EUNOIA JUNIOR COLLEGE
JC1 Promotional Examination 2017
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	1	7	-			REGISTRATION NUMBER			

PHYSICS

9749/02

Paper 2 Structured Questions

03 October 2017

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	
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Total	

This document consists of **22** printed pages and **2** blank page.

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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	=	ρgh
gravitational potential,	ϕ	=	$-\dfrac{Gm}{r}$
temperature,	T/K	=	T / °C + 273.15
pressure of an ideal gas,	p	=	$\dfrac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\dfrac{3}{2}kT$
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	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\dfrac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\dfrac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant	λ	=	$\dfrac{\ln 2}{t_{\frac{1}{2}}}$

1 During a war, a helicopter was travelling at a velocity of 20.0 m s^{-1} at an angle of 30° above the horizontal as shown in Fig. 1.1.

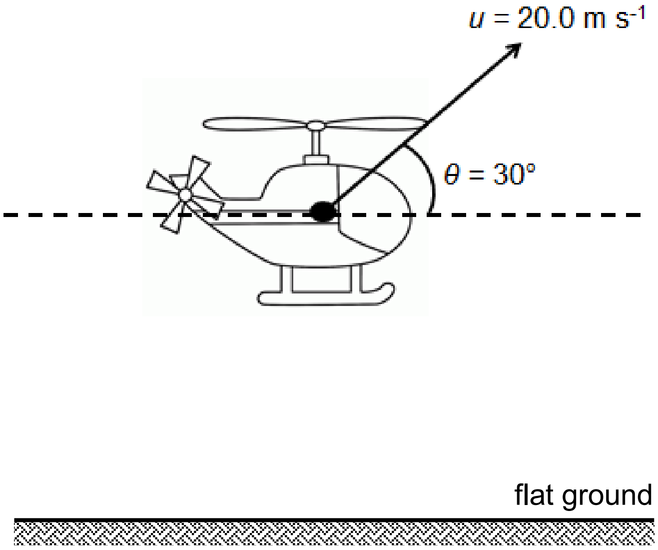

Fig. 1.1

(a) Neglecting the effects of air resistance, determine the vertical component of the velocity of the helicopter, u_y.

magnitude of u_y = **………………..** m s^{-1} [1]

(b) A bomb was dropped from the helicopter.

(i) Determine the vertical displacement, from the point of release, that the bomb falls 4.0 s after it was released, assuming that it has yet to hit the ground.

vertical displacement = **………………..** m [1]

(ii) Hence, determine the distance of the bomb from the helicopter 4.0 s after it was released.

distance from helicopter = **………………..** m [1]

(c) To ensure that the enemy is wiped out completely, the pilot dropped a second bomb 2.0 s after the first.

(i) On the axis provided on Fig. 1.2, sketch a graph showing how of the vertical component of velocity v_y of the first bomb varies against time t, for the first 5 s after the bomb was released. Take t = 0 s to be the time of release of the first bomb. Label this graph **A**. [2]

(ii) On the same axis on Fig. 1.2, sketch a graph showing how of the vertical component of velocity v_y of the second bomb varies against time t in this same time period. Label this graph **B**. [1]

Appropriate values should be indicated.

