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

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541/01

PHYSICS

ASSESSMENT UNIT PH1: Waves, Light and Basics

A.M. MONDAY, 13 January 2003

(1 hour 30 minutes)

Centre Number ....

Candidate's Name (in full) ....

Candidate's Examination Number ....

For Examiner's use only.	
1	
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Total	

INSTRUCTIONS TO CANDIDATES

Write your centre number, name and candidate number in the spaces provided above.

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	$= 6{\cdot}0 \times 10^{23}\ \text{mol}^{-1}$
Fundamental electronic charge	e	$= 1{\cdot}6 \times 10^{-19}\ \text{C}$
Mass of electron	m_e	$= 9{\cdot}1 \times 10^{-31}\ \text{kg}$
Molar gas constant	R	$= 8{\cdot}3\ \text{J mol}^{-1}\ \text{K}^{-1}$
Acceleration due to gravity at sea level	g	$= 9{\cdot}8\ \text{m s}^{-2}$
Planck constant	h	$= 6{\cdot}6 \times 10^{-34}\ \text{J s}$
Speed of light *in vacuo*	c	$= 3{\cdot}0 \times 10^{8}\ \text{m s}^{-1}$
Permittivity of free space	ε_0	$= 8{\cdot}9 \times 10^{-12}\ \text{F m}^{-1}$
Permeability of free space	μ_0	$= 4\pi \times 10^{-7}\ \text{H m}^{-1}$

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1. *(a)* State *Hooke's law* for a spring. [1]

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(b) You are asked to carry out an experiment to confirm that a spring obeys Hooke's law.

(i) Draw a labelled diagram of the apparatus you would use. [2]

(ii) State what measurements you would make and any precautions you would take in order to improve your results. [3]

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(c) (i) Sketch a graph of your expected results. [2]

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(ii) What does the gradient of the graph represent? [1]

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(iii) Sketch, on the same axes, a graph for a 'stiffer' spring which also obeys Hooke's law. **Label this graph 'S'**. [1]

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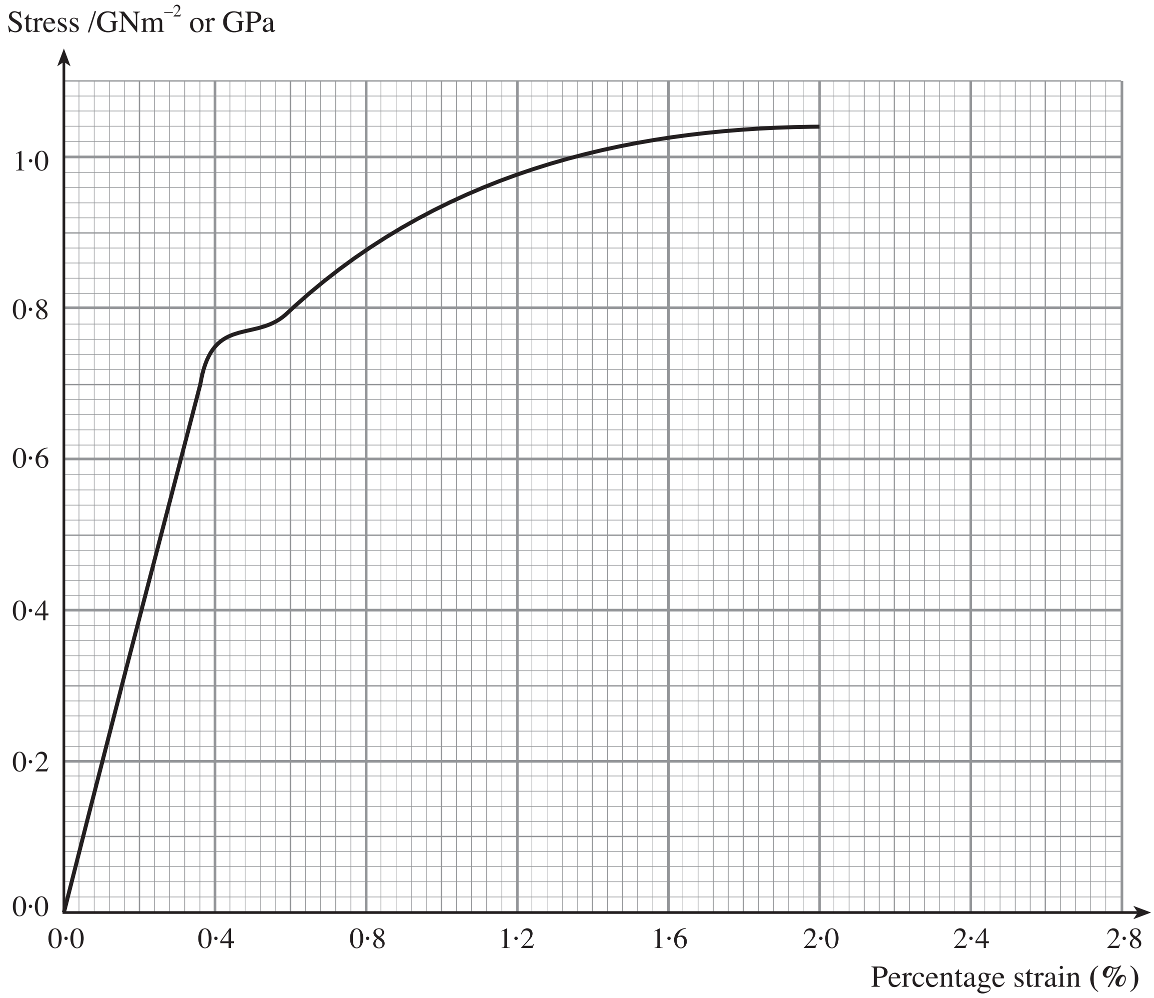
2. *(a)* Solid materials vary in their arrangement of atoms and molecules with differing amounts of long and short range order. Complete the table which characterizes different types of solids.

