Candidate Name	Centre Number	Candidate Number

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Subsidiary/Advanced

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch Gyfrannol/Uwch

541/01

PHYSICS

ASSESSMENT UNIT PH1: Waves, Light and Basics

A.M. WEDNESDAY, 12 January 2005

(1 hour 30 minutes)

For Examiner's use only.	
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Total	

ADDITIONAL MATERIALS

In addition to this paper you may require a calculator.

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

You are advised to spend not more than 45 minutes on questions 1 to 5.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 90.

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

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

Your attention is drawn to the information "Mathematical Data and Relationships" on the back page of this paper.

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

Fundamental Constants

Avogadro constant	$N_A = 6{\cdot}0 \times 10^{23}$ mol^{-1}
Fundamental electronic charge	$e = 1{\cdot}6 \times 10^{-19}$ C
Mass of electron	$m_e = 9{\cdot}1 \times 10^{-31}$ kg
Mass of proton	$m_p = 1{\cdot}67 \times 10^{-27}$ kg
Molar gas constant	$R = 8{\cdot}3$ J mol^{-1} K^{-1}
Acceleration due to gravity at sea level	$g = 9{\cdot}8$ m s^{-2}
[Gravitational field strength at sea level	$g = 9{\cdot}8$ N kg^{-1}]
Universal constant of gravitation	$G = 6{\cdot}7 \times 10^{-11}$ N m^2 kg^{-2}
Planck constant	$h = 6{\cdot}6 \times 10^{-34}$ J s
Unified mass unit	1 u $= 1{\cdot}66 \times 10^{-27}$ kg
Boltzmann constant	$k = 1{\cdot}38 \times 10^{-23}$ J K^{-1}
Speed of light *in vacuo*	$c = 3{\cdot}0 \times 10^8$ m s^{-1}
Permittivity of free space	$\varepsilon_0 = 8{\cdot}9 \times 10^{-12}$ F m^{-1}
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}

1. *(a)* (i) Some solids can be classified as *crystalline*. Explain the meaning of this term by referring to the microscopic structure of the solid. [2]

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(ii) The table shows three different solids, of which only one is crystalline. Place a tick next to the crystalline solid. [1]

Rubber	
Sodium Chloride (common salt)	
Fibreglass	

(b) (i) Sketch, using the given axes, a typical stress-strain graph for a ductile metal when it is gradually loaded to breaking. [1]

(ii) Clearly label the following points or regions on the graph:

(I) the region of elastic stretching;
(II) the region of plastic stretching;
(III) the elastic limit;
(IV) the breaking stress (or ultimate tensile strength). [4]

(iii) Explain briefly, in terms of the arrangement of atoms, how plastic stretching occurs. [2]

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2. *(a)* State the Principle of Moments. [2]

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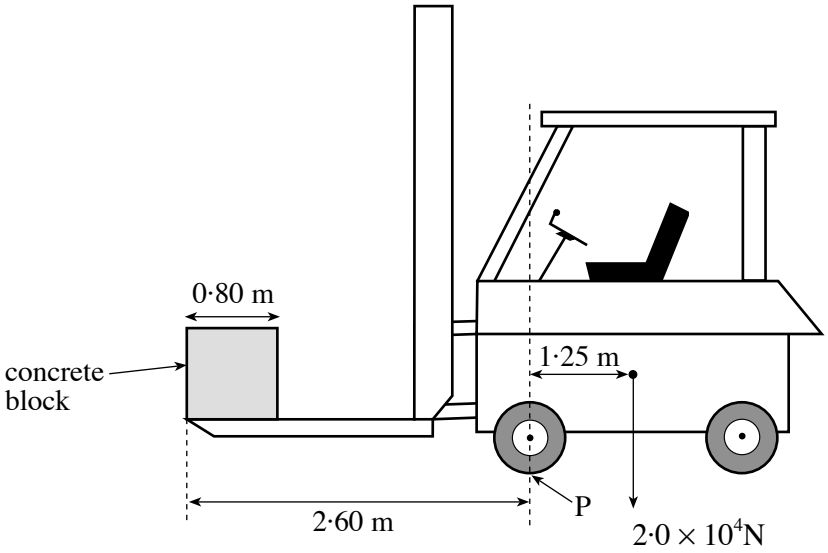
(b) The diagram shows a forklift truck of weight $2{\cdot}0 \times 10^4$N carrying a uniform block of concrete of side 0·80 m.



