YISHUN INNOVA JUNIOR COLLEGE
JC 1 PROMOTIONAL EXAMINATION
Higher 2

CANDIDATE NAME

CG INDEX NO

PHYSICS 9749/02

Paper 2 Structured Questions **28 September 2023**

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	**/8**
4	**/5**
5	**/5**
6	**/12**
7	**/9**
8	**/6**
9	**/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_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	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	=	$A n v q$
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 ship at rest, located distance D away from the foot of a tower needs to receive an important piece of landing equipment from the top of the tower.

For this equipment to land at the front of the ship's deck, the equipment is thrown at 15.0 m s^{-1} at 60° above the horizontal from the top of a tower at the edge of the water, 8.75 m above the ship's deck as shown in Fig. 1.1.

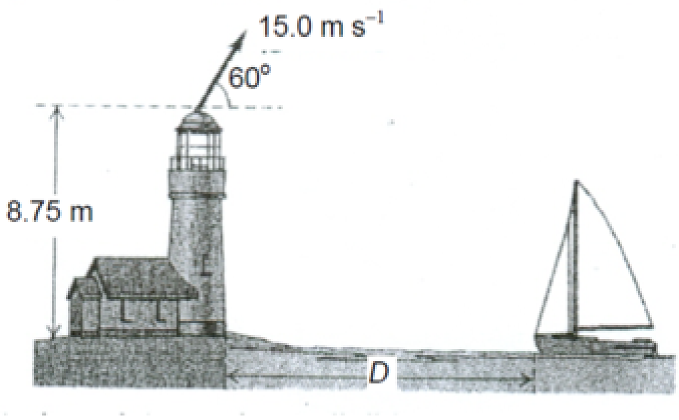

Fig. 1.1

(a) Assuming that air resistance is negligible,

(i) determine the time of flight of the equipment.

time = ……………….. s [2]

(ii) hence determine the value of D.

D = ……………….. m [2]

(b) If air resistance is not negligible, explain how *D* would be affected.

……

……

…… [2]

(c) Sketch and label clearly on the same axes in Fig 1.2, a graph to show the variation with time *t* of the vertical component of velocity V_y of the equipment during its flight if

(i) air resistance is negligible. Label the graph as (i).

(ii) air resistance is not negligible. Label the graph as (ii).

For both graphs, take upwards direction as positive.

Fig. 1.2

[4]

[Total: 10]

BLANK PAGE

2 **(a)** State Newton's second law of motion.

....

.... [1]

(b) A skydiver jumps from a hovering helicopter.

Explain briefly why the acceleration of the skydiver decreases with time.

....

....

.... [2]

(c) The variation with time t of the vertical speed v of the skydiver is shown in Fig. 2.1.

