Name: ____________________________ (   ) **CT Group: 22S0** _______

RAFFLES INSTITUTION

2021 YEAR 5 PROMOTIONAL EXAMINATION

30 September 2021

H2 PHYSICS

Section B

INSTRUCTIONS TO CANDIDATES

Write your name, index number and CT Group.

Write your answers to Section B in the spaces provided on the question paper.

For Examiner's Use		
Section A	MCQ	/ 15
Section B	1	/ 10
	2	/ 10
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	7	/ 15
Deductions		
Total		/ 95
%		

This document consists of **12** printed pages.

Section B (50 marks)

1 A sphere of mass 0.040 kg and density 8910 kg m^{-3} is suspended by a thin string and submerged in a tall container of liquid of density 1410 kg m^{-3} as shown in Fig. 1.1.

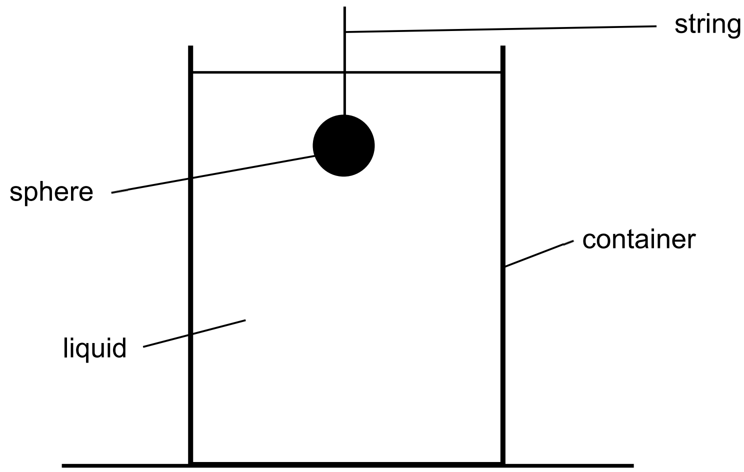

Fig. 1.1

The string is cut and the sphere begins falling from rest through the liquid, where it experiences a drag force F_D such that

$$F_D = \beta v$$

where v is the speed of the sphere and β is a constant with a value of 0.26 kg s^{-1}.

After falling for 2.0 s, the sphere reaches terminal velocity. The sphere then continues to fall at terminal velocity for another 2.5 s.

(a) (i) Show that the upthrust on the sphere is 0.062 N.

[1]

(ii) Determine the terminal velocity of the sphere.

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

(iii) Determine the magnitude of the average force acting on the sphere during the first 4.5 s of its motion through the liquid.

average force = ... N [2]

(b) On Fig. 1.2, sketch the variation with time t of the displacement s of the sphere for the first 4.5 s of the sphere's motion through the liquid.

At t = 0, the string is cut and s = 0. Take the downwards direction to be positive.

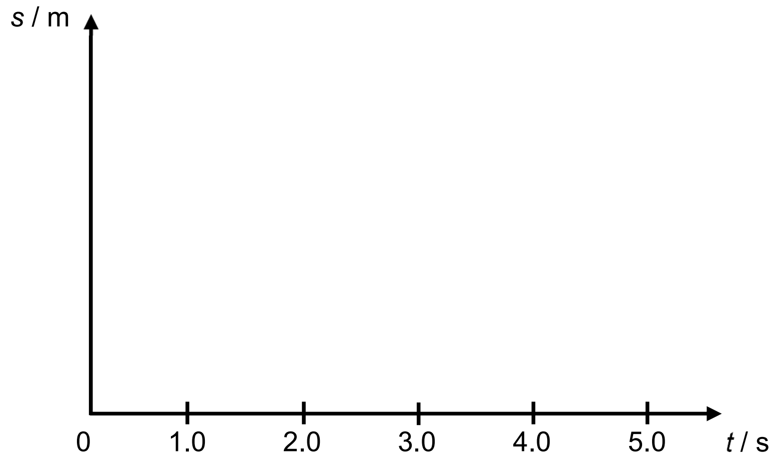

Fig. 1.2 [2]

(c) The setup shown in Fig. 1.1 is placed on top of a mass balance.

Immediately after the string is cut, the reading on the mass balance is X. When the sphere is moving at terminal velocity, the reading on the mass balance is Y.

State and explain if Y is smaller, equal to, or larger than X.

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.... [3]

2 A small smooth ring of mass m is threaded on a light inextensible string of length $8L$. The two ends of the string are fixed at a distance of $4L$ apart on a vertical rod as shown in Fig. 2.1.