Type of solid	Order	Arrangement of particles
(i)	No long range order between molecules, although there is order within each molecule.	Long-chain molecules
Amorphous	(ii)	Individual atoms or small molecules
(iii)	Short and long range order.	(iv)

[1]

[1]

[1, 1]



(b) A stress vs strain graph for a mild steel wire is shown above. Label on the graph

(i) the yield point, [1]

(ii) a region where the wire's behaviour is elastic. [1]

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(c) Define

(i) *tensile stress,* [1]

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(ii) the *Young modulus*. [1]

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(iii) Find the strain in the wire when the stress is 0·40 GNm^{-2} (GPa). [1]

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(iv) Hence determine the Young modulus for the wire. [1]

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3. *(a)* One law of refraction states: 'The incident ray, the refracted ray and the normal at the point of incidence are all in the same plane'. State the other law of refraction (Snell's law). [2]

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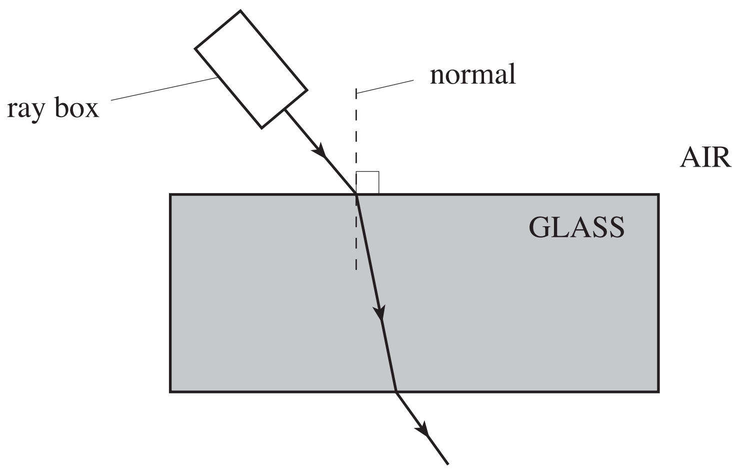
(b) A student uses the apparatus shown to find the refractive index of a sample of glass with respect to air. The results are shown in the table.



