YISHUN INNOVA JUNIOR COLLEGE
JC 1 PROMOTIONAL EXAMINATION
Higher 2

CANDIDATE NAME

CG | INDEX NO

PHYSICS **9749/02**

Paper 2 Structured Questions **29 September 2022**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Paper 1	
	/25
Paper 2	
1	**/10**
2	**/10**
3	**/10**
4	**/5**
5	**/14**
6	**/10**
7	**/6**
8	**/10**
Penalty	
	/75
Overall (Paper 1 & 2) Percentage (%)	

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature,	T/K	=	$T/°C + 273.15$
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle C^2\rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm\, \omega \sqrt{(x_o^2 - x^2)}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil,	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** questions.

1 A ball is kicked from horizontal ground towards a vertical wall as shown in Fig. 1.1.

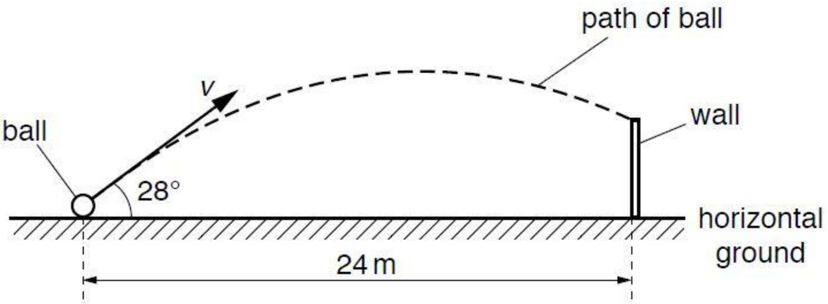


Fig. 1.1 (not to scale)

The horizontal distance between the initial position of the ball and the base of the wall is 24 m. The ball is kicked with an initial velocity v at an angle of 28° to the horizontal. The ball just hits the top of the wall after a time of 1.5 s.

(a) Calculate the horizontal component v_X of the velocity of the ball.

v_X = ... m s^{-1} [1]

(b) Hence, determine the initial vertical component v_Y of the velocity of the ball.

v_Y = ... m s^{-1} [2]

(c) The ball is kicked at time $t = 0$. Assume that the vertical component v_Y of the velocity of the ball is positive in the upwards direction.

(i) On Fig. 1.2, sketch the variation with time t of v_Y for the time between 0 and 1.5 s.

