

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS
AS GCE**

G492/01

PHYSICS B (ADVANCING PHYSICS)

**Understanding Processes/
Experimentation and Data Handling**

MONDAY 9 JUNE 2014: Morning

**DURATION: 2 hours
plus your additional time allowance**

MODIFIED ENLARGED

Candidate forename		Candidate surname	
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Centre number						Candidate number				
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Candidates answer on the Question Paper.

OCR SUPPLIED MATERIALS:

**Insert (Advance Notice for this Question Paper) (inserted)
Data, Formulae and Relationships Booklet
(sent with general stationery)**

OTHER MATERIALS REQUIRED:

**Electronic calculator
Protractor
Ruler (cm/mm)**

READ INSTRUCTIONS OVERLEAF

INSTRUCTIONS TO CANDIDATES

The Insert will be found inside this document.

Write your name, centre number and candidate number in the boxes on the first page. Please write clearly and in capital letters.

Use black ink. HB pencil may be used for graphs and diagrams only.

Answer ALL the questions.

Read each question carefully. Make sure you know what you have to do before starting your answer.

Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [] at the end of each question or part question.

The total number of marks for this paper is 100.

You may use an electronic calculator.

You are advised to show all the steps in any calculations.

The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.



Where you see this icon you will be awarded marks for the quality of written communication in your answer.

This means, for example, you should

ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;

organise information clearly and coherently, using specialist vocabulary when appropriate.

Any blank pages are indicated.

The questions in Section C are based on the material in the Insert.

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Answer ALL the questions.

SECTION A

1 Here is a list of units.

$$\text{kg m s}^{-1}$$

$$\text{J s}^{-1}$$

$$\text{kg m}^2 \text{s}^{-2}$$

$$\text{J m}$$

$$\text{kg m s}^{-2}$$

(a) Which unit is equivalent to a watt?

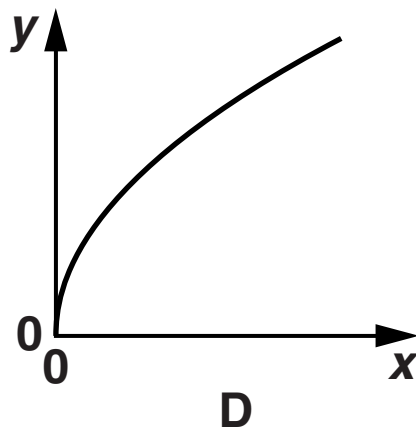
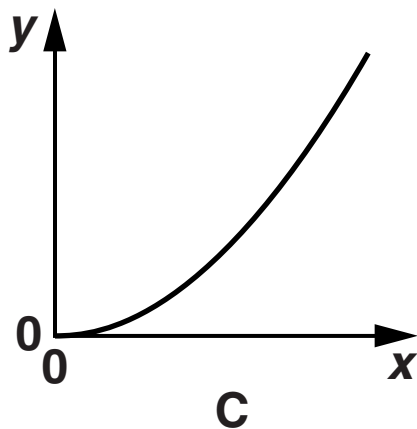
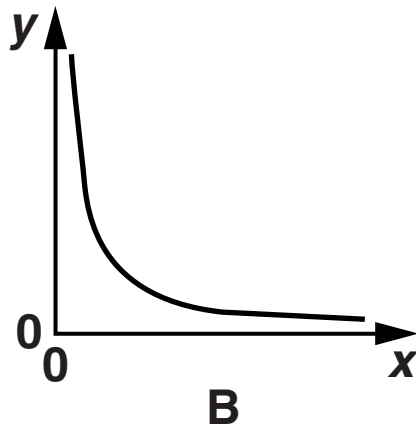
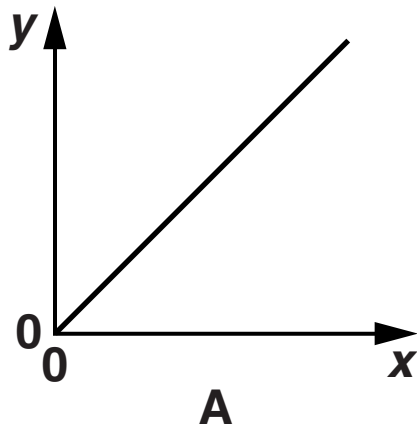
_____ [1]

(b) Which unit is equivalent to a newton?

_____ [1]

2 Fig. 2.1 shows four graphs, A, B, C and D.

FIG. 2.1



Which graph best fits the situation when the y - and x -axes represent the two quantities given in each case below?

Each graph may be used once, more than once, or not at all.

- (a) **y-axis: the period of a wave**
x-axis: its frequency
_____ [1]
- (b) **y-axis: the kinetic energy of a moving object**
x-axis: its speed
_____ [1]
- (c) **y-axis: the separation of interference fringes on a distant screen after light passes through two slits**
x-axis: the distance between the two slits and the screen
_____ [1]
- (d) **y-axis: the distance travelled by an object moving from rest with constant acceleration**
x-axis: the time taken
_____ [1]

3 Here is a list of orders of magnitude.

$$10^{-6}$$

$$10^{-4}$$

$$10^{-2}$$

$$1$$

$$10^2$$

$$10^4$$

(a) Choose the value closest to the height, in m, of an adult human being.

_____ [1]

(b) Choose the value closest to the area of cross-section, in m^2 , of your finger.

_____ [1]

- 4 Which one of the following comparisons between red light of wavelength 650 nm and violet light of wavelength 400 nm is correct?**

Put a tick (✓) in the box after the correct statement.

The red light has the higher frequency.

☐

The red light will diffract through a wider angle when passing through a narrow slit.

☐

The red light travels slower in a vacuum.

☐

The interference maxima formed on a distant screen by light passing through two narrow slits will be closer together for red light.