The ring is then made to move in a horizontal circle around the rod at constant speed with the string taut and the lower portion of the string horizontal.

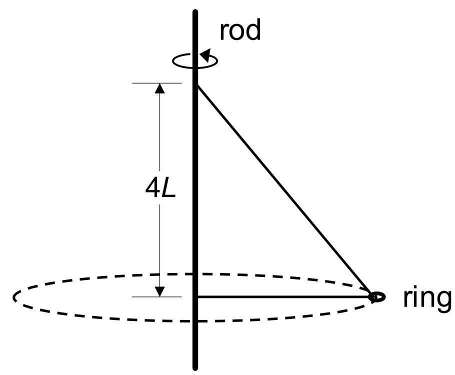

Fig. 2.1

(a) Determine, in terms of m, L and the acceleration of free-fall g, where appropriate,

(i) the radius of the circular motion of the ring,

radius = ... [2]

(ii) the tension in the string,

tension = ... [3]

(iii) the angular speed of the ring,

angular speed = ... [2]

(iv) the linear speed of the ring.

linear speed = ... [1]

(b) State and explain in terms of the forces acting on the ring, whether the ring will rise or fall while undergoing circular motion if its angular speed is increased slightly.

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.... [2]

3 **(a)** A ball thrown vertically upwards from the edge of a tabletop reaches its highest point, reverses direction and bounces off the ground below the table, before returning to its initial position. Fig. 3.1 shows this path of the ball.

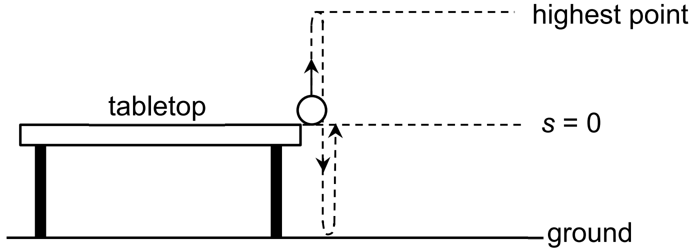

Fig. 3.1

Fig. 3.2 shows the variation with vertical displacement *s* from the tabletop of the acceleration *a* of the ball, with the position of the tabletop taken as *s* = 0. Ignore all energy losses.

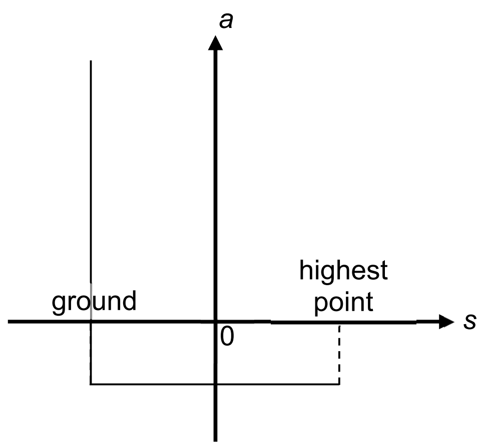

Fig. 3.2

With reference to Fig. 3.2 and the definition for simple harmonic motion, discuss whether the motion of this bouncing ball is considered simple harmonic.

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.... [3]

(b) A pendulum of length L is suspended from a fixed point as shown in Fig. 3.3.

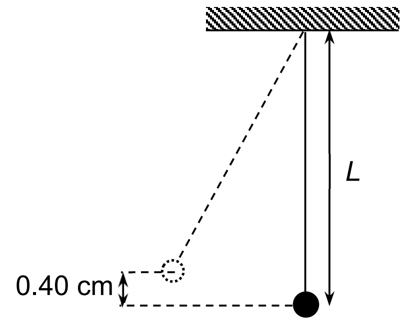

Fig. 3.3
(not drawn to scale)

Keeping the string taut, the pendulum of mass m is displaced by a small angle such that its centre of mass rises vertically by 0.40 cm.

When the pendulum is released from this position, it performs simple harmonic motion.

The total potential energy of the pendulum is zero at the equilibrium position.

The variation with horizontal displacement x from the equilibrium position of the kinetic energy E_K of this pendulum is as shown in Fig. 3.4.