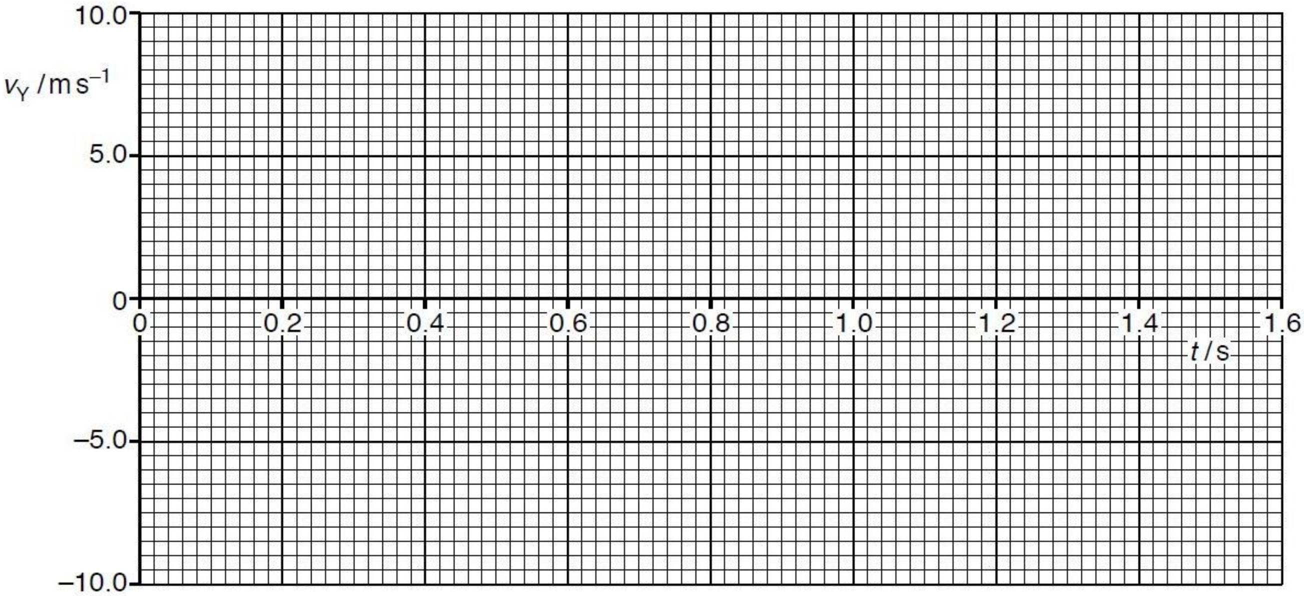


Fig. 1.2

[3]

(ii) Using Fig. 1.2, determine the maximum height above the ground that the ball reached.

maximum height = ………………………… m [2]

(iii) When air resistance is not negligible, state and explain the acceleration of the ball at the highest point of its path.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

[Total : 10]

2 In a car test, a car with a dummy driver and passenger, moving at a speed of 6.9 m s^{-1}, collides head-on into a wall. The masses of the car, driver and front passenger are 1250 kg, 85 kg and 65 kg respectively. The average deceleration of the car, as it comes to a stop, is 48 m s^{-2}.

Both passenger and driver have their seat belts tightly fastened.

(a) Define *impulse*.

………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

(b) Calculate the magnitude of the average force exerted on the car and its occupants.

average force = ………………….. N [1]

(c) Determine the magnitude of impulse of the car and its occupants.

impulse = ………………….. N s [2]

(d) Hence, using answers in **(b)** and **(c)**, calculate the time taken for the car to come to a stop.

time = ………………….. s [2]

(e) Assuming that the average deceleration remains the same, state and explain how your answer in **(d)** will change (if any) when the total mass of car and occupants has doubled.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(f) Explain if the collision between the car and the wall is elastic.

………

………

……… [2]

[Total : 10]

3 **(a)** A cylinder is made from a material of density 2.7 g cm^{-3}. The cylinder has diameter 2.4 cm and length 5.0 cm.

Show that the weight of the cylinder is 0.60 N.

[2]

(b) The cylinder in **(a)** is hung with a thread from end A of a non-uniform bar AB, as shown in Fig. 3.1.

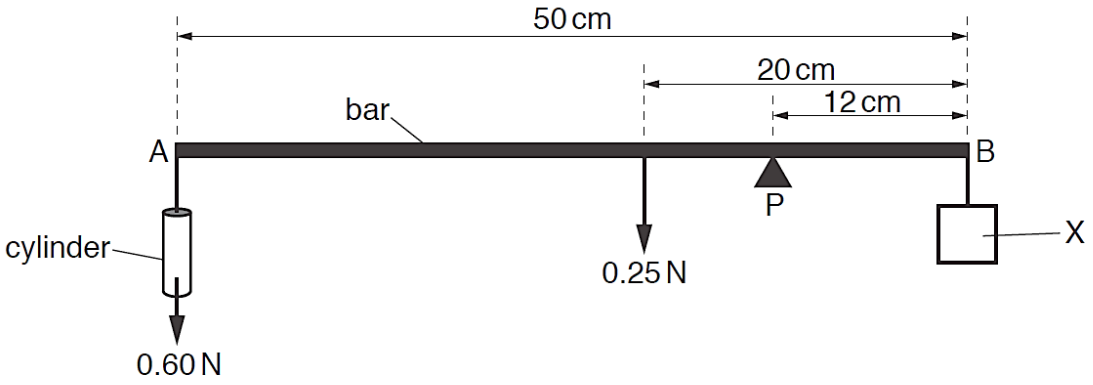


Fig. 3.1 (not to scale)

The length of the bar is 50 cm and its weight is 0.25 N. The centre of gravity of the bar is 20 cm from B.

