EUNOIA JUNIOR COLLEGE
JC1 PROMOTIONAL EXAMINATIONS 2021
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	2	1	-			REGISTRATION NUMBER		

PHYSICS

9749/02

Paper 2 Structured Questions

September/October 2021

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
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 paper clips, highlighters, glue or correction fluid.

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	
1	7
2	7
3	10
4	10
5	10
6	10
7	9
8	17
s.f.	
c.f.	
Total	80

This document consists of **20** printed pages and **no** blank page.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$\left(1/\left(36\pi\right)\right) \times 10^{-9}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ 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,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
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.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm\, \omega \sqrt{\left(x_0^2 - x^2\right)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 A hot air balloon rises vertically at a constant speed of 5.0 m s^{-1}. A stone is dropped from the balloon at time t = 0 s, and takes more than 4.0 s to reach the ground. A second stone is dropped from the hot air balloon at time t = 2.0 s. Air resistance is negligible.

(a) On the axes of Fig. 1.1, sketch a graph to show **quantitatively** how the velocity v of the

(i) first stone varies with time from t = 0 s to t = 4.0 s. Label this graph A. [1]

(ii) second stone varies with time from t = 2.0 s to t = 4.0 s. Label this graph B. [1]

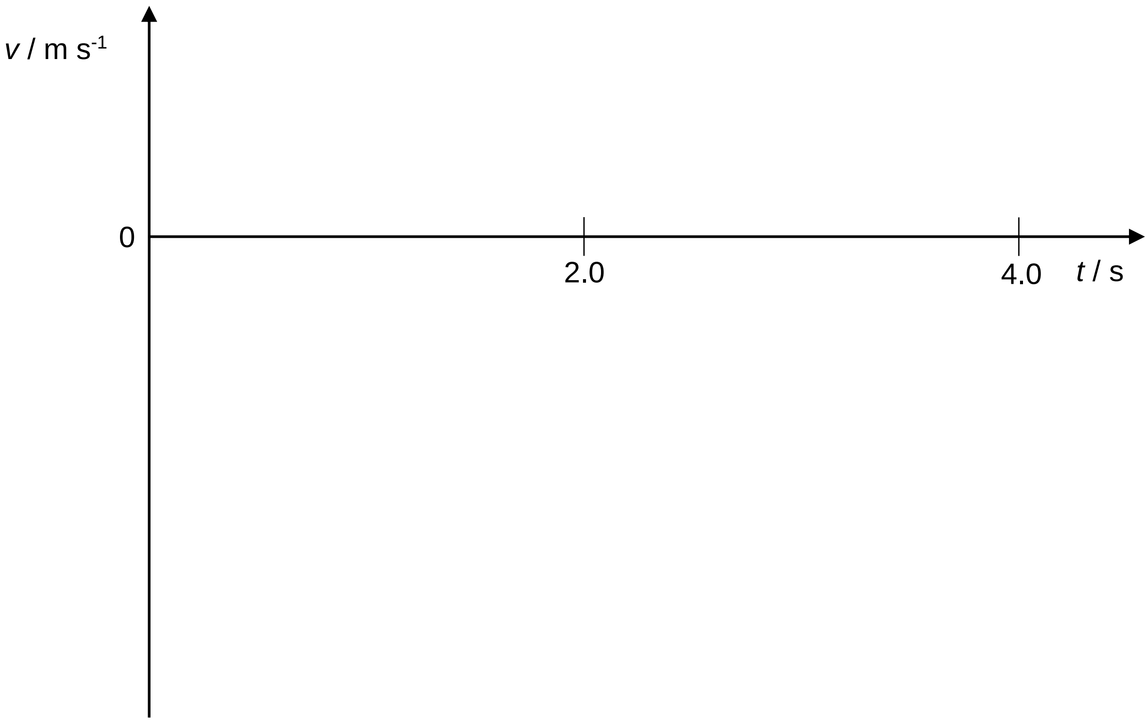

Fig. 1.1

(b) Find the vertical distance between the two stones at t = 4.0 s.

vertical distance = ………………………………….. m [3]

(c) On the same axes of Fig. 1.1, sketch a graph to show how the velocity v of the first stone varies with time from t = 0 s to t = 4.0 s where the effects of air resistance is not negligible. Label this graph C. [2]

[Total: 7]

2 Fig. 2.1 shows the variation with time of the momentum of two colliding lorries A and B. The masses of lorries A and B are 1500 kg and 3000 kg respectively.