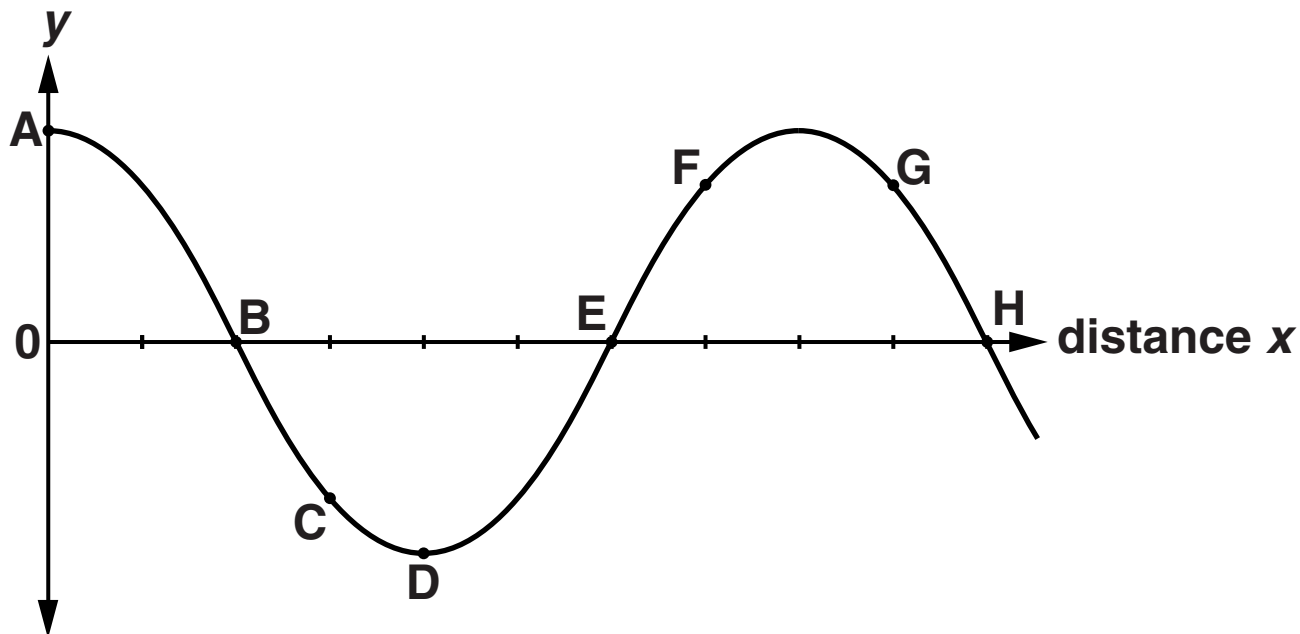
☐

[1]

- 5 Fig. 5.1 shows a wave at an instant in time with eight positions along the wave labelled A–H.

FIG. 5.1

displacement

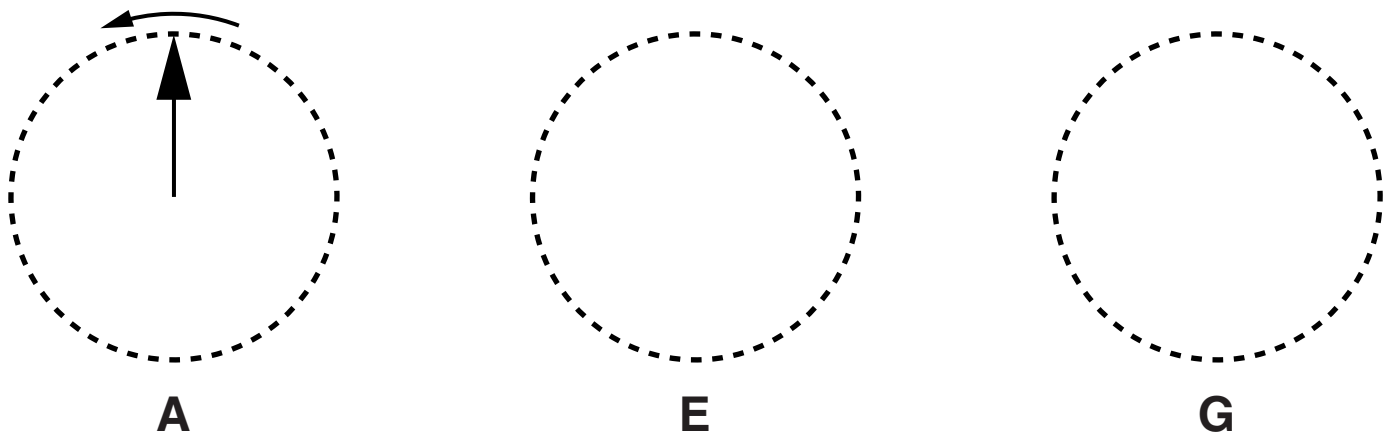


- (a) Write down the letters for TWO positions where the wave has the same phase.

_____ and _____ [1]

- (b) The phasor for the wave at position A at this instant is shown in Fig. 5.2.

FIG. 5.2



Sketch phasors for points E and G in the appropriate places in Fig. 5.2.

[2]

- (c) Three waves, each with the same amplitude and wavelength, can superpose to give a resultant amplitude of zero.
Complete the phasor diagram below to show this.