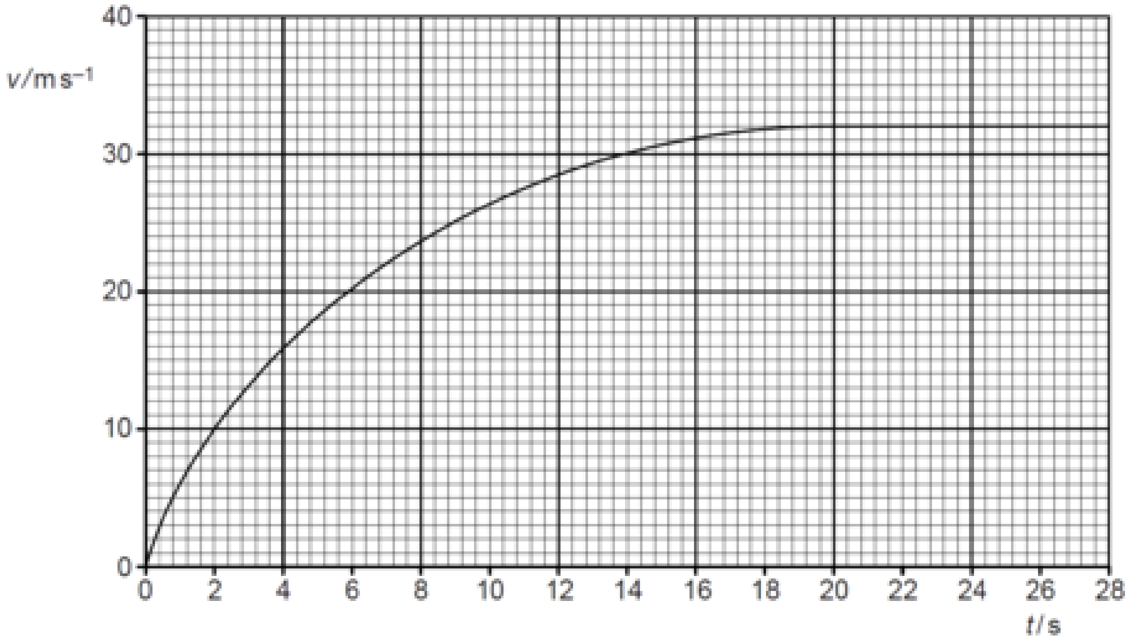

Fig. 2.1

(i) In Fig. 2.2, draw and label the forces acting on the skydiver and his equipment at t = 4.0 s.

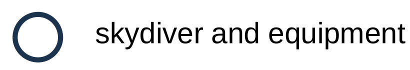

Fig. 2.2

[1]

(ii) The skydiver and his equipment have a total mass of 80 kg.

Use Fig. 2.1 to show that, for the skydiver and his equipment, the net force is approximately equal to 190 N at time t = 4.0 s.

[2]

(iii) Use your answer in **(ii)** to determine the total resistive force acting on the skydiver at time t = 4.0 s.

total resistive force =…………………….. N [2]

(iv) When the skydiver opens his parachute, explain what happens to the direction of the resultant force on him and how it helps to reduce injury on him upon landing.

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

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

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

[Total: 10]

BLANK PAGE

3 **(a)** Explain what is meant by the *moment of a force*.

……….

……… [1]

(b) Fig. 3.1 shows a flat metal sheet bird sculpture created by an artist.

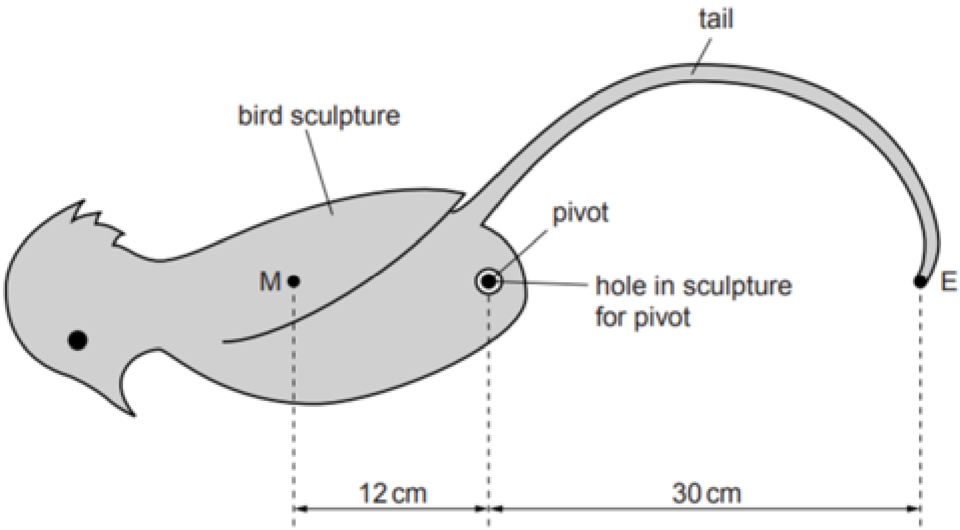

Fig. 3.1

M is the centre of mass of the bird sculpture, including its tail (but not including the counter-weight that will be added later). The mass of the bird sculpture is 1.50 kg.

The bird sculpture is placed on a fricionless pivot. The artist then adds the counter-weight at the end of the tail at E so that the bird remains stationary in the position shown in Fig. 3.1.

(i) Calculate the mass of the counter-weight.

mass = ………………….. kg [2]

(ii) Calculate the upward force acting at the pivot.

force = …………………… N [1]

(iii) The sculpture is rotated clockwise to the position shown in Fig. 3.2. It is held still and then carefully released.