(i) Label clearly the centre of gravity of the concrete block. [1]

(ii) With the concrete block positioned as shown, the forklift truck is **on the point of toppling**. Calculate the **mass** of the block. [Refer to the data on page 2]. [4]

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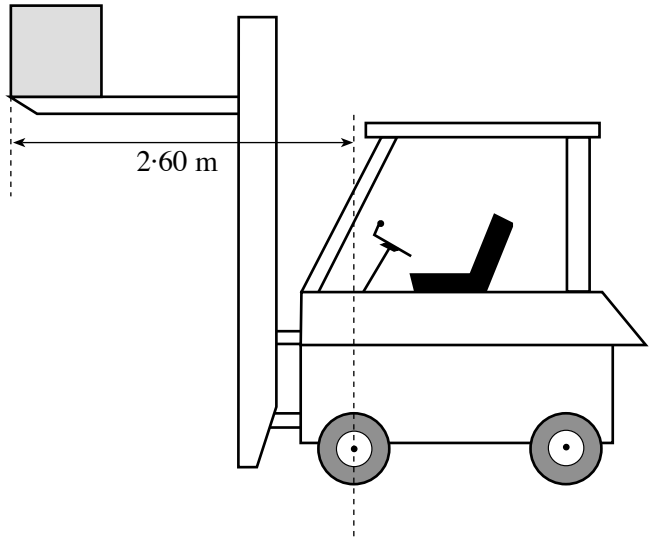
(iii) Explain, in terms of moments, whether or not it would be possible for the forklift truck to support this concrete block in the raised vertical position shown below. [2]



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(iv) State one change that can be made to the **forklift truck** that would allow it to carry greater masses. [1]

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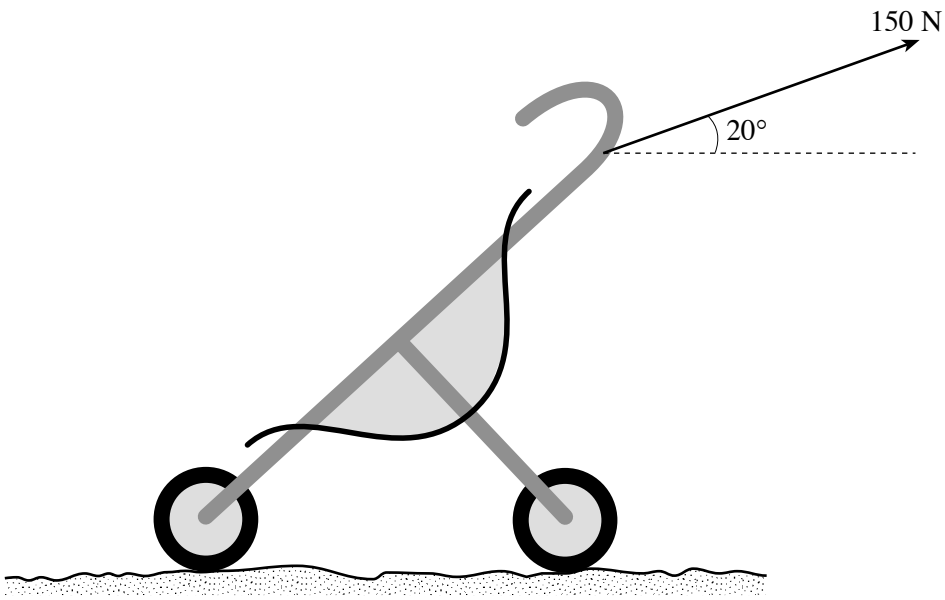
3. A pushchair is being pulled through soft sand with a force of 150 N, as shown.



(a) (i) Determine the horizontal and vertical components of the 150 N force.

Horizontal component ..... [2]

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Vertical component ..... [2]

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(ii) The pushchair moves at a constant speed.