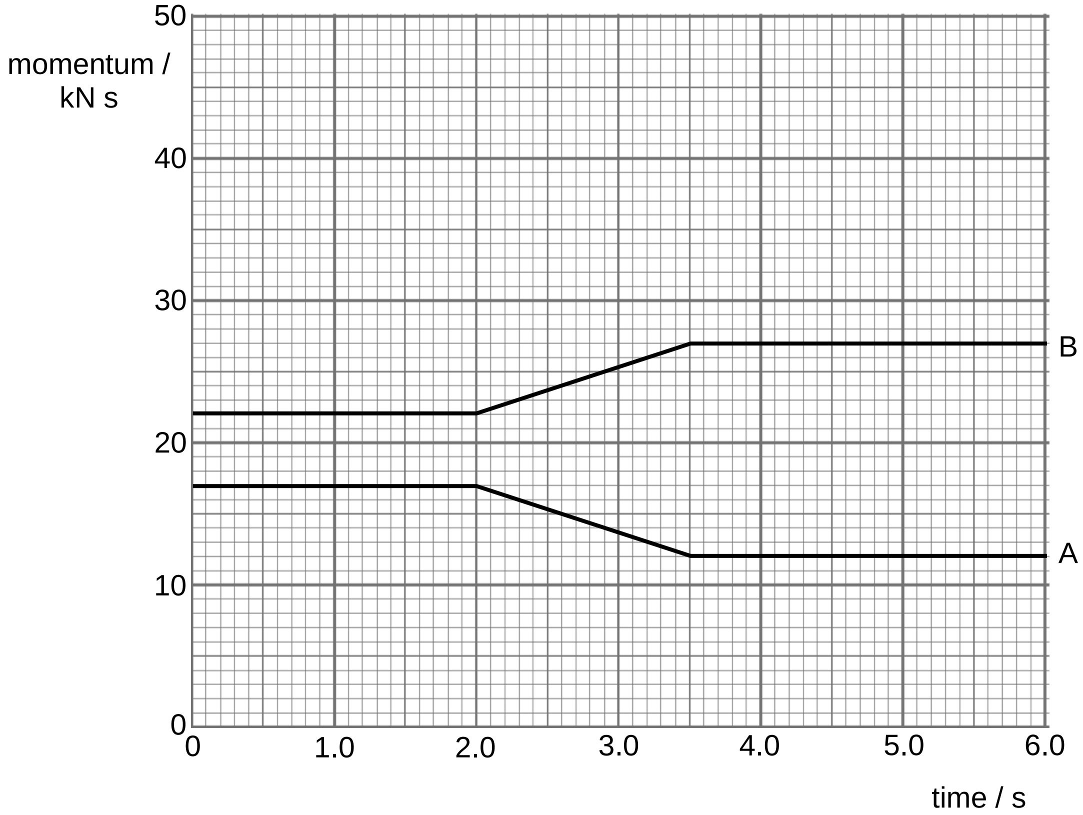

Fig. 2.1

(a) (i) State the *principle of conservation of linear momentum.*

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....

....

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....

.... [1]

(ii) On Fig 2.1, draw a line to show the total momentum of the colliding lorries from time t = 0 s to t = 6.0 s. Label the line P. [1]

(b) **(i)** State *Newton's Second Law of motion.*

....

....

....

.... [1]

(ii) Determine the magnitude of the force acting on lorry A during the collision.