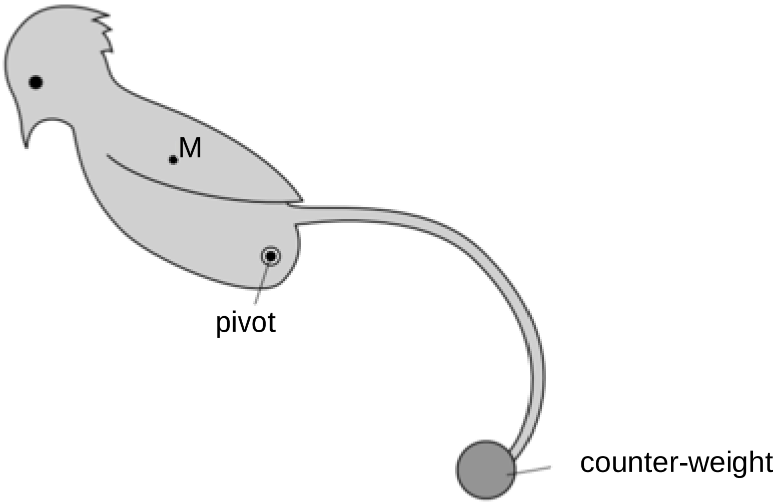

Fig. 3.2

1. After the sculpture is released, state whether it will stay in that position, rotate further clockwise, or rotate back anticlockwise.

…………………………………………………………………………………………….

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

2. Explain your answer to **1**.

…………………………………………………………………………………………….

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

3. The counterweight in **(b)(i)** is replaced with one of a greater mass.

When the sculpture is now tilted slightly about the pivot and released, explain its subsequent motion.

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

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

[Total: 8]

4 A 4.0 kg block is released from rest down a rough 30° slope for 3.0 m. It continues to travel another 4.0 m on smooth ground until it hits a spring of force constant $k = 30\ \text{N m}^{-1}$. The block then compresses the spring 0.35 m before coming to rest momentarily.

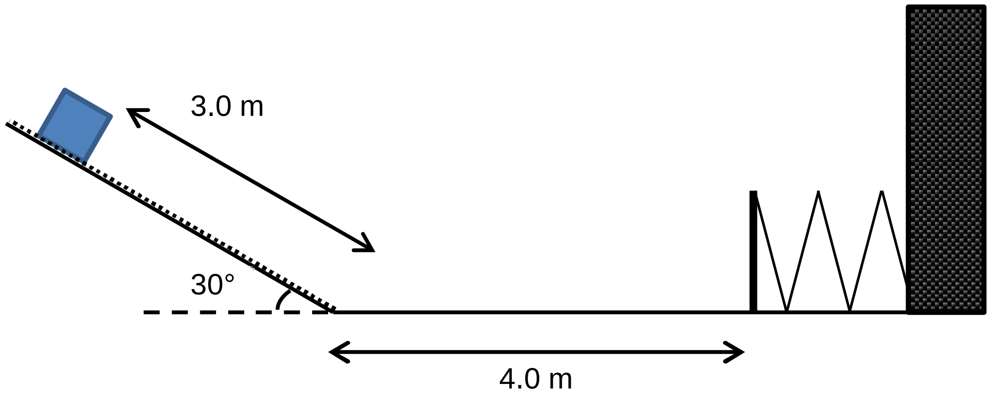

Fig. 4.1

(a) Determine the speed of the block just before it compresses the spring.

speed = ……………………….. m s^{-1} [2]

(b) Hence, find the average frictional force the box experiences when moving down the slope.

average frictional force = ……………………… N [3]

[Total: 5]

5 A stone of mass 200 g is tied to a string of length 73 cm and is whirled in a vertical circle with the other end of the string at the centre. At a certain instant the stone is at its lowest position A and has a speed 6.0 m s^{-1}.

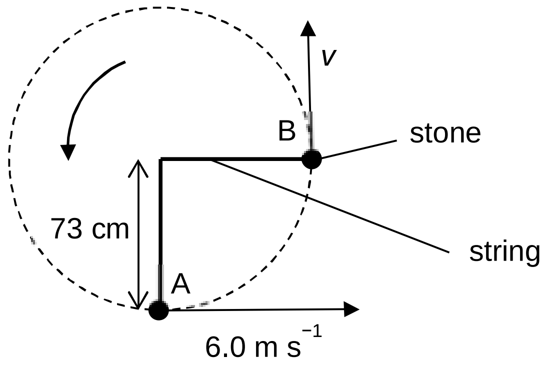

Fig. 5.1

(a) The stone has a speed *v* when the attached string reaches the horizontal position B.