(I) State the size of the frictional force. [1]

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(II) Draw an arrow on the diagram to indicate the direction of this frictional force. [1]

(iii) The pushchair weighs 200 N. Calculate the vertical force exerted by the pushchair on the ground. [1]

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(b) (i) If, instead of being pulled, the pushchair were pushed as shown below, calculate the vertical force now exerted by the pushchair on the ground. [1]

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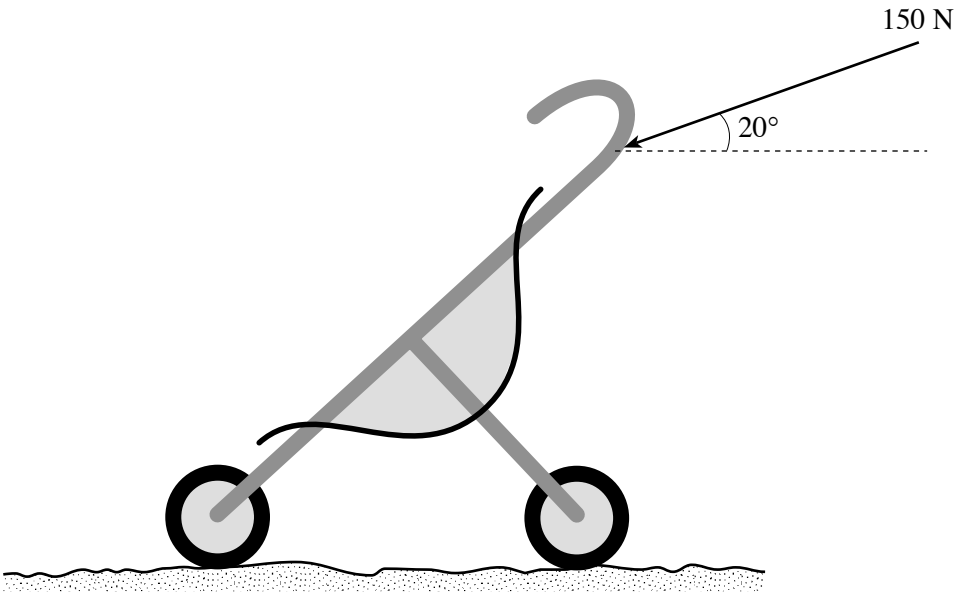

(ii) Hence suggest why it would be more difficult to push the pushchair through the sand. [2]

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4. *(a)* Write down Young's double-slit formula for interference and state the meaning of **each** of the symbols. [3]

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(b) (i) Describe an experiment that demonstrates two-source interference for microwaves. Draw a labelled diagram of the apparatus. Your description should include an explanation of how the interference pattern is detected given a suitable probe. [5]

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(ii) Young's double-slit formula may be applied to your experimental arrangement (provided the probe is far enough away). State **two** adjustments that can be made to the experimental set-up described in part *(b)*(i) that would increase the separation between points of constructive interference i.e. increase the fringe separation.

Adjustment 1: [1]

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Adjustment 2: [1]