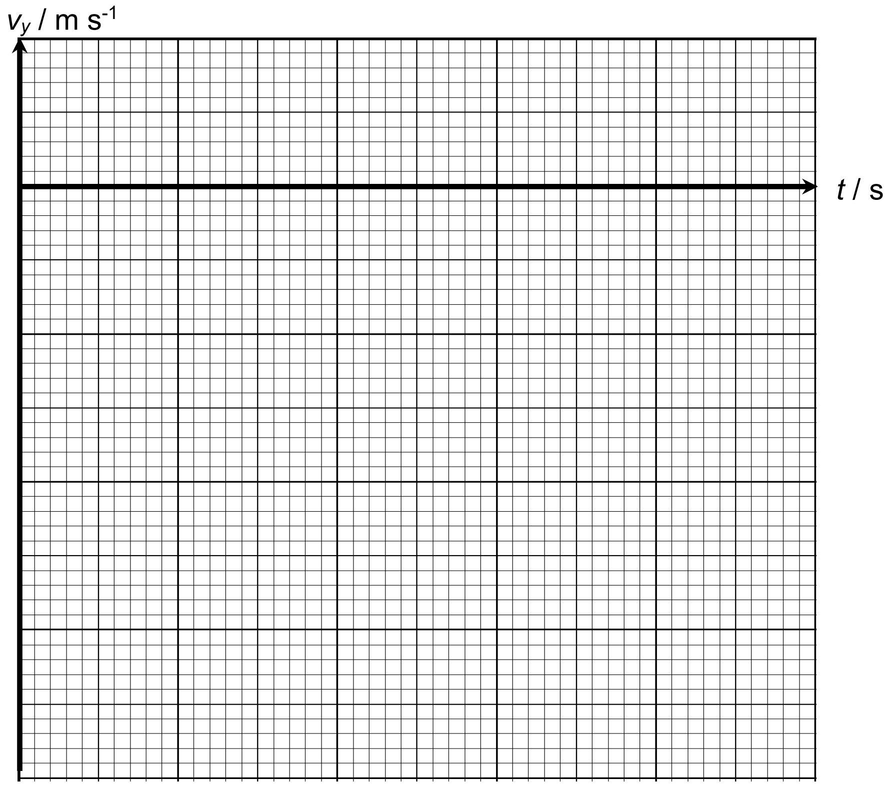

Fig. 1.2

(d) Using your answer to **(c)** or otherwise, calculate the vertical distance of the second bomb above the first bomb 3.0 s after the second bomb was released.

distance = **………………..** m [2]

(e) State and explain whether the 2 bombs are going to hit the same spot when it eventually lands on the flat ground.

....

....

....

.... [2]

2 **(a)** State the *principle of conservation of momentum*.

....

....

.... [1]

(b) Block A, of mass 2.0 kg, has a light spring attached to it as shown in Fig. 2.1. Block B has a mass of 5.0 kg and is initially at rest.

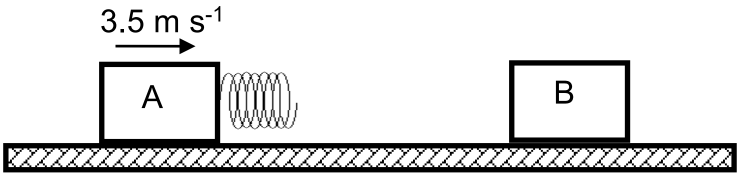

Fig. 2.1

Block A moves with a velocity of 3.5 m s^{-1} over the frictionless surface towards Block B and the two blocks undergo a head-on, elastic collision, during which the spring on block A is compressed as shown in Fig. 2.2.

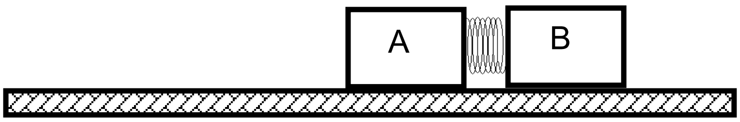

Fig. 2.2

At a certain time during this collision, the two blocks A and B have a common velocity v_o.

(i) Determine the value of v_o.

magnitude of v_o = **………………..** m s^{-1} [1]

(ii) Hence, calculate the total kinetic energy of the system during this time.

kinetic energy = **………………..** J [1]

(iii) Explain how is it possible that the answer to **(b)(ii)** is less than the initial kinetic energy of A.

....

.... [1]

(c) Blocks A and B separate after the collision in **(b)**.