[1]

6 An aircraft is in level flight through still air.

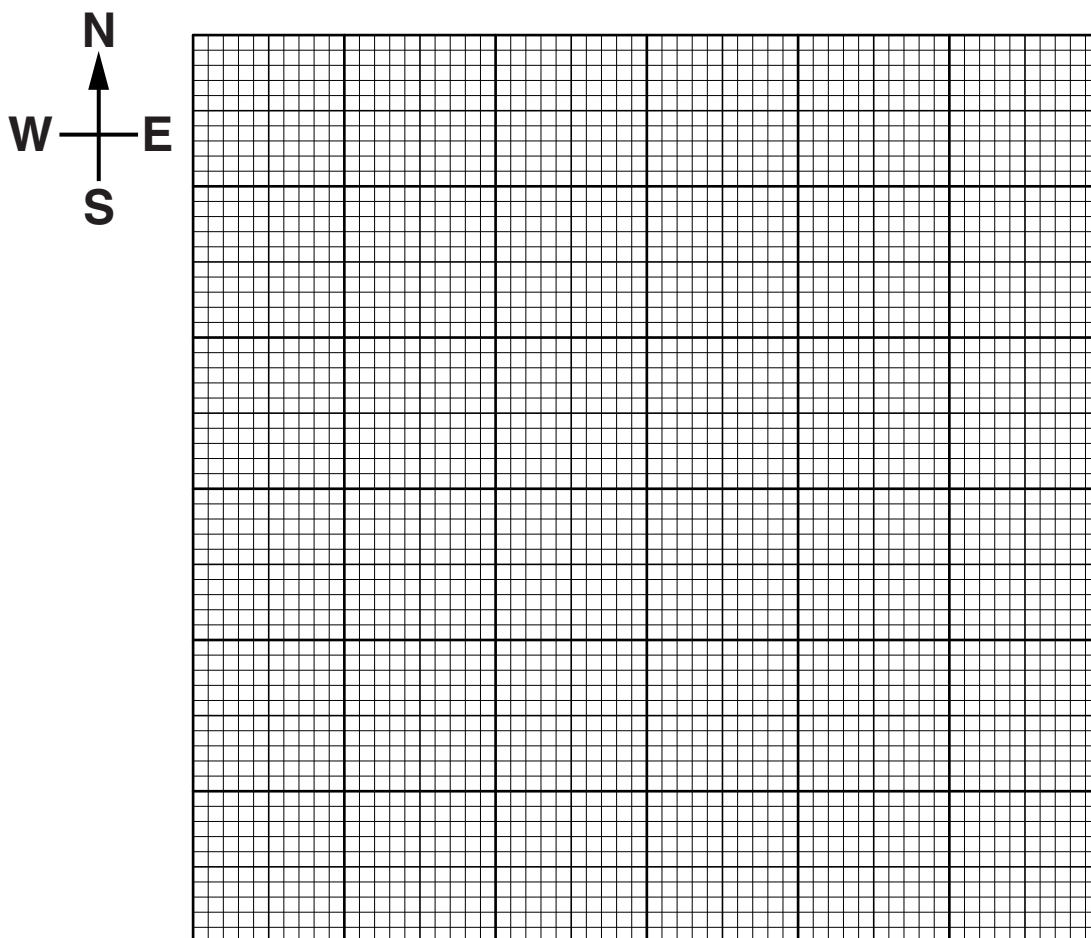
It has the following components of velocity:

north-south: 50 m s^{-1} towards the south

east-west: 35 m s^{-1} towards the east

(a) Using a suitable scale, draw these components on the grid below.

Hence or otherwise find the speed and direction of flight of the aircraft.



speed = _____ m s^{-1}

direction = _____

[4]

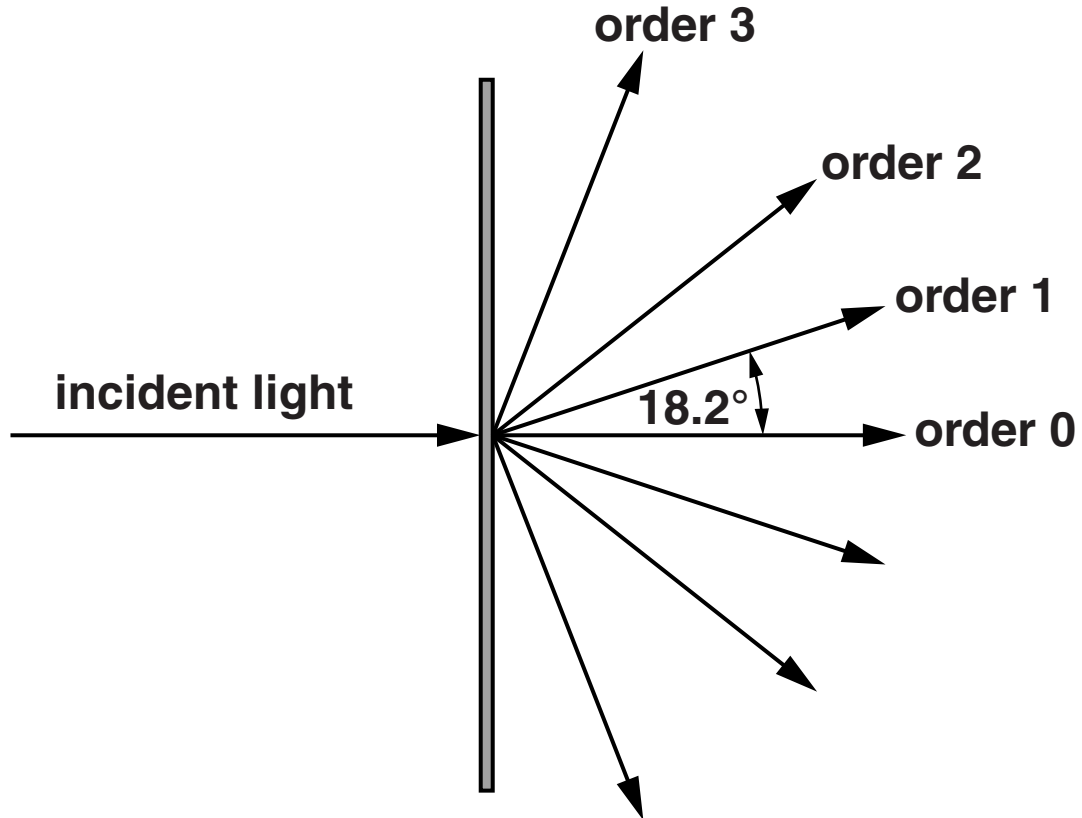
- (b) A wind later acts upon the aircraft, changing the aircraft's direction so that it travels due south. Deduce the speed and direction of this wind.**

speed = _____ m s⁻¹

direction = _____ [2]

- 7 Light of wavelength 590 nm is incident on a diffraction grating as shown in Fig. 7.1. Three orders of diffraction are produced.

