Candidate Name	Centre Number	Candidate Number
		2

GCE AS/A level

541/01

PHYSICS

ASSESSMENT UNIT PH1: WAVES, LIGHT AND BASICS

P.M. THURSDAY, 22 May 2008

1½ hours

ADDITIONAL MATERIALS

In addition to this examination 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.

For Examiner's use only.	
1	
2	
3	
4	
5	
6	
7	
Total	

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 table of "Mathematical Data and Relationships" on the back page of this paper.

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 an electron	m_e	=	$9{\cdot}1 \times 10^{-31}$ kg
Mass of a 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
Boltzmann constant	k	=	$1{\cdot}38 \times 10^{-23}$ J K^{-1}
Unified mass unit	1 u	=	$1{\cdot}66 \times 10^{-27}$ kg
Speed of light *in vacuo*	c	=	$3{\cdot}0 \times 10^8$ m s^{-1}
Permittivity of free space	ε_o	=	$8{\cdot}9 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}

1. *(a)* The clarinet is a 'reed' instrument. A reed is a thin strip of material which vibrates to produce a sound. A musician, playing the clarinet in an orchestra, produces a note of frequency 440 Hz. Calculate how many vibrations the reed will make before the sound reaches a listener sitting 30 m away in the audience. Take the speed of sound to be 330 ms^{-1}. [3]

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(b) A second clarinet is now played together with the original. The second clarinet is slightly out of tune with the original which results in a series of *beats* which the listener estimates to have a frequency of 3 Hz.

(i) What is meant by beats? Explain why beats arise in this situation. [2]

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(ii) What is the beat period? [1]

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(iii) Write down two possible values for the frequency of the note produced by the second clarinet. [2]

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(iv) The frequency of the first clarinet is now increased to 445 Hz. The listener now determines that the beat frequency has **decreased**. Showing clearly how you obtained your answer, determine the frequency of the note played by the second clarinet. [2]

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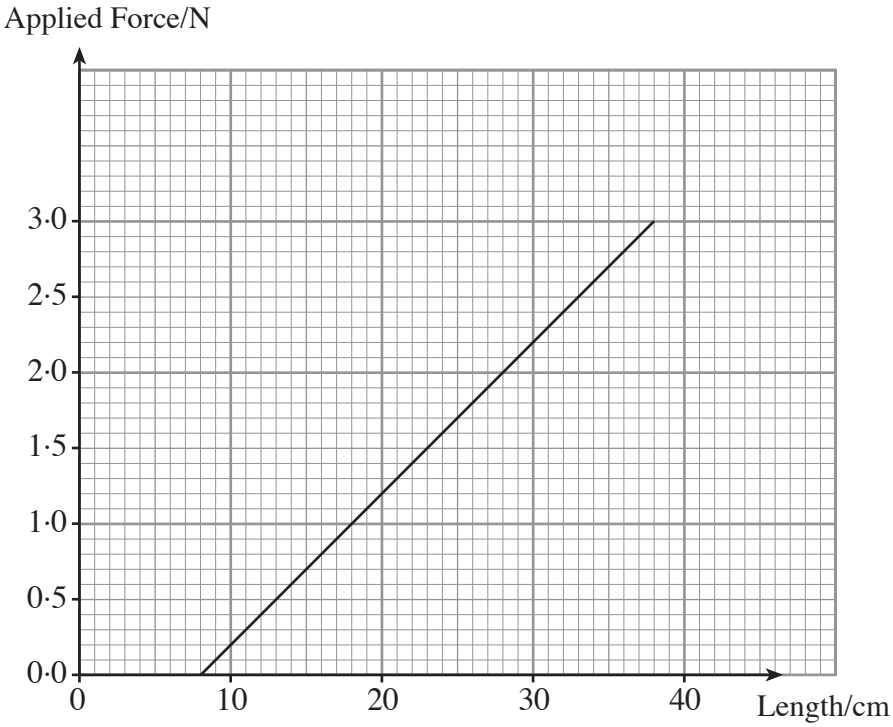
2. The following graph shows how the length of a spring varies with applied force. Hooke's law is obeyed throughout.