The bar is pivoted at P. The pivot is 12 cm from B.

An object X is hung with another thread from end B. The weight of X is adjusted until the bar is horizontal and in equilibrium.

(i) Define the *moment* of a force about a point.

………………………………………………………………………………………………………..

………………………………………………………………………………………………………..

……………………………………………………………………………………………………….. [2]

(ii) Calculate the weight of X.

weight of X = …………………….. N [2]

(c) The cylinder is now fully immersed in water of density 1.0 g cm^{-3}, as illustrated in Fig. 3.2.

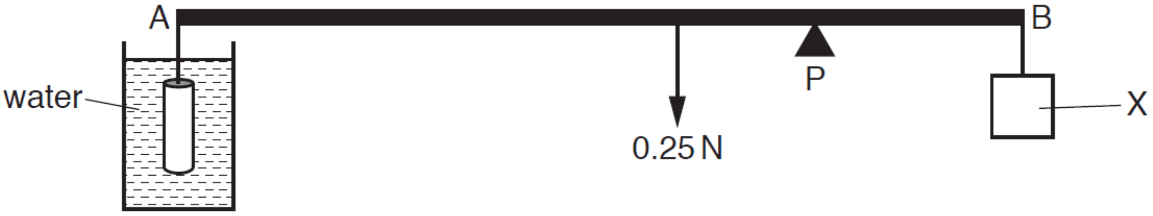


Fig. 3.2 (not to scale)

An upthrust acts on the cylinder and the bar is not in equilibrium.

(i) Using information from **(a)**, show that the upthrust acting on the cylinder is 0.22 N.

[1]

(ii) Hence, calculate the new weight of X in order to obtain equilibrium for bar AB.

weight of X = …………………….. N [3]

[Total : 10]

4 Fig. 4.1 shows the drum of a washing machine.

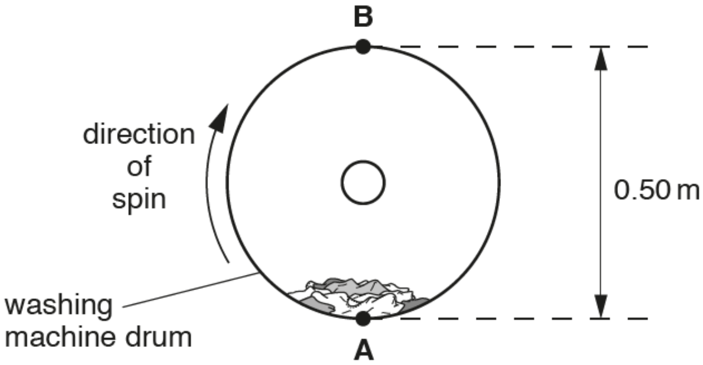


Fig. 4.1

The clothes inside the drum are spun in a **vertical** circular motion in a clockwise direction.

(a) The drum has diameter 0.50 m. The manufacturer of the washing machine claims that the drum spins at 1600 ± 100 revolutions per minute.

Calculate the speed of rotation of the drum and the absolute uncertainty in this value.

speed = ……………….± ……………… m s^{-1} [3]

(b) The washing machine is switched off and the speed of the drum slowly decreases. The clothes at the top of the drum at point **B** start to drop off at a certain speed *v*.

At this speed *v*, the normal contact force on the clothes is zero.

Calculate the speed *v*.

speed = …………………… m s^{-1} [2]

[Total : 5]

5 **(a)** Phobos is one of the two moons orbiting Mars. Fig. 5.1 shows Phobos and Mars.