Angle of incidence in air.	Angle of refraction in glass.		
17·5°	11·5°		
30·0°	20·5°		
48·5°	29·0°		
65·0°	37·0°		

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(i) Using these results draw a suitable graph that would allow the refractive index of the glass to be found. Two blank columns are provided in the table to help you with your calculations. [3]

(ii) From the graph find the refractive index of the glass. [2]

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(iii) Calculate the speed of light in glass. (You will need to refer to the list of constants given on page 2). [2]

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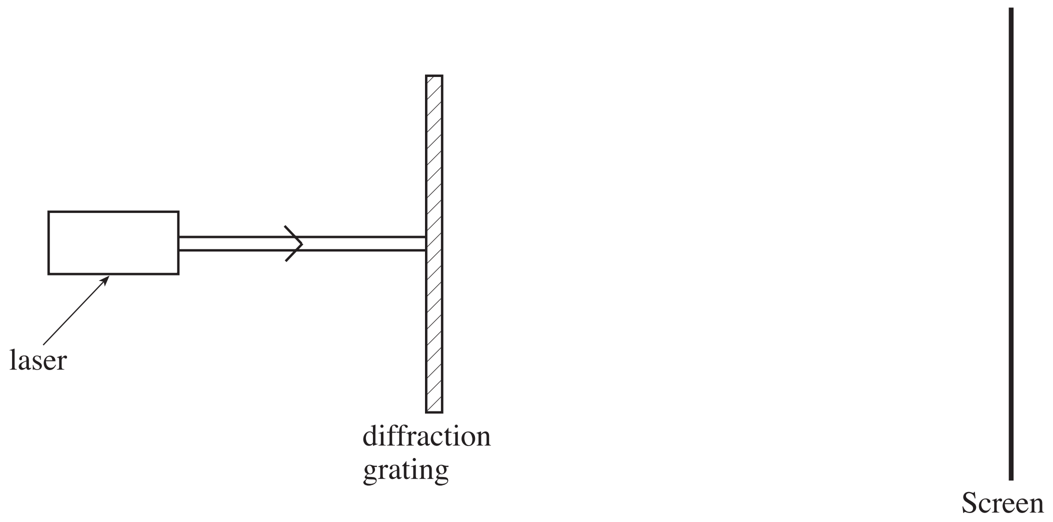
(c) The refractive index of clear plastic is less than that of glass. Sketch, on the same axes, a graph that might be expected if the glass block was replaced with a block of clear plastic. No calculations are necessary here. **Label this graph 'P'.** [1]

4. Laser light of wavelength, λ, is incident normally on an optical diffraction grating as shown. The diffracted light is observed on a screen.



The diffraction grating formula is given below

$$n\lambda = d\sin\theta$$

(a) The grating has $3{\cdot}0 \times 10^5$ lines per metre. It is found that the first order beam is diffracted through an angle of 10·2°. Calculate the wavelength of the laser light. [2]

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(b) (i) The maximum angle through which a beam may be diffracted is 90°. Show that the maximum order possible is given by [3]

$$n \leq \frac{d}{\lambda}$$

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(ii) Calculate the maximum order possible using this equipment. [2]

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(iii) How many bright spots (maxima) would be seen on the screen? [1]

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(c) The grating is now replaced by one which has double (i.e. 6×10^5)lines per metre. Explain how this would affect your answer to *b*(ii). [2]

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5. *(a)* What is meant by the *centre of gravity* of a body? [1]

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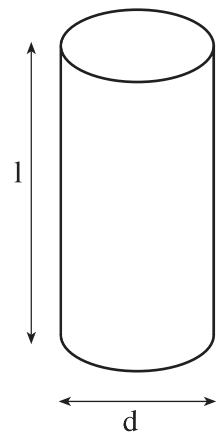
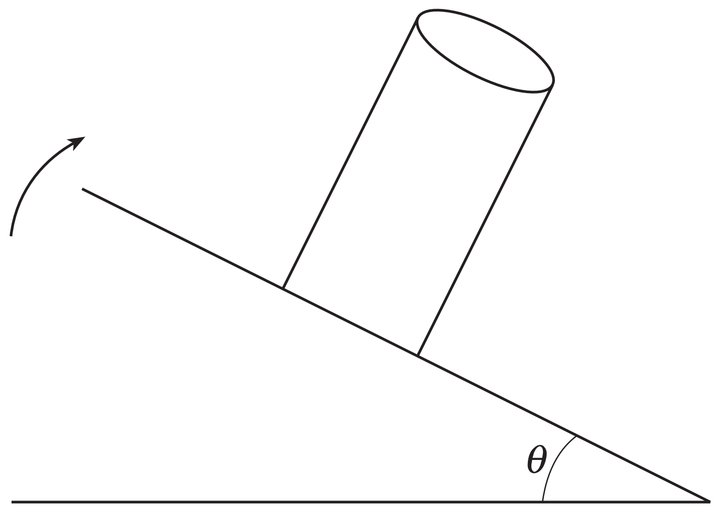
(b)



