



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	

(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. 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 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.

(Turn over)

ANSWER ALL QUESTIONS.

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

[1 mark]

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 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.

continued on the next page . . .

(Turn over)

Question 1 (b) continued

The ruler is suspended by a spring of spring constant, $k = 20 \text{ N m}^{-1}$ 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.

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

(Turn over)

Question 1 (b) continued

(Turn over)

[4 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 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}

continued on the next page . . .

(Turn over)

Question 1 (c) continued

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

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

12

[2 marks]

(Total for Question 1 = 7 marks)

(Turn over)

- 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.

continued on the next page . . .

(Turn over)

Question 2 continued

He obtains the following values:

Diameter of ball bearing

$$= 18.76 \pm 0.02 \text{ mm}$$

Mass of ball bearing

$$= 26.3 \pm 0.5 \text{ g}$$

continued on the next page . . .

(Turn over)

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

$$\mathbf{= 3.4 \pm 0.1 \text{ cm}^3}$$

$$\mathbf{\text{Mass of ball bearing} = 26.3 \pm 0.5 \text{ g}}$$

continued on the next page . . .

(Turn over)

Question 2 continued

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%**

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

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.

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

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.**

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

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.

continued on the next page . . .

(Turn over)

Question 2 (c) continued

2. (c) Explain how Tomos' conclusion differs from Jerry's.

[2 marks]

(Total for Question 2 = 11 marks)

(Turn over)

- 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.

continued on the next page . . .

(Turn over)

Question 3 (a) continued

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 . . .

(Turn over)

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 . . .

(Turn over)

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.**

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

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.]

continued on the next page . . .

(Turn over)

Question 3 (b) continued

3. (b) (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 . . .

(Turn over)

Question 3 (b) continued

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

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

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.**

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

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}

(Turn over)

[3 marks]

(Total for Question 3 = 15 marks)

(Turn over)

- 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.

(Turn over)

[illegible]

(Turn over)

(Total for Question 4 = 6 marks)

(Turn over)

5. (a) Newton's second law of motion is sometimes expressed as

$$\Sigma F = ma$$

Explain the term ΣF giving an example to illustrate your answer.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

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 . . .

(Turn over)

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.**

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

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 . . .

(Turn over)

Question 5 continued

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

continued on the next page . . .

(Turn over)

Question 5 (c) continued

**Describe the motion of the
block at this point.**

Explain your answer.

(Turn over)

48

[4 marks]

(Total for Question 5 = 11 marks)

(Turn over)

- 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.

continued on the next page . . .

(Turn over)

Question 6 continued

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

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

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.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

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]

continued on the next page . . .

(Turn over)

Question 6 (c) continued

**6. (c) (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)

(Turn over)

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]

continued on the next page . . .

(Turn over)

Question 7 continued

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

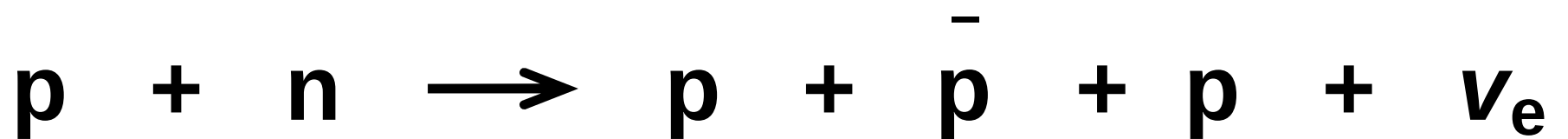
Determine its charge and identify the particle. Show your working clearly.

[2 marks]

(Turn over)

Question 7 continued

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



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.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 7 (c) continued

- 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.**

(Turn over)

61

[1 mark]

(Total for Question 7 = 10 marks)

(Turn over)

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 . . .

(Turn over)

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.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

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.

continued on the next page . . .