FIG. 7.1



The first-order angle of diffraction is 18.2° .

- (a) Show that the separation of lines in this grating is about $2\ \mu\text{m}$.

[2]

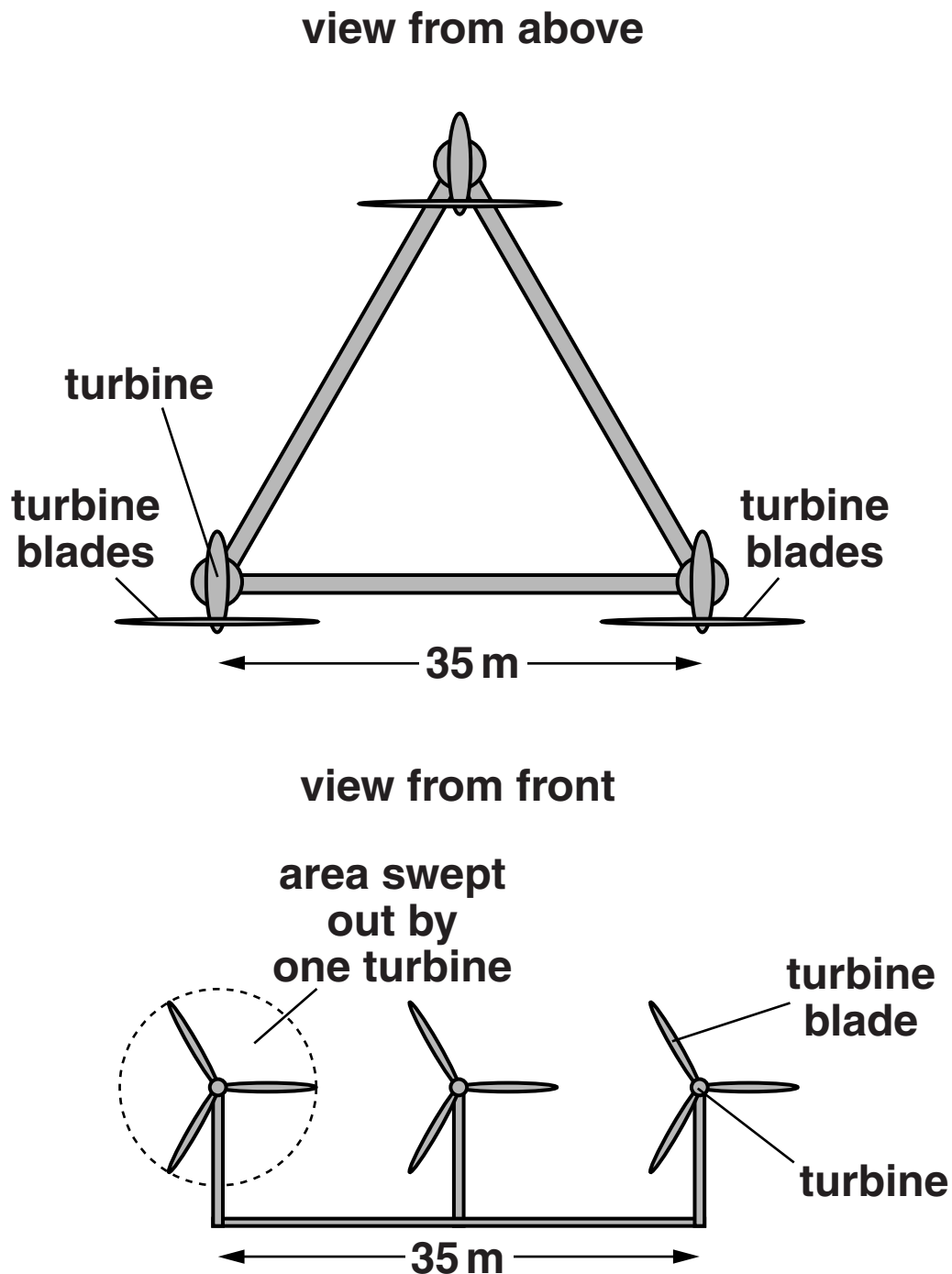
(b) Calculate the longest wavelength of light which will produce three orders of diffraction with this grating.

[1]

SECTION B

- 8 One alternative energy project involves extracting energy from tidal flows of water. The test unit, shown in Fig. 8.1, has three turbines on a triangular frame of side 35 m. The unit is fixed to the sea bed and is completely submerged at all times. The turbines turn to face the direction of water flow.

FIG. 8.1



- (a) (i) The diagrams are drawn to scale.
Use measurements from the diagram to show
that the area swept out by all three turbines is
about 500 m^2 .**

[2]

- (ii) The speed of the water moving into the
turbines is 2.5 m s^{-1} .**

**Show that the mass of water passing through
an area of 500 m^2 in one second is about
 $1 \times 10^6 \text{ kg}$.**

density of sea water = 1030 kg m^{-3}

[2]

- (b) (i) Use the answer to (a)(ii) to show that the total kinetic energy of the water passing into the three turbines in one second is about 4 MJ.**

[1]

- (ii) The electrical energy output of the test unit is 1.2 MJ per second under the conditions above.**

Suggest and explain TWO reasons for the difference between this value and the answer to (b)(i).