Determine the magnitude of the velocities v_A and v_B of blocks A and B respectively after collision.

v_A = **………………..** m s^{-1}

v_B = **………………..** m s^{-1} [4]

3 Fig. 3.1 shows a side view of a bathroom wall cabinet. Its lower edge rests against the wall at A. It is fastened by screws at a height *h* vertically above A. The mass of the cabinet is 10 kg and its centre of gravity is 0.15 m from the wall. Fig. 3.2 shows the free body diagram for the cabinet.

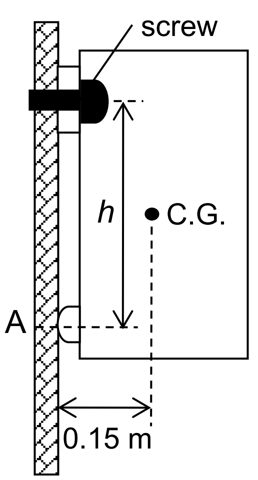

Fig. 3.1

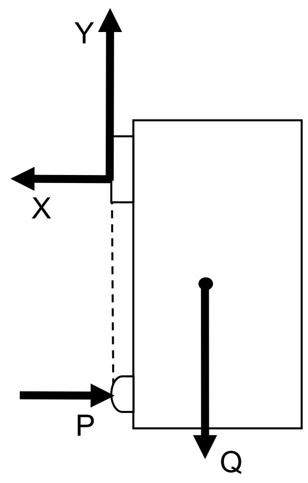

Fig. 3.2

(a) State the magnitude of force Y.

magnitude of Y = ………………….. N [1]

(b) Explain why forces X and P must have equal magnitude.

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

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

(c) Calculate the magnitude of force X when *h* = 0.60 m.

magnitude of X = ………………….. N [2]

(d) In principle, the fixing screws could be positioned anywhere between point A and the top of the cabinet. Sketch on the axis provided in Fig. 3.3, a graph to show how the magnitude of force X would vary for the values of h from zero up to 0.60 m. [1]

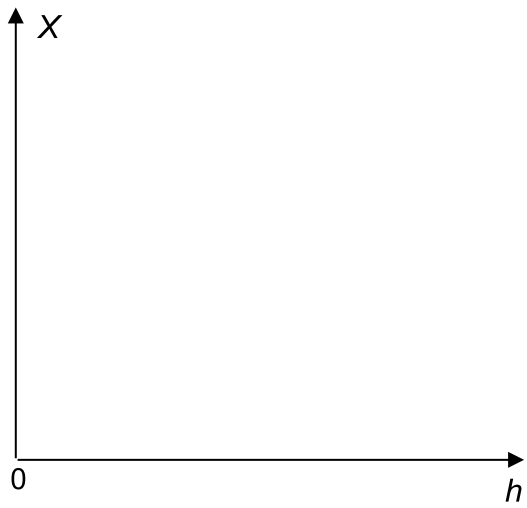

Fig. 3.3

4 A cylinder and piston used in a car engine is as shown in Fig. 4.1.

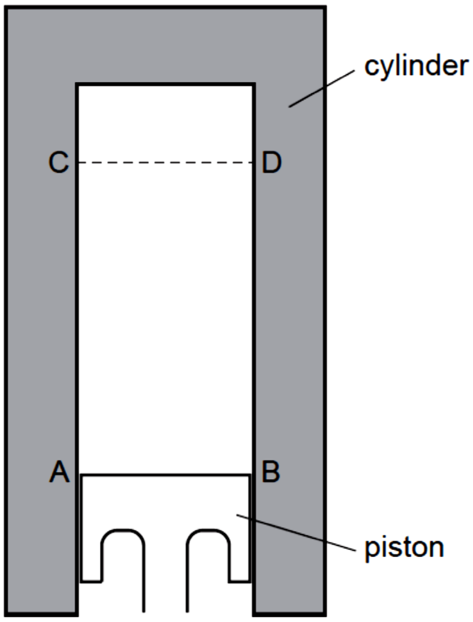

Fig. 4.1

The vertical oscillation of the piston in the cylinder can be assumed to be simple harmonic. The top surface of the piston in the cylinder is at AB when it is at its lowest position and at CD when it is at its highest position as marked in Fig. 4.1.