Show your working clearly.

force = ……………………………… N [2]

(c) By considering the total kinetic energies of the lorries, state and explain the type of collision that the lorries experience.

....

....

.... [2]

[Total: 7]

3 A uniform ladder of weight W rests in equilibrium against a rough vertical wall, tilted at an angle θ from the rough floor. Fig. 3.1 shows a labelled diagram of the ladder, where N_G is the normal force on the ladder by the floor and N_W is the normal force on the ladder by the wall.

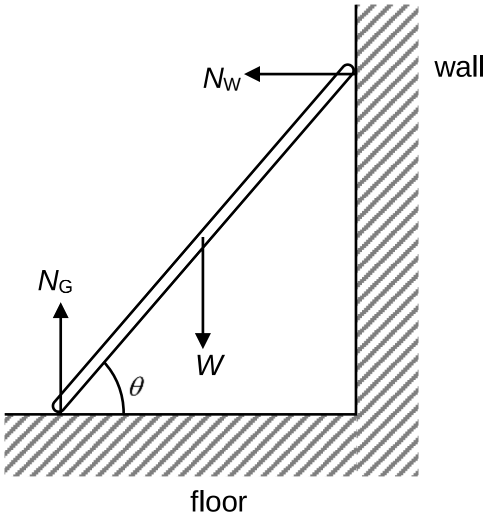

Fig. 3.1

(a) State what is meant by the ladder is *in equilibrium*.

....

....

....

.... [2]

(b) Complete Fig. 3.1 to include the friction exerted by the wall f_W and the friction exerted by the floor f_G. [2]

(c) Show that

$$N_W \tan\theta = N_G - \frac{W}{2}$$

[2]

(d) The weight of the ladder is 100 N, the angle of tilt is 40° and the normal force acting on the ladder by the floor is 70 N.

Find the magnitude of f_G.

magnitude of f_G = ………………………………… N [2]

(e) The top of the ladder is then coated with a grippy, rubbery material. The ladder is placed back in its original position with the same angle of tilt.

State and explain the changes, if any, that will occur to N_G and N_W.

....

....

....

.... [2]

[Total: 10]

4 **(a)** A snow sled starts to ascend a smooth slope that is inclined at 30° to the horizontal. The sled comes to rest after travelling up the slope to a vertical height of 4.1 m, as shown in Fig. 4.1.

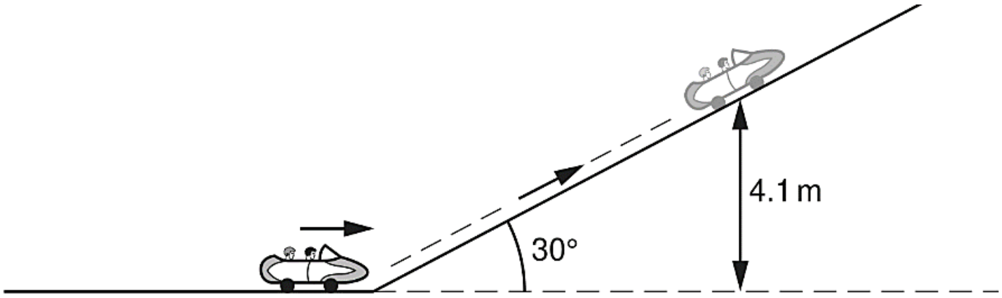

Fig. 4.1

Fig. 4.2 shows the variation with distance along slope of the total magnitude of force acting on the snow sled in the direction down the slope.