In your answer, distinguish clearly between the two reasons you suggest and link each reason to its explanation.

[4]

[TOTAL: 9]

9 This question is about the quantum behaviour of photons and electrons.

(a) An X-ray photon has an energy of $3.0 \times 10^{-15} \text{ J}$.

**(i) Calculate the wavelength of these X-rays.
Express your answer in pm.**

$$c = 3.0 \times 10^8 \text{ m s}^{-1}$$

$$h = 6.6 \times 10^{-34} \text{ J s}$$

wavelength = _____ pm [2]

- (ii) An X-ray generator of input power 12 kW transfers 0.50% of the input energy into photons of energy $3.0 \times 10^{-15} \text{ J}$.

Calculate the number of photons emitted each second.

number per second = _____ s^{-1} [2]

- (iii) Suggest why the X-ray generator in (ii) has to be fitted with a powerful cooling device.

[1]

- (b) The wavelength associated with electrons of mass m and speed v is

$$\lambda = \frac{h}{mv}.$$

- (i) The electrons used in an electron diffraction experiment each have a kinetic energy of $7.0 \times 10^{-17} \text{ J}$.

Show that the electron speed v is about $1 \times 10^7 \text{ m s}^{-1}$.

$$m = 9.1 \times 10^{-31} \text{ kg}$$

[2]

- (ii) Show that these electrons show wave behaviour corresponding to a wavelength of about 60 pm.**

$$h = 6.6 \times 10^{-34} \text{ J s}$$

[1]

- (iii) Explain what would happen to this wavelength if the kinetic energy of the electrons was reduced by a factor of 4.**

[2]

[TOTAL: 10]

10 A flautist produces notes on the flute by blowing near one end. This produces stationary waves in the flute. In this question, the flautist uses her fingers to close the holes so that the flute is treated as a tube open at both ends.

(a) Any standing wave produced in the flute has a displacement antinode at each end.

(i) Calculate the LOWEST (fundamental) frequency that can be produced.

**speed of sound in air = 340 m s^{-1}
length of flute = 66 cm**

frequency = _____ Hz [2]

- (ii) By blowing differently, a note of three times the fundamental frequency can be produced.

On the sectional diagram of a flute in Fig. 10.1, indicate the positions of displacement nodes and antinodes for this higher note. Mark each node N and each antinode A.

FIG. 10.1



not to scale

[3]

- (b) During a long concert, the flute and the air inside it become warmer, making the speed of sound higher. To compensate for this, the flautist must adjust the length of the flute.**
- (i) Explain whether the flute needs to be made shorter or longer to keep it in tune.**

[2]

- (ii) The speed of sound v in air depends on the air temperature according to the relationship

$$v = k\sqrt{T}$$

where k is a constant and T is the absolute temperature of the air in kelvin, obtained from

T in kelvin = temperature in $^{\circ}\text{C}$ + 273.

In a concert, the air temperature inside the flute can rise from 10°C to 25°C .

Calculate the percentage change in the frequency of the note that this temperature rise would produce if the player did not adjust the length of the flute.

change in frequency = _____ % [3]

[TOTAL: 10]

- 11 This question is about a person diving into a swimming pool from a springboard.
Fig. 11.1 opposite shows the sequence of events.**

In this simplified model, the diver is shown as a point and the horizontal outwards component of the diver's velocity is ignored, so only vertical motion is shown.

The diver jumps vertically at the end of the springboard and then lands on it, bending it downwards to the position shown in A. This is the time $t = 0$. The board then accelerates the diver upwards as it springs back, launching the diver upwards (time B). On leaving the board, the diver is in free-fall, rising to his highest point (time C), until he hits the water (time D). He then decelerates to a stop (time E).