Show speed *v* is 4.7 m s^{-1}.

[1]

(b) **(i)** In Fig. 5.2, draw and label the forces acting on the stone when it reaches horizontal position B.

Fig 5.2

[1]

(ii) Hence determine the tension in the string.

tension = …………………… N [2]

(c) In practice, the speed will be lower than what is derived in part **(a)**.

Explain why.

……..

…… [1]

[Total: 5]

6 **(a)** State what is meant by a *gravitational field*.

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

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

(b) Table 6.1 shows how the gravitational potential varies at three points above the centre of an unknown planet.

Table 6.1

Distance from centre of planet, r / 10^5 m	Gravitational potential, ϕ / 10^3 J kg^{-1}	ϕr / 10^8 J m kg^{-1}
1.25 (surface of planet)	− 15.0	
3.00	− 6.25	
7.50	− 2.50	

(i) In Table. 6.1, calculate and write down the value of the product, ϕr, for the data given.

Hence, show, using these values, that the gravitational potential is inversely proportional to the distance from the centre of the planet.

[2]

(ii) Use the data in Table. 6.1 to show that the mass of this unknown planet is 2.82 x 10^{19} kg.

[1]

(iii) It is suggested that a space vehicle could land on the planet to search for valuable minerals. The planet is spinning and the time for one rotation is 5.0 hours.

The space vehicle of mass 3.0×10^4 kg is located on the equator of the planet at a distance of 1.25×10^5 m from the centre, as shown in Fig. 6.2.

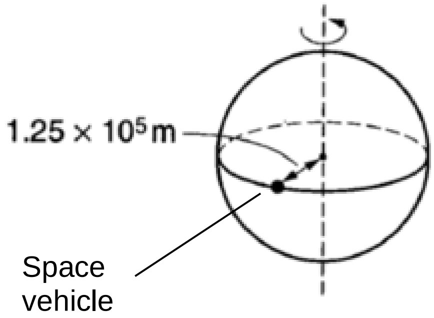

Fig. 6.2

1. Determine the centripetal force needed to keep the vehicle on the surface of the planet.

centripetal force = ………………... N [2]

2. the gravitational force on the vehicle on the surface of the planet.

gravitational force = ……………… N [1]

3. Hence deduce and explain whether the vehicle will stay on the surface of the rotating planet.

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

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

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

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

(c) A space probe is launched from the north pole of the planet. During the launch, the energy E given to the space probe of mass m is

$$E = \frac{3GMm}{4R}$$

where G is the gravitational constant and M and R are the mass and radius of the planet respectively. Work done in overcoming frictional force can be neglected.

(i) Explain what is meant by *escape speed*.

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

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

(ii) By considering the gravitational potential energy of the space probe, state and explain why the space probe was not launched at the escape speed.

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

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

[Total: 12]

BLANK PAGE

7 A ball is held between two fixed points A and B by means of two stretched springs, as shown in Fig. 7.1.

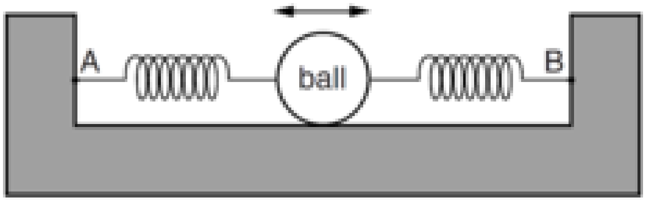

Fig 7.1

The ball of mass 100 g is free to oscillate along the straight-line AB. The springs remain stretched, and the motion of the ball is simple harmonic.

The variation with time t of the displacement x of the ball from its equilibrium position is shown in Fig. 7.2.