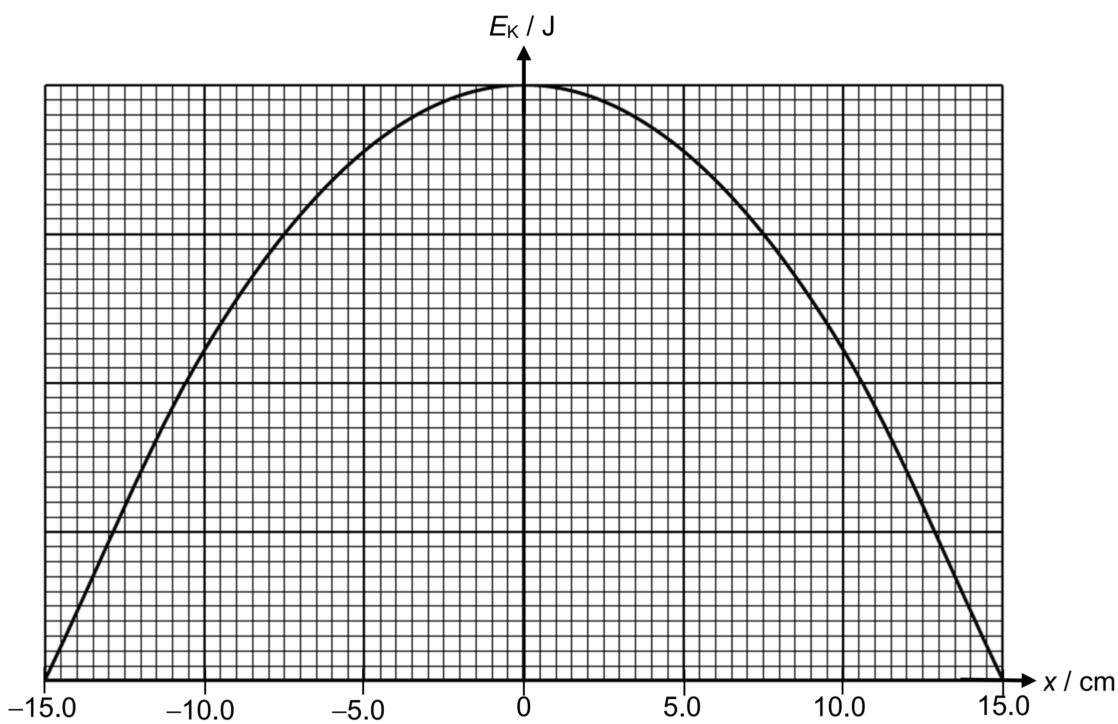

Fig. 3.4

(i) Determine an expression, in terms of m and the acceleration of free-fall g, for the total energy of the pendulum.

Explain your working clearly.

total energy = ... J [2]

(ii) If the angular frequency ω of the pendulum is $\sqrt{\frac{g}{L}}$, use your expression in **(b)(i)** to deduce the length L of the pendulum.

L = ... m [3]

(iii) The pendulum is now displaced such that its centre of mass rises vertically by 0.30 cm instead and released.

Without any further calculations, use Fig. 3.4 to determine the new amplitude of the oscillations.

Show your construction clearly on Fig. 3.4.

amplitude = ... cm [2]

4 **(a)** State what is meant by *polarisation* with respect to an electromagnetic wave.

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.... [2]

(b) Two sheets of polarisers P and Q are placed close to each other with their polarising axes vertical.

A parallel beam of unpolarised light passes through polariser P. After passing through polariser P, the light beam has amplitude A_0 and intensity I_0.

The light beam then passes through polariser Q.

Polariser Q is now rotated clockwise about the axis of the light beam through an angle θ as shown in Fig. 4.1. At this angle θ, the amplitude of the light beam after passing through polariser Q first reaches $\frac{A_0}{3}$.

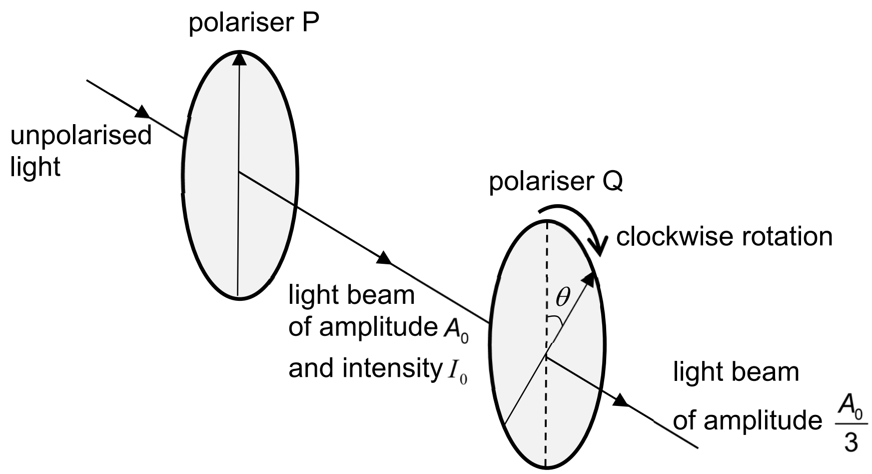

Fig. 4.1

(i) Determine, in terms of I_0, the intensity of the light beam after passing through polariser Q.

intensity = ... [2]

(ii) Calculate the angle θ.