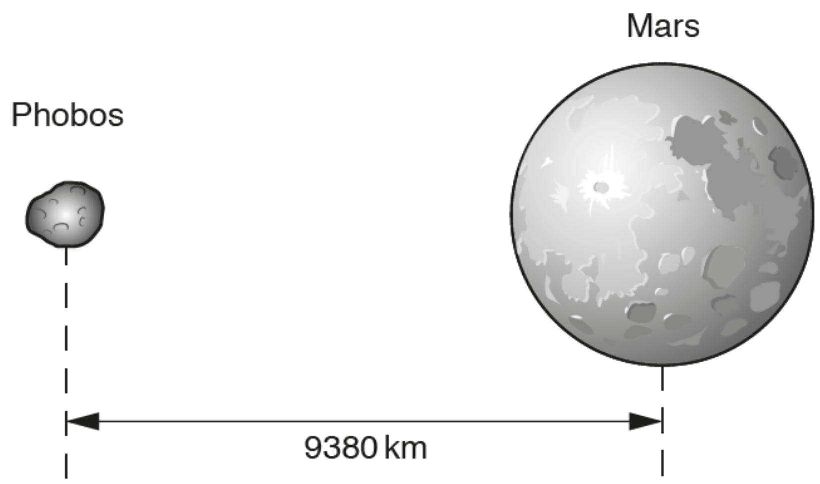


Fig. 5.1

The orbit of Phobos may be assumed to be a circle. The centre of Phobos is at a distance 9380 km from the centre of Mars and it has an orbital speed 2.14×10^3 m s^{-1}.

(i) Calculate the orbital period T of Phobos.

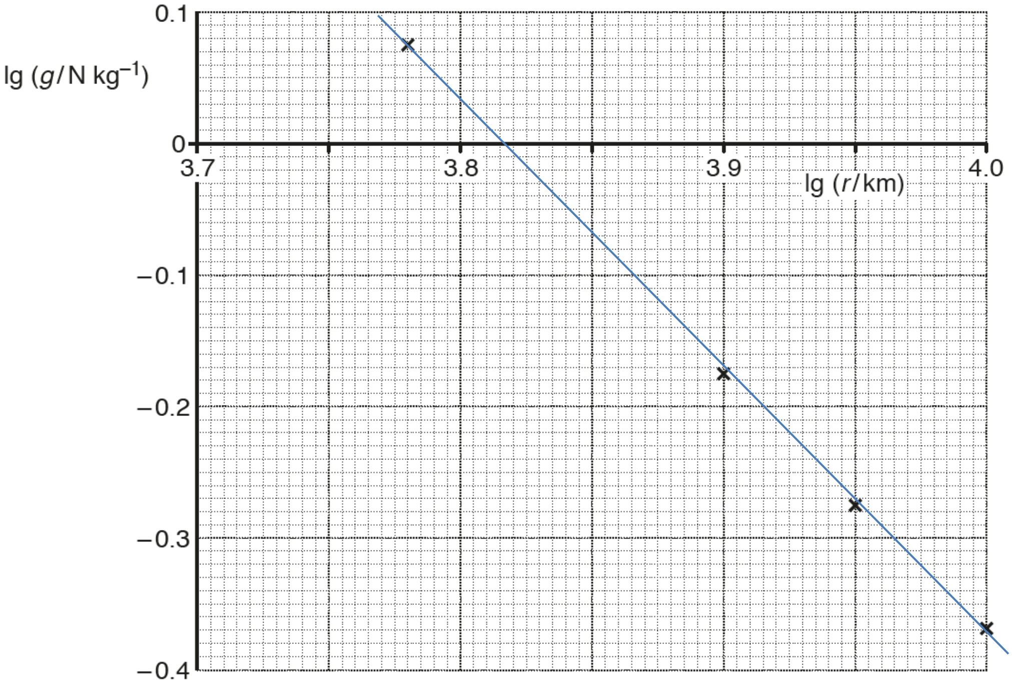
T =…………………… s [2]

(ii) Show that the mass M of Mars is 6.44×10^{23} kg.

[2]

(b) The gravitational field strength at a distance r from the centre of Mars is g.

Fig. 5.2 shows the graph of lg (g/ N kg^{-1}) against lg (r/ km).



Explain why the gradient of the straight line of best fit is −2.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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…………………………………………………………………………………………………… [2]

(c) In July 2018, the closest distance between the centre of Mars and the centre of Earth will be 5.8×10^{10} m.