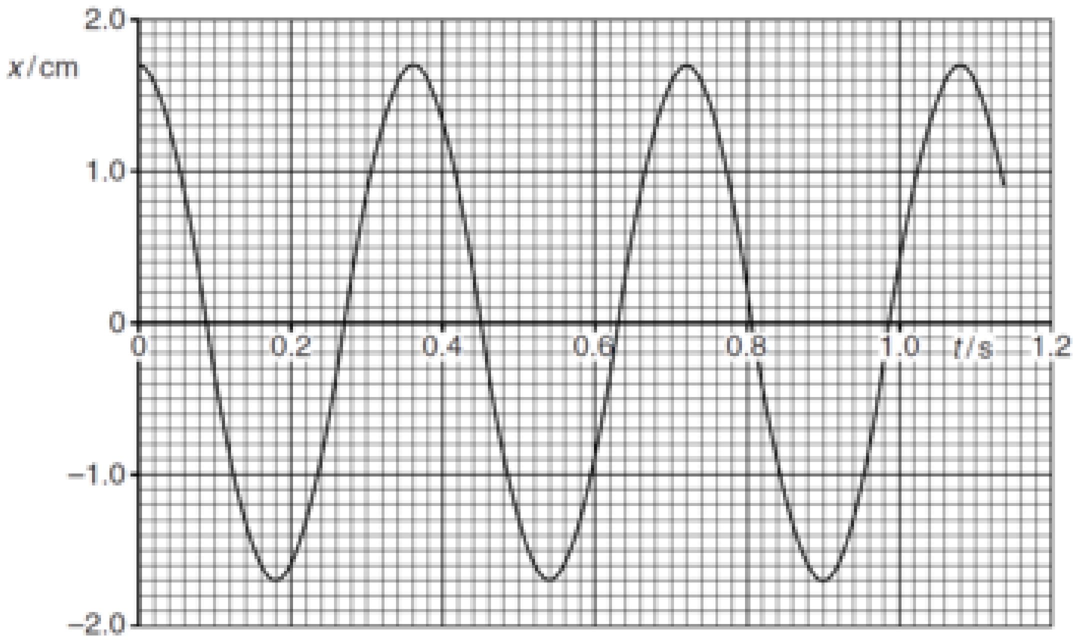

Fig 7.2

(a) Define simple harmonic motion.

....

....

.... [1]

(b) **(i)** Calculate the maximum acceleration of the ball.

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

(ii) Calculate the total energy of the ball.

total energy = ……………………………. J [2]

(iii) Calculate the displacement of the ball at which its kinetic energy is equal to half of the total energy of oscillation.

displacement = ……………………………. cm [2]

(c) The spring-mass system in Fig 7.1 is placed on a rough surface vibrating along the direction of oscillating ball.

Fig. 7.3 shows how the amplitude of the ball varies with the frequency of the vibrating surface.

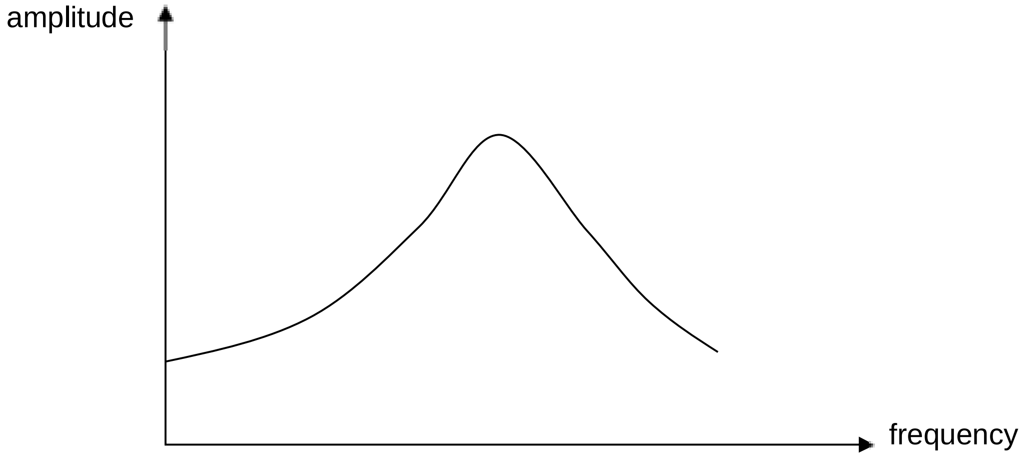

Fig. 7.3

The spring-mass system is then placed on a smoother vibrating surface.