(a) Explain what it means when the oscillation of the piston is *simple harmonic*.

....

....

....

.... [2]

(b) At a particular engine speed, the displacement *d* of the piston may be represented by the equation

$$d = -4.0\cos(220t)$$

where *d* is measured in centimetres.

(i) State the distance between the lowest position AB and the highest position CD of the top surface of the piston.

distance = ……………….. cm [1]

(ii) Determine the number of oscillations made per second by the piston.

number of oscillations per second = **………………..** [2]

(iii) On Fig. 4.1, draw a horizontal line to indicate the position of the top surface of the piston where the speed of the piston is maximum. [1]

(iv) Calculate the maximum speed of the piston.

maximum speed = **………………..** m s^{-1} [2]

(v) If the mass of the piston is 1.5 kg, determine the maximum resultant force on the piston.

maximum resultant force = **………………..** N [2]

(c) The engine of a car has several cylinders. Two of these cylinders are as shown in Fig. 4.2.

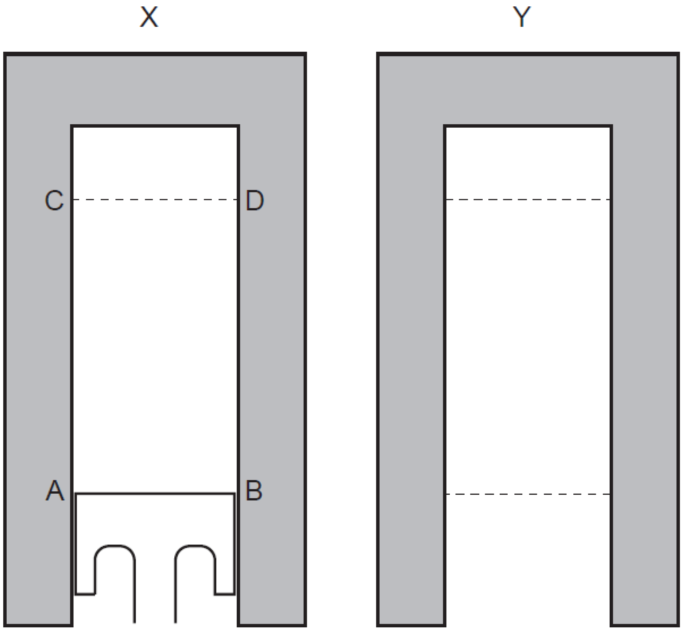

Fig. 4.2

X is the same cylinder and piston as in Fig. 4.1. The position of the top surface of the piston in cylinder X at a particular instant in time is as shown in Fig. 4.2. Y is similar cylinder and piston with the lowest and highest position of the top surface of its piston as indicated.

The pistons in the cylinders each have the same frequency and amplitude of oscillation, but the oscillations of the piston in cylinder Y leads those of the piston in cylinder X by a phase difference of 120° ($\frac{2}{3}\pi$ rad).

For the instant in time depicted, draw on Fig. 4.2

(i) a horizontal line to indicate the position of the top surface of the piston in cylinder Y. [1]

(ii) a vertical arrow to show the direction of movement of the piston. [1]

5 A horizontal flat plate is free to rotate about a vertical axis through its centre as shown in Fig. 5.1.

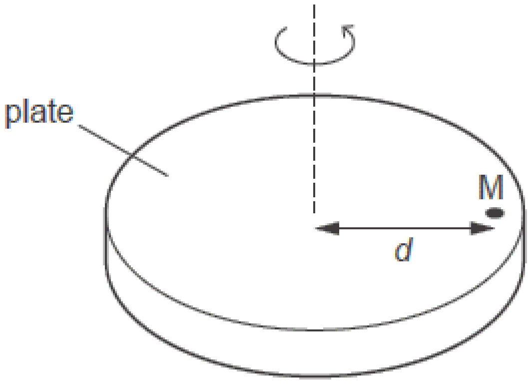

Fig. 5.1

A small mass M is placed on the plate, a distance d from the axis of rotation. The maximum frictional force f between the plate and the mass is given by the expression

$$f = 0.78W,$$

where W is the weight of mass M.