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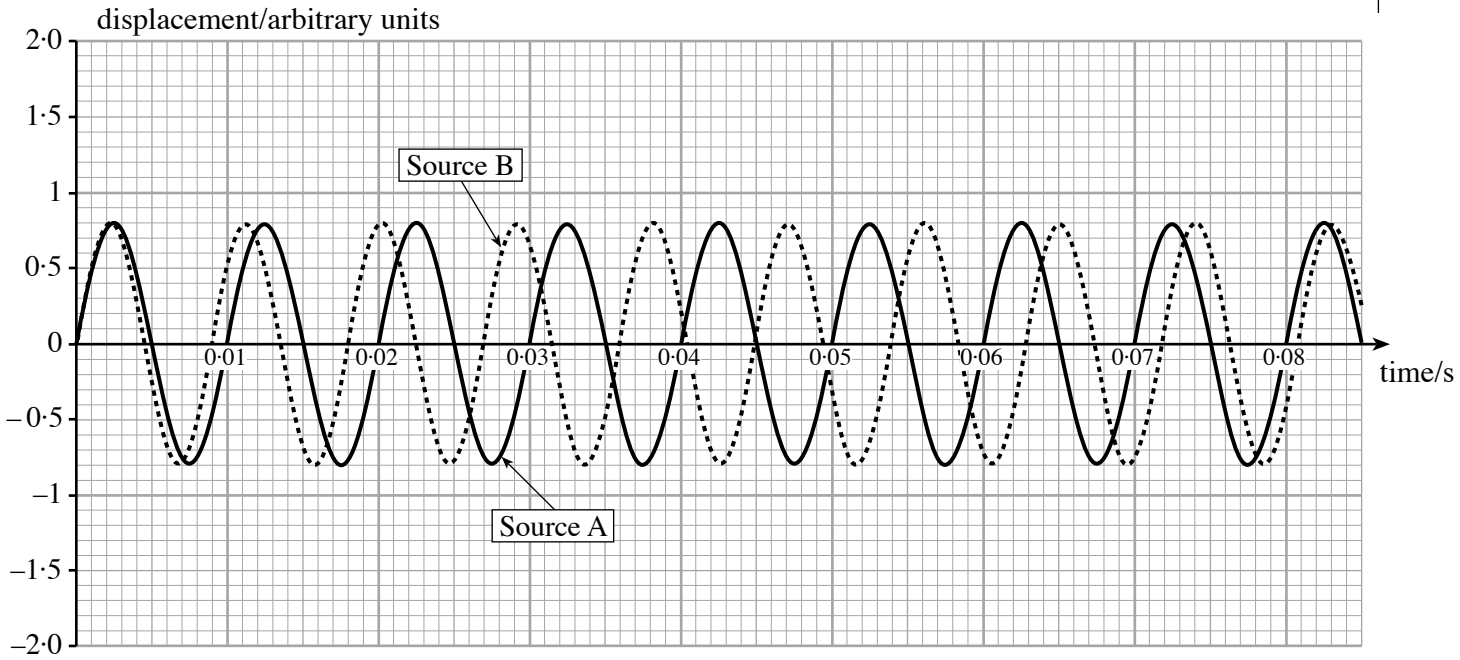
5. In order to demonstrate beats, two loudspeakers connected to two separate signal generators (sources A and B), of nearly equal frequencies and of the same amplitude, are sounded together. The signals from the two generators are shown on the graphs.



(a) (i) Find, from the graphs

(I) the period of source A, [1]

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(II) the period of source B. [1]

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(ii) Hence calculate the beat frequency. [3]

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(b) (i) Estimate the resultant displacement at

(I) time t = 0·0025 s, [1]

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(II) time t = 0·0425 s. [1]

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(ii) Describe briefly how the intensity of the sound varies between times t = 0·000s and t = 0·085 s. [1]

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(c) Describe and explain what would be heard if the **period** of source B were increased by 0·001s. [2]

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6. This question is about the physics of optical fibres.

(a) State Snell's law of refraction. [2]

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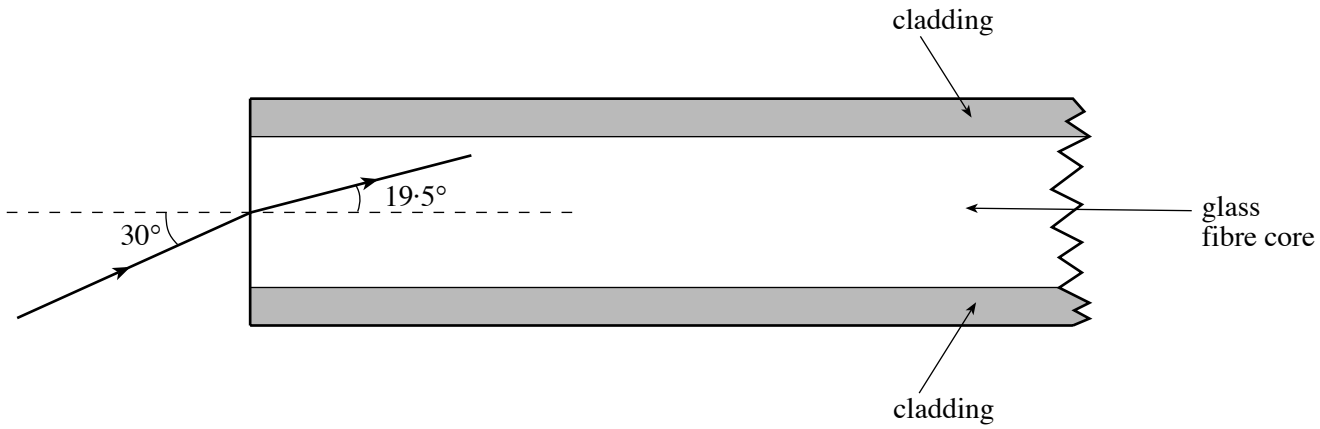
(b) Optical fibres transmit information encoded as pulses of electromagnetic radiation in the infrared part of the spectrum. The diagram shows one of the first types to be developed, called a step-index optical fibre.



