Candidate Name	Centre Number	Candidate Number

541/01

PHYSICS

Assessment Unit PH1: Waves, Light and Basics

P.M. FRIDAY, 12 January 2007

(1 hour 30 minutes)

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	
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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.

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

Fundamental Constants

Avogadro constant	N_A	$=$	$6.0 \times 10^{23}\ \text{mol}^{-1}$
Fundamental electronic charge	e	$=$	$1.6 \times 10^{-19}\ \text{C}$
Mass of an electron	m_e	$=$	$9.1 \times 10^{-31}\ \text{kg}$
Mass of a proton	m_p	$=$	$1.67 \times 10^{-27}\ \text{kg}$
Molar gas constant	R	$=$	$8.3\ \text{J mol}^{-1}\ \text{K}^{-1}$
Acceleration due to gravity at sea level	g	$=$	$9.8\ \text{m s}^{-2}$
[Gravitational field strength at sea level	g	$=$	$9.8\ \text{N kg}^{-1}$]
Universal constant of gravitation	G	$=$	$6.7 \times 10^{-11}\ \text{N m}^2\text{kg}^{-2}$
Planck constant	h	$=$	$6.6 \times 10^{-34}\ \text{J s}$
Unified mass unit	$1\ \text{u}$	$=$	$1.66 \times 10^{-27}\ \text{kg}$
Boltzmann constant	k	$=$	$1.38 \times 10^{-23}\ \text{J K}^{-1}$
Speed of light *in vacuo*	c	$=$	$3.0 \times 10^8\ \text{m s}^{-1}$
Permittivity of free space	ε_o	$=$	$8.9 \times 10^{-12}\ \text{F m}^{-1}$
Permeability of free space	μ_o	$=$	$4\pi \times 10^{-7}\ \text{H m}^{-1}$

1. An object of mass $1 \cdot 0\,kg$ is attached to a trolley of mass $2 \cdot 5\,kg$ as shown. Initially the $1 \cdot 0\,kg$ mass is held at $1 \cdot 6\,m$ above the floor. Ignore the efforts of friction and air resistance.

Friction free pulley

$M_{trolley} = 2 \cdot 5\,kg$

$M_{object} = 1 \cdot 0\,kg$

$1 \cdot 6m$
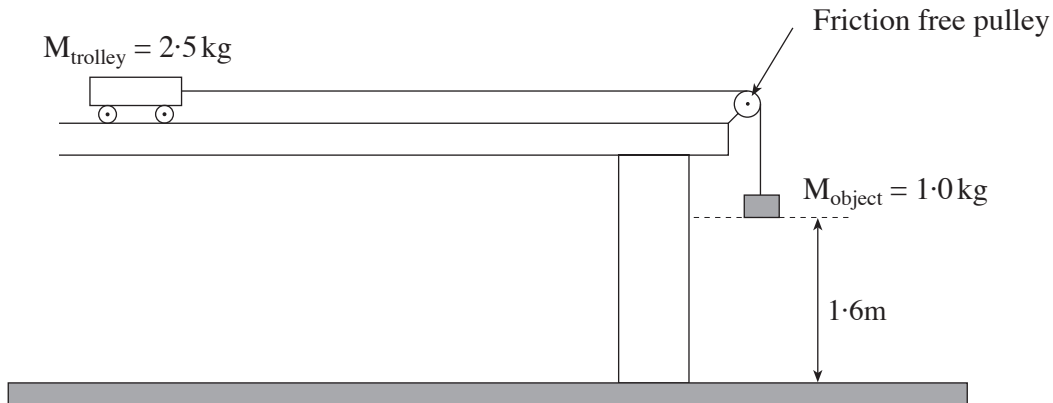
(a) Show that, when the $1 \cdot 0\,kg$ mass is released, the acceleration of both the trolley and mass is $2 \cdot 8\,ms^{-2}$. [Refer to the data on page 2]. [2]

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....

(b) The trolley continues to accelerate while the $1 \cdot 0\,kg$ mass is falling.

(i) Determine the time taken for the mass to hit the floor. [2]

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....

....

(ii) Calculate the trolley's velocity at this time. [2]

....

....