(Turn over)

Question 8 (c) continued

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
= $6.2 \times 10^{18} \text{ m}^2$]**

(Turn over)

[4 marks]

(Total for Question 8 = 9 marks)

END OF PAPER

TOTAL 80 MARKS

(Turn over)

[illegible]

(Turn over)

[illegible]

(Turn over)

[illegible]

(Turn over)

[illegible]



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**The Diagram Booklet MUST
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and sent for marking.**

Diagram Booklet

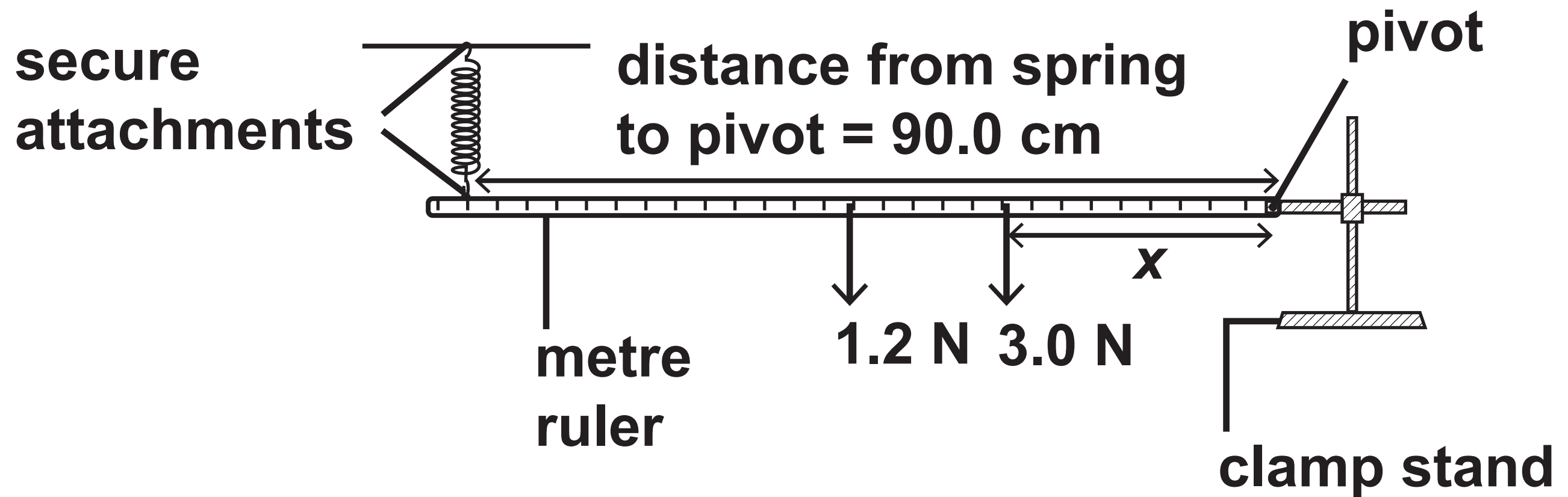
Surname: _____

First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

Question 1 (b)



Question 1 (c)