Fig. 5.3 shows the variation of the **resultant** gravitational field strength g between the two planets with distance r from the centre of the **Earth**.

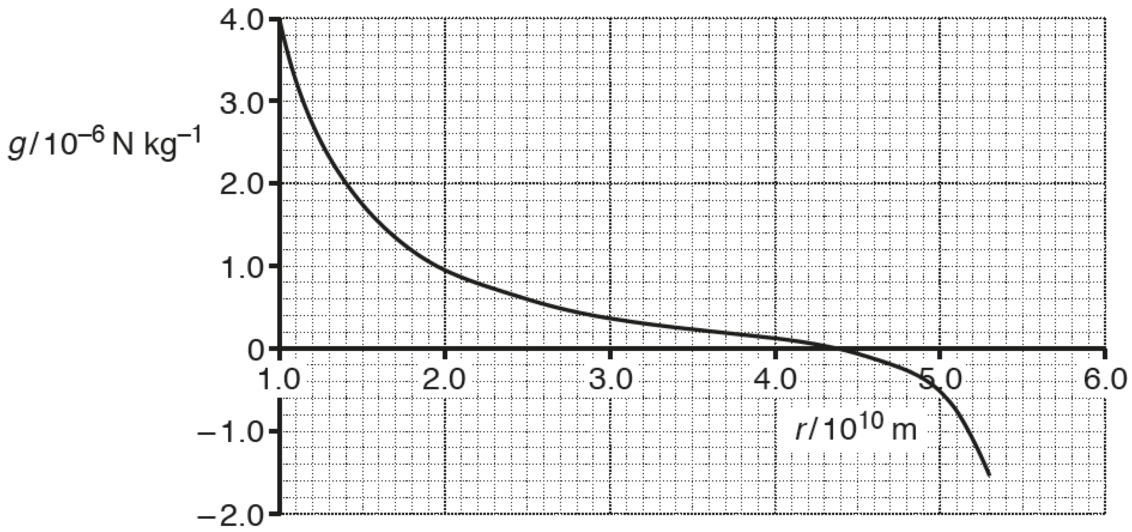

Fig. 5.3

(i) Explain why the resultant field strength has different signs.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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……………………………………………………………………………………………………

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…………………………………………………………………………………………………… [2]

(ii) Use your answer in **(a)(ii)** and the value of r when g = 0 from Fig. 5.3 to show that the mass of Earth is 6.4×10^{24} kg.

[2]

(iii) Determine the total gravitational potential of the Earth–Mars system at the point where $g = 0$. Ignore the gravitational effects of the other planets and the Sun.

total potential =…………………… J kg^{-1} [2]

(iv) An object is projected from this point where $g = 0$, such that the object is just able to reach infinity.

Calculate the minimum speed at which the object is projected.

speed =…………………… m s^{-1} [2]

[Total : 14]

6 A small metal ball is suspended from a fixed point by means of a string, as shown in Fig. 6.1.

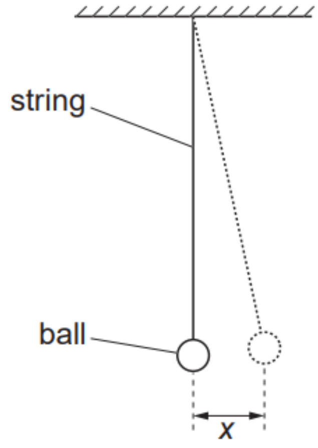


Fig. 6.1

The ball is pulled a small distance to one side and then released. The variation with time *t* of the horizontal displacement *x* of the ball is shown in Fig. 6.2.