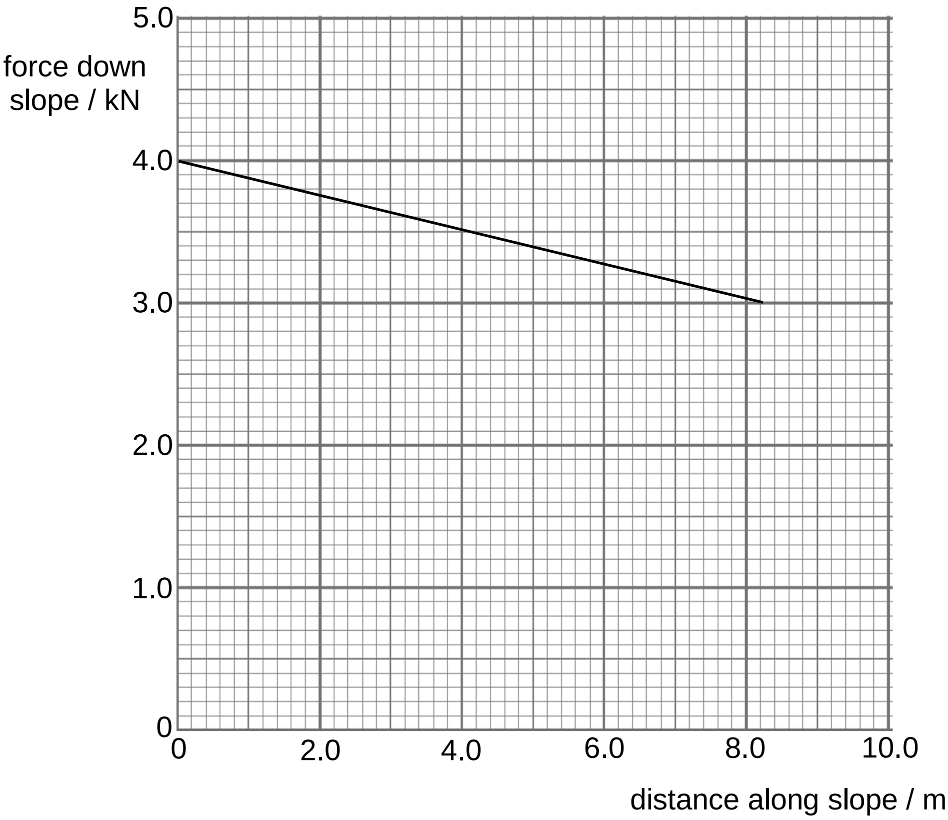

Fig. 4.2

(i) On Fig. 4.2, shade the area representing the work done against air resistance. [1]

(ii) Hence or otherwise, find the initial kinetic energy of the snow sled.

initial kinetic energy = ………………………………… J [2]

(b) Block A of mass 50 kg and block B of mass 100 kg are connected by a light, inextensible string over a smooth pulley located at the apex of a rough incline, as shown in Fig. 4.3.
Both blocks are initially at rest.

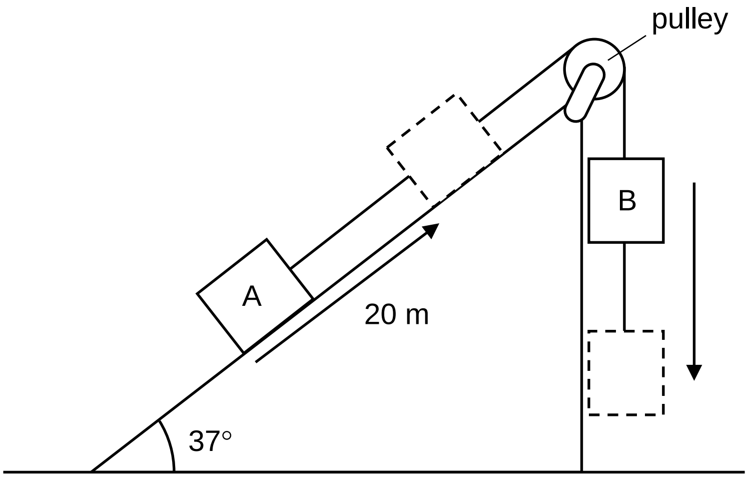

Fig. 4.3

The friction f acting on block A by the surface of the incline is related to the normal force N, exerted by the surface on A by

$$f = 0.25N$$

Determine the increase in kinetic energy of A as it moves a distance of 20 m up the incline.

increase in kinetic energy = …………………………………. J [5]

(c) In a particular lighthouse, it takes the keeper of mass 74 kg exactly two minutes to ascend the spiral staircase to reach the top. There are 131 steps each of height 23 cm.