FIG. 11.1

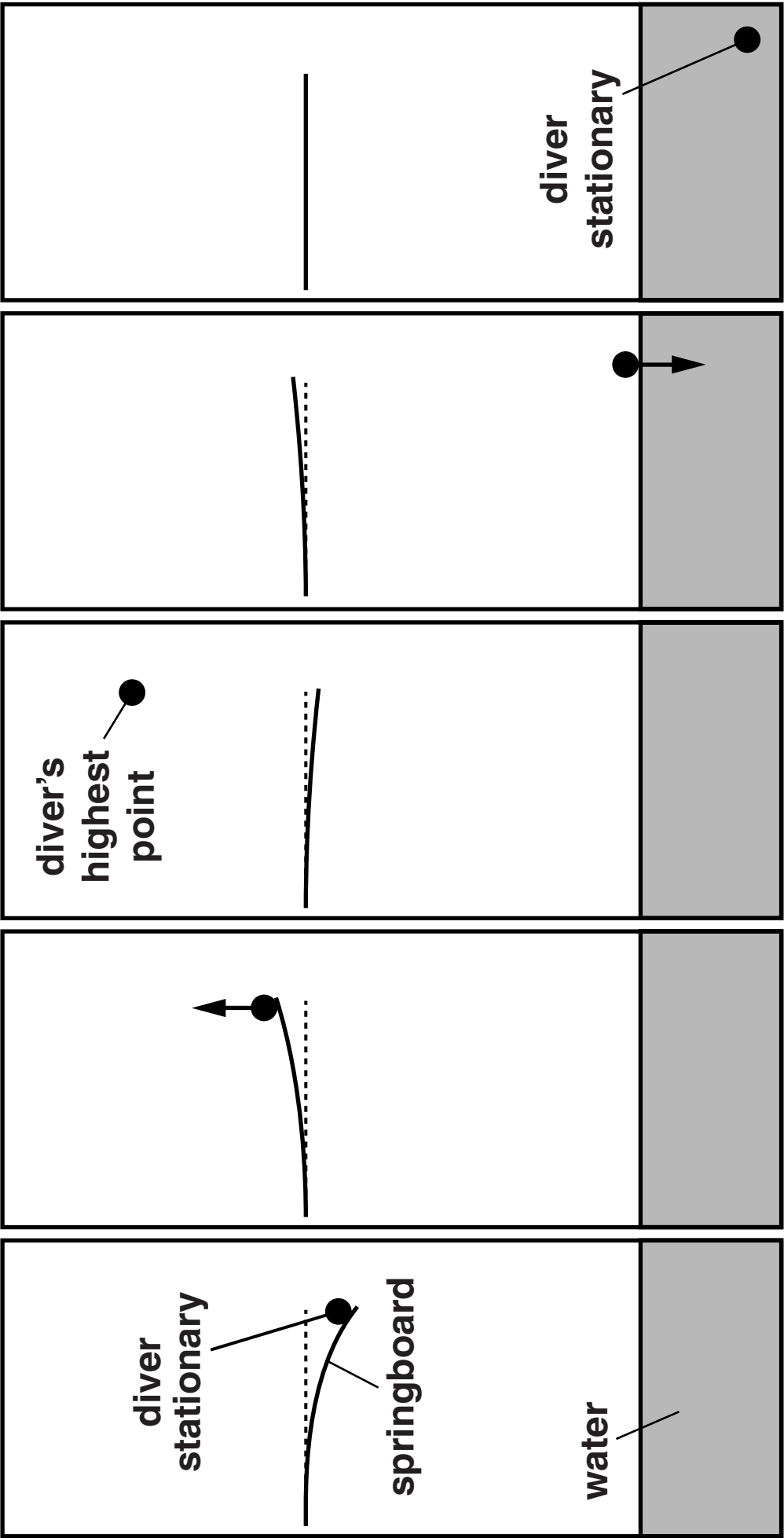
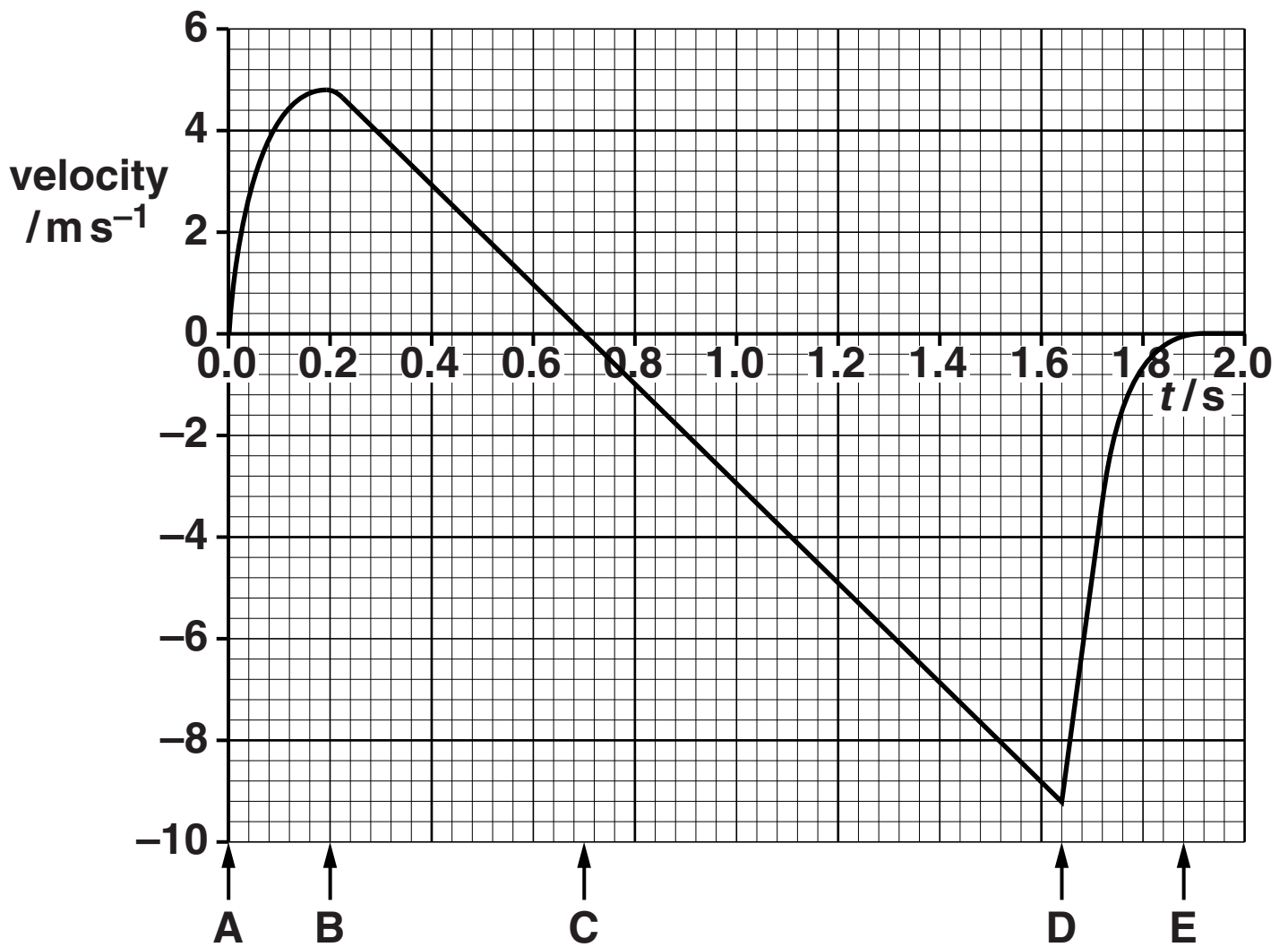


Fig. 11.2 shows the velocity-time graph for the diver's vertical motion with the times A to E shown.