On Fig. 7.3, sketch to show how the amplitude of the ball varies with the frequency of the vibrating surface. [2]

[Total: 9]

BLANK PAGE

8 The variation with distance x of the displacement y of a progressive transverse wave is shown in Fig. 8.1.

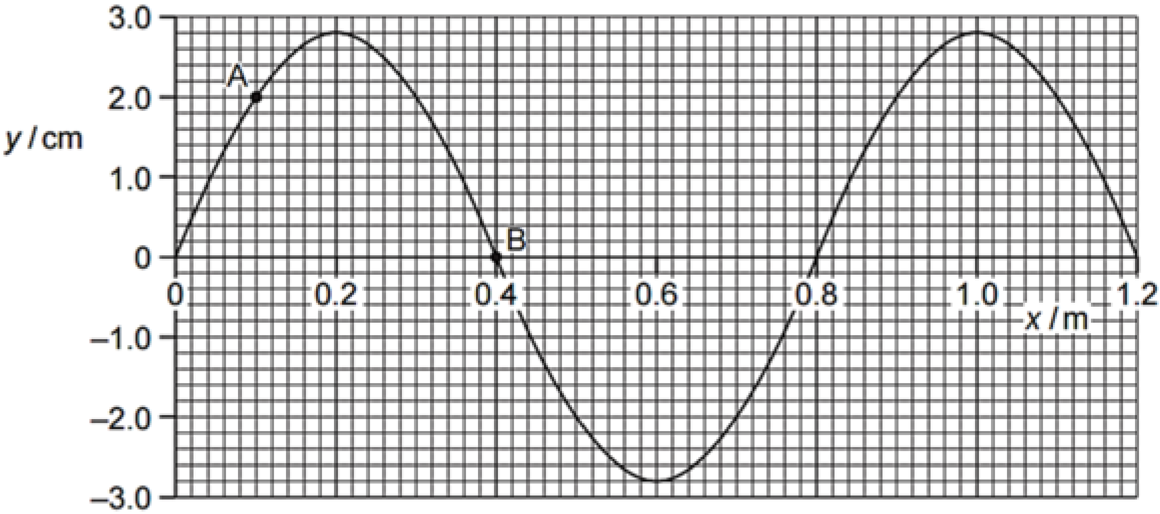

Fig. 8.1

(a) (i) Use Fig. 8.1 to determine the phase difference between the points labelled A and B.

phase difference = …………………….. rad [1]

(ii) Determine the amplitude of a wave with half the intensity of that shown in Fig. 8.1.

amplitude = ………………………. cm [2]

(iii) Calculate the speed of the wave, given that the wave has a period of 0.20 s.

speed = ……………………….... m s^{-1} [1]

(b) Fig. 8.1 shows the position of the particles of the wave at time t = 0 s.

Describe how the motion of point B varies with time from t = 0 to t = 0.10 s given that the wave is moving rightwards.

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

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

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

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

[Total: 6]

9 A horizontal string is stretched between two fixed points A and B. An oscillator is used to oscillate the string and produce an observable stationary wave. At one instant, the moving string is straight, as shown in Fig. 9.1.

Fig. 9.1

The dots in the diagram represent the positions of the nodes on the string. The particle at point P on the string is moving downwards.

The wave on the string has a speed of 35 m s^{-1} and a period of 0.040 s.

(a) Explain how the stationary wave is formed on the string.

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

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

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

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

(b) **(i)** State the phase difference between particle at point P and the particle at Point Q.

phase difference = ………………………... rad [1]

(ii) Determine the horizontal distance from A to B.

distance = …………………………. m [2]

(iii) A particle on the string has zero displacement at time $t = 0$. From time $t = 0$ to $t = 0.060$ s, the particle moves through a total distance of 72 mm.

Calculate the amplitude of oscillation of the particle.

amplitude = ……………………… mm [2]

(c) On Fig. 9.1, sketch a line to show a possible position of the string a quarter of a cycle later than the position shown in the diagram. [1]

(d) The frequency of the oscillator is increased gradually.

Determine the frequency of the oscillator that results in the next mode of the stationary wave formed in the string.

frequency = …………………… Hz [2]

[Total: 10]

END OF PAPER

BLANK PAGE