(c) Describe and explain the motion of the trolley after the $1 \cdot 0\,kg$ mass hits the floor. [2]

....

....

(d) Suppose the $1 \cdot 0\,kg$ mass had initially been at only $1 \cdot 0\,m$ above the floor. Without further calculation, state the effect this would have had on the trolley's

(i) acceleration; [1]

....

(ii) maximum velocity. [1]

....

Turn over.

2. You are asked to carry out an experiment to determine the Young modulus of a metal in the form of a wire.

(a) Draw a labelled diagram of the apparatus you would use. [3]

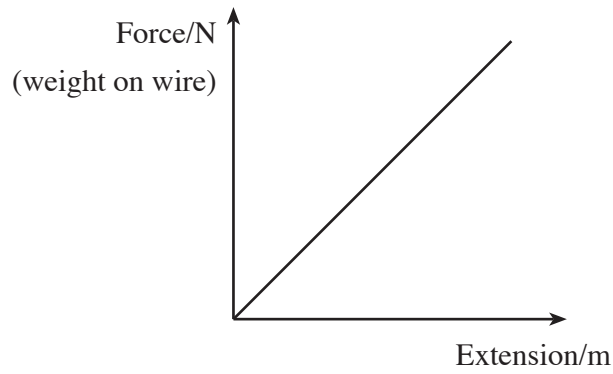*(b)* List the **measurements** you would make and the **apparatus** you would use to make them. [3]

Measurements	Apparatus

(c) State **one** precaution you would take in order to achieve accuracy. [1]

....

(d) The following sketch graph represents the results obtained from such an experiment.

Force/N
(weight on wire)

Extension/m

Explain how you would use an accurately drawn graph of force against extension, as well as other measurements you have made, to obtain a value for the Young modulus of the metal.

[3]

....

....

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Turn over.

3. *(a)* One condition for a body to remain in equilibrium is that there should be *no net moment* acting on it. State the other condition necessary for a body to remain in equilibrium. [1]

....

(b) The diagram shows a uniform plank of weight w pivoted so that it remains in equilibrium when weights w_1 and w_2 are placed on it at distances x_1 and x_2 from the pivot as shown. R represents the normal reaction at the pivot.
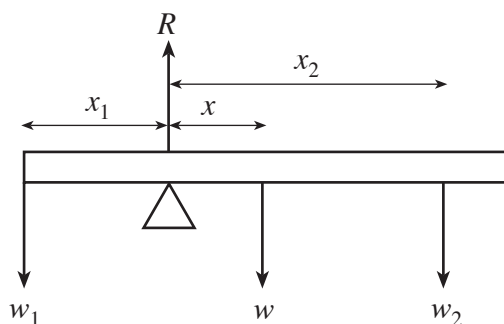
(i) Applying the principle of moments about the pivot, complete the expression:

$$w_1x_1 = \text{..} \quad [1]$$

(ii) Using your answer to part *(a)*, write down an expression for R. [1]

....

(c) An experiment is carried out to find the weight of a Physics student. A uniform plank of wood PQ, 3·0 m long, weighing 80 N is pivoted about a point 0·5 m from P. The student stands 0·3 m from P. A 20 N weight is placed 0·5 m from Q in order to balance the plank horizontally.

(i) Draw a diagram of the plank representing **each** force on it by an arrow. Indicate distances in your diagram. [3]

(ii) Calculate the weight of the student. [3]

....

....

....

(iii) Determine the value of the force exerted by the pivot on the plank. [1]

....

4. *(a)* Beams of red light of wavelength 700 nm and green light of wavelength 550 nm are incident normally on a diffraction grating which has 5000 **lines per cm**. Bright spots (maxima) are observed on a distant screen.

(i) State **one** use of a diffraction grating. [1]

....

(ii) Show clearly that the grating spacing, d is $2 \cdot 0 \times 10^{-6}$ m. [1]

....

....

(iii) Show clearly which of the two colours would give a **second** order maximum at an angle of diffraction between 33° and 34°. [3]

....

....

....

....

(b) (i) Show that the maximum order possible is given by [2]

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

....

....

(ii) Determine the maximum order for

(I) the green light, [1]

....