(i) A pulse of infrared light travelling from air enters the fibre as shown. Show that the refractive index of the fibre is 1·50. [The refractive index of air = 1·00.] [1]

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(ii) State which of the following materials (A, B or C) would be suitable for the cladding, giving a reason for your answer. [2]

Material	Refractive Index
A	1·60
B	1·50
C	1·40

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(iii) Assuming that your chosen material is used for the cladding, calculate the critical angle at the fibre-cladding boundary. [2]

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(iv) Determine whether or not the ray shown in the diagram on page 12 will be totally internally reflected or not. A simple calculation should support your answer. [2]

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(v) Calculate the speed of the pulse in the fibre. [Refer to the data on page 2.] [2]

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(vi) The wavelength of the infrared light in air is 1300 nm. Determine the wavelength in the fibre optic core. [2]

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(vii) Calculate the frequency of the infrared light. [2]

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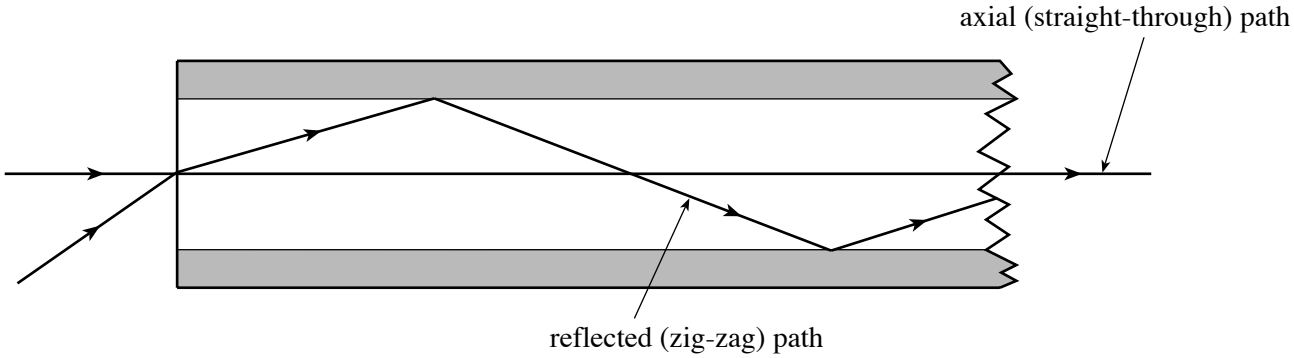
(c) A pulse of infrared light can travel through the fibre along many paths, two of which are shown in the diagram below.



For this optical fibre the difference in time of travel between the two rays is **30ns per km** of fibre. Use this information to calculate the **extra** distance travelled by the 'zigzag' ray, compared with the 'axial' ray in **ten km** of this fibre. [2]

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(d) Give **three** advantages of using optical fibres rather than copper wires for transmitting information. [3]

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7. *(a)* Using one of the equations of motion for constant acceleration, show that, for a body dropped from rest over a small distance s, the acceleration due to gravity g, can be found from the equation [3]