The diagram shows a uniform cylinder of length l and diameter d. **Clearly** indicate on this diagram the position of the cylinder's centre of gravity G. [1]

(c) The cylinder is now placed on a **rough** surface which is gradually tilted as shown. Assume no sliding can occur



(i) Indicate on the diagram the line of action of the cylinder's weight at the point of toppling. [1]

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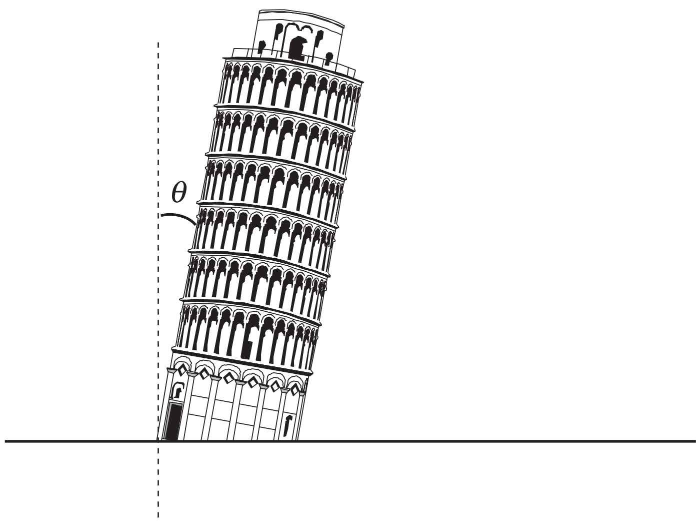
(ii) Hence show that

$$\tan\theta = \frac{d}{l}$$

where θ is the angle at which the cylinder will begin to topple. [3]

(d) As a rough approximation the Leaning Tower of Pisa can be considered to be a regular cylinder of height 56 m and base diameter 16 m. Recently the tower has been under threat of collapse.



(i) Estimate the angle θ to the vertical at which the tower would topple. [1]

(ii) Engineers estimate that the tower would collapse before reaching this angle due to crumbling masonry. On the diagram label the point where the **compression is greatest** with the letter **C.** [1]

(iii) Concrete can withstand a much higher compressive stress than tensile stress. Explain this. [2]

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6. *(a)* Figures A and B show two graphs which refer to the **same wave.**