(a) (i) Determine the spring's original length. [1]

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(ii) Explain how the graph supports the claim that Hooke's law is obeyed. [1]

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(iii) Determine the spring constant, *k*. [2]

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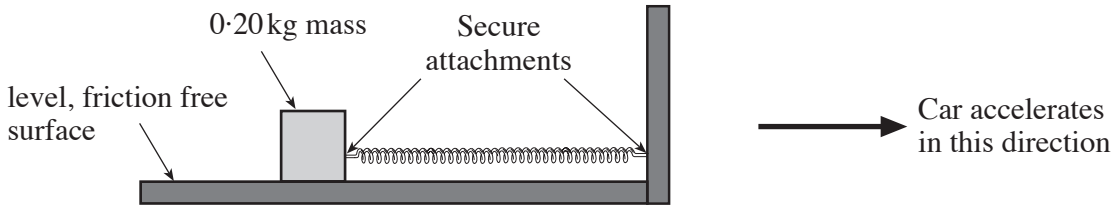
(b) The spring is now used in a simple accelerometer (a device for measuring acceleration). The spring is attached to a block of mass 0·20 kg which is placed on a friction-free surface as shown. The device is installed in a car.



The car accelerates uniformly from rest. During the acceleration the spring **extends** by 9·0 cm.

(i) Calculate the car's acceleration. [4]

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(ii) State the spring's **extension** if the car travels with constant velocity. Explain your answer. [2]

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3. *(a)* Explain, with the aid of a diagram, what is meant by *critical angle*. [2]

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(b) Diamonds rely on light for their 'sparkle' and are valued because of their ability to reflect light. They are cut or shaped to reflect as much light as possible. Diamond has a refractive index of 2·4.

(i) (I) Calculate the critical angle for diamond. [2]

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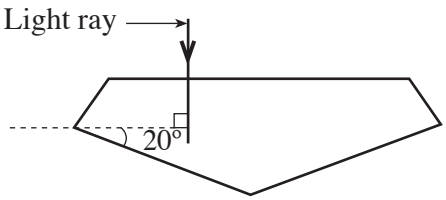
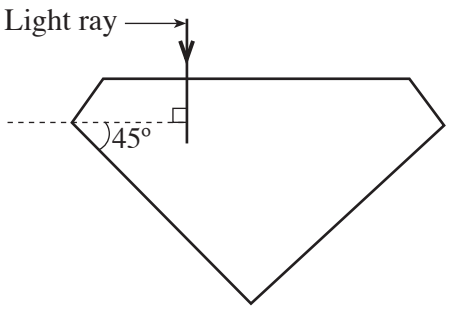
(II) The diagrams below show two differently cut diamonds, **A** and **B**. A ray of light is incident on each as shown. Complete the diagrams to show the path of the light through each diamond and out into the air again. [4]



Diamond A



Diamond B

(III) Which of these diamonds would appear to have the greater 'sparkle'? Explain your answer. [1]

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(ii) Calculate the speed of light in diamond. [Refer to the data on page 2]. [1]

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4. Monochromatic light of wavelength λ is incident on a *diffraction grating* and the diffracted light is observed on a screen. The diffraction grating formula is

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

(a) What is a diffraction grating? [1]

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(b) The grating has $5{\cdot}0 \times 10^5$ lines per metre. The second order beam is seen to diffract through an angle of 24·8°.

(i) Calculate λ. [3]

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(ii) Determine the maximum order observed on the screen. [2]

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(iii) How many lines are observed on the screen? [1]

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(c) The diffraction grating is now replaced with one which has **double** the number of lines per metre. Explain, using the formula given above and **without repeating the calculation in *(b)***, how this change would affect the number of lines observed on the screen (i.e. your answer to *(b)*(iii)). [3]

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5. *(a)* State the principle of superposition. [2]