θ = ... ° [2]

(iii) State the angles through which polariser Q must be further rotated from the angle calculated in **(b)(ii)** in the clockwise direction, to observe two consecutive intensity maxima of the light beam after passing through polariser Q.

Explain your answers.

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.... [2]

5 **(a)** A loudspeaker is connected to a signal generator to produce a progressive longitudinal sound wave.

Fig. 5.1 shows the variation with distance from the loudspeaker of the displacement of air particles at a particular instant in time. Displacement towards the right is taken to be positive.

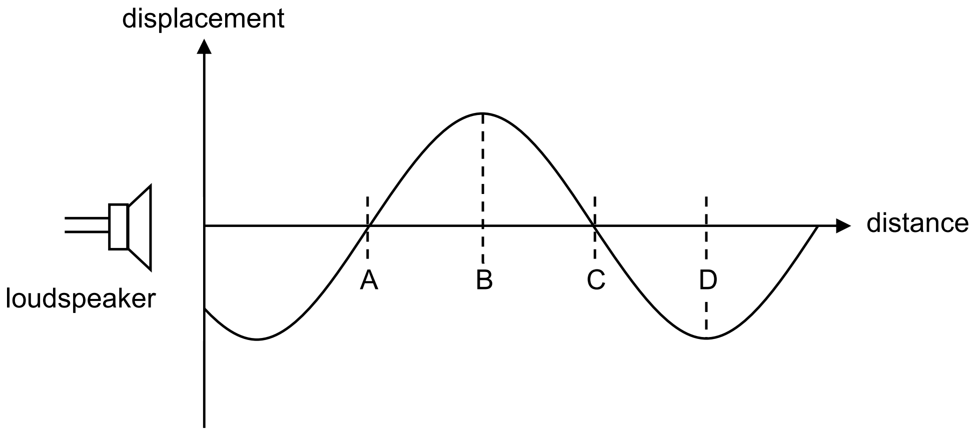

Fig. 5.1

(i) Distinguish between *longitudinal* and *transverse* waves in terms of the motion of the particles.

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.... [2]

(ii) State and explain which point (A, B, C or D) has the highest pressure.

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.... [2]

(b) To produce a stationary wave, a tube QR with a piston P is placed in front of the loudspeaker as shown in Fig. 5.2. As piston P is moved from Q towards R, a loud sound is first heard when QP is 0.15 m. The next loud sound is heard when QP is 0.47 m.

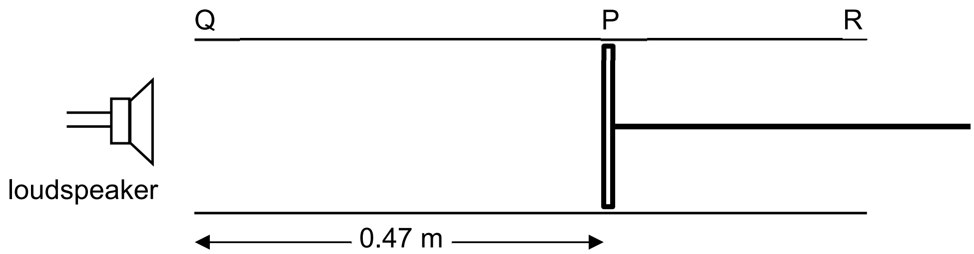

Fig. 5.2

(i) Explain the formation of a *stationary wave* in the tube.

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.... [2]

(ii) Given that the speed of sound in air is $330\ \text{m s}^{-1}$, determine

1. the end-correction for the tube,

end-correction = ... m [2]

2. the frequency of the sound waves.

frequency = ... Hz [2]

(iii) Complete Fig. 5.2 to represent the stationary wave in the tube when QP is 0.47 m. Indicate the positions of antinodes with A and nodes with N.

[2]

END OF SECTION B