(II) the red light. [1]

....

(iii) Assuming that the diffracted beams from both lights only overlap at $n = 0$, determine the total number of bright spots which can be observed. [1]

....

....

Turn over.

5. *(a)* (i) Define the spring constant k. [1]

....

(ii) Show that the unit of k may be written as kgs^{-2}. [2]

....

....

(b) A quick experiment is carried out in order to determine k for a spring. The following results are obtained.

Stretched
length

w
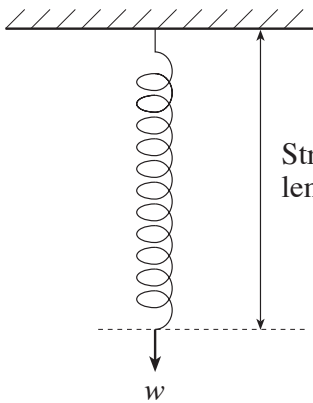
Weight, w, attached to spring/N	Stretched length of spring/m
10	0·25
30	0·55

(i) Calculate k, stating an assumption that you make. [3]

....

....

....

(ii) Determine the unstretched length of the spring. [1]

....

....

(c) In some restaurants, plates are dispensed from a platform attached to three springs hung in parallel, as shown in the diagrams.

PLAN VIEW
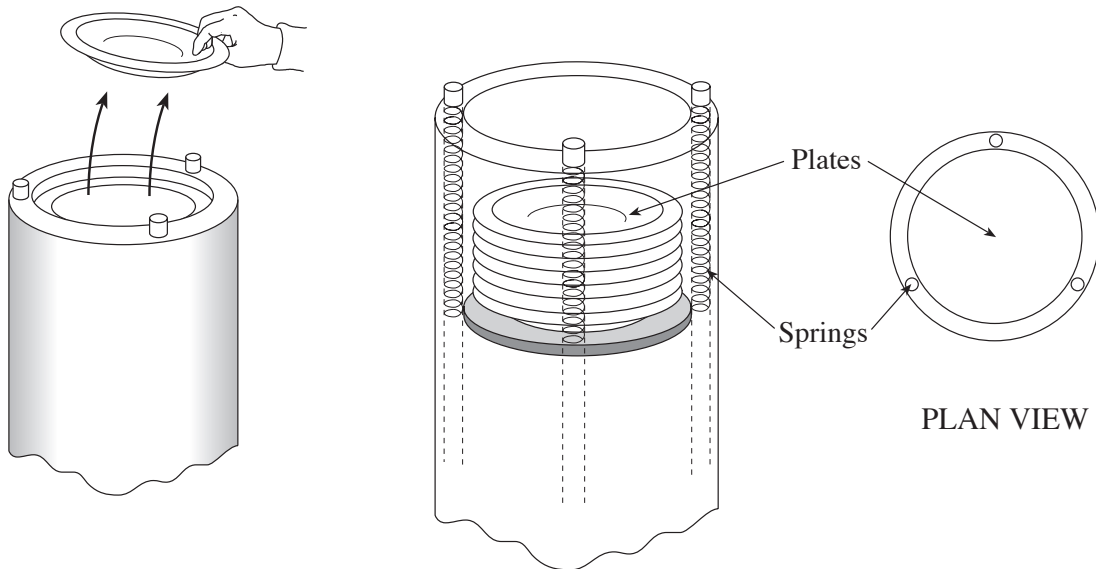
(i) Each of the springs used in such a system has the same spring constant, k, as that calculated in *(b)*(i). Determine the overall spring constant for this three-spring system.
[1]

....

....

(ii) Assuming each plate weighs 6·0 N, determine the number of plates the system can hold without exceeding the maximum safe spring extension of 0·75 m. (The springs have no extension when the device is empty, they only begin to extend when a plate is placed in the device). [2]

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Turn over.