The speed of rotation of the plate is gradually increased from zero until the mass is seen to slide off the plate.

(a) Determine the maximum number of revolutions of the plate per minute for the mass M to remain on the plate if the distance d is 35 cm.

number of revolution per minute = **………………..** [3]

(b) The plate, when stationary, is covered with mud.

State and explain whether the mud near the edge or the centre of the plate will first leave the plate as the speed of rotation of the plate is gradually increased from zero.

....

....

....

.... [2]

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6 **(a)** **(i)** Explain what is meant by a *polarized* wave.

....

.... [1]

(ii) A plane-polarized wave is incident normally on a polarizer P as shown in Fig 6.1. In Fig. 6.2, the polarizer is rotated clockwise by an angle of θ.

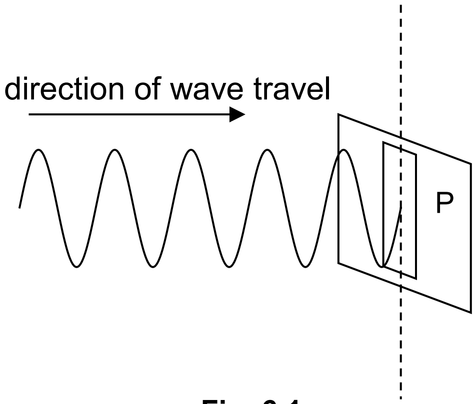

Fig. 6.1

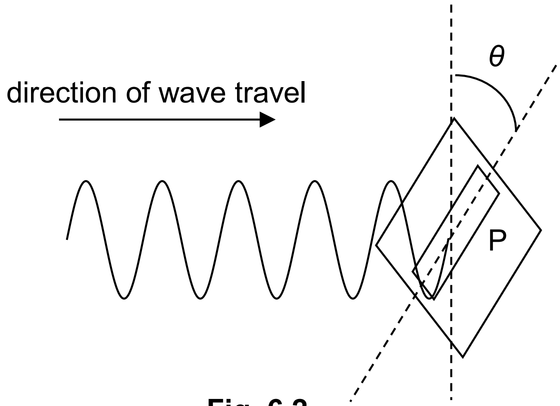

Fig. 6.2

Determine the angle θ if the intensity of the emergent wave is 20% of the intensity of the incident wave.

θ = **………………..** ° [2]

(b) State two conditions that must be satisfied in order to have observable interference pattern.

1. ....

2. .... [2]

(c) The apparatus illustrated in Fig. 6.3 is used to demonstrate two-source interference using light.