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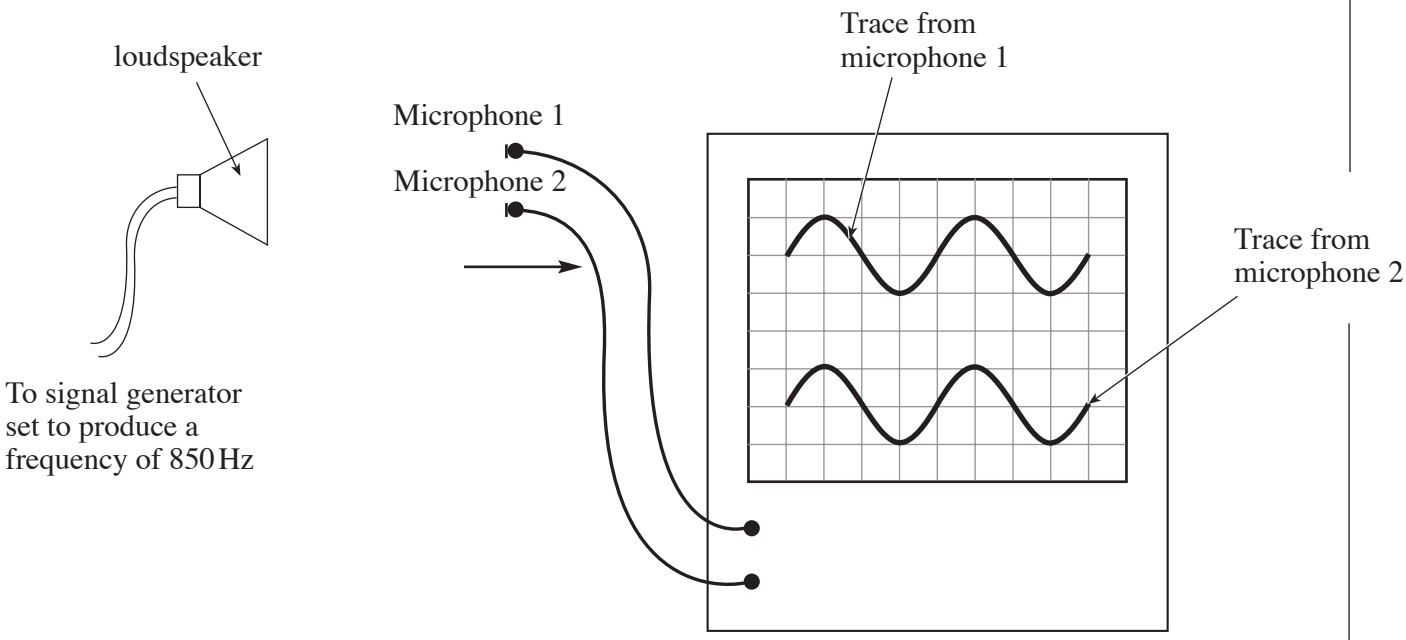
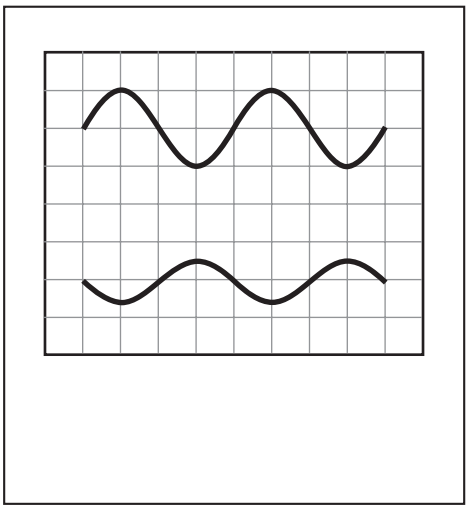
(b) The diagram shows an experimental set-up to measure the speed of sound in air. The double beam oscilloscope displays the output from each microphone. When both microphones are equidistant from the loudspeaker, **which is emitting sound of frequency 850 Hz**, the trace on the oscilloscope is adjusted to appear as in the diagram.



Microphone 1 is kept stationary and microphone 2 is moved 0·2 m further away from the loudspeaker in the direction of the arrow until the following trace is observed on the screen.