Find the average power developed by the keeper in ascending the lighthouse.

average power = ………………………………….. W [2]

[Total: 10]

5 **(a)** Two balls A and B of different masses are connected to a spring, as shown in Fig. 5.1.

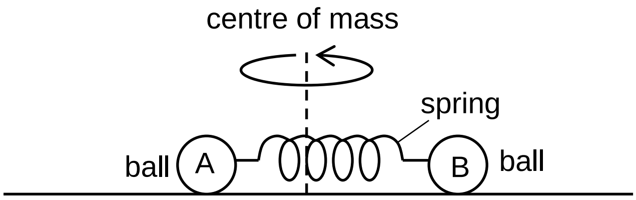

Fig. 5.1

They are then set rotating at a constant angular velocity about their common centre of mass on a smooth horizontal surface.

(i) State and explain the variation with time of the extension and/or compression of the spring as the balls rotate about their centre of mass.

....

....

.... [2]

(ii) Ball A of mass $m_A = 50$ g rotates at a radius $r_A = 6.0$ cm from the common centre of mass with ball B of mass $m_B = 30$ g. The spring constant of the spring is 4.0 N m^{-1}.

1. Show that the radius r_B at which ball B rotates around the common centre of mass is 10 cm.

[1]

2. The natural length of the spring is 12 cm. Find the angular speed of the rotation.

angular speed = ………………………………….. rad s^{-1} [2]

(b) Fig. 5.2 shows a sandbag that is secured to a point on the ceiling via a light, inextensible rope of length *r*. The rope is just taut at the initial position A.

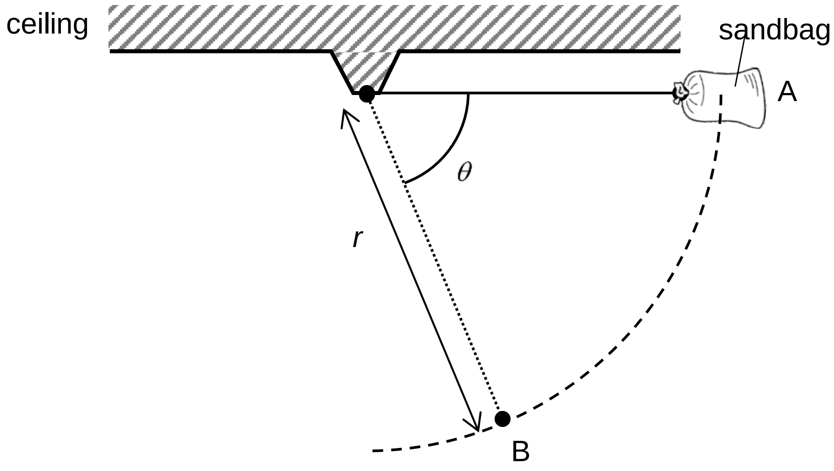

Fig. 5.2

(i) The speed v of the sandbag varies with the angle θ that the rope makes with the horizontal. Show clearly that $v = \sqrt{2gr\sin\theta}$, where g is the acceleration due to gravity.

[1]

(ii) The mass of the sandbag is 20 kg. Find the tension in the rope at $\theta = 45°$.

tension = ………………………………….. N [4]

[Total: 10]

6 The Earth may be considered to be an isolated sphere of radius $R = 6.4 \times 10^6$ m with its mass concentrated at its centre. The variation of the gravitational potential ϕ with distance x from the centre of the Earth is shown in Fig. 6.1.