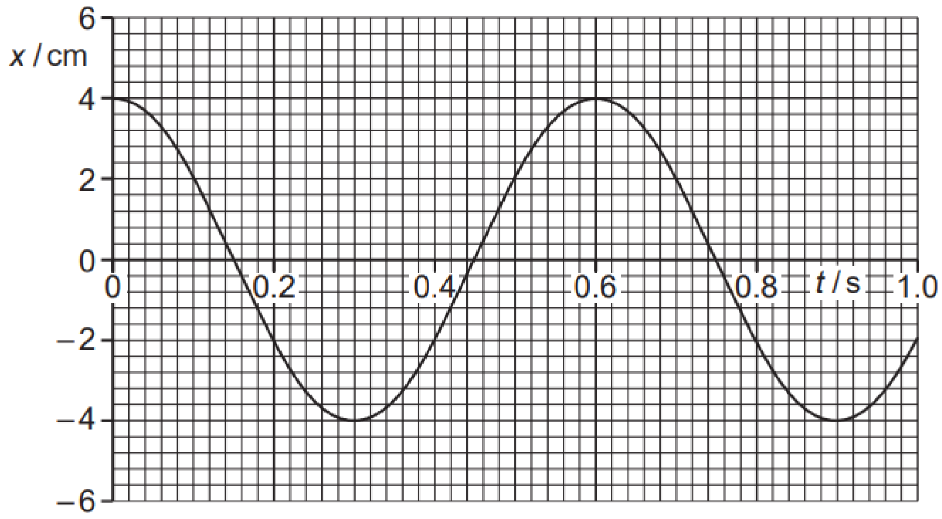


Fig. 6.2

The motion of the ball is simple harmonic.

(a) Using Fig. 6.2, determine

(i) the angular frequency of the oscillation,

angular frequency = ………………….. rad s^{-1} [1]

(ii) the horizontal acceleration of the ball for a displacement x of 2.0 cm.

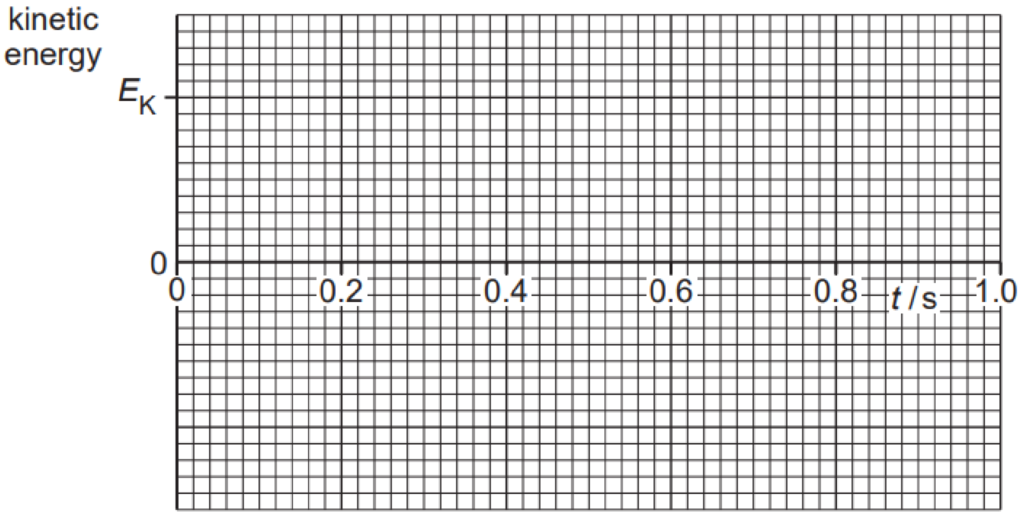
horizontal acceleration = ………………….. m s^{-2} [2]

(iii) the velocity of the ball when the ball is at the lowest position.

velocity = ………………….. m s^{-1} [2]

(b) The maximum kinetic energy of the ball is E_K.

On the axes of Fig. 6.3, sketch a graph to show the variation with time t of the kinetic energy of the ball for the first 1.0 s of its motion.



[2]

Fig. 6.3

(c) State the maximum kinetic energy of the ball, in terms of E_K, when the ball is pulled to a horizontal distance of 2.0 cm instead before releasing.

…………………………………………………………………………………………… [1]

(d) When the oscillation is done in an environment where air resistance is not negligible, the amplitude of vibration is reduced from 4.0 cm to 2.5 cm after eight complete oscillations due to the light damping.