6. Mean (average) velocity is defined by the equation
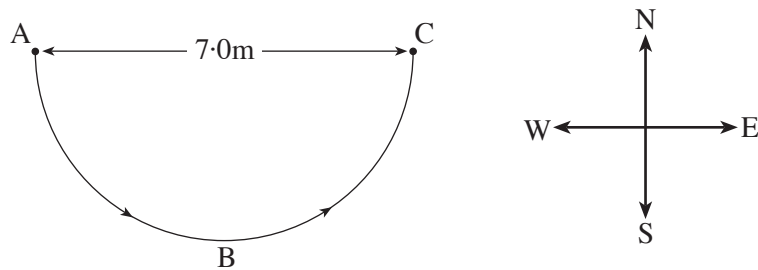
$$\text{Mean velocity} = \frac{\text{Displacement}}{\text{Time}}$$

(a) Write down the definition of mean speed. [1]

....

....

(b) A toy car takes 11·0 s to travel at constant speed in a semicircle from A to C as shown.

(i) Show that the car's speed is 1·0 ms⁻¹. [2]

....

....

(ii) Calculate the car's mean velocity. [2]

....

....

(iii) Draw arrows on the diagram to indicate the direction of the car's velocity at A and at C. Hence calculate the change in velocity between A and C, and **state the direction of this change**. [3]

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....

(iv) Explain why the car is accelerating even though its speed is constant. [2]

....

....

....

(v) State the direction of the car's acceleration at point B. [1]

....

(c) From C, the car continues in a straight line northwards with a velocity of 1·0 ms^{-1} for 2·0 s. It then slows down at a uniform rate to rest. During the deceleration the car travels a distance of 2·0 m.
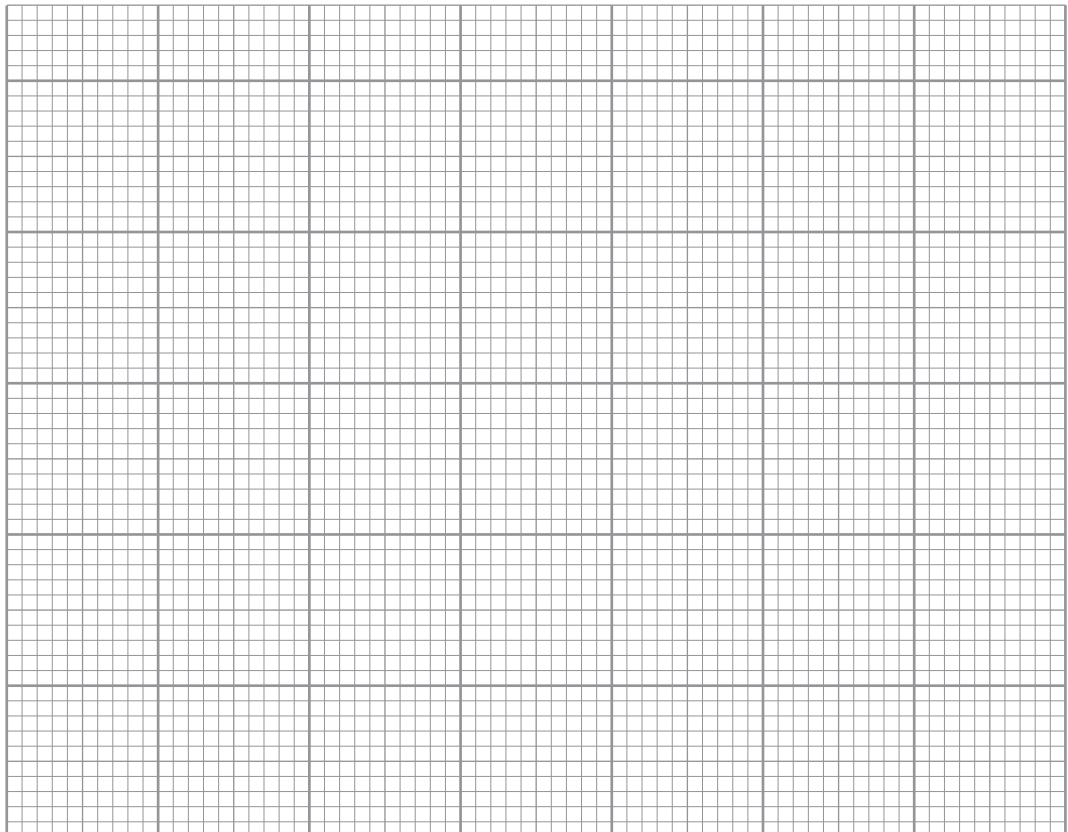
(i) Draw a velocity-time graph for **this** motion (from C) on the grid below.
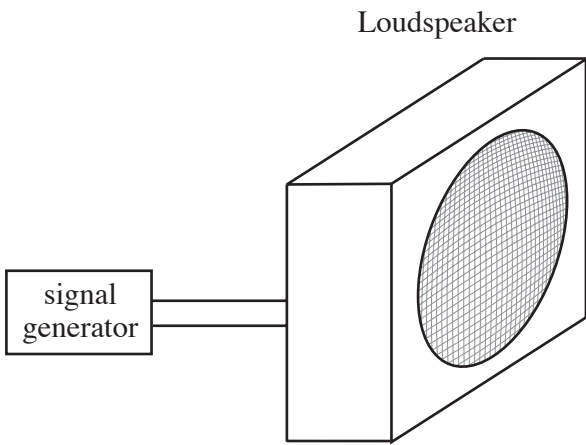Space is provided for your calculations. [5]

