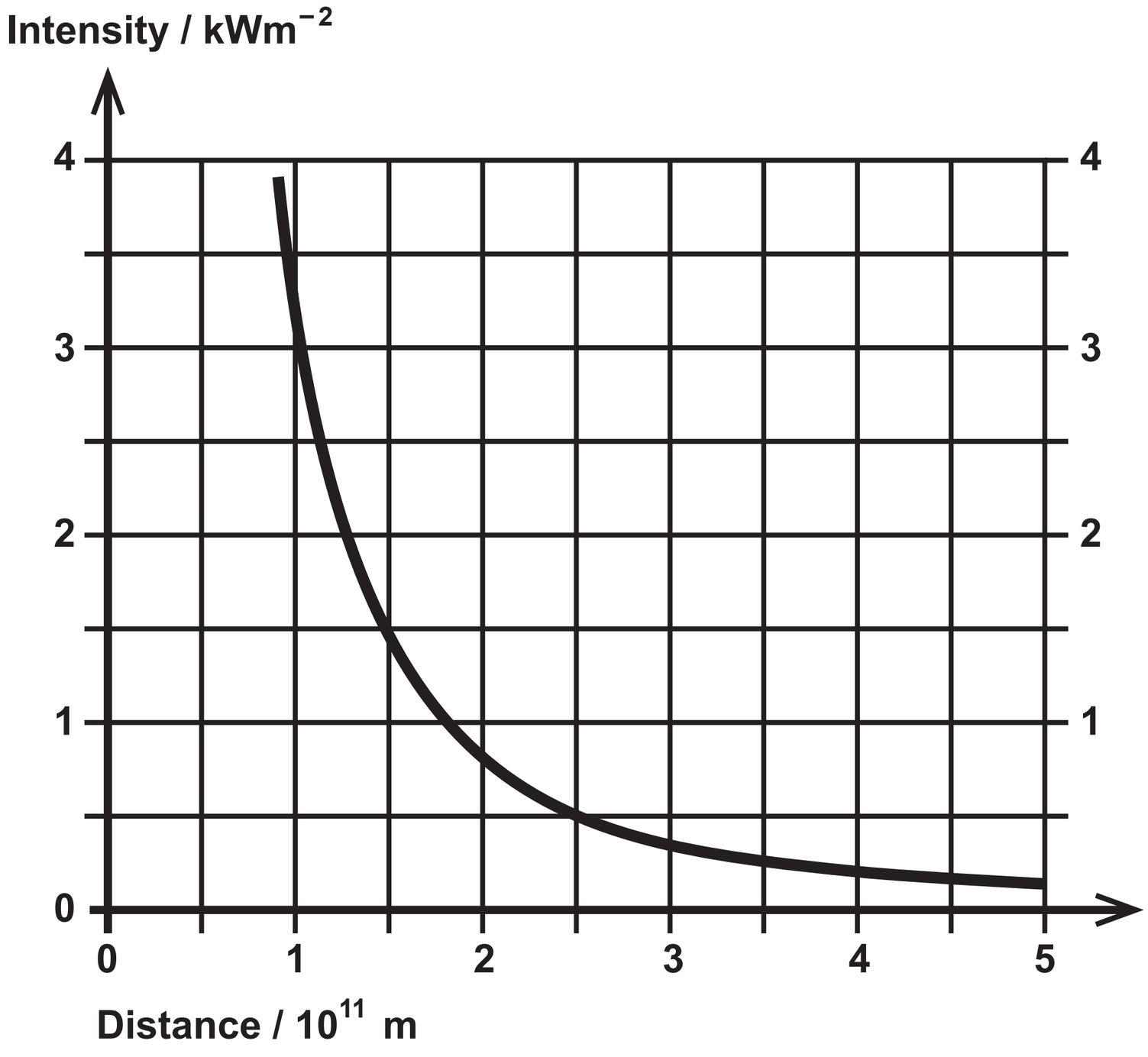

Momentum / kg m s−1
0.12
0.08
0.04
0.00
0
1
2
3
4
Time / s

Question 7 (a)