FIG. 11.2



- (a) Explain how the graph of Fig. 11.2 shows that the force exerted on the diver by the springboard between times A and B is greatest at the start.**

[2]

- (b) Explain how the graph shows that:**

- (i) The diver leaves the board at time B,**

[1]

- (ii) The diver is at his highest point at time C.**

[1]

- (c) (i) State what the area between the graph and the time axis between B and C represents.**

[1]

- (ii) Use data from Fig. 11.2 to calculate the distance fallen by the diver between C and D.**

Show your working clearly.

distance = _____ m [2]

- (d) Use information from Fig. 11.2 to describe how the resultant force upon the diver changes between D and E.**

Suggest why the force changes in this way.

[2]

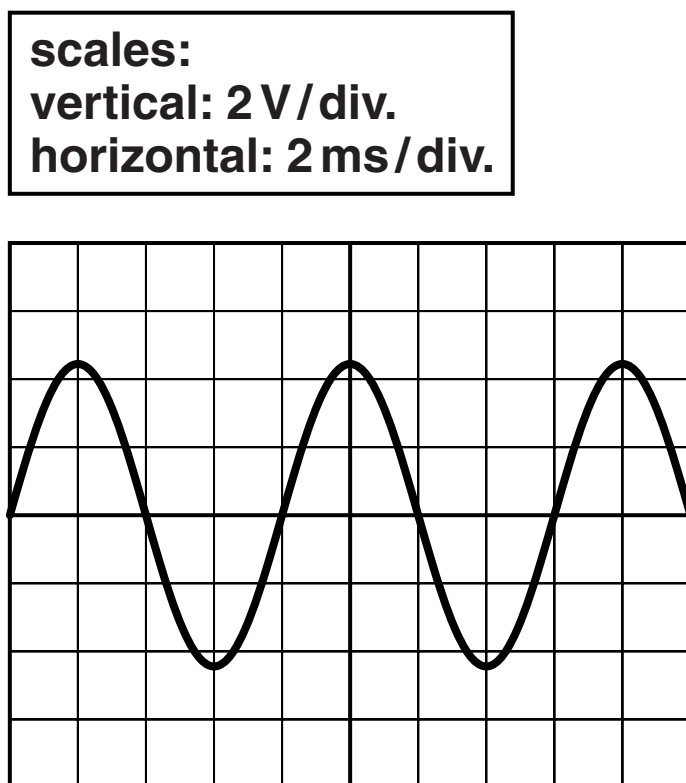
[TOTAL: 9]

SECTION C

The questions in this section are based on the material in the insert.

12 This question is about the article ‘Oscilloscopes’.

FIG. 12.1



- (a) (i) Use data from Fig. 12.1 to calculate a value for the amplitude of the signal.

amplitude = _____ V [1]

- (ii) Use data from Fig. 12.1 to calculate the frequency of the signal shown.

frequency = _____ Hz [2]

- (b) A CRO has time-base settings ranging from 20 ns/div to 5 s/div. It is possible to take a reading from the screen of this CRO to the nearest 0.1 division.

State the best possible time-resolution of this CRO.

resolution = _____ s [1]

- (c) Describe and explain one advantage and one disadvantage of a CRO as a method of displaying changing voltages.**

[2]

- (d) Over the past 20 years, CROs have been largely replaced by digital storage oscilloscopes.**

Describe and explain developments that were necessary for this change to happen.

[4]

[TOTAL: 10]

13 This question is about the article ‘Powering electric cars’.

(a) Table 1 in the article (reproduced below) compares three different types of battery.

TABLE 1

Battery type	Max energy density /Wh kg⁻¹	Percentage energy efficiency in discharging	Battery cost per kWh capacity
lead-acid	35	85	£65
NiMH	80	80	£320
lithium-ion	200	90	£500

(i) Modern electric vehicles have batteries of 24 kWh capacity.

Show that a lead-acid battery of this capacity has a mass of over half a tonne (1 tonne = 1000 kg).

[2]

- (ii) Explain why this would be a disadvantage for a car, but an advantage for a forklift truck.**



In your answer, you should describe in detail the physics of the disadvantage and advantage.

[3]

- (iii) NiMH batteries have the lowest efficiency in charging and discharging.

Use data from Table 1 to calculate the energy dissipated per second in the battery when it delivers an output power of 50 kW.

energy dissipated in one second

= _____ J [2]

(iv) Explain why this energy dissipation is a significant disadvantage for NiMH batteries.

[2]

- (b) Table 2 in the article has performance data for different electric cars. The performance data for the Peugeot Ion car are reproduced below.

Mass /kg	Maximum power/kW	Charging time/h	Time/s to accelerate from 0–27 m s ⁻¹	Battery capacity /kWh
1170	49	7	15.4	16

- (i) Show that the mean resultant force on the Peugeot Ion while accelerating from 0–27 m s⁻¹ is about 2 kN.

[2]

- (ii) Calculate the mean power required to accelerate this car from 0–27 m s⁻¹.

Make your method clear.

mean power = _____ W [2]

- (iii) Peugeot state the range of the Ion is 120 km at a cruising speed of 80 km/h for a battery charged to 16 kWh.**

Show that these data imply an output power much less than the 49 kW given in the table.

[2]

[TOTAL: 15]

14 This question is about the article ‘Simple pendulum experiment’.

(a) A student obtains the following data for a pendulum of length 30 cm.

