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, 12 January 2004

(1 hour 30 minutes)

Centre Number ....

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

Candidate's Examination Number ....

For Examiner's use only.	
1	
2	
3	
4	
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7	
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	=	$6{\cdot}0 \times 10^{23}$ 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
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
Speed of light *in vacuo*	c	=	$3{\cdot}0 \times 10^{8}$ m s^{-1}
Permittivity of free space	ε_0	=	$8{\cdot}9 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}

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1. *(a)* A student gives the following **incorrect** definition for the moment of a force.

'Moment of force = mass × distance from pivot'

Give two reasons why this definition is incorrect.

(i) Reason 1. [1]

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(ii) Reason 2. [1]

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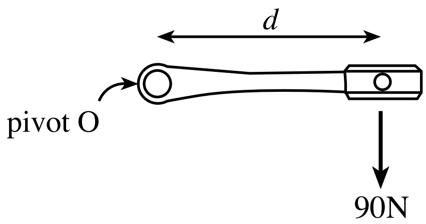
(b) A cyclist exerts a **constant downward force** of 90 N on one pedal as shown. When the pedal is in the horizontal position, a moment of 27 Nm is produced about the pivot O.



(i) Calculate *d*. [2]

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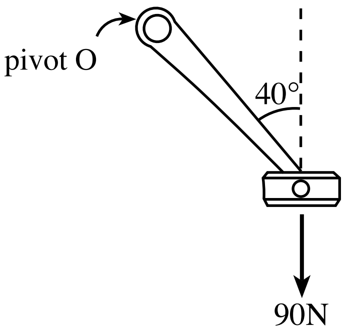
(ii) Hence calculate the moment about O when the pedal is in the following position. [3]



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(iii) Draw, in the space below, two positions of the pedal that would give zero moment about O. [2]

(iv) Explain why the force has zero moment in these positions. [1]

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2. The following results were recorded in an experiment where different masses were hung on the end of a light vertical spring, the other end of which was firmly fixed.

length of spring (m)	0·40	0·46	0·52	0·57	0·62
attached mass (kg)	0·20	0·40	0·60	0·80	1·00
applied force (N)					

(a) Calculate the weight of the 0·20 kg mass. (You will need to refer to the list of constants given on page 2). [1]

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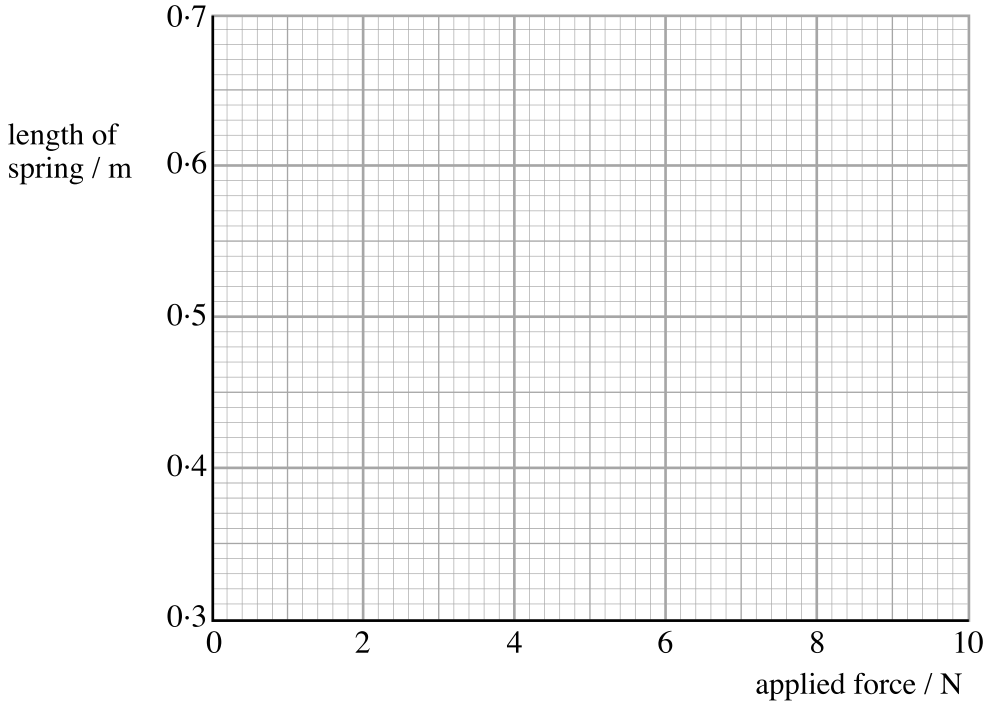
(b) (i) Draw a graph of *length of spring* against *applied force*. Another row has been added to the table to help you with your calculations. [3]