Velocity / ms^{-1}
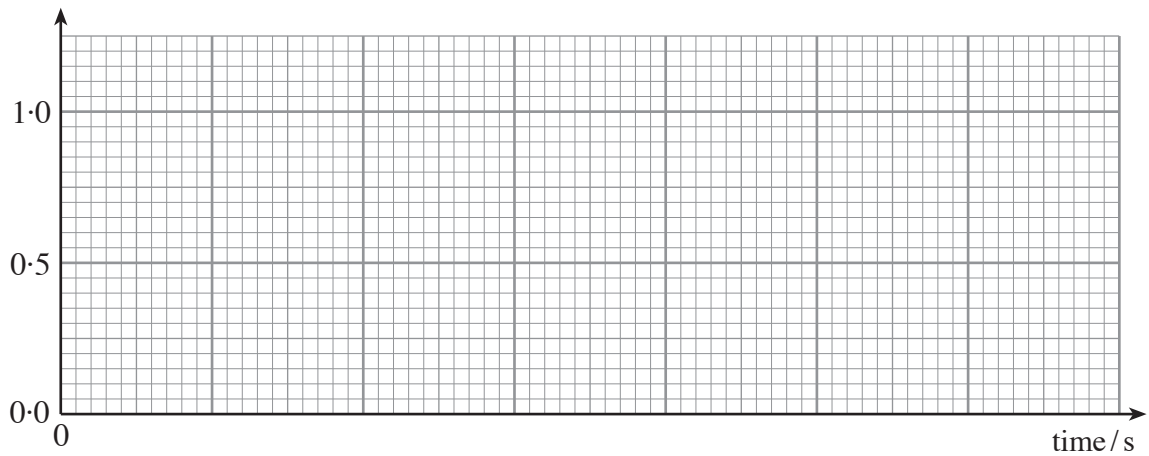
(ii) Draw a displacement-time graph for this motion on the grid below. [4]

Turn over.

7. A loudspeaker connected to a signal generator is used to investigate sound.

Loudspeaker

signal
generator

(a) (i) Sound waves are described as being *progressive* and *longitudinal*.