$$g = \frac{2s}{t^2}$$

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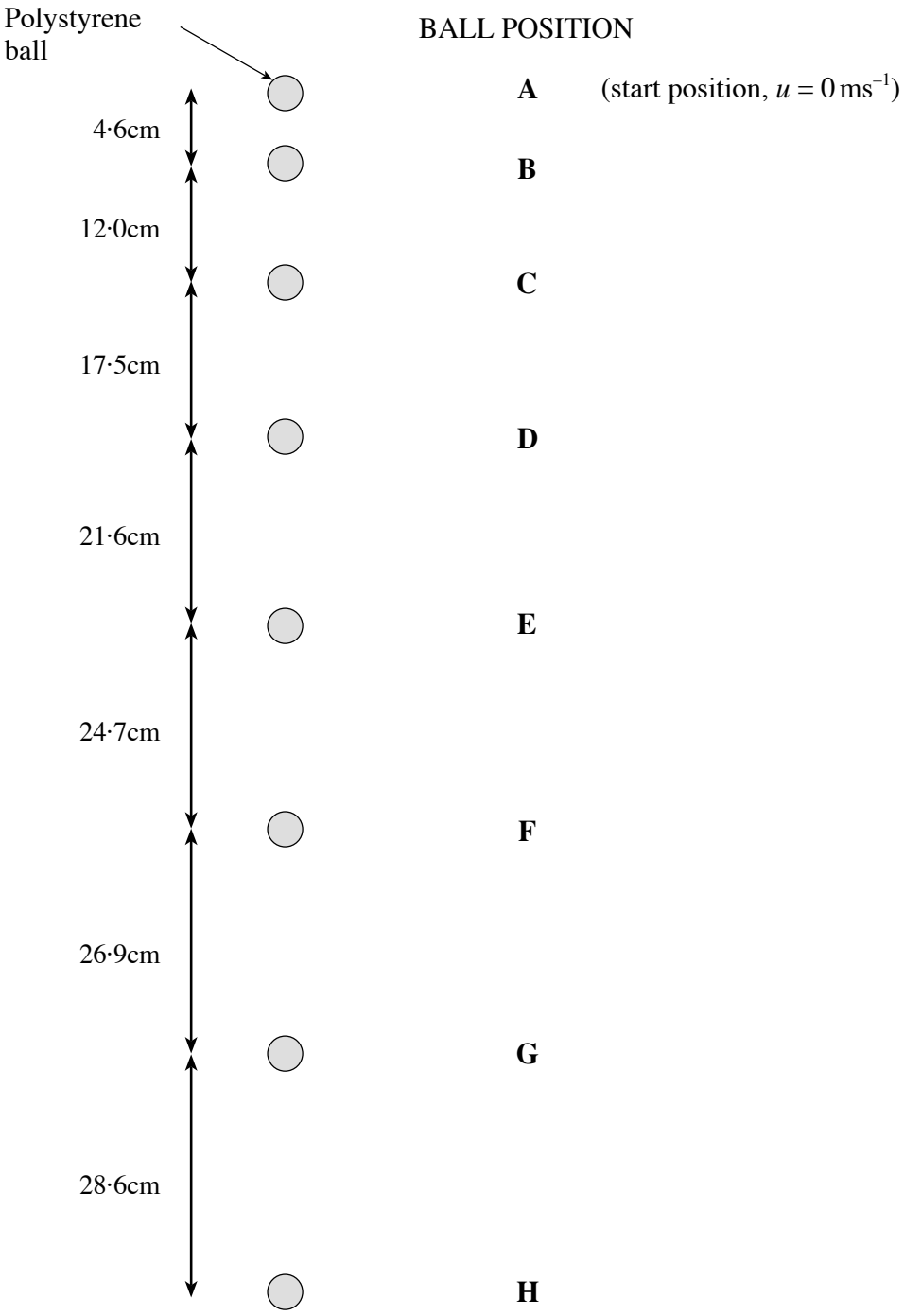
(b) An experiment is carried out to investigate the motion of a light polystyrene ball when it is allowed to fall from rest, at point **A**, in air. A camera is used to record the positions of the falling ball after regular intervals of time. The diagram is not to scale.