(ii) Using the graph, determine

(I) the unstretched length of the spring, [1]

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(II) the value of the spring constant. [3]

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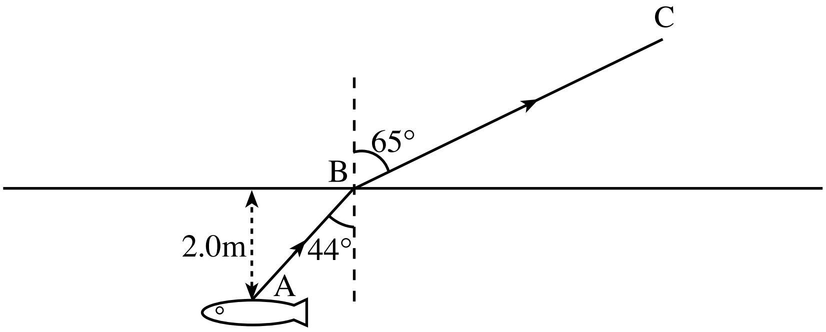
(c) The experiment is repeated using a 'stiffer' spring with a spring constant which is **double** that calculated in *b*(ii)(II). Draw, on the same axes, a possible force-length graph for this spring. [2]

3. The diagram shows a fish swimming under the surface of a lake. A light ray (ABC) travelling to the surface is refracted as shown.



(a) Using the information in the diagram, calculate the refractive index of water. (Refractive index of air = 1·00) [2]

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(b) (i) Calculate the critical angle at the water-air boundary. [2]

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(ii) Explain what is meant by the term *'total internal reflection'*. A space is provided so that you may answer this question by drawing a diagram if you wish. [2]

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(iii) Draw on the top diagram a light ray from the fish which is totally internally reflected. [1]

(c) Calculate the time taken for the light to travel from A to B. (You will need to refer to the list of constants given on page 2.) [3]

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4. *(a)* The speed, v of transverse waves along a stretched string having tension T, length l, and mass m, is given by

$$v^2 = \frac{T \times l}{m}$$

Show that the equation is correct as far as units (or dimensions) are concerned. [4]

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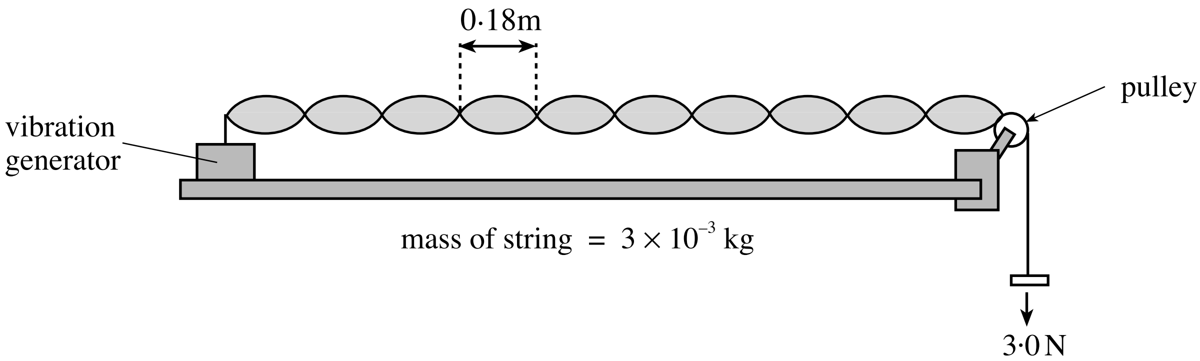
(b) The diagram shows a stationary wave in a string under tension.