Question 2 (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

wire connecting rifle
to electromagnet

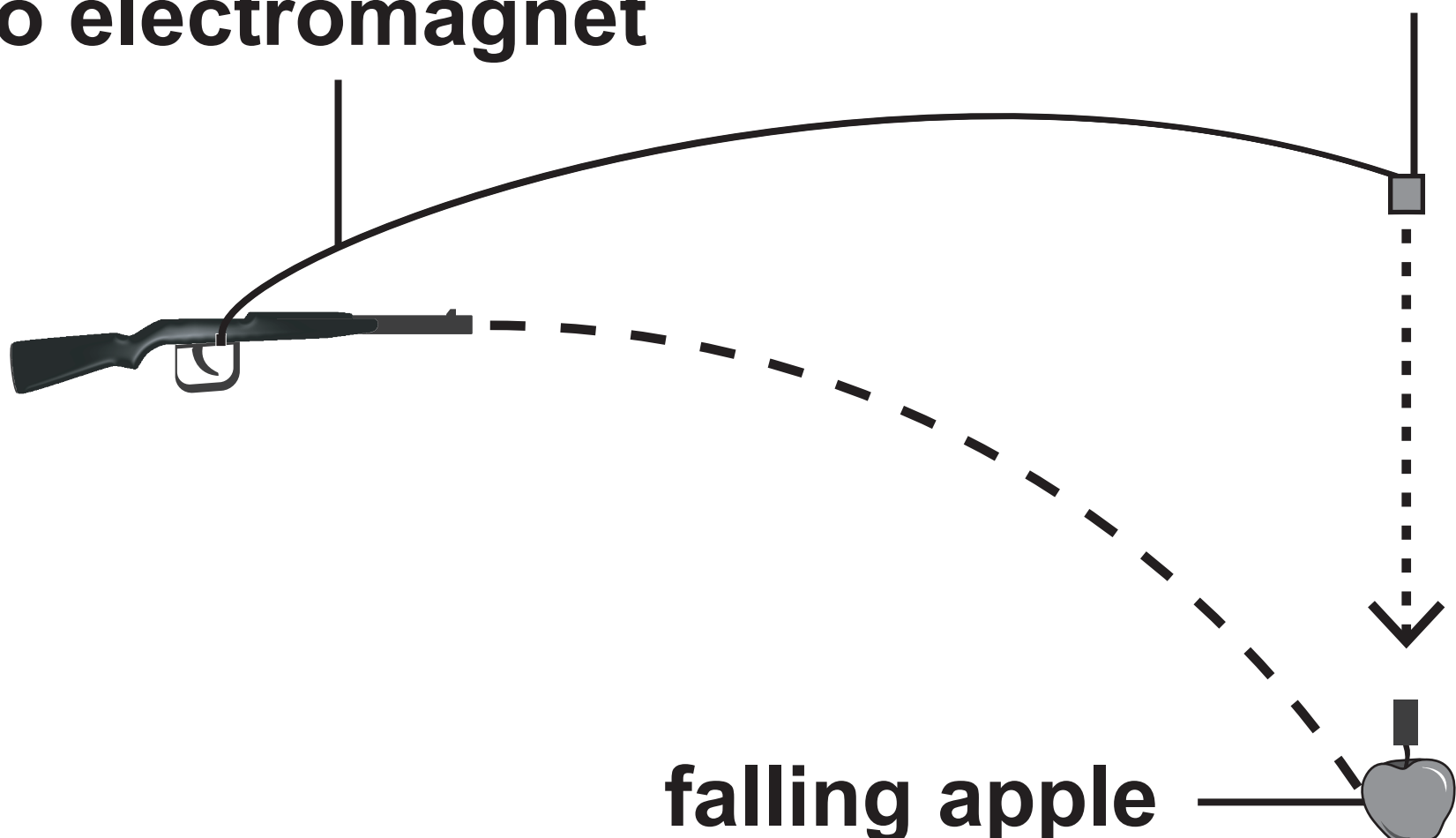
electromagnet
– releases apple
at the instant
the gun is fired