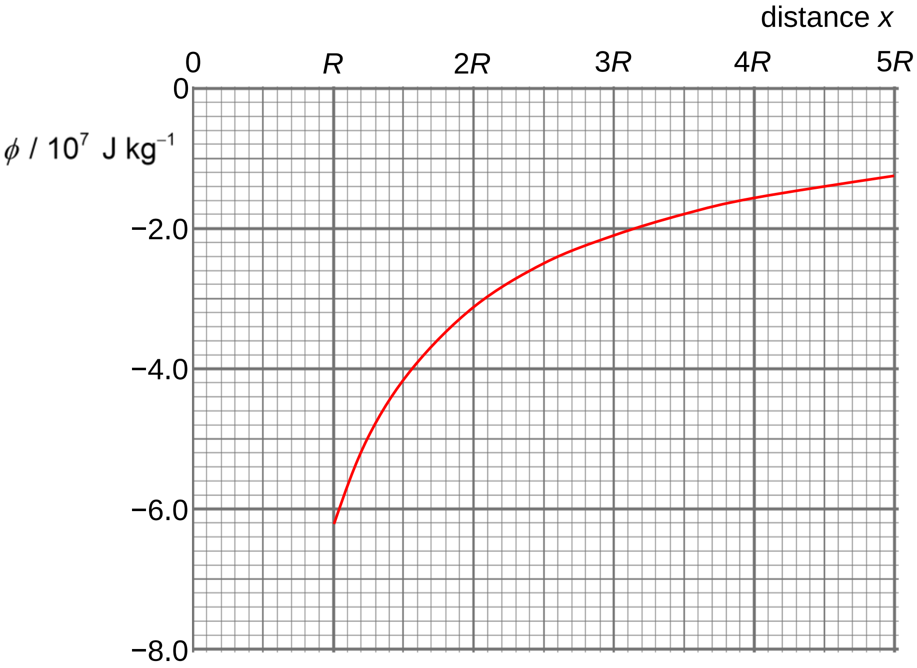

Fig. 6.1

(a) (i) Use Fig. 6.1 to show that the gravitational field strength at $x = 1.6R$ is 3.8 N kg^{-1}.

Show your working clearly.

[2]

(ii) Hence, determine the magnitude of force exerted on a satellite of mass 2.0 kg at a distance of 1.6R.

force = ... N [1]

(b) A meteorite is initially at rest at infinity.

(i) State if the total energy, gravitational potential energy, and kinetic energy will *increase*, *decrease,* or *remain unchanged* when the meteorite travels from infinity towards Earth. [3]

	type of energy	change
1.	total energy	
2.	gravitational potential energy	
3.	kinetic energy	

(ii) Using Fig. 6.1, find the speed of the meteorite when it is at a distance of 2R above the Earth's surface.

speed = ………………………………… m s^{-1} [4]

[Total: 10]

7 A dish is made from a section of a hollow glass sphere.

The dish, fixed to a horizontal table, contains a small solid ball of mass 45 g, as shown in Fig. 7.1.

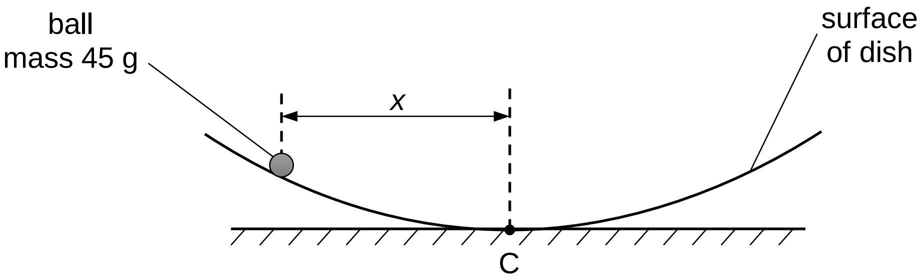

Fig. 7.1

The horizontal displacement of the ball from the centre C of the dish is x.

Initially, the ball is held at rest with distance x = 3.0 cm.