(i) Explain why the amplitude of the sound detected by microphone 2 has now decreased. [1]

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(ii) Determine the phase difference between the sound now arriving at microphone 1 and microphone 2. [1]

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(iii) Calculate the wavelength of the sound emitted by the loudspeaker. [1]

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(iv) Calculate a value for the speed of sound. [2]

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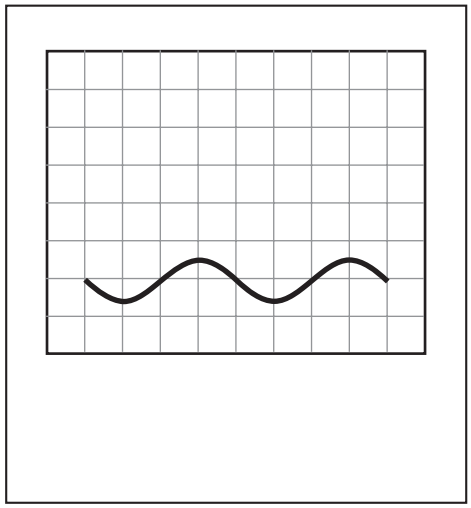
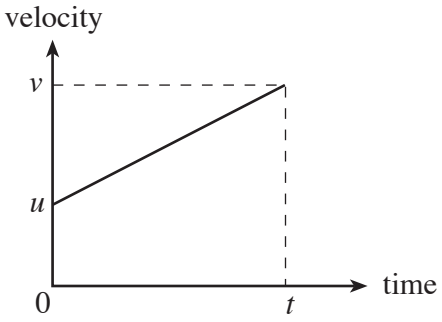
(c) Microphone 1 is now moved 0·4 m towards the loudspeaker. Sketch **carefully**, on the diagram below, the trace that might be expected from microphone 1. The trace from microphone 2 has not changed and is shown. [3]



6. *(a)* A velocity-time graph is given for a body which is accelerating.



(i) Using the symbols given on the graph, write down an expression for the gradient and state what it represents. [2]

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(ii) Using the symbols given on the graph, write down an expression for the area under the graph and state what it represents. [3]

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(iii) Use your answers to (i) and (ii) to show clearly that, using the usual symbols, [2]

$$s = ut + \tfrac{1}{2}at^2.$$

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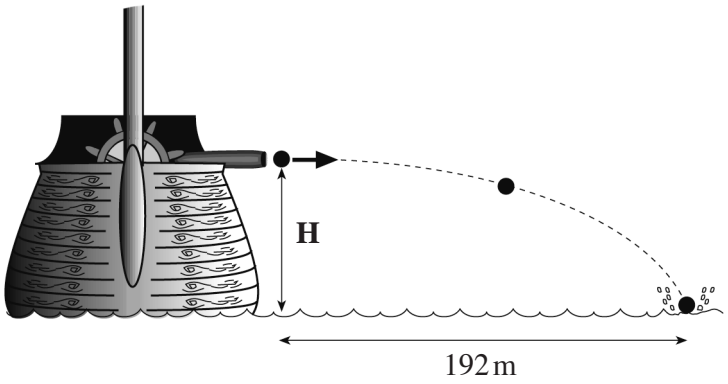
(b) Cannonballs, fired as shown, from a sail ship travel a horizontal distance of 192 m in 1·6 s before striking the sea. Ignore air resistance and refer to the data on page 2.



(i) Calculate the horizontal velocity of the cannon balls. [1]

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(ii) Determine the height **H**, of the cannon above the sea. [3]

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(iii) Calculate the resultant **velocity** of the cannon balls as they strike the sea. [5]

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(iv) The horizontal velocity is now increased. Explain the effect, if any, that this would have on the time of flight, i.e. the time taken for the cannon balls to strike the sea. [2]

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(c) Discuss the effect that air resistance would have on the cannon ball's motion. [2]

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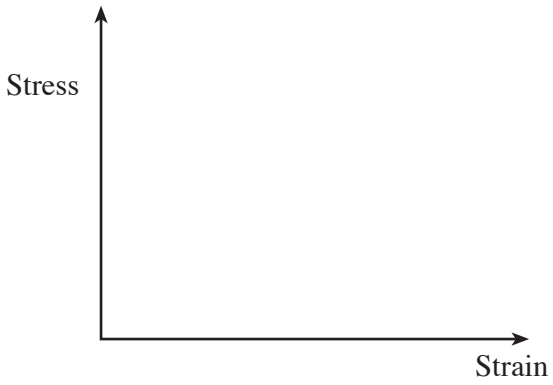
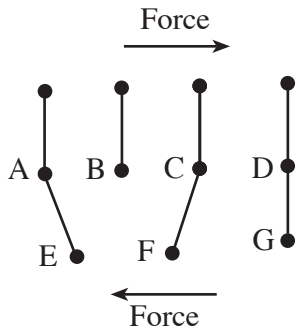
7. *(a)* (i) Sketch, using the given axes, a typical stress-strain graph for a metal when it is gradually loaded to breaking and label **three** key features of your graph. [1,3]