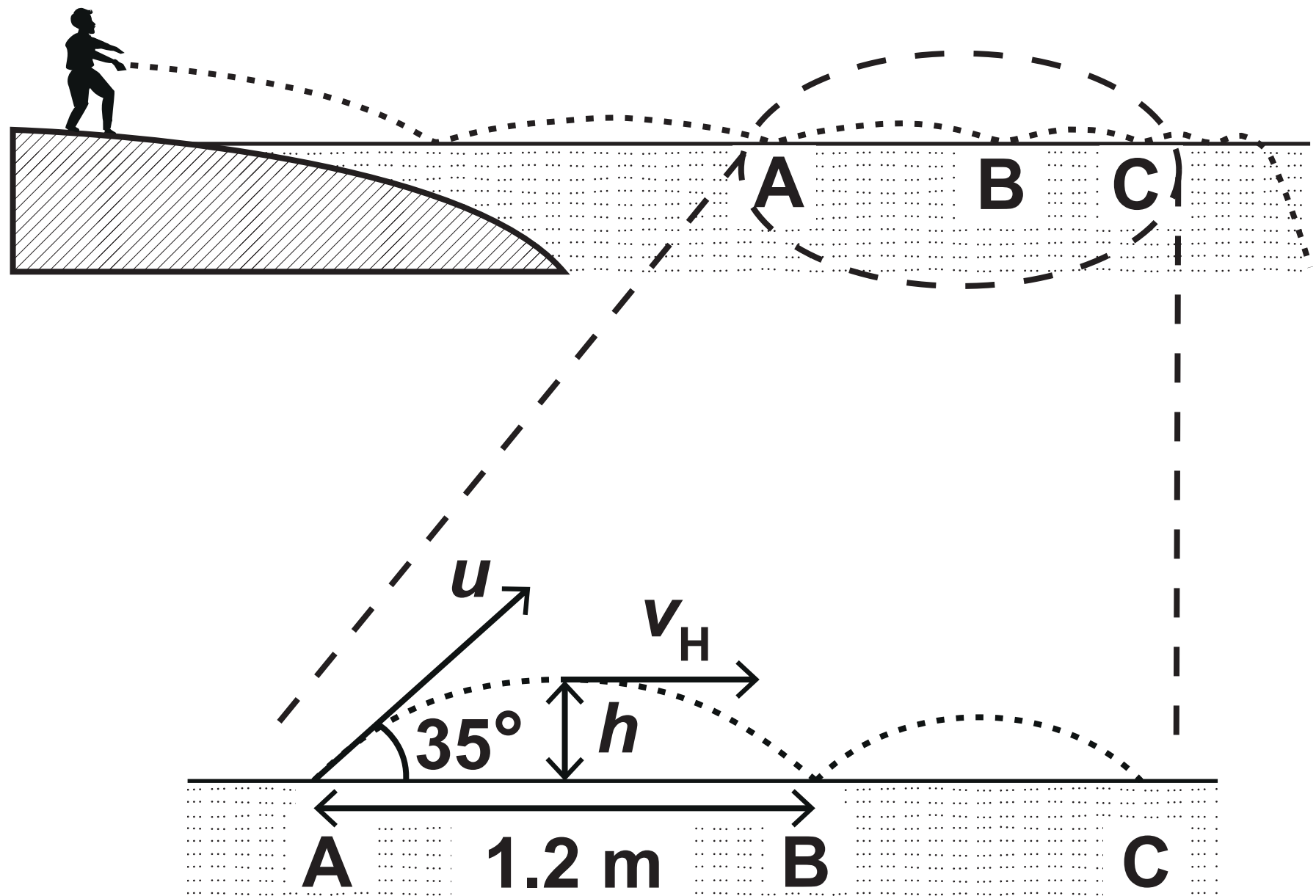
AFTER GUN IS FIRED

wire connecting rifle
to electromagnet

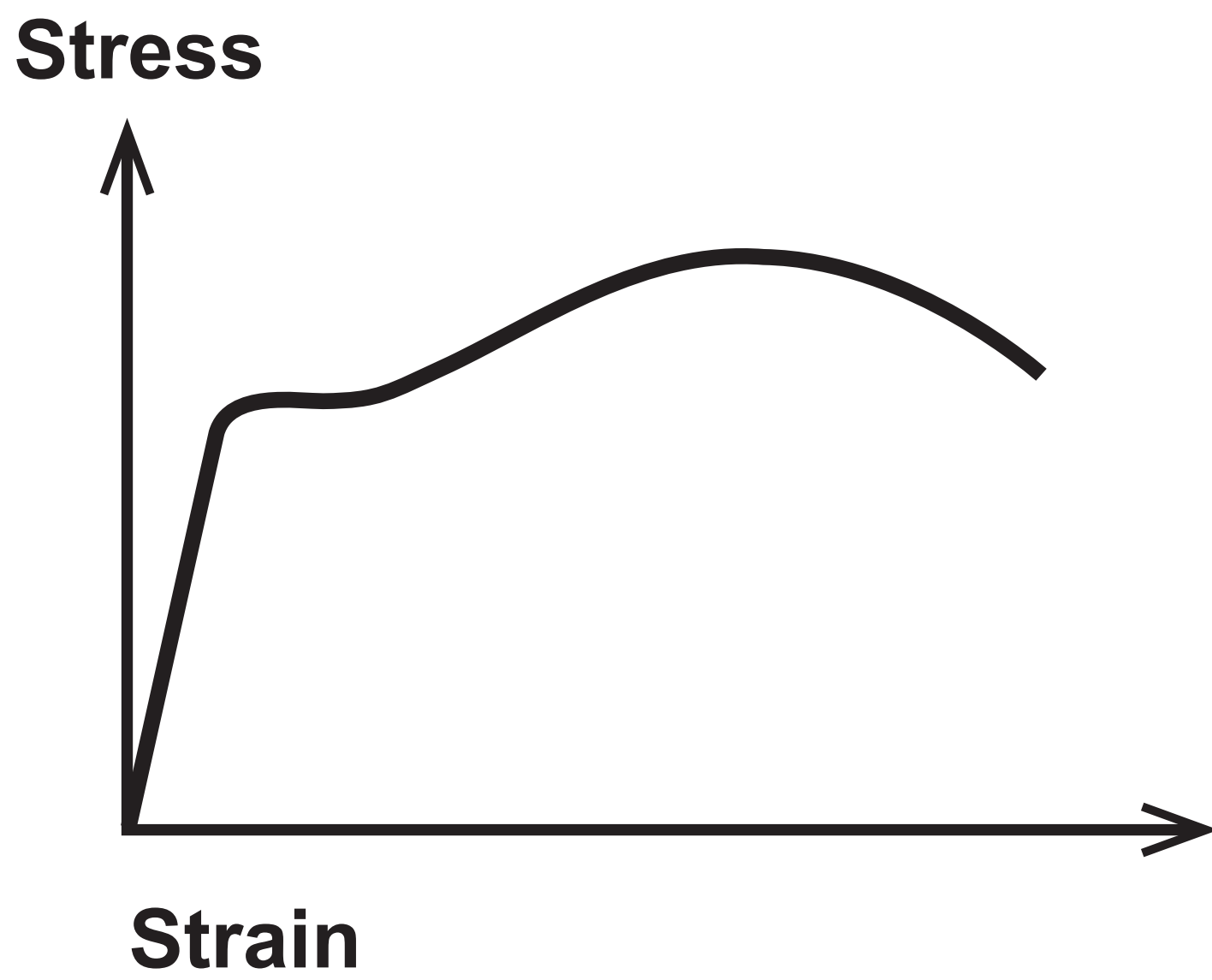
electromagnet
– releases apple
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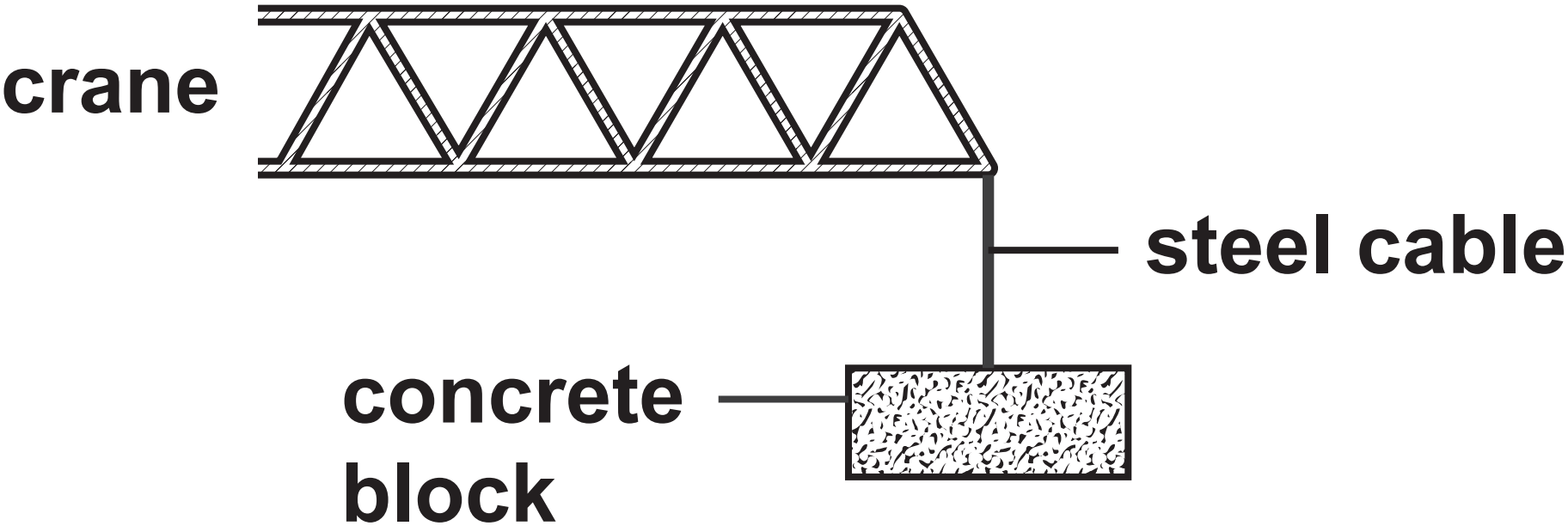
Question 3 (b)



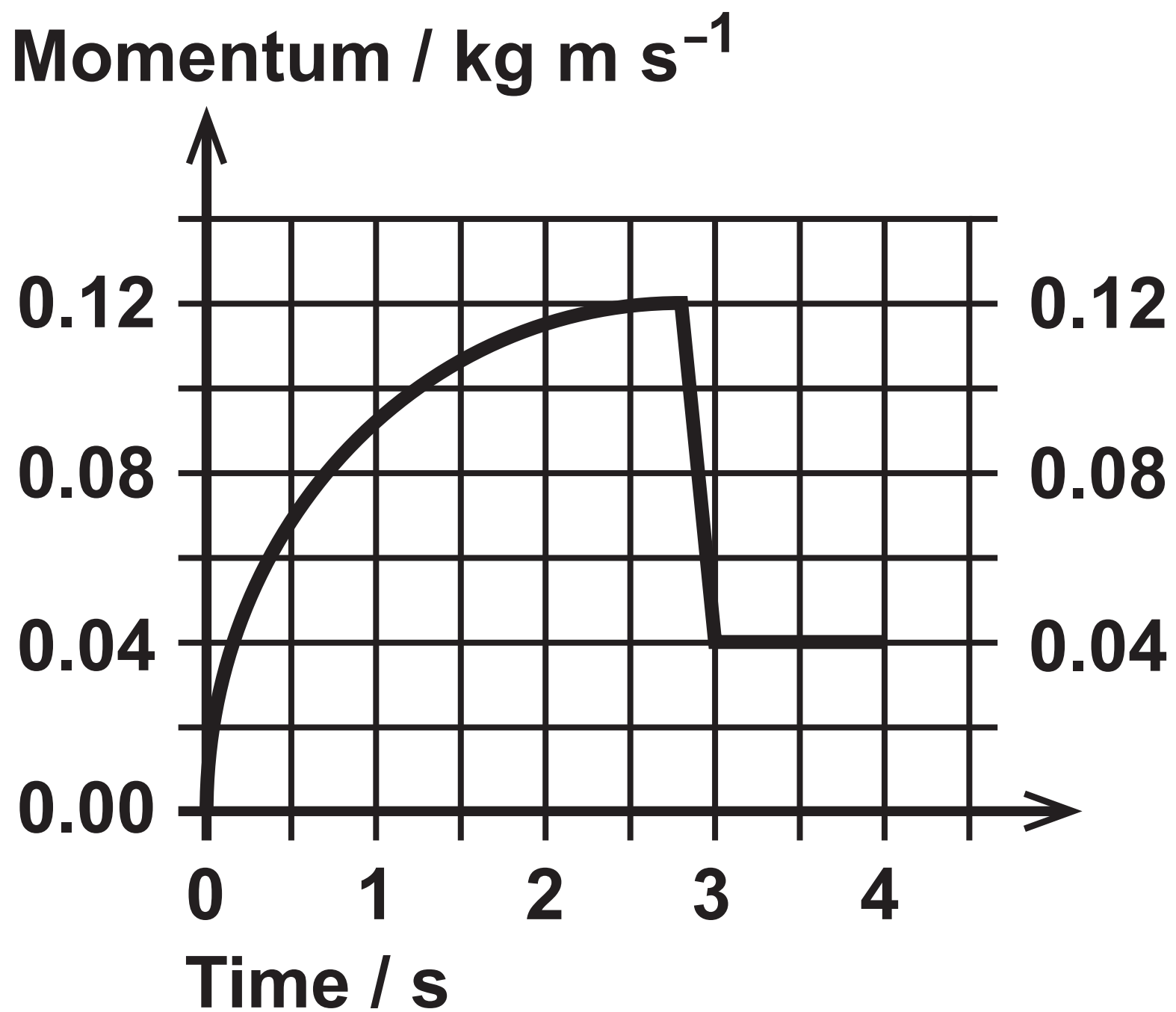
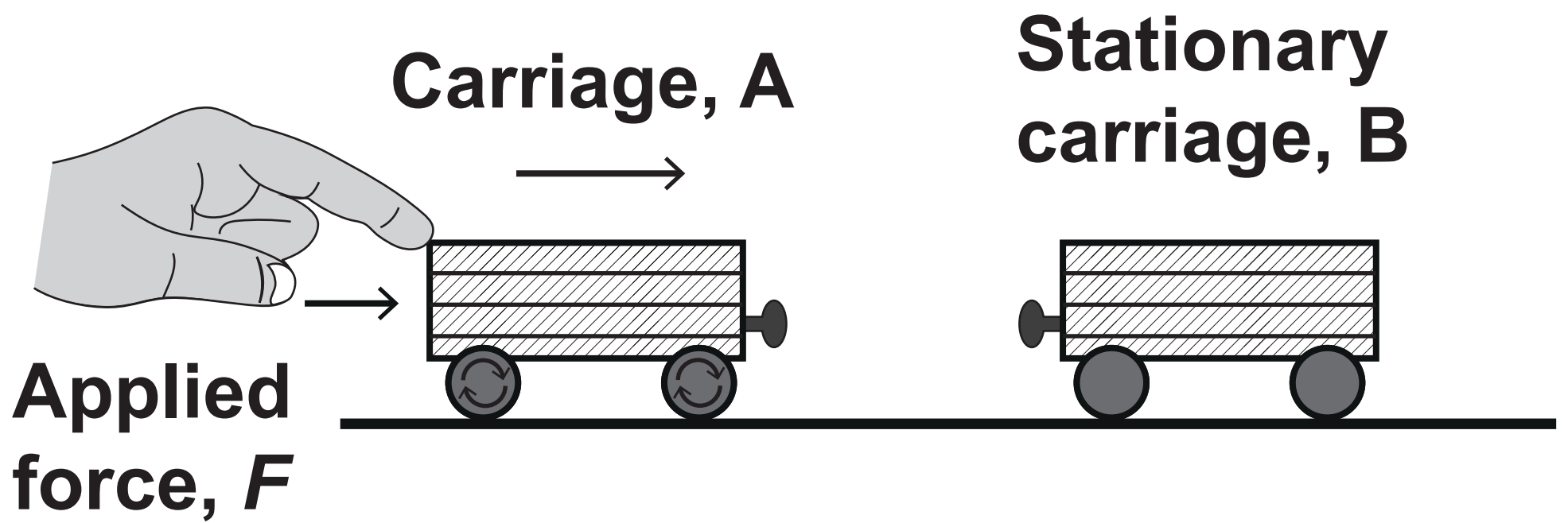
Question 4



Question 5 (b)



Question 6

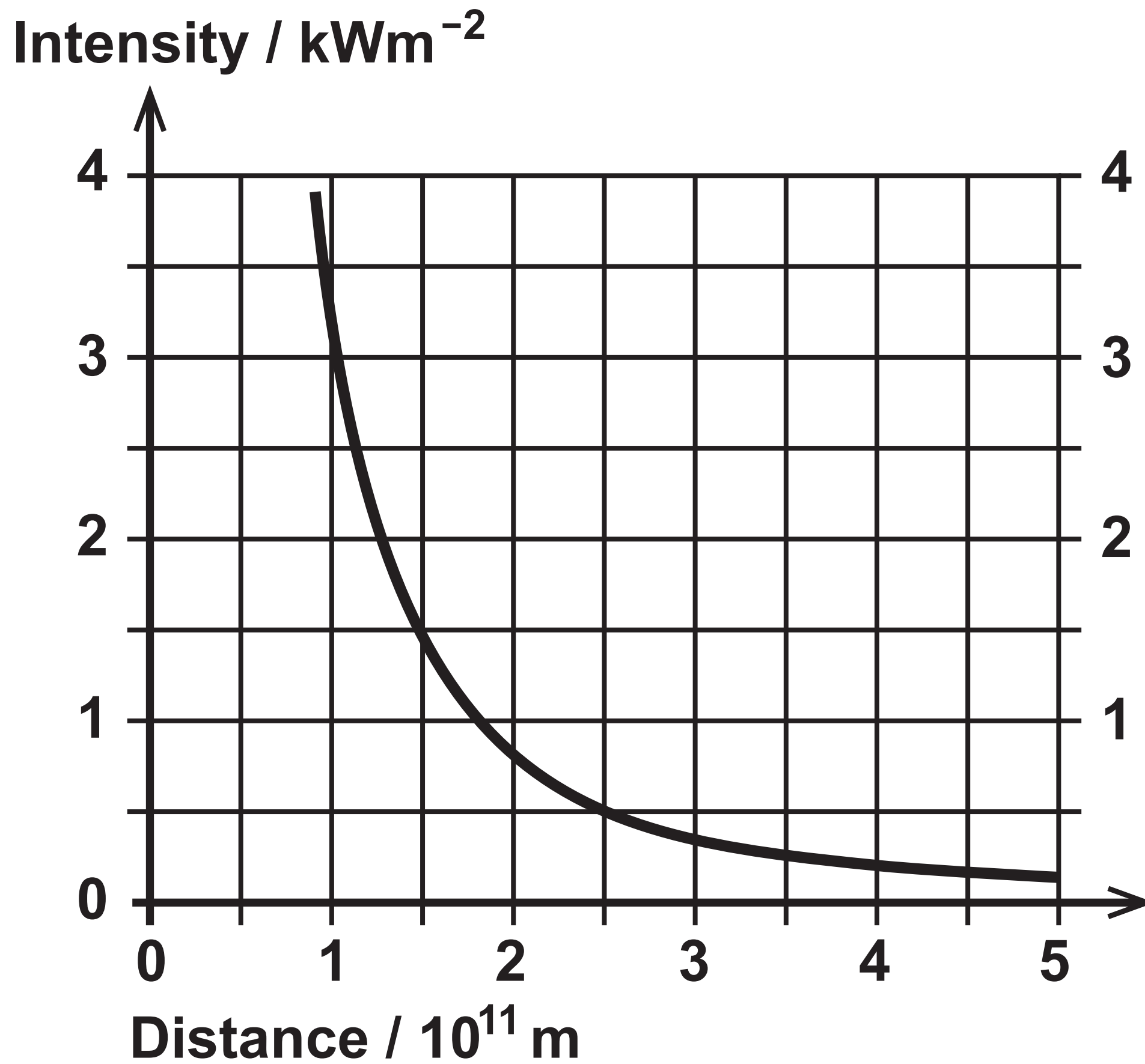


Question 7 (a)

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