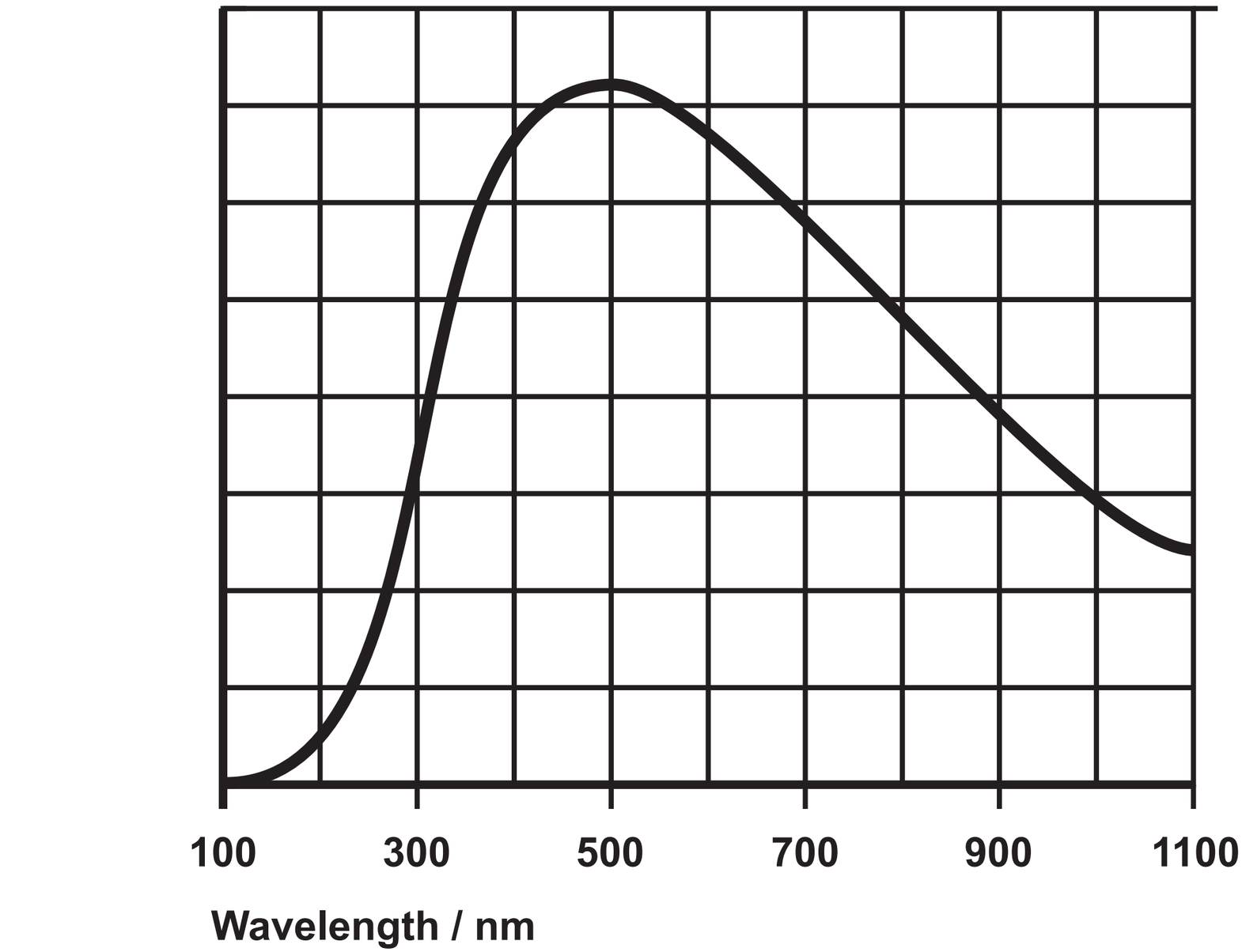
Table

Description of particle or type of interaction	Name of particle or interaction
The quark combination of this particle is u u d.	_____ _____
The electron and electron neutrino are examples of this group of particles.	_____ _____
Antibaryons are a combination of three of these.	_____ _____
Neutrino involvement and quark flavour changes are exclusive to this type of interaction.	_____ _____

Question 8 (b)



Question 8 (c)


Spectral intensity / arbitrary units
100
300
500
700
900
1100
Wavelength / nm