(i) How many complete wavelengths are shown in the above diagram? [1]

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(ii) Explain how stationary waves are produced in the above set up. [2]

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(iii) Use the information given in the diagram, and the equation given in *(a)* to calculate the speed of the wave in the string. [1]

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(iv) The tension in the string is reduced by a factor 4 (i.e. it is a quarter of the previous value). By what factor will the speed v change? [2]

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5. The following table is taken from the Highway Code and gives data for 'Typical Stopping Distances' of a car when braking on a dry road.

speed/MPH	speed/ms^{-1}	thinking distance/m	braking distance/m	stopping distance/m
20	8·9	6	6	12
30	13·4	9	14	23
50	22·4	15	38	53
70	31·3	21	75	96

(a) The 'thinking distance' is the distance the car moves while the driver is reacting before applying the brakes. Calculate the 'thinking time' for a speed of 50MPH (22·4 ms^{-1}). [1]

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(b) The 'braking distance' is the distance the car travels while decelerating once the brakes have been applied. A car of mass 450 kg is travelling at a speed of 70MPH (31·3 ms^{-1}) when the driver makes an emergency stop.

(i) Calculate the deceleration of the car. (Assume an uniform deceleration). [3]

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(ii) Hence determine the mean force which produces this deceleration. [2]

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(iii) The car is then filled with passengers so that its mass is doubled. Calculate its **stopping distance** when travelling at 70MPH. Assume the force calculated in *b*(ii) remains constant. [3]

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(iv) Factors such as air resistance contribute to the stopping distance of the car. Taking these factors into account explain whether the assumption made in *b*(iii) is justified. [1]

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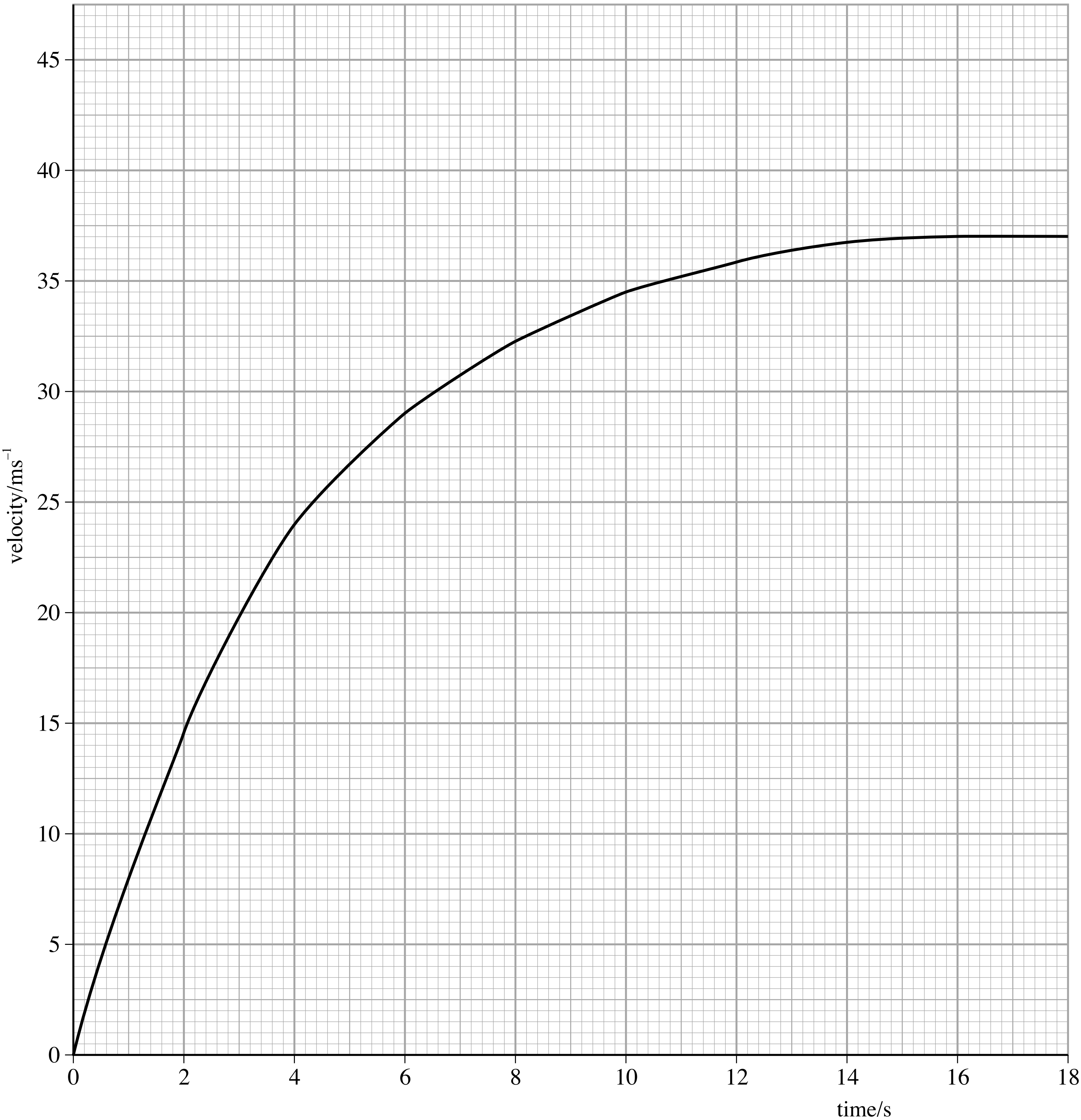
6. A velocity-time graph for a sky-diver jumping from an aeroplane is shown.