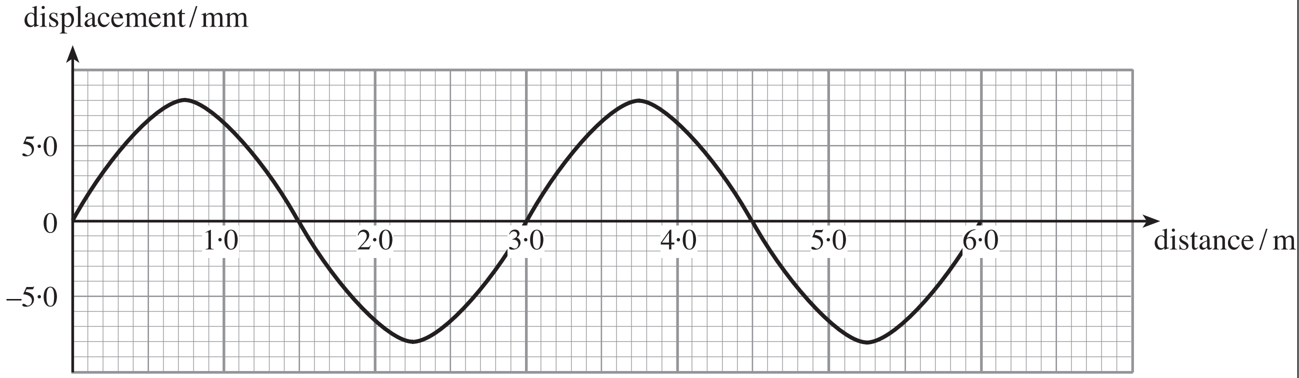

Fig. A

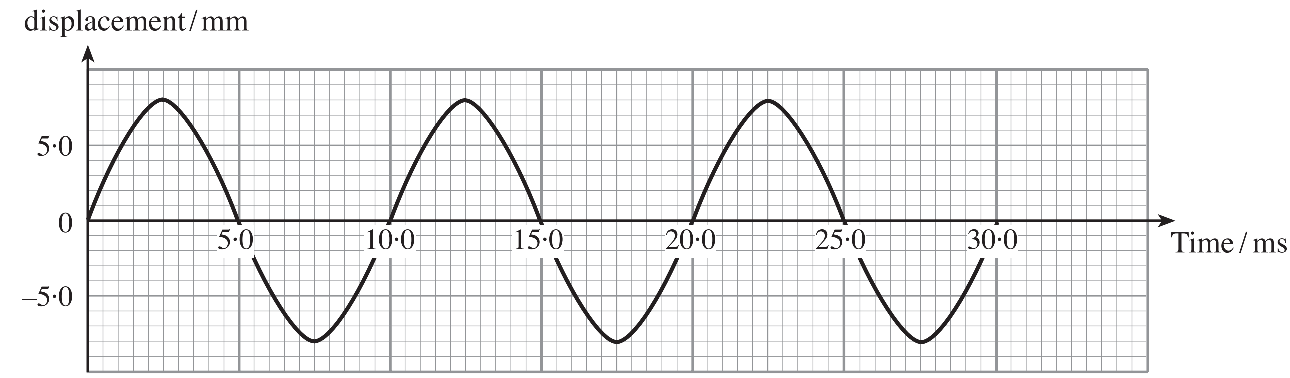

Fig. B

(i) Deduce from the graphs

(I) the amplitude of the wave, [1]

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(II) the wavelength of the wave, [1]

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(III) the period of the wave. [1]

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(ii) Hence find

(I) the frequency of the wave, [2]

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(II) the speed of the wave. [2]

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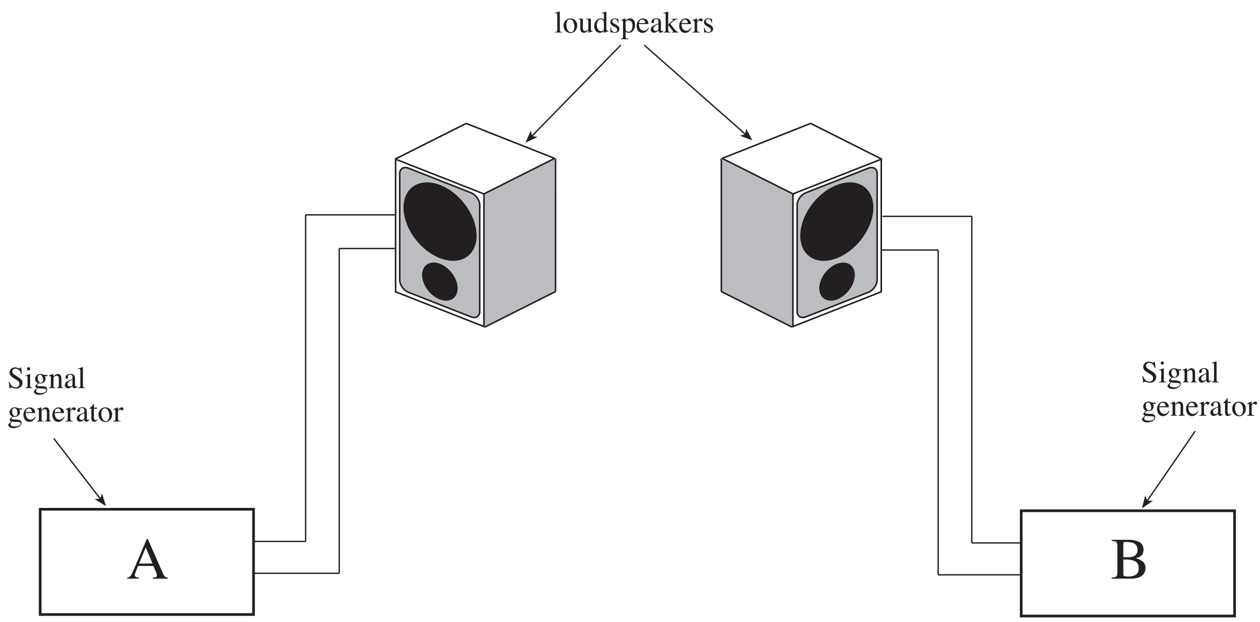
(iii) The period and amplitude of the wave are kept constant, however its speed is doubled. Sketch a curve to represent this change **on Fig A**. [2]