(i) The camera takes pictures at a frequency of 10·0 Hz. Calculate the time interval between pictures. [1]

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(ii) It is possible to use the photograph to estimate a value for g. Between which two positions will the ball have an acceleration closest to g? Explain your answer. [2]

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(iii) Using the equation given in part *(a)*, estimate a value for g. [2]

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(iv) After studying the photograph, a student states: *'The acceleration of the ball decreases as it falls.'* Explain, in terms of the forces acting on the ball, why the acceleration decreases. [3]

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(c) (i) Show that the average speed in the interval **A** to **B** is 0·46 ms^{-1}. [1]

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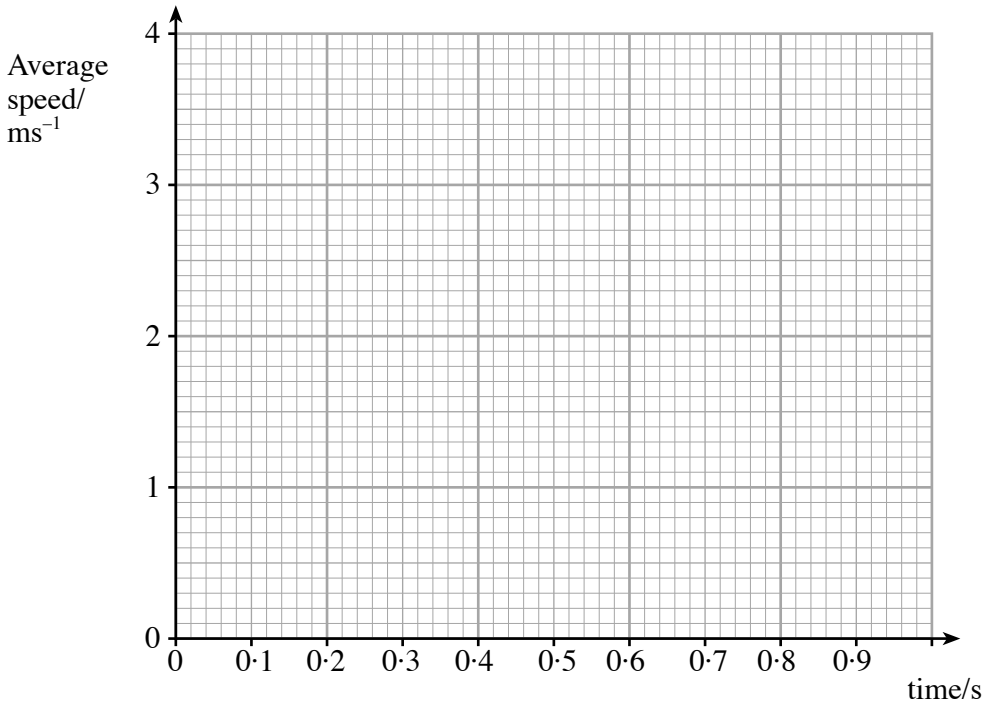
(ii) Hence complete the table for the average speed of the ball in the intervals **C** to **D**, **E** to **F** and **G** to **H**. Space is provided for your calculations. The average time of each interval, from the start, is given in the table. [1]

Interval	Average speed/ms^{-1}	Average time from start/s
A to **B**	0·46	0·05
C to **D**		0·25
E to **F**		0·45
G to **H**		0·65

(iii) Plot a graph of average speed against time on the grid below. [2]



(iv) Explain what is meant by the term '*terminal velocity*'. [2]

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(v) Use your graph to estimate the terminal velocity of the polystyrene ball. [1]

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(vi) Sketch, using the same axes, a graph that might be expected if the experiment were carried out in a vacuum. [2]

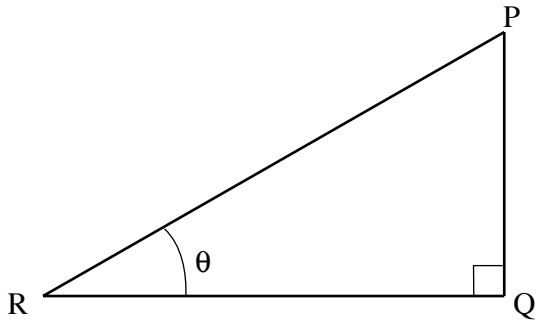
Mathematical Data and Relationships

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m

Multiple	Prefix	Symbol
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P

Geometry and trigonometry



$$\sin\theta = \frac{PQ}{PR}, \quad \cos\theta = \frac{QR}{PR}, \quad \tan\theta = \frac{PQ}{QR}, \quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$PR^2 = PQ^2 + QR^2$$

Areas and Volumes

Area of a circle = $\pi r^2 = \frac{\pi d^2}{4}$

Area of a triangle = ½ base × height

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$