(a) Estimate the distance fallen by the sky-diver in the first four seconds. [2]

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(b) (i) Determine the sky-diver's acceleration at time t = 6·0s. [3]

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(ii) The sky diver has a mass of 80 kg. Calculate the resultant force on the sky-diver at time t = 6·0s. [2]

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(iii) Write down an equation relating 'weight', 'air resistance' and 'resultant force'. [1]

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(iv) Hence calculate the force of air resistance on the sky-diver at time t = 6·0s. (You will need to refer to the list of constants given on page 2). [2]

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(v) Explain clearly why the gradient (slope) of the graph decreases as the time increases. Your answer should refer to the forces acting on the sky-diver. [4]

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(vi) Write down the maximum value of air resistance that the sky-diver will experience. Label on the graph, with the letter **'R',** a time when the air resistance will be a maximum. [2]

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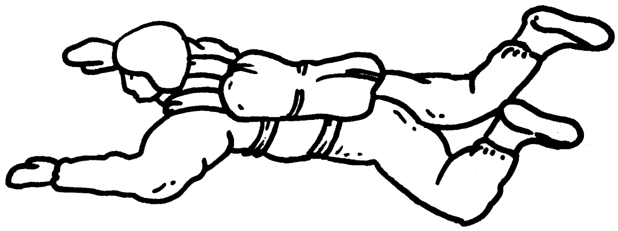
(vii) The graph corresponds to the sky-diver falling in the horizontal position as shown. Sketch, on the same axes, a graph that might be expected if the sky diver had fallen 'head first'. [2]



(viii) In the 'head first' position, would you expect the maximum value of air resistance on the sky-diver to be greater than, less than or the same as that deduced in *(b)*(vi)? Explain your answer. [2]

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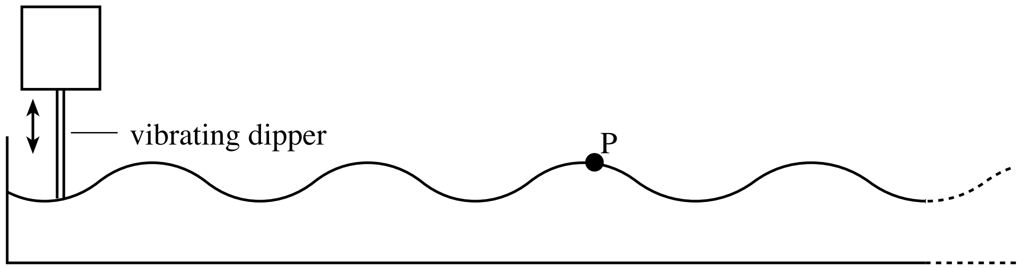
Turn over.

7. Water ripples are made to travel across the surface of a shallow tank by means of a vibrating dipper. The dipper is set to oscillate up and down at a fixed frequency, *f*. At one instant the position of the waves is shown in the cross-section below.