(ii) The diagram shows the arrangement of atoms in a metal in the region of a dislocation. Using the diagram, explain **briefly**, how **plastic stretching** occurs when forces are applied in the directions shown. [2]



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(b) The diagrams show cross-sectional and plan views of a riverside walkway. The walkway, made from uniform wooden planks, extends out over the river and is supported by steel cables attached to 5 equally spaced vertical pylons as shown.

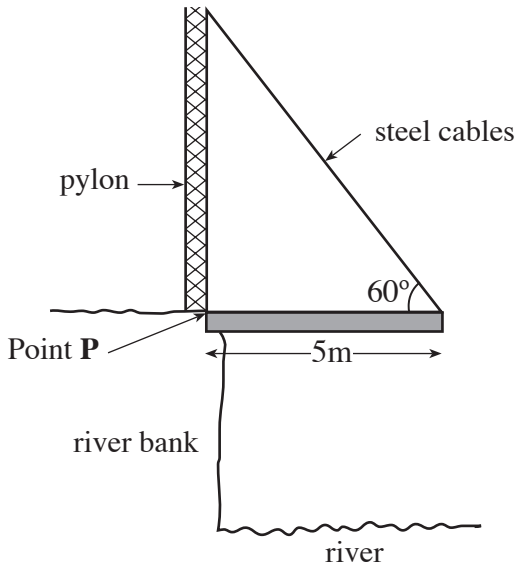

Diagram A
cross-sectional view

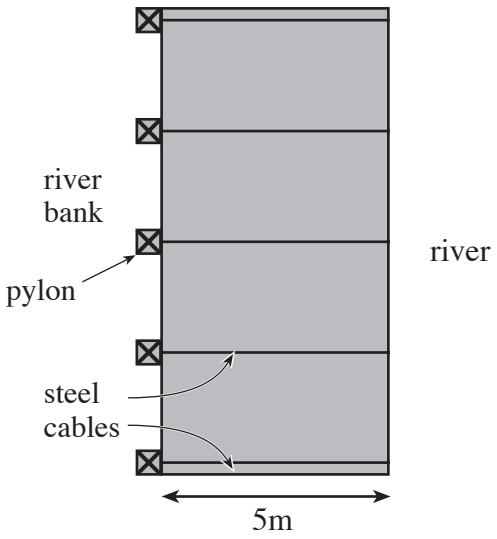

Diagram B
plan view

(i) Draw an **arrow** on **diagram A**, and place a **cross** on **diagram B** to indicate the centre of gravity of the walkway. [2]

(ii) At one particular time 200 people are evenly distributed on the whole of the walkway. The average mass of each is 60 kg and the mass of the walkway is 10000 kg. Calculate the total **weight** of walkway and people. [Refer to the data on page 2]. [2]

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(iii) Hence calculate the 'clockwise' turning moment about point **P**. [1]

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(iv) Calculate the tension in **each** cable assuming that each cable carries the same load. [4]

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(v) Hence calculate the extension in **each** cable given that the cross-sectional area of each is $7{\cdot}0 \times 10^{-4}\,m^2$. Young Modulus of steel = $2{\cdot}0 \times 10^{11}$ Pa. [4]

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(vi) Explain why your answers to (iv) and (v) would be larger if the majority of people walked towards the outer edge of the walkway. [1]

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Examiner only

Examiner only

Turn over.

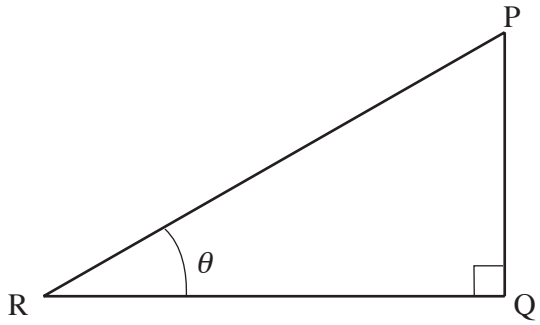
Mathematical Data and Relationships

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