State and explain whether, after a further eight complete oscillations, the amplitude will be 1.0 cm.

………

………

……… [2]

[Total : 10]

7 The graph in Fig. 7.1 shows how particle displacement varies with distance for a progressive wave moving from left to right with a frequency of 250 Hz at time t = 0.0 s.

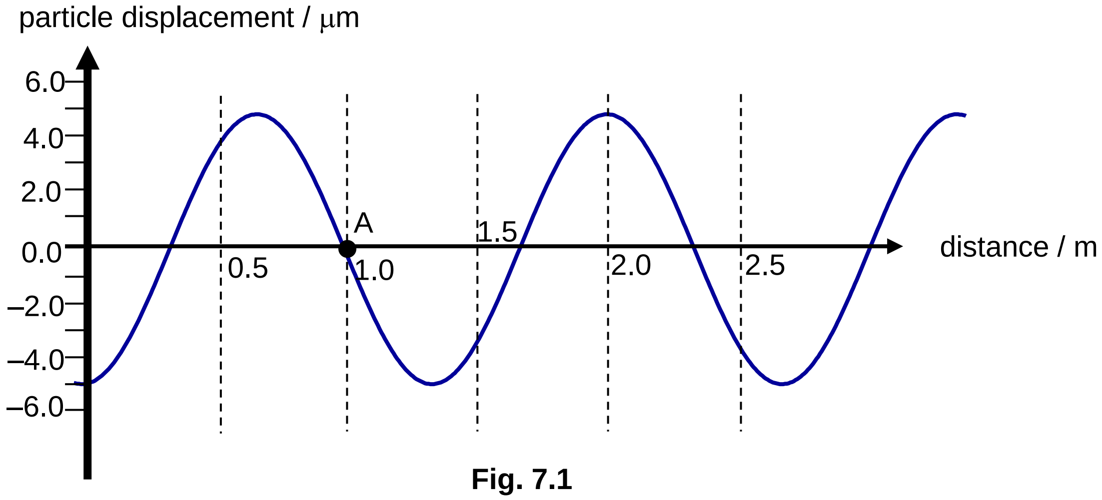


Fig. 7.1

(a) Using the graph in Fig. 7.1,

(i) determine the wavelength of the wave. Show your working clearly.

wavelength = …………….. m [2]

(ii) state the amplitude of the wave.

amplitude = ………………µm [1]

(b) For the particle at position A shown on Fig. 7.1, sketch, in Fig. 7.2, the variation with time of its displacement on the axes with all relevant values, for the first 10 ms.

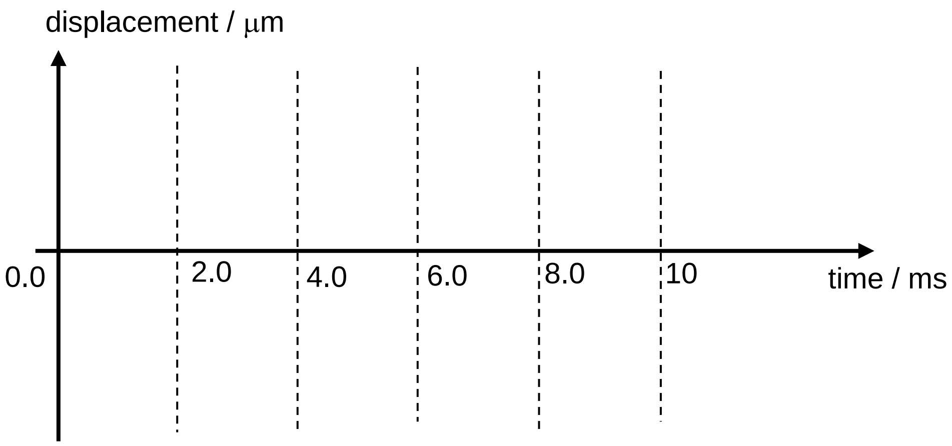


Fig. 7.2

[3]

[Total : 6]

8 **(a)** Explain how stationary waves are formed.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(b) State two differences between a progressive wave and a stationary wave.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(c) A microphone that is connected to a cathode-ray oscilloscope (c.r.o.) is used by a student to detect the sound from a loudspeaker.