(b) The diagram shows an experimental set up to investigate the phenomenon of *beats*.



(i) Explain what is meant by the term *beats*. [2]

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(ii) Initially, A is set to a frequency of 450 Hz and B is set at 400 Hz. The frequency of B is gradually and steadily increased to 500 Hz. Both signal generators are set to give the same amplitude. Carefully explain what a stationary observer standing in front of the two speakers would hear. Use numerical values to help clarify your answer. [4]

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(iii) B is now switched off and A (f = 450 Hz) is then sounded together with a tuning fork of unknown frequency. A beat frequency of 3 Hz is heard. Calculate **two** possible values for the frequency of the tuning fork. [2]

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(iv) Carefully explain how it would be possible to determine the correct value of the tuning fork's frequency using this experimental set up. [3]

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7. *(a)* A body moving with a velocity u in a straight line accelerates uniformly for a time t until it reaches a velocity v, during which it travels a distance s.

(i) Sketch a velocity-time graph for the body. [2]

(ii) State the significance of the gradient of the graph. [1]

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(iii) Deduce from your graph that

$$v = u + at$$

[2]

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(iv) Give **one** other kinematical equation for uniform acceleration. [1]

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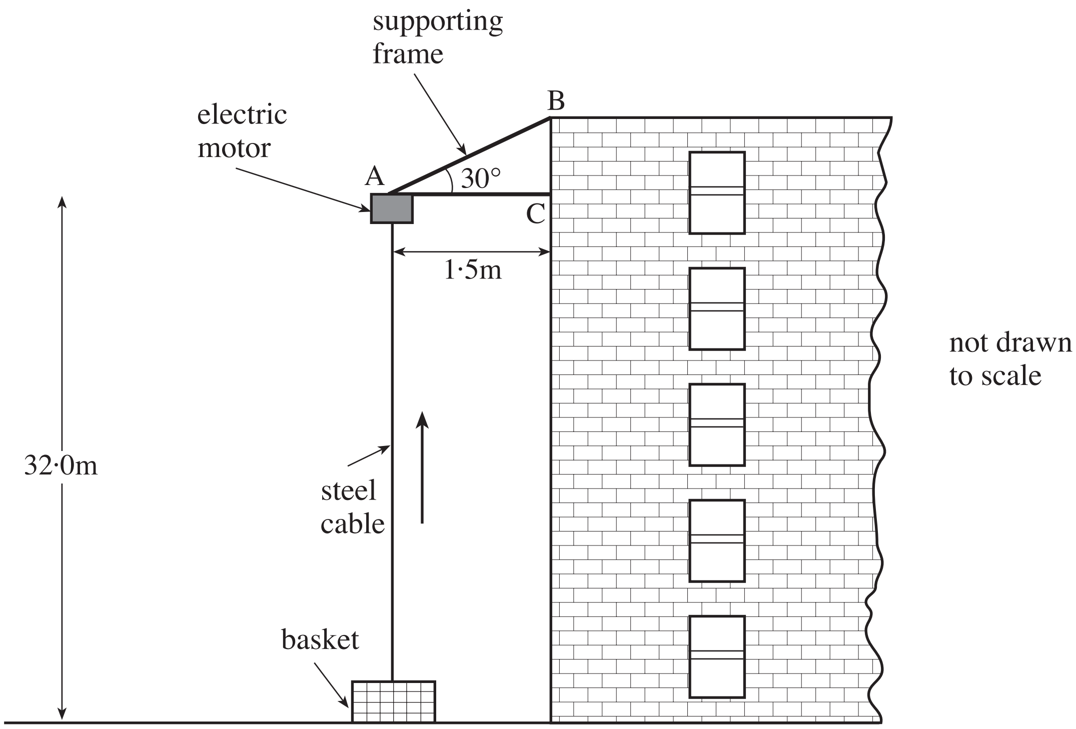
(b) On a building site a motorised hoist is used to transport bricks a distance of 32·0 m towards the top of a building. The hoist is attached to the top of the building as shown. The basket, when full of bricks, has a mass of 35·0 kg.