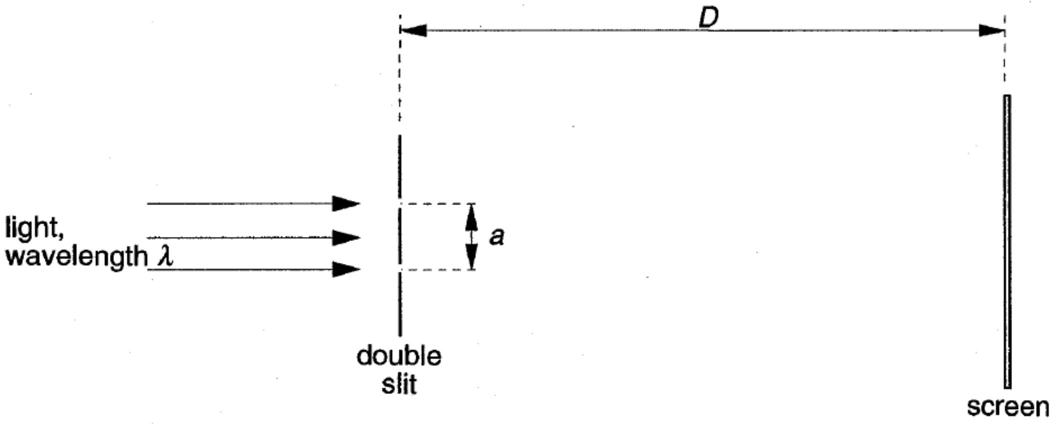

Fig. 6.3 (not to scale)

The separation of the two slits in the double slit arrangement is *a* and the interference fringes are viewed on a screen at a distance *D* from the double slit. When light of wavelength *λ* is incident on the double slit, the separation of the bright fringes on the screen is *x*.

(i) **1.** Suggest a suitable value for the separation, *a,* of the slits in the double slit.

.... [1]

2. Write down an expression relating *λ, a, D* and *x.*

.... [1]

(ii) Describe the effect, if any, on the separation and on the maximum brightness of the fringes when the following changes are made independently of each other. [7]

1. The distance *D* is increased to 3*D*, while keeping *a* and *λ* constant.

....

....

....

2. The wavelength *λ* is increased to 2*λ*, while keeping *a* and *D* constant.

....

....

....

3. The intensity of the light incident on the double slit is increased, while keeping *λ, a* and *D* constant.

....

....

....

(d) A glass tube, closed at one end, has fine dust sprinkled along its length. A sound source is placed near the open end of the tube, as shown in Fig. 6.4.

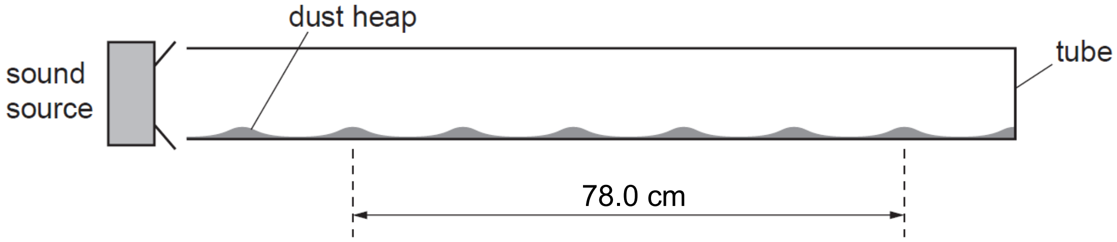

Fig. 6.4

The frequency of the sound emitted by the source is varied and, at one frequency, the dust forms small heaps in the tube.

(i) One frequency at which heaps are formed is 1.07 kHz. The distance between six heaps, as shown in Fig. 6.4, is 78.0 cm.

Calculate the speed of sound in the tube.

speed of sound = **………………..** m s^{-1} [3]

(ii) The wave in the tube is a stationary wave. Explain, by reference to the formation of a stationary wave, what is meant by the speed calculated in **(d)(i)**

....

....

....

....

.... [3]

7 **(a)** The moon Charon (discovered in 1978) orbits the planet Pluto. Fig. 7.1 shows the variation of the gravitational potential ϕ with distance d above the surface of Pluto along a line joining the centres of Pluto and Charon.