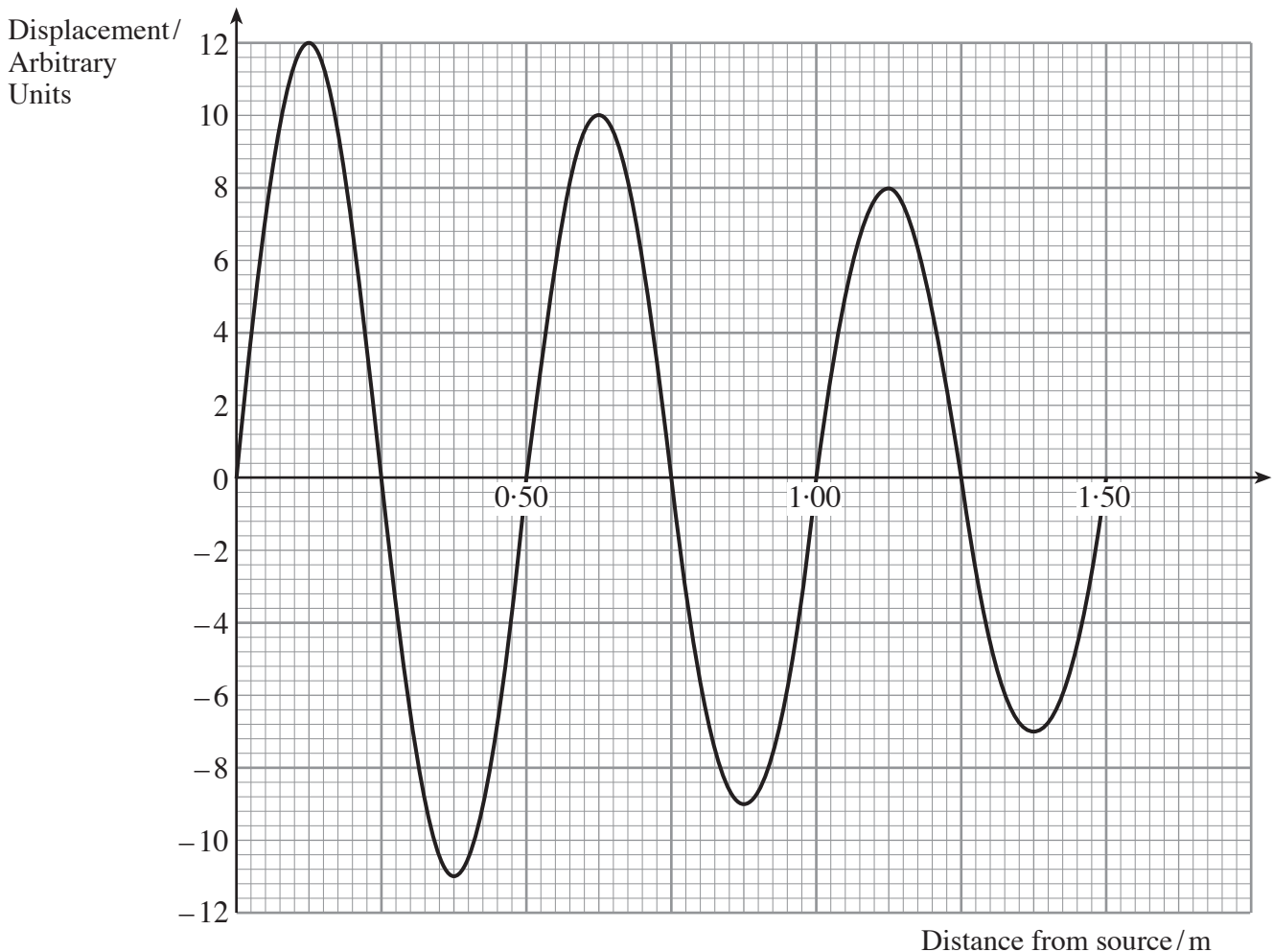(I) Explain what is meant by longitudinal wave. [1]

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....

(II) List **two** properties of a progressive wave. [2]

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....

(ii) The signal generator is adjusted to give a frequency of 680 Hz. The sound wave produced at a particular instant is represented by the following graph.

Displacement/
Arbitrary
Units

Distance from source/m

(I)   Suggest why the amplitude of vibration decreases with distance from the speaker.   [1]

....

(II)   Use information from the graph to calculate the speed of sound.   [2]

....

....

(iii)   Write down the amplitude at $0 \cdot 125$ m and at $1 \cdot 125$ m from the speaker. Hence calculate the ratio of the intensities at these distances.   [3]

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(b)   The signal generator ($f = 680$ Hz) and loudspeaker are now sounded together with a tuning fork of unknown frequency. A beat frequency of 5 Hz is heard.