(a) (i) It is found that the waves travel a distance of 16·8 cm in 0·8 s.Calculate the speed of the waves. [2]

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(ii) State what is meant by the *wavelength* of a wave. [2]

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(iii) The horizontal distance between a crest and a neighbouring trough is 1·5 cm.Calculate the wavelength of the waves. [1]

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(iv) Calculate the frequency of the vibrating dipper. [2]

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(v) Hence determine the period of the vibrating dipper. [2]

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(vi) Draw, on the diagram, a double headed arrow to show the direction of the oscillating motion of a particle at point P. Assume that the waves are transverse. [1]

(vii) Giving your answer in either degrees or fractions of a cycle, determine the phase difference between the oscillations of points on the wave separated by 0·75 cm. [1]

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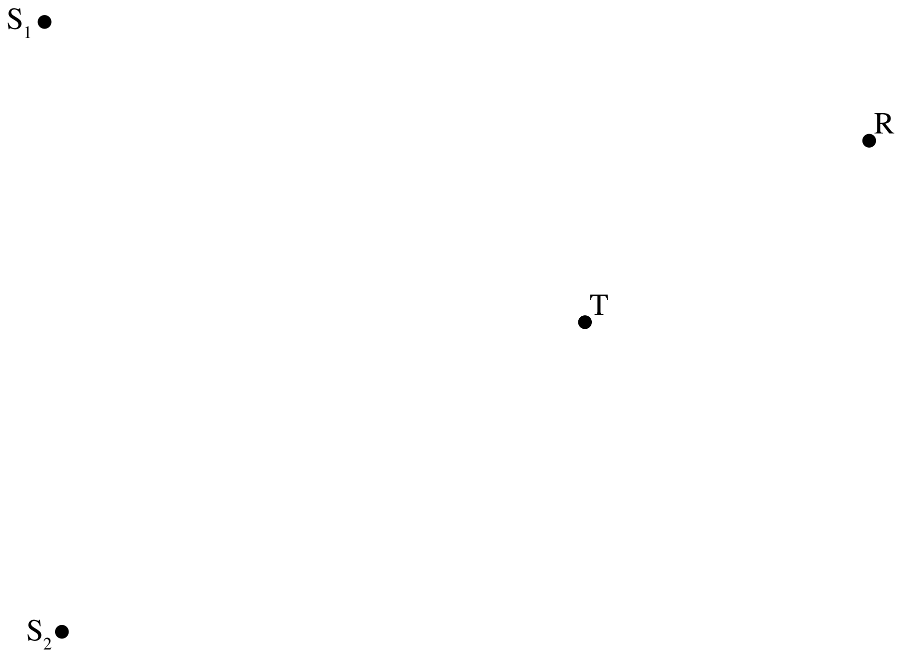
(viii) Mark on the above diagram with the letter **Q**, one point which is 180° (½ of a cycle) out of phase with point P. [1]

(b) The single dipper is now replaced by two identical dippers, S_1 and S_2 as shown. They oscillate in phase with the **same frequency** as the single dipper in *(a)*. A stable interference pattern is observed in the tank due to the superposition of the two waves generated by the sources. The diagram shows the view from above and is actual size. R and T are two points within the interference pattern.



(i) State the *Principle of Superposition*. [2]

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(ii) Taking the necessary measurements and, clearly showing your reasoning, determine whether R corresponds to a point of constructive interference or destructive interference. [4]

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(iii) Deduce the amplitude of the resulting wave at R. [1]

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(iv) T is a point, which is equidistant from S_1 and S_2. State the type of interference expected here. [1]

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Turn over.

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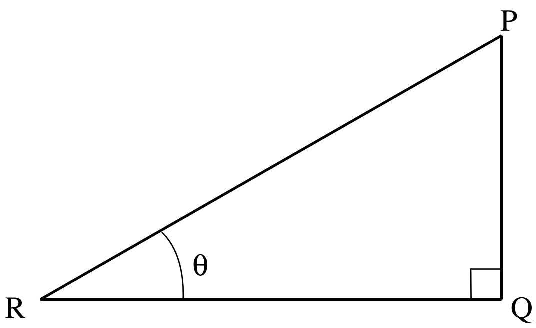
Mathematical Data and Relationships

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