The ball is then released. The variation with time t of the horizontal displacement x of the ball from point C is shown in Fig. 7.2.

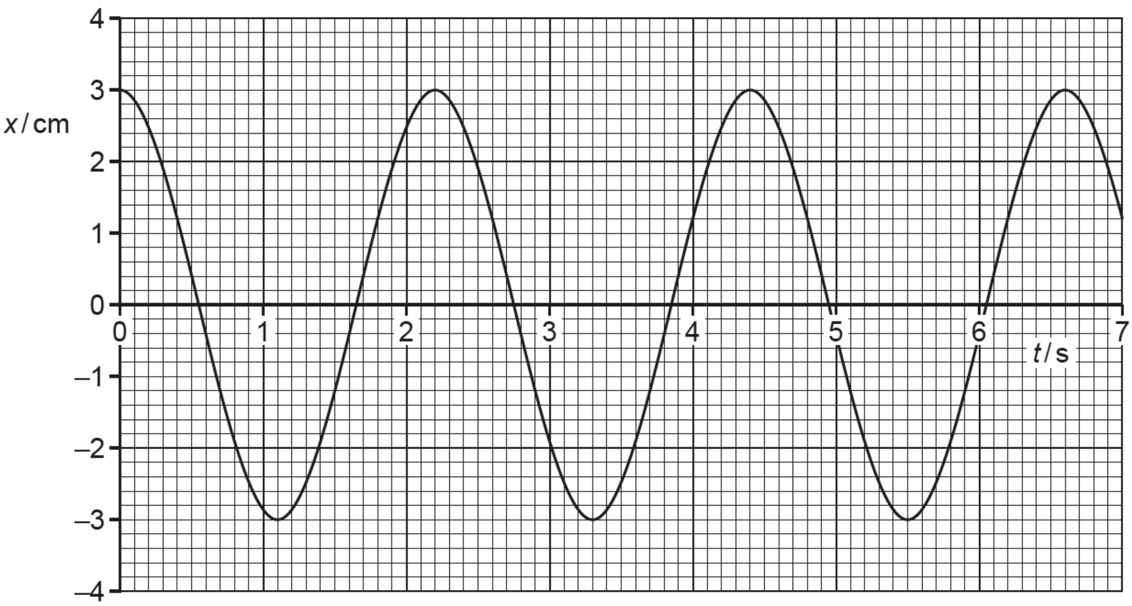

Fig. 7.2

The motion of the ball in the dish is simple harmonic with its acceleration a given by the expression

$$a = -\left(\frac{g}{R}\right)x$$

where g is the acceleration of free fall and R is a constant that depends on the dimensions of the dish and the ball.

(a) Explain what is meant by *simple harmonic motion*.

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....

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.... [2]

(b) Use Fig. 7.2 to show that the angular frequency ω of oscillation of the ball is 2.9 rad s^{-1}.

[1]

(c) Use the information in **(b)** to

(i) determine R,

R = ………………………………….. m [2]

(ii) calculate the speed of the ball as it passes over the centre C of the dish.

speed = …………………………………. m s^{-1} [2]

(d) Dust collects on the dish surface such that the motion of the ball becomes lightly *damped*.

(i) Explain what is meant by *damped*.

....

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....

.... [1]

(ii) On the axes of Fig. 7.2, sketch the variation of x with time t to show the lightly damped motion of the ball for the first 6.0 s after the release of the ball. [1]

[Total: 9]

8 **(a)** A small point source emits 2.5 W of sound at a frequency of 4500 Hz. The displacement amplitude of the sound waves emitted is 4.0 μm where the intensity is 2.0 W m^{-2}.

A microphone of effective surface area 15 cm^2 is placed at a distance of 6.7 m away from the source.

(i) Find the power of sound waves received by the microphone.

.

power = ………………………………… W [2]

(ii) The displacement amplitude of the sound waves emitted from the point source is tripled.

Find the distance from the point source where the microphone should be such that the power received is the same as in **(a)(i)**.