Fig. 8.1 shows the trace on the screen of the c.r.o.

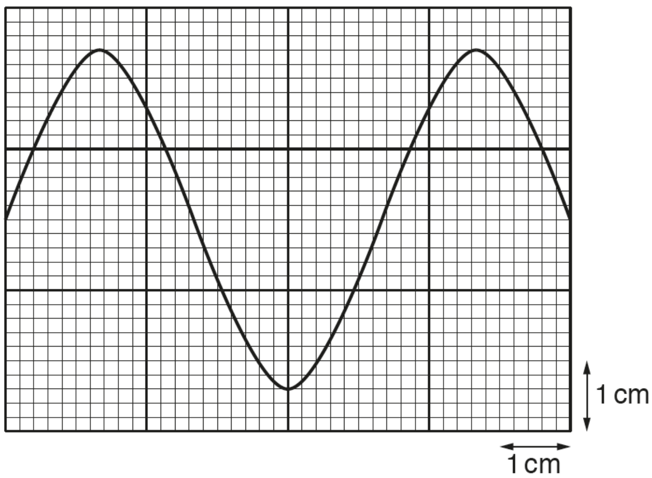


Fig. 8.1

In air, the sound wave has a speed of 330 m s^{-1} and a wavelength of 0.18 m.

(i) Calculate the frequency of the sound wave.

frequency = ………………………………. Hz [1]

(ii) Determine the time-base setting, in s cm^{-1}, of the c.r.o.

time-base setting = ……………………………… s cm^{-1} [2]

(d) Next, the student fills a long tube, fitted with a tap, with liquid. The loudspeaker in **(c)** is held above the top of the vertical tube as the liquid is allowed to run out of the tube, as shown in Fig. 8.2.

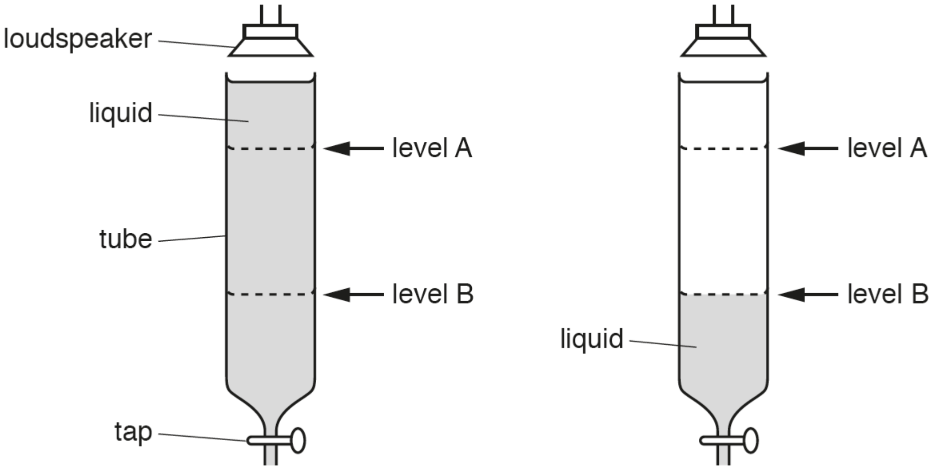


Fig. 8.2 **Fig. 8.3**

A loud sound is first heard when the liquid level reaches level A and then heard again when the liquid level reaches B, as shown in Fig. 8.3.

(i) Determine the vertical distance between level A and level B. Explain your working clearly.

distance = ………………….. m [2]

(ii) The method used in **(d)(i)** is to determine the wavelength of a sound and also to overcome end-correction.

Explain what causes end-correction.

………………………………………………………………………..……..……..……

……………………………………………………………………………………………. [1]

[Total : 10]

END OF PAPER