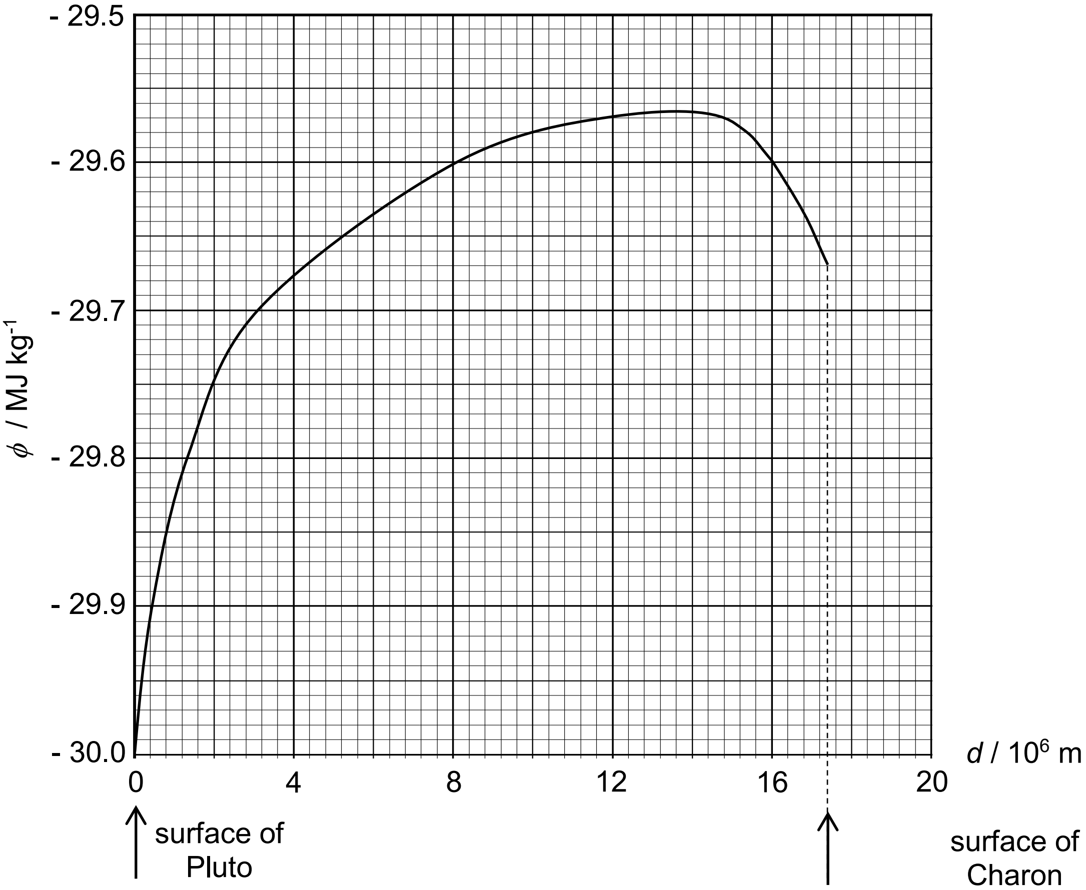

Fig. 7.1

The gravitational potential is taken as being zero at infinity.

(i) Suggest why all values of gravitational potential in Fig. 7.1 are negative and explain how they may be obtained.

....

....

....

....

.... [2]

(ii) Explain how Fig. 7.1 can be used to determine the resultant gravitational force acting on an object with mass m placed at a point between Pluto and Charon.

....

....

.... [2]

(iii) With a clear explanation of your method, use Fig. 7.1 to determine

1. the distance from the surface of Pluto at which the acceleration of free fall is zero.

distance = ……………….. m [1]

2. the acceleration of free fall on the surface of Charon.

acceleration = ……………….. m s^{-2} [3]

(iv) A lump of rock of mass 5.0 kg is ejected from the surface of Charon such that it travels towards Pluto.

1. Using data from Fig. 7.1, determine the minimum speed at the rock hits the surface of Pluto.

minimum speed = ……………….. m s^{-1} [3]

2. State and explain in the case when a rock is projected from Pluto to Charon, how its minimum speed when reaching Charon will be different from that calculated in **(iv)1**.

....

....

....

....

.... [2]

(b) In another planetary system as shown in Fