



Surname _____

Forename(s) _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

I declare this is my own work.

AS

PHYSICS

Paper 1

7407/1

Wednesday 15 May 2024 Morning

Time allowed: 1 hour 30 minutes

[Turn over]



BLANK PAGE



On the front of this book, write your surname and forename(s), your centre number, your candidate number and add your signature.

MATERIALS

For this paper you must have:

- **a pencil and a ruler**
- **a scientific calculator**
- **a Data and Formulae Booklet**
- **a protractor.**

[Turn over]



INSTRUCTIONS

- **Use black ink or black ball-point pen.**
- **Answer ALL questions.**
- **You must answer the questions in the spaces provided. Do not write on blank pages.**
- **If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).**
- **Do all rough work in this book. Cross through any work you do not want to be marked.**
- **Show all your working.**



INFORMATION

- **The marks for questions are shown in brackets.**
- **The maximum mark for this paper is 70.**
- **You are expected to use a scientific calculator where appropriate.**
- **A Data and Formulae Booklet is provided as a loose insert.**

DO NOT TURN OVER UNTIL TOLD TO DO SO

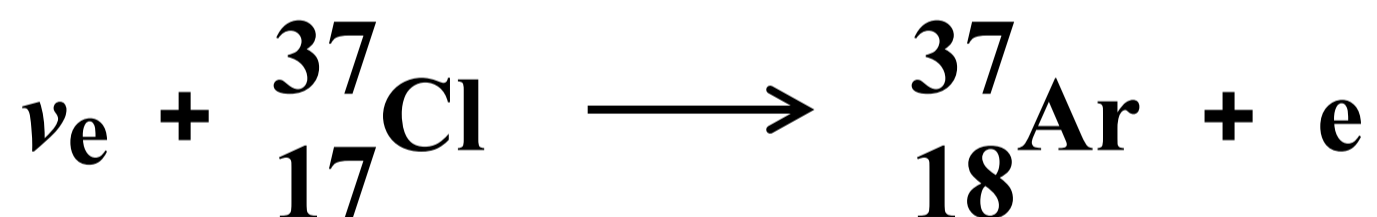


Answer ALL questions in the spaces provided.

0	1
----------	----------

An electron neutrino interacts with a chlorine-37 nucleus to produce an argon-37 nucleus and an electron.

The interaction is represented by the equation:



0	1	.	2
---	---	---	---

Calculate the specific charge of the argon-37 nucleus. [2 marks]

specific charge = _____ C kg⁻¹



BLANK PAGE

[Turn over]

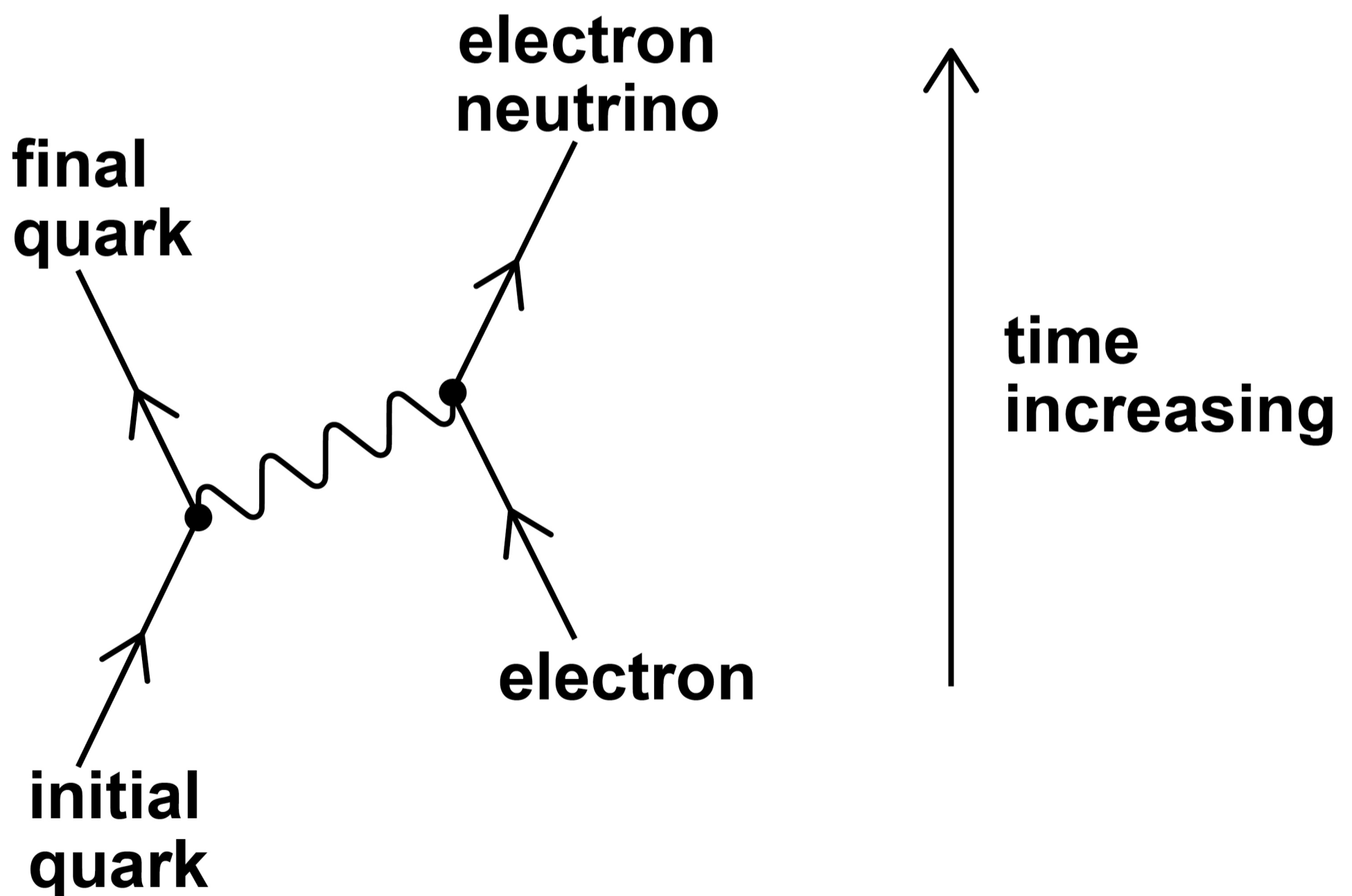


01.3

In a different interaction, the argon-37 nucleus interacts with an electron.

FIGURE 1 represents the interaction of a quark in a baryon of the nucleus.

FIGURE 1



Deduce the exchange particle and the effect on the baryon.

Give ONE reason to support each answer. [4 marks]

exchange particle _____

reason _____

effect on baryon _____

[Turn over]



reason _____



BLANK PAGE

[Turn over]



01.4

The argon-37 nucleus decays into a stable nucleus.

Describe the nature of the forces that act between nucleons and how these forces can maintain nuclear stability.

In your answer, describe:

- the forces of repulsion and attraction that act between nucleons**
- exchange particles associated with these forces**
- the role of these forces in keeping the nucleus stable.**

[6 marks]



0	2
---	---

A tube contains a vapour of mercury atoms at low pressure. In an experiment, the vapour is bombarded by a beam of electrons.

An electron in the beam gains 6.7 eV of kinetic energy by moving through a potential difference V .

0	2	.	1
---	---	---	---

Deduce V . [1 mark]

$V =$ _____ **V**

[Turn over]



The electron collides with a mercury atom. The atom subsequently emits a photon of ultraviolet radiation with an energy of 6.7 eV.

0 2 . 2

Calculate the wavelength of the emitted photon of this ultraviolet radiation.
[3 marks]

wavelength = _____ m



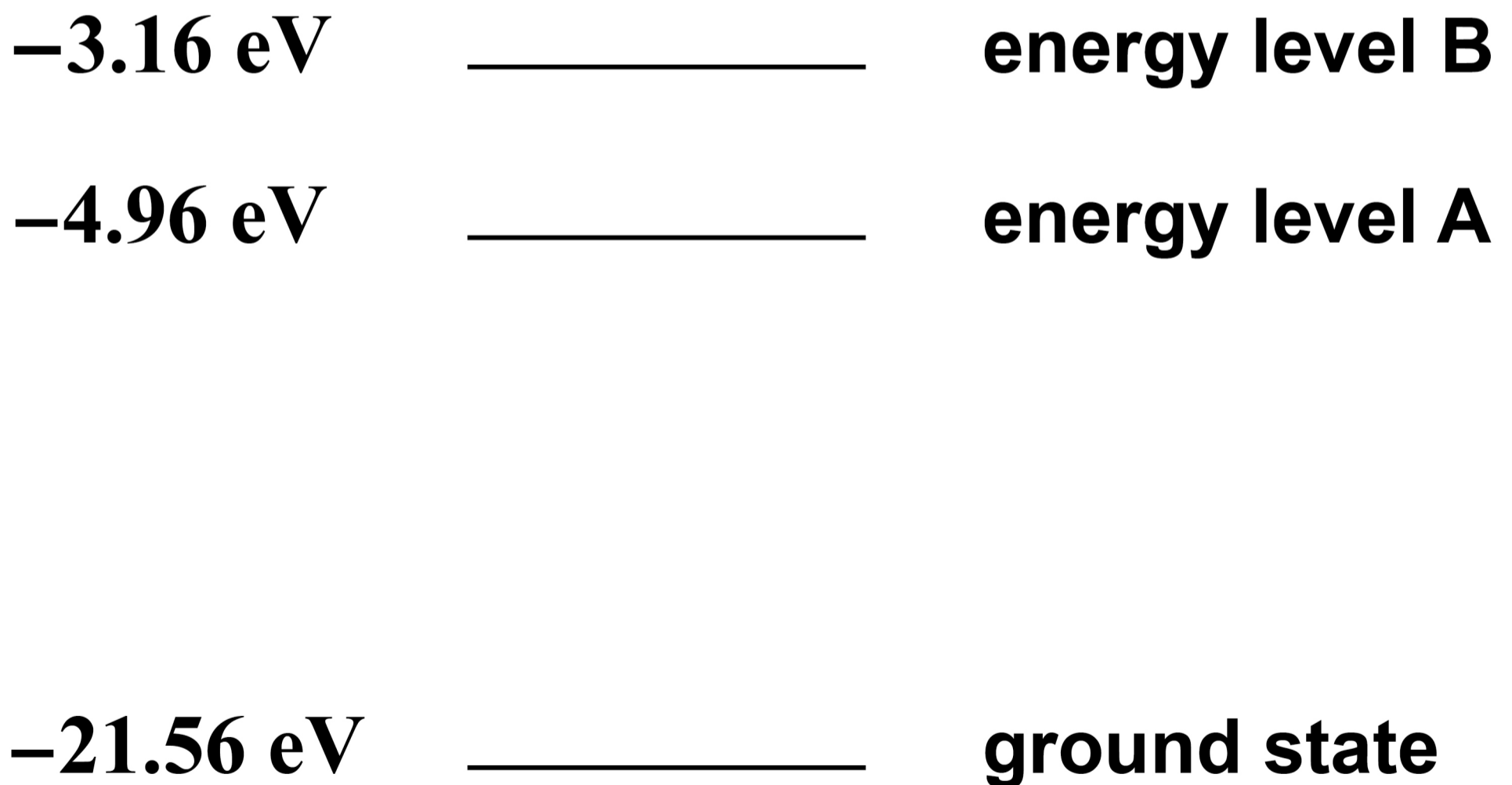
0 2 . 3

The experiment is repeated with a different gas.

FIGURE 2 shows the three lowest energy levels for an atom of the gas.

FIGURE 2

The diagram is NOT drawn to scale.



[Turn over]



When an electron in the beam collides with the gas atom, 18.4 eV of energy is transferred to the atom.

The atom subsequently emits a photon of visible light.

State and explain the energy transitions that are involved.

Support your answer with appropriate calculations. [4 marks]



0	3
---	---

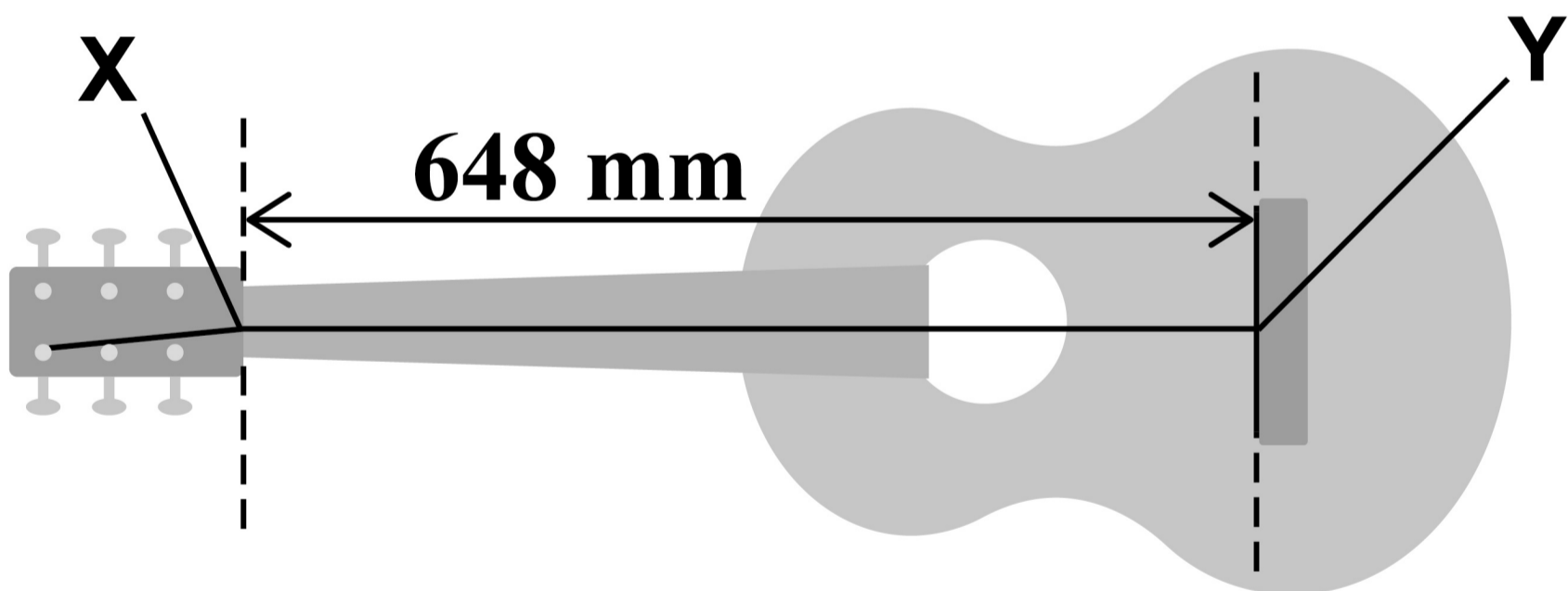
FIGURE 3 shows a guitar with only one of its strings attached.

The string is fixed at **X** and **Y**.

The string is plucked and vibrates freely between **X** and **Y**.

The distance **XY** is 648 mm.

FIGURE 3



0	3	.	1
---	---	---	---

The frequency of the first harmonic is 147 Hz.

Calculate the speed of the wave travelling in the string. [2 marks]

speed of wave = _____ m s^{-1}

[Turn over]



0	3	.	2
---	---	---	---

The tension in the string is 71 N.

Calculate the mass of the string between X and Y. [3 marks]

mass = _____ kg



The sound produced by the guitar is analysed.

The sound is the superposition of the first harmonic f_1 with harmonics f_2, f_3, f_4 and f_5 of the stationary waves that exist on the string.

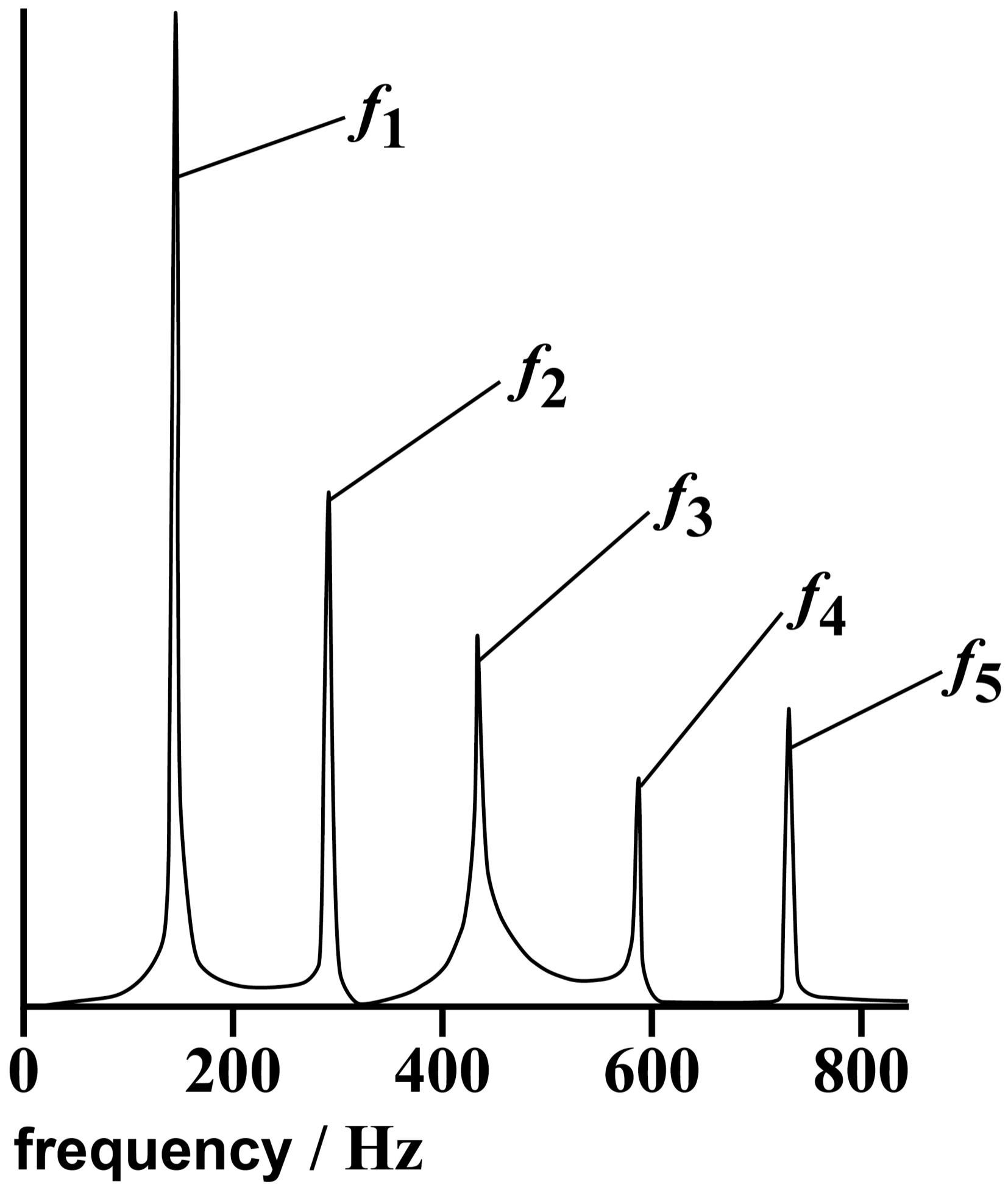
FIGURE 4, on page 28, shows the frequencies of these harmonics and their relative amplitudes.

[Turn over]



FIGURE 4

relative amplitude

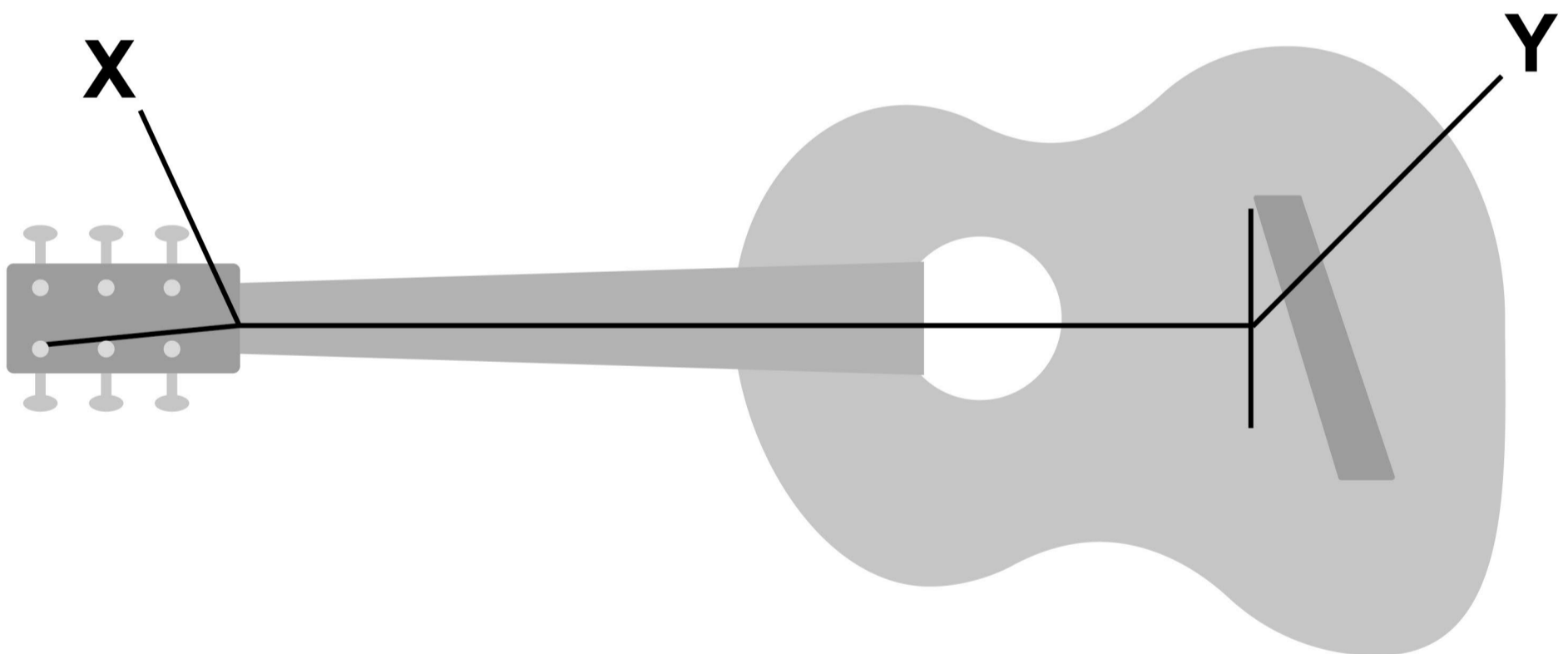


0	3	.	3
---	---	---	---

Draw, on FIGURE 5, the stationary wave that produces the harmonic f_3 .

Label the positions of all nodes N and all antinodes A. [3 marks]

FIGURE 5



[Turn over]



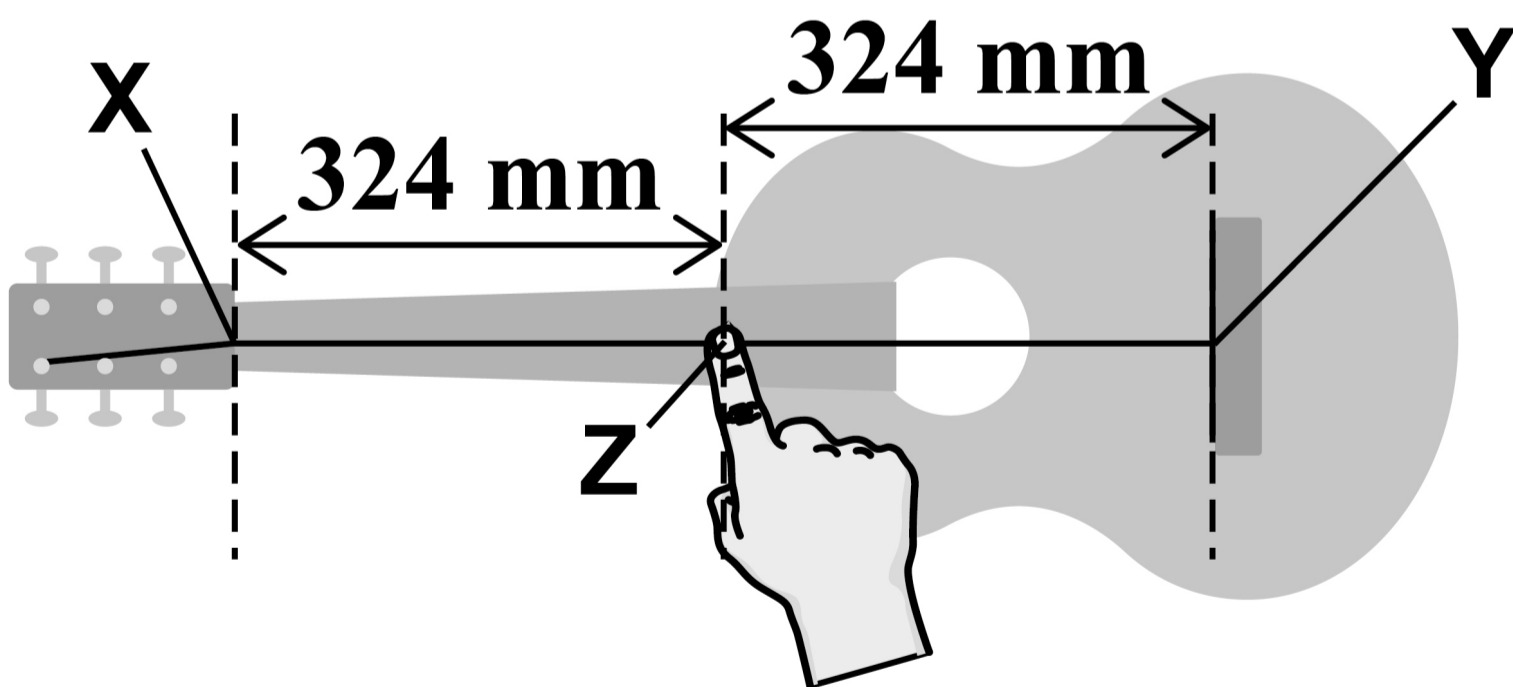
0 3 . 4

The string is vibrating freely.

The player then touches the string lightly at its midpoint **Z** as shown in **FIGURE 6**. This prevents the string from vibrating at **Z**.

The sections **XZ** and **ZY** of the string continue to vibrate.

FIGURE 6



11



BLANK PAGE

[Turn over]



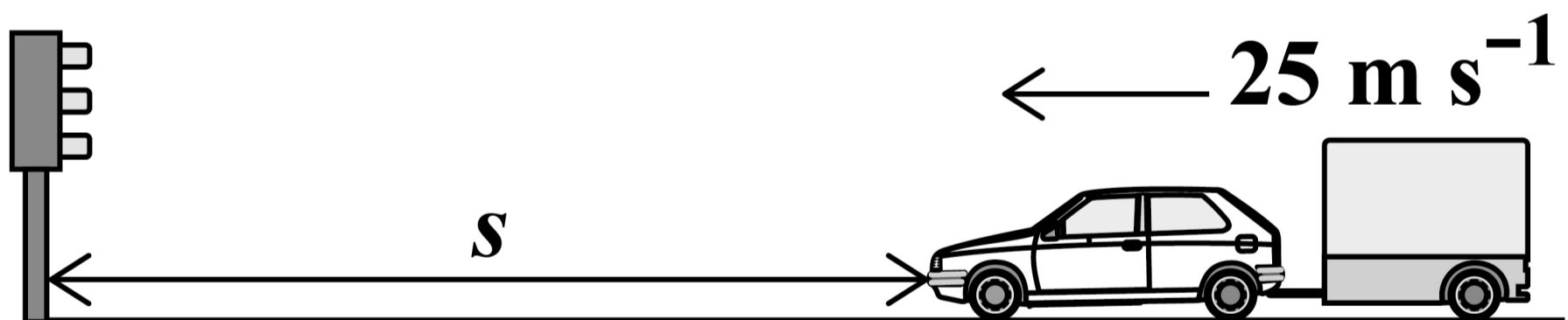
04

In this question, assume that all forces are coplanar.

04.1

FIGURE 7 shows a car and trailer moving at 25 m s^{-1} at a distance s from traffic lights.

FIGURE 7



The driver applies the brakes so that the car and trailer stop at the lights.

The car and trailer undergo a constant deceleration of 2.8 m s^{-2} .

Calculate s . [2 marks]

$s =$ _____ m

[Turn over]

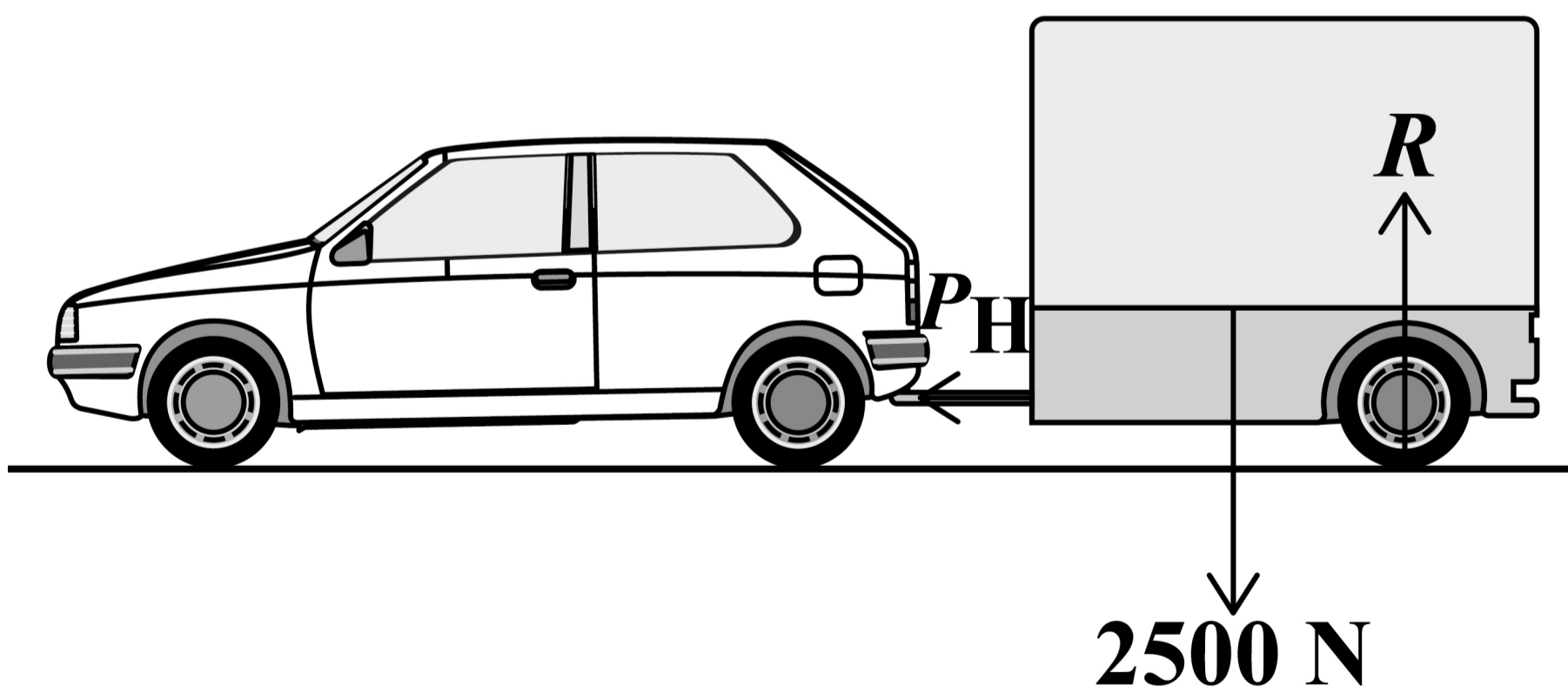


The car and trailer accelerate from rest along a horizontal road.

FIGURE 8 shows:

- that the car exerts a horizontal force P_H on the trailer
- that the trailer has a weight of 2500 N
- the reaction force R on the wheels of the trailer.

FIGURE 8



0	4	.	2
---	---	---	---

Initially, there are no resistive forces and the trailer accelerates at 1.5 m s^{-2} .

Calculate the initial value of P_H .

[2 marks]

$P_H =$ _____ N

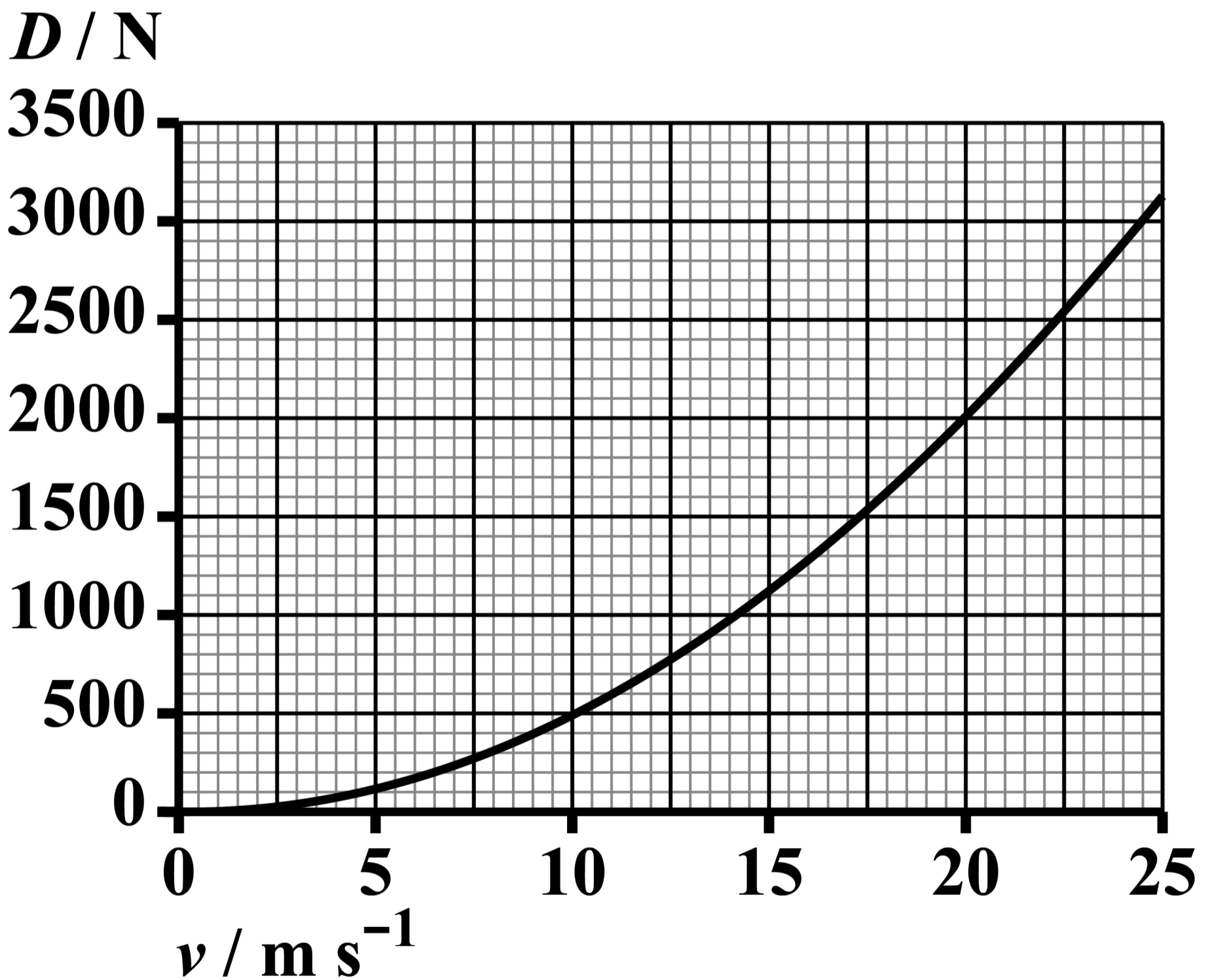
[Turn over]



Air resistance D acts on the trailer when it is moving. D increases as the velocity v of the trailer increases.

FIGURE 9 shows how D varies with v .

FIGURE 9



BLANK PAGE

[Turn over]



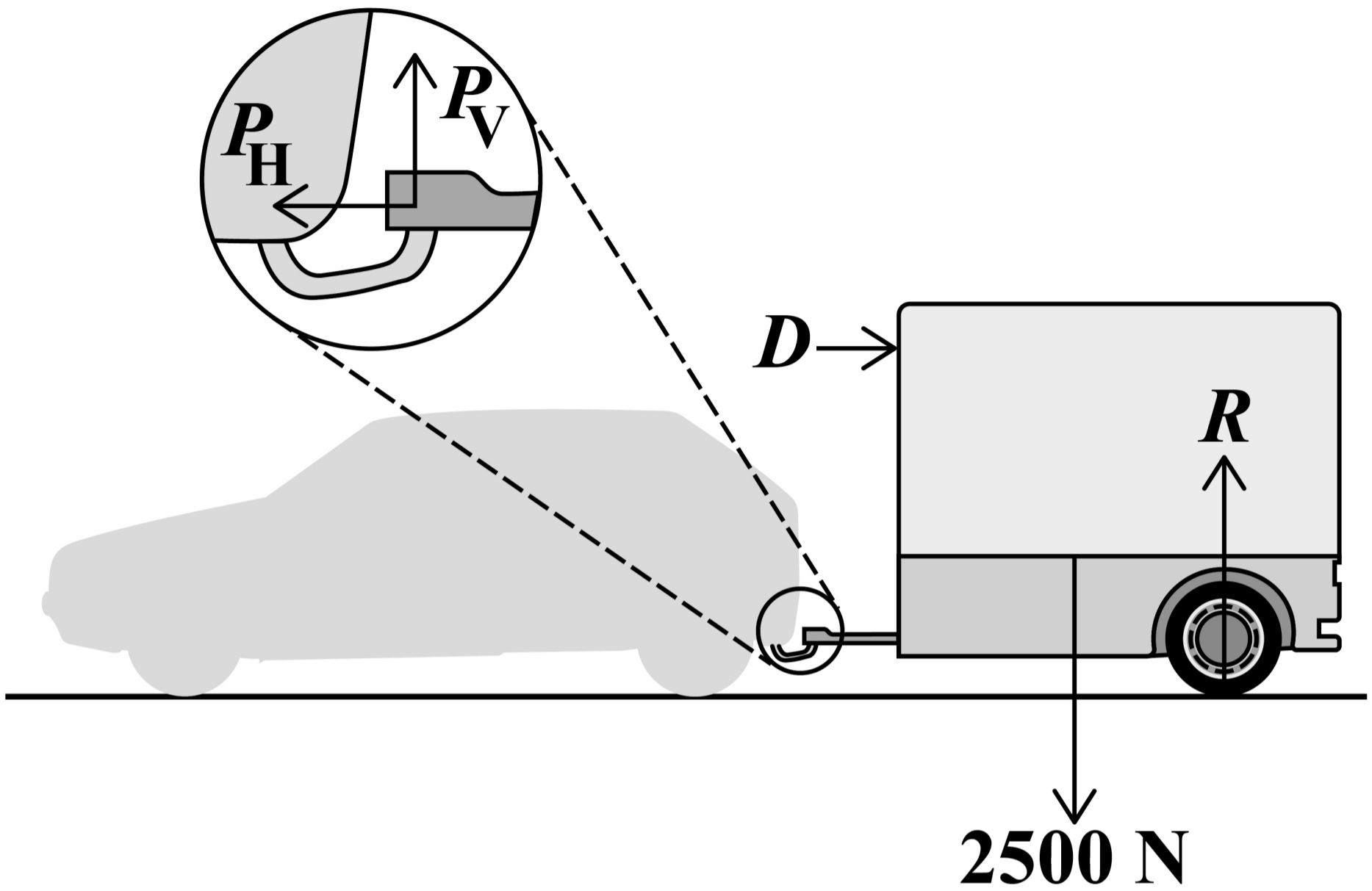
FIGURE 10 shows the forces acting on the trailer when it is travelling at a constant horizontal velocity.

The car exerts a vertical force P_V and a horizontal force P_H on the trailer when it is travelling at a constant horizontal velocity v_1 .

An enlarged view of P_V and P_H is also shown in FIGURE 10, on the opposite page.



FIGURE 10



[Turn over]



BLANK PAGE



The horizontal force P_H is now greater than the value calculated in Question 04.2.

0 **4** . **3**

The vertical force P_V is 762 N.

The resultant of P_H and P_V is 912 N.

Determine v_1 . [3 marks]

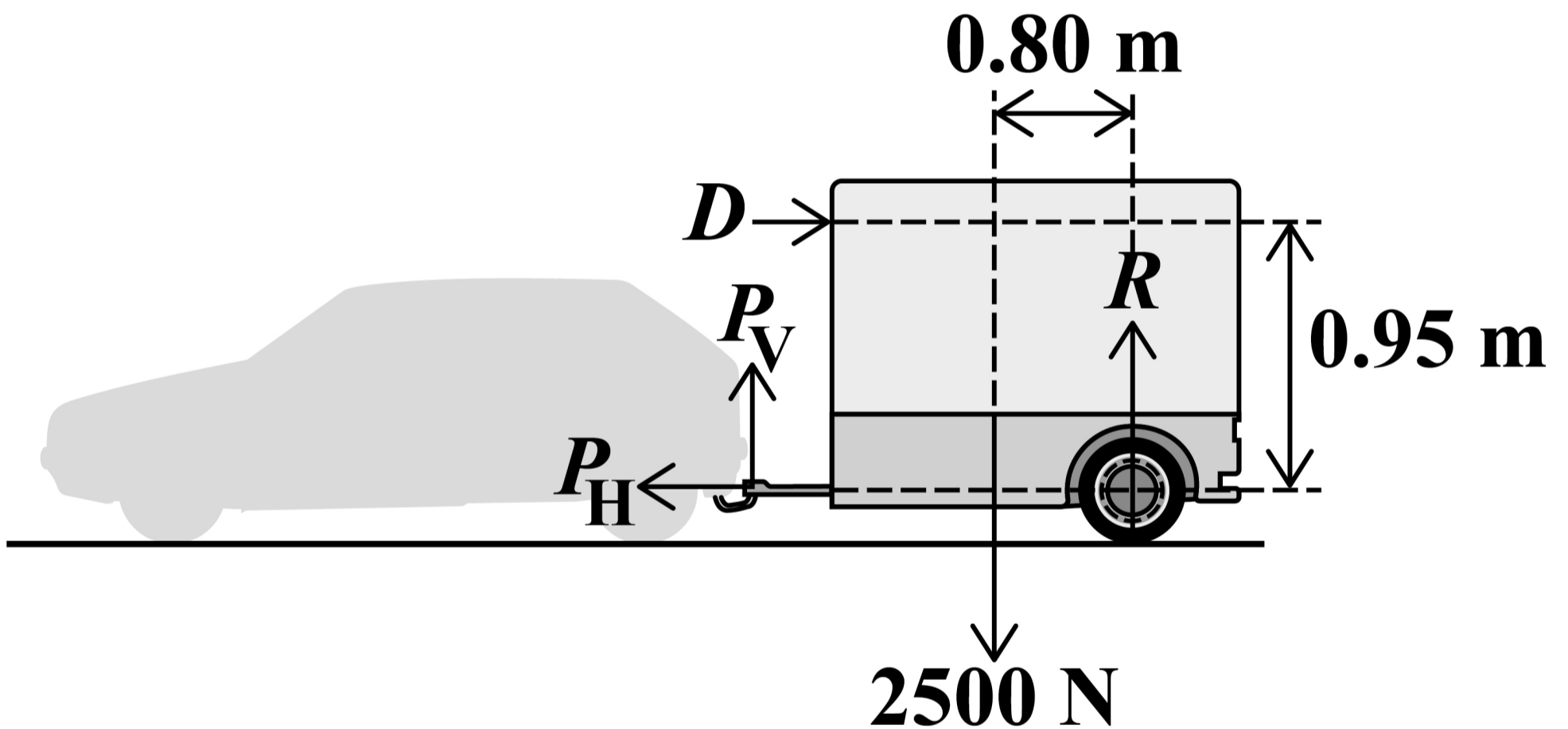
$v_1 =$ _____ m s^{-1}

[Turn over]



D can be considered to act at the position shown in **FIGURE 11**. For some of the forces, the distances of their lines of action from the centre of the trailer's wheel have been included.

FIGURE 11



0	4	.	4
---	---	---	---

Explain why P_H has no moment about the centre of the trailer's wheel in FIGURE 11. [1 mark]

[Turn over]



04.5

When the car and trailer travel with velocity v_2 , P_V is zero.

Determine v_2 . [3 marks]

$v_2 =$ _____ m s^{-1}



BLANK PAGE

[Turn over]



04.6

The air resistance D acting on the trailer increases as the velocity v of the trailer increases.

Explain this increase in D with reference to the momentum of the air displaced by the trailer.

You should also refer to appropriate Newton's laws of motion. [3 marks]

[Turn over]



04.7

The car has a maximum power output of 95 kW.

The maximum velocity of the car and trailer is 25 m s^{-1} .

At this velocity, the force D on the trailer is 3100 N.

The car exerts a horizontal force P_H on the trailer and the trailer exerts an equal and opposite force of magnitude P_H on the car.

Assume that air resistance and P_H are the only resistive forces acting on the car.



Calculate the air resistance acting on the car when it is travelling at a constant velocity of 25 m s^{-1} . [3 marks]

air resistance on car = _____ N

[Turn over]

17

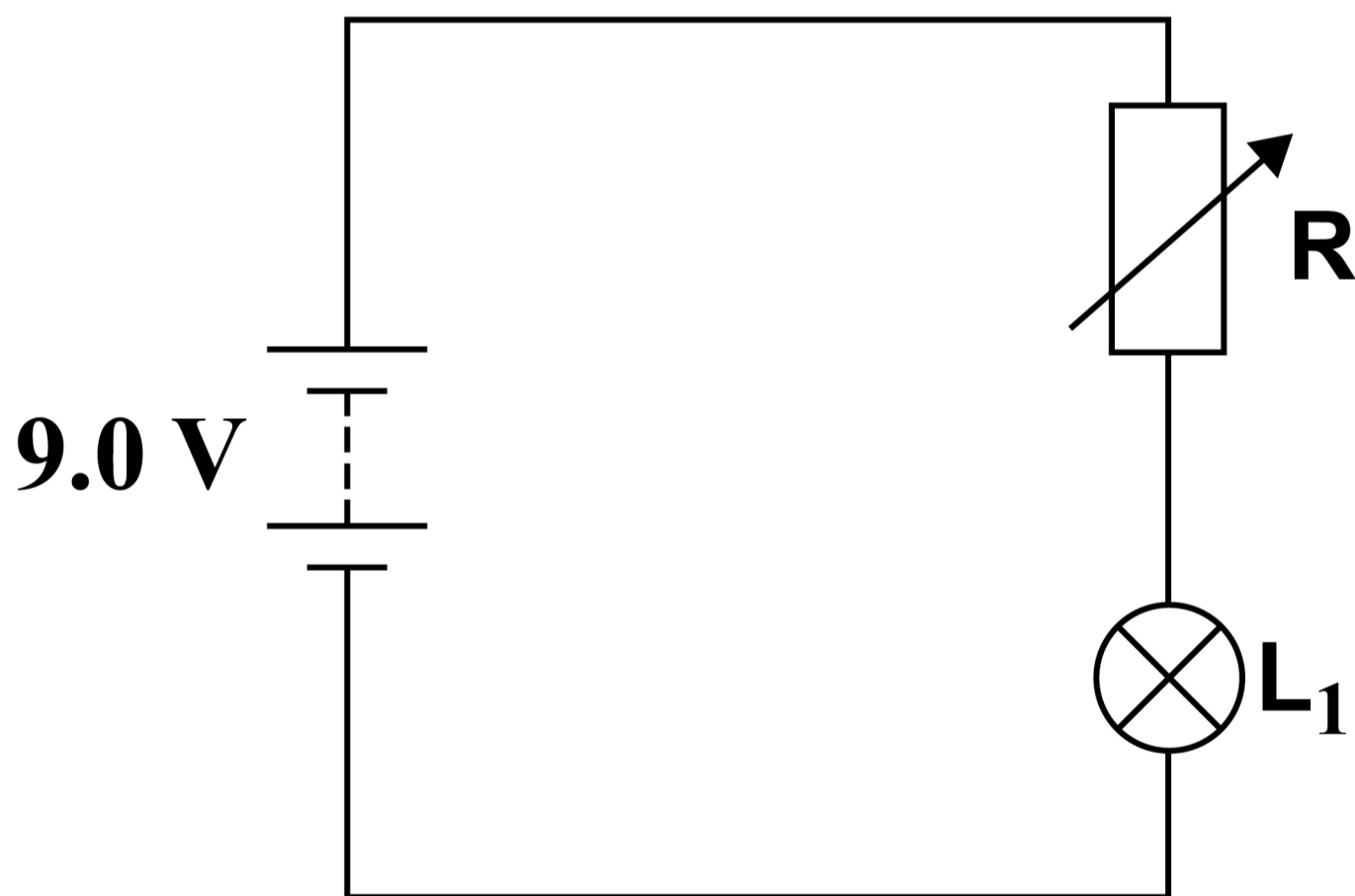


0	5
---	---

FIGURE 12 shows a circuit for controlling the current I in a filament lamp L_1 .

The battery has negligible internal resistance.

FIGURE 12



BLANK PAGE

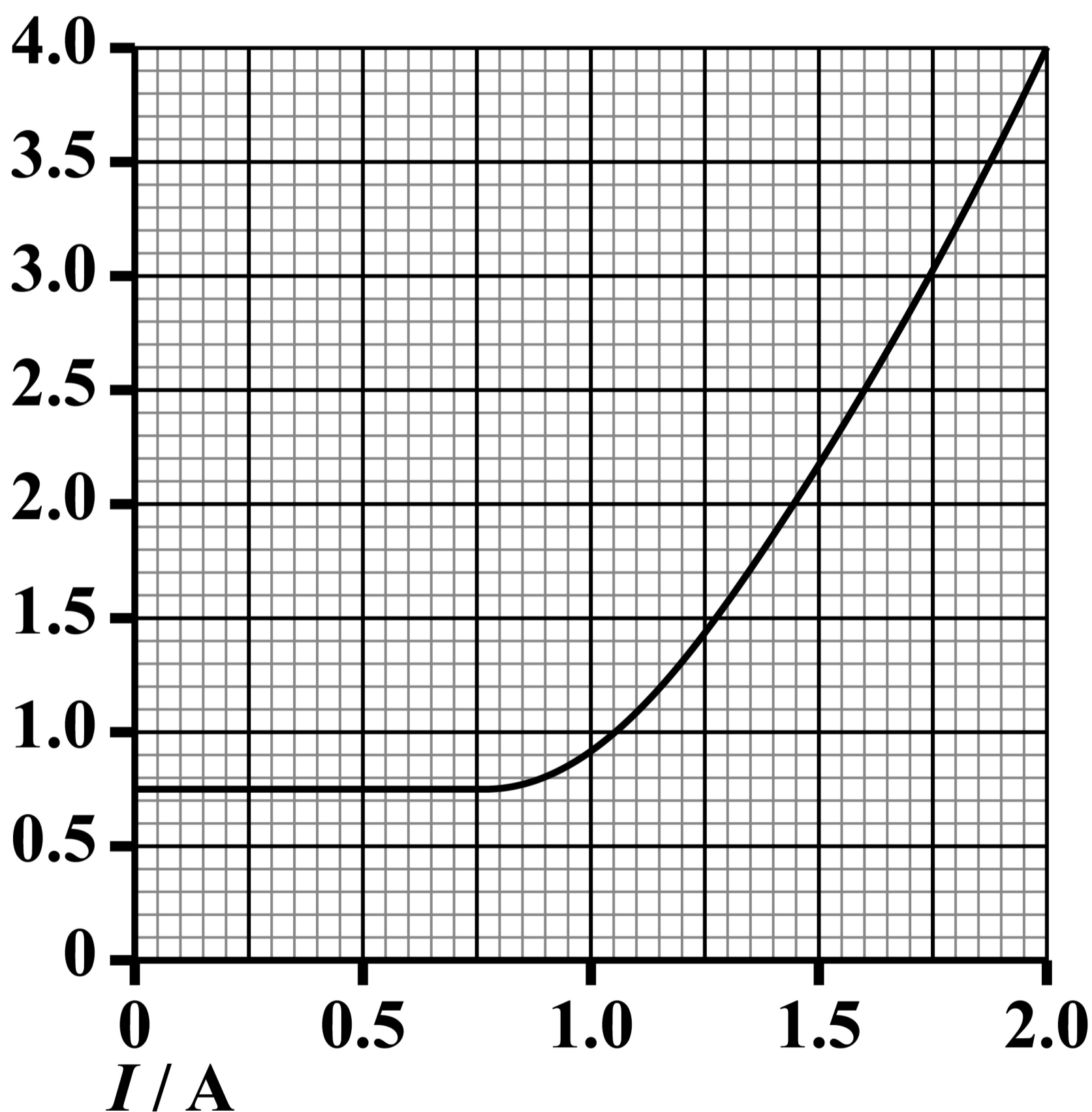
[Turn over]



FIGURE 13 shows how the resistance of L_1 varies with I .

FIGURE 13

resistance / Ω



BLANK PAGE

[Turn over]



0 5 . 1

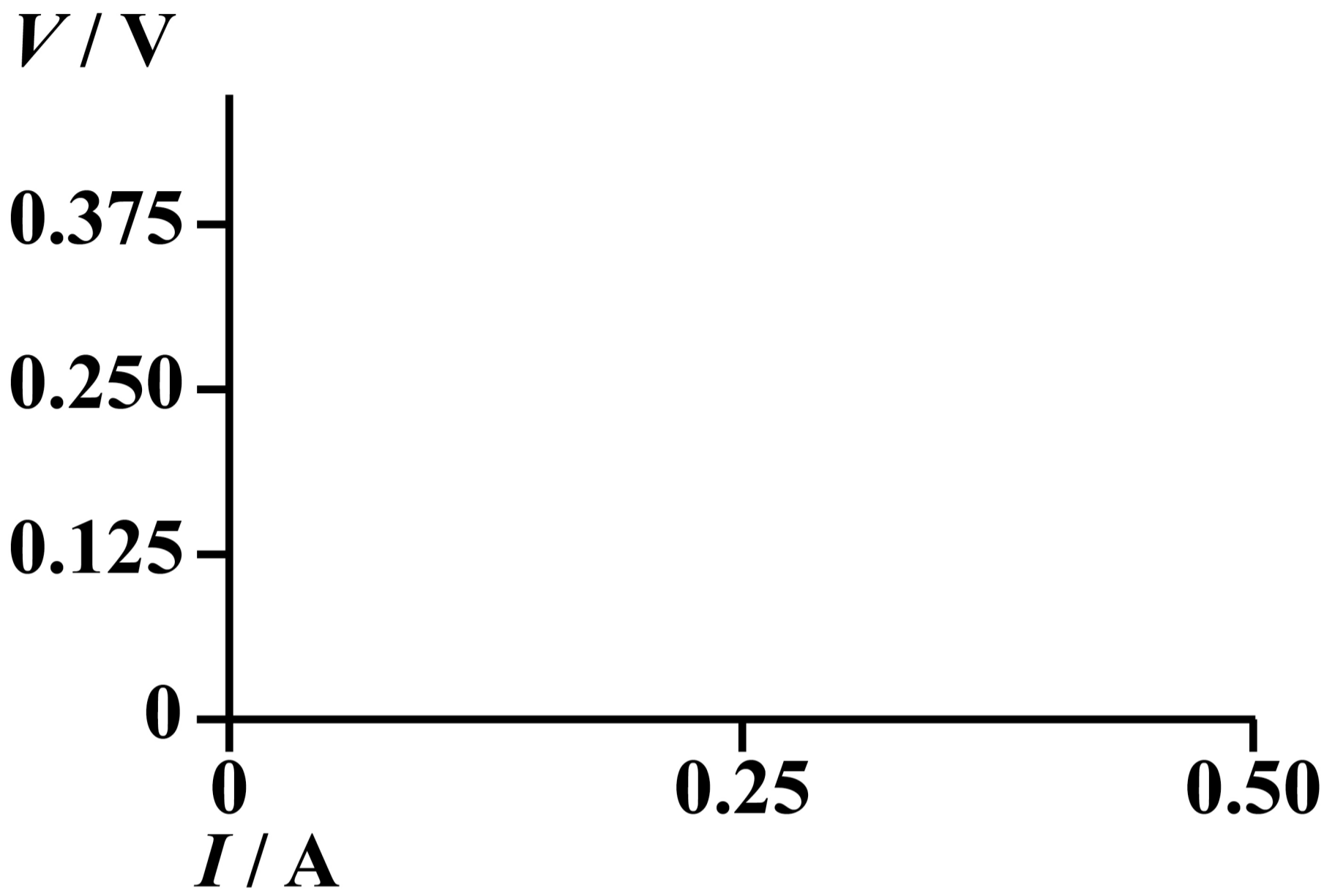
The current in L_1 is increased from 0 to 0.50 A.

The potential difference V across L_1 is 0.375 V when I is 0.50 A.

Draw, on FIGURE 14, on the opposite page, a V - I graph for L_1 in the current range 0 to 0.50 A. [1 mark]



FIGURE 14



[Turn over]



0	5	.	2
---	---	---	---

**Calculate the power dissipated in L_1
when I is 1.9 A. [2 marks]**

power dissipated = _____ W



0	5	.	3
---	---	---	---

The variable resistor R in FIGURE 12, on page 52, is adjusted until I is 1.5 A and V is 3.3 V.

Calculate the resistance of R . [2 marks]

resistance of $R =$ _____ Ω

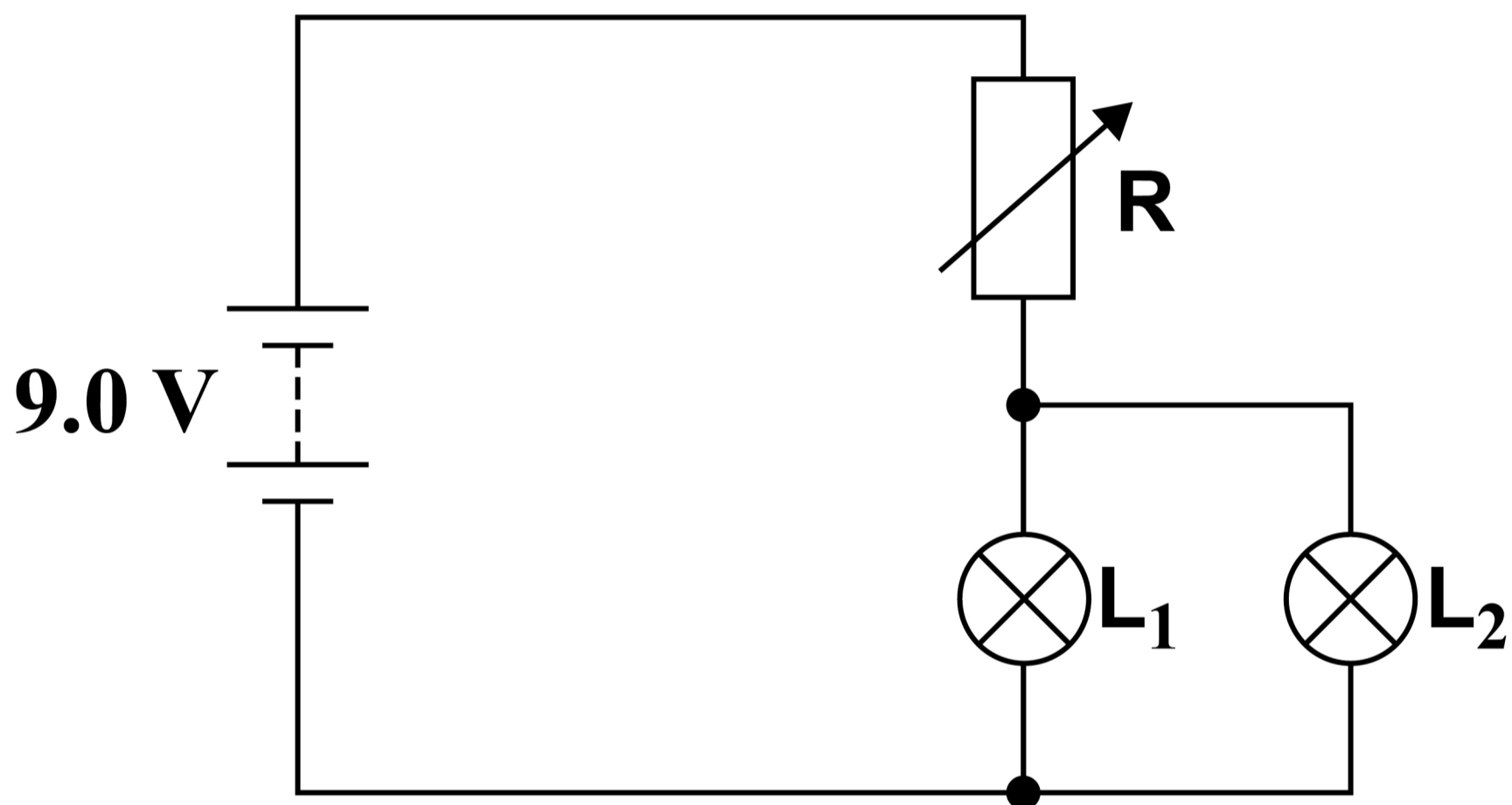
[Turn over]



05.4

FIGURE 15 shows a second lamp L_2 , identical to L_1 , connected to the circuit.

FIGURE 15



R is adjusted so that the potential difference across L_1 is again 3.3 V.

Deduce, without calculation, the change in the resistance of R. [3 marks]



0	6
---	---

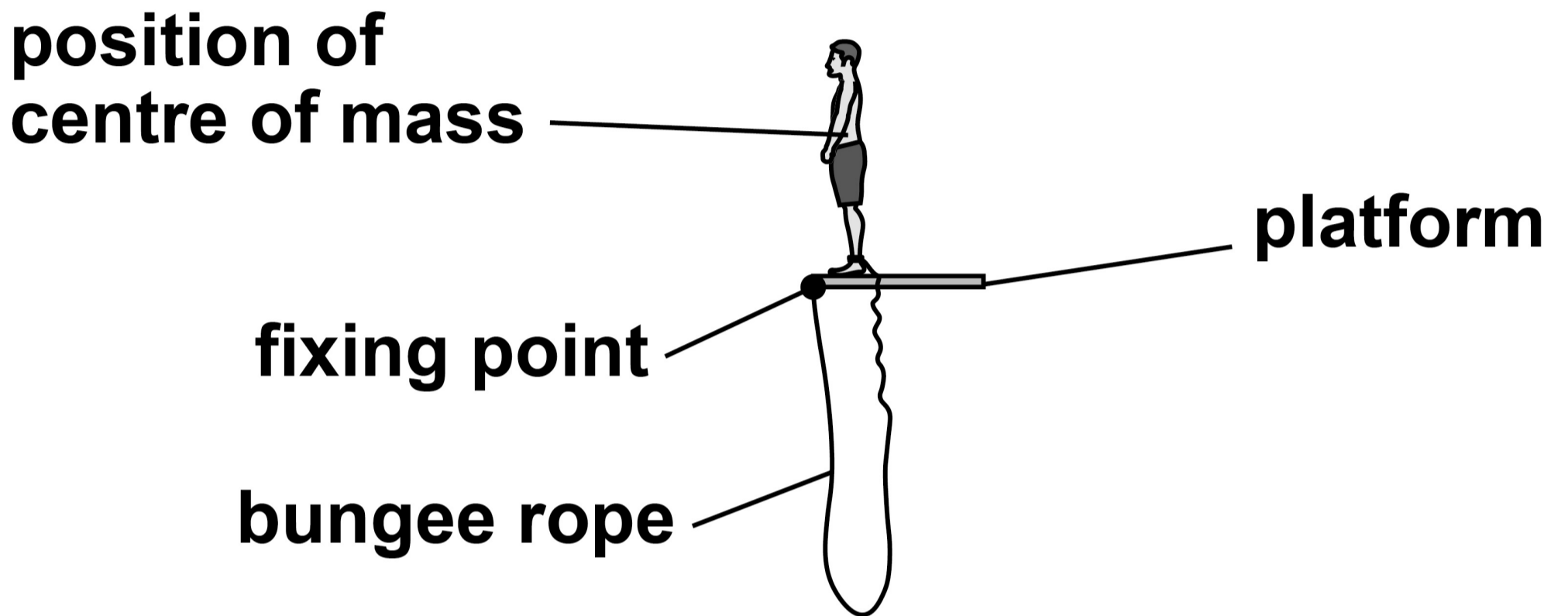
FIGURE 16, on the opposite page, shows a boy of mass m standing on a platform about to perform a bungee jump. He steps off the platform and falls vertically. The tension in the rope increases as it stretches. The boy decelerates to rest at the lowest point of the jump.

Assume that air resistance is negligible throughout this question.



FIGURE 16

The diagram is **NOT** drawn to scale.



[Turn over]

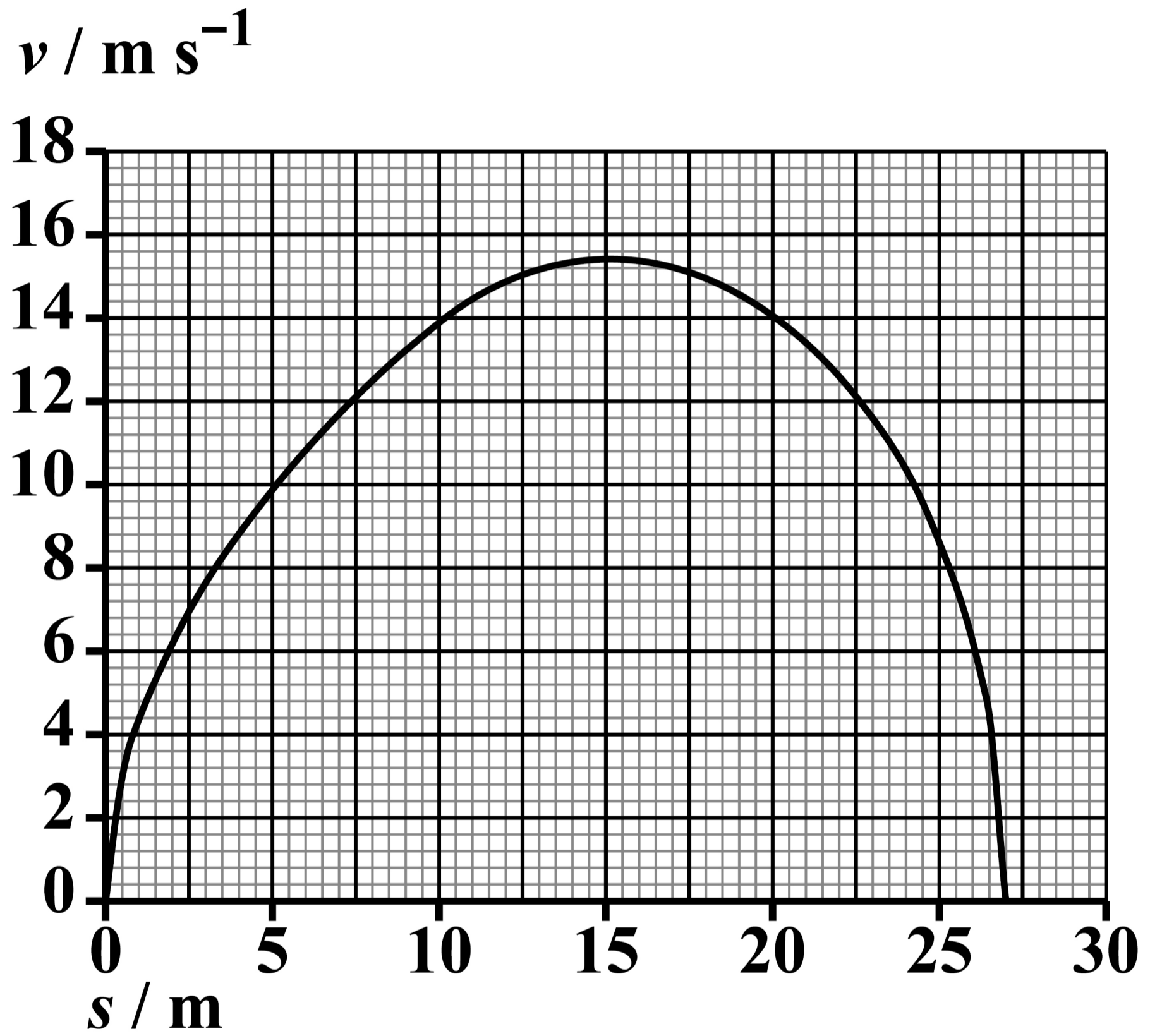


During the jump, s is the vertical displacement moved by the boy's centre of mass. The lowest point of the jump occurs when s is 27 m.

FIGURE 17, on the opposite page, shows the variation of his velocity v with s during the jump.



FIGURE 17



[Turn over]



BLANK PAGE



0	6	.	1
---	---	---	---

The boy experiences freefall when he steps off the platform.

**During which part of the jump does the boy's acceleration begin to decrease?
[1 mark]**

Tick (✓) ONE box.

between $s = 0$ and $s = 7.5$ m

between $s = 7.5$ m and $s = 15$ m

between $s = 15$ m and $s = 22.5$ m

between $s = 22.5$ m and $s = 27$ m

[Turn over]



0	6	.	2
---	---	---	---

When the boy's centre of mass has moved through a distance s of 15.0 m the change in his gravitational potential energy is 9.56 kJ.

Calculate the mass m of the boy.
[2 marks]

$m =$ _____ kg



The bungee rope has a stiffness k of 110 N m^{-1} and obeys Hooke's law.

0 6 . 3

The maximum kinetic energy of the boy is 7.71 kJ .

Calculate, by considering the energy transfers, the extension ΔL of the bungee rope when the kinetic energy of the boy is at a maximum. [3 marks]

$\Delta L =$ _____ m

[Turn over]



0	6	.	4
---	---	---	---

Deduce the tension in the rope when the kinetic energy of the boy is at a maximum.

**Give a reason to support your answer.
[2 marks]**

tension = _____ N

reason _____



BLANK PAGE

[Turn over]





The original rope is replaced with a second rope and the boy repeats the jump.

TABLE 1 contains information about the original rope and the second rope. Both ropes obey Hooke's law.

TABLE 1

	YOUNG MODULUS	CROSS-SECTIONAL AREA	UNSTRETCHED LENGTH
ORIGINAL ROPE	E	A	L
SECOND ROPE	$1.2E$	A	$1.2L$



The Young modulus is given by:

$$\text{Young modulus} = \frac{\text{stiffness} \times \text{unstretched length}}{\text{cross-sectional area}}$$

0 6 . 5

Show that each rope has the same stiffness. [1 mark]

[Turn over]



7 4

0 6 . 6

Deduce whether the boy's maximum velocity is increased when using the second rope. [3 marks]



END OF QUESTIONS

	12
--	-----------

BLANK PAGE

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

Copyright information

For confidentiality purposes, all acknowledgements of third-party copyright material are published in a separate booklet. This booklet is published after each live examination series and is available for free download from www.aqa.org.uk

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and AQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team.

Copyright © 2024 AQA and its licensors. All rights reserved.

WP/M/NC/Jun24/7407/1/G4001/V3



7 8



2 4 G A 7 4 0 7 / 1