(i)   Use the beat frequency to calculate possible values for the frequency of the tuning fork.   [2]

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(ii)   It is noted that, as the frequency of the signal generator is **increased**, the beat frequency also **increases**. Determine the actual value of the tuning fork's frequency. Explain your answer.   [2]
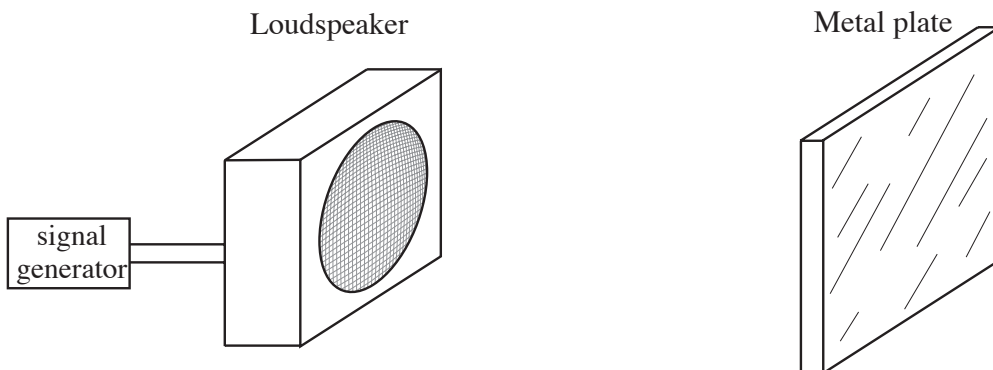
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Turn over.

(c) The tuning fork is now removed and a large metal plate is placed at some distance from the loudspeaker as shown in the diagram. A stationary wave is produced between the plate and the loudspeaker.

Loudspeaker   Metal plate

signal
generator

    (i)   What part does the metal plate play in producing the stationary wave?   [1]

....

    (ii)   List **two** properties of this type of wave.   [2]

....

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(d)

Sound probe

Loudspeaker

signal
generator

Sound
meter

Metal
plate
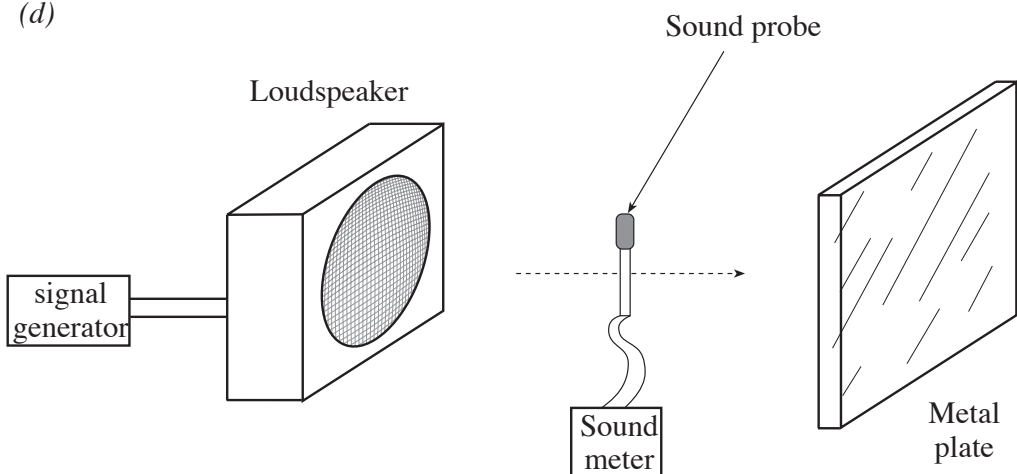
A sound probe is moved slowly in a straight line from the loudspeaker to the plate, as shown in the diagram. Explain carefully how a value for the speed of sound can be obtained from this procedure.   [4]

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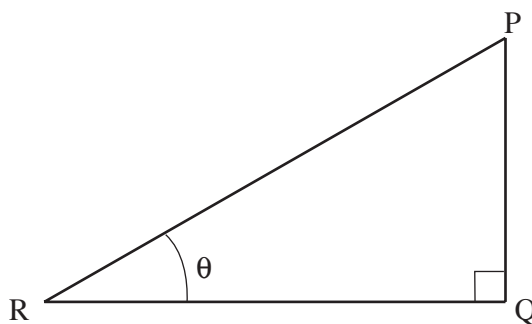
$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

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

Areas and Volumes

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

Area of a triangle $= \tfrac{1}{2}$ base $\times$ height

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