.

distance = ………………………………… m [2]

(b) **(i)** State the *principle of superposition*.

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.... [1]

(ii) Fig. 8.1 shows a sound wave entering the mouth of a closed pipe and travelling along the axis of the pipe.

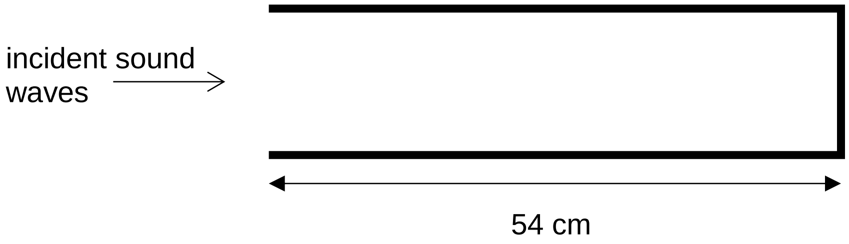

Fig. 8.1

Explain how a stationary wave is formed in the pipe.

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....

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....

.... [3]

(iii) The frequency of the sound wave in **(b)(ii)** is gradually increased from a low value.

A loud sound is heard for the second time at a frequency of 470 Hz.

On Fig. 8.1,

1. sketch the displacement wave profile of the stationary wave formed, and
2. mark the position of **pressure** nodes using the letter N. [2]

(iv) Calculate the speed of sound in the pipe.

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

(v) A stationary wave does not propagate. Explain what does the speed in **(b)(iv)** represent.

....

....

.... [1]

(c) A collimated beam of white light comprising wavelengths from 450 nm to 750 nm is incident normally on a diffraction grating that has 290 lines per millimetre.

(i) Determine the

1. maximum angle of diffraction observed in the third order spectrum

maximum angle = ………………………………….° [1]

2. largest order for which the complete spectrum can be observed.

largest order = …………………………………. [2]

(ii) A recent advancement in smart phones places the front-facing camera below the screen such that the camera module is almost invisible when the screen is active. The light-emitting pixels above the camera lens has less surface area as compared to the rest of the screen so that the camera can capture the image of the subject, as shown in Fig. 8.2.

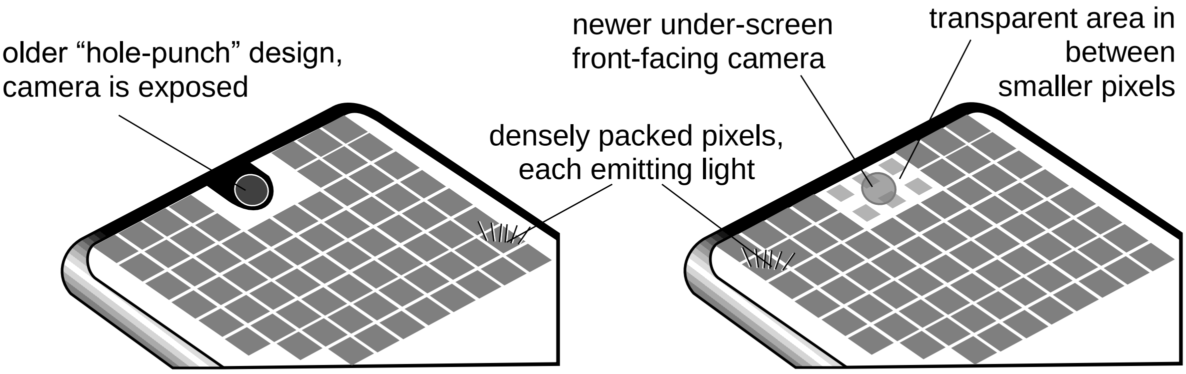

Fig. 8.2 (pixels are magnified for illustrative purposes)

Explain why photographs from the new cameras exhibit *a rainbow-coloured halo effect around light sources such as ceiling lamps, when the light sources are photographed.*

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.... [2]

[Total: 17]