Time for 10 oscillations/s									
10.9	10.9	11.0	11.0	10.9	11.0	11.0	11.1	10.9	11.0

(i) The student uses a stopwatch which records time to the nearest 0.01 s.

She decides to quote the data to one decimal place.

Give a reason for this choice.

[1]

(ii) State why measuring the time for 10 oscillations instead of one improves the quality of the results.

[1]

- (iii) For the data on page 44, the student correctly writes:

$$\begin{aligned} \text{mean time for 10 oscillations} \\ = 11.0 \pm 0.1 \text{ s.} \end{aligned}$$

Explain why the uncertainty in the period T is $\pm 0.01 \text{ s}$.

[1]

- (iv) Show that a period $T = 1.10 \pm 0.01$ s leads to a value of

$$T^2 = 1.21 \pm 0.02 \text{ s}^2.$$

[2]

- (b) A second student times 10 oscillations for the range of lengths given in the table. He does not repeat the timing at each length.

L/m	Time for 10 oscillations/s	T/s	T^2/s^2
0.10	6.0		
0.15	7.9		
0.20	9.2	0.92	0.85
0.25	10.0	1.00	1.00
0.30	11.2	1.12	1.25
0.35	11.7	1.17	1.37
0.40	12.5	1.25	1.56

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(i) Complete the first two rows of the table on page 46, and use those data to complete the graph opposite. [2]

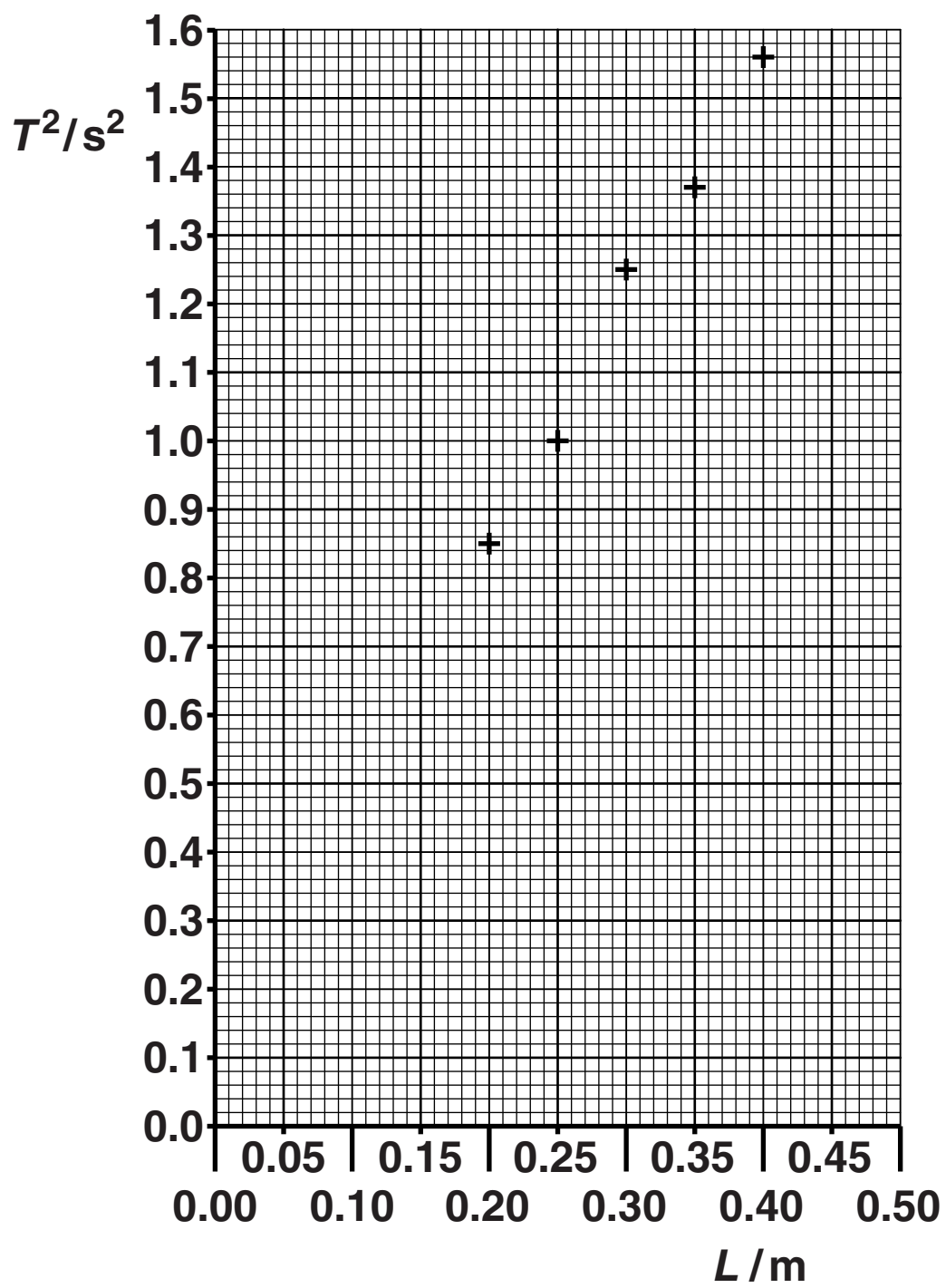
(ii) Explain why the gradient of this graph should be

$$\frac{4\pi^2}{g}$$

given that

$$T = 2\pi\sqrt{\frac{L}{g}}$$

[2]



(iii) Use the graph to determine a value for g . Show your working clearly.

$$g = \text{_____} \text{ m s}^{-2} [3]$$

- (c) A third student suggests that the experiment could be improved by using pendulums of lengths between 2 m and 3 m.**

Discuss the advantages and disadvantages of this suggestion.

[3]

[TOTAL: 15]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question number(s) must be clearly shown in the margins.

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