(i) The basket is filled with bricks on the ground and the motor switched on. Initially the basket accelerates uniformly from rest to a speed of 1·6 ms^{-1} in 2·0 seconds. Calculate the initial acceleration. [1]

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(ii) Whilst the basket is **accelerating** calculate

(I) the distance travelled, [2]

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(II) the tension in the cable. (You will need to refer to the list of constants given on page 2). [3]

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(iii) After the initial acceleration (i.e. after 2·0 s) the basket continues to move with **constant speed** for the remainder of the journey.

(I) Calculate the **total time** taken to reach the top. [2]

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(II) When the basket is moving with **constant speed** would you expect the tension in the cable to be more than, less than or the same as that calculated in *b*(ii)(II)? Justify your answer. [2]

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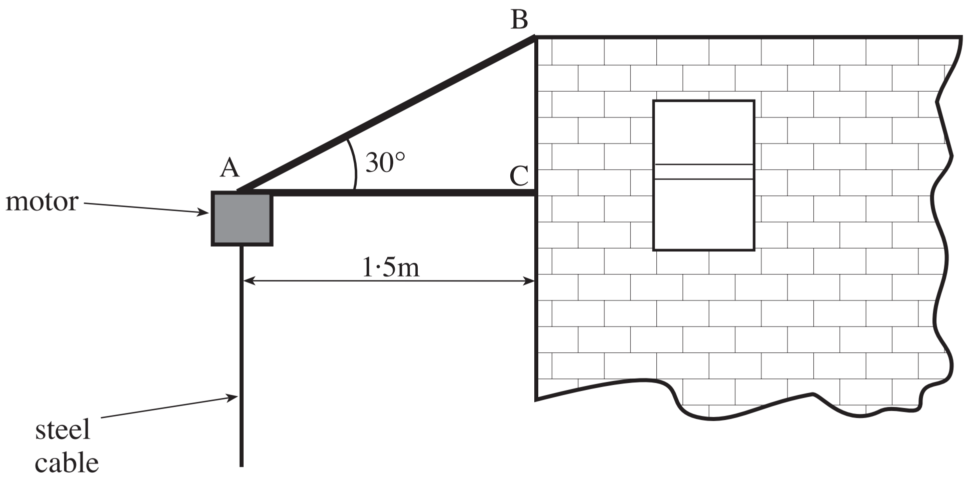
(iv) This is an enlarged diagram showing the supporting frame.



Calculate the tension in AB when the basket is moving at **constant speed.** Assume that the total mass of the motor and steel cable is 20 kg. You may ignore the mass of the support AC. [4]

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Turn over.

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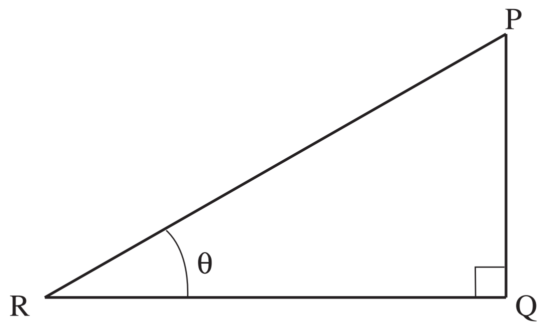
Mathematical Data and Relationships

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 $= \pi r^2 = \dfrac{\pi d^2}{4}$

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	$4\pi r^2$	$\frac{4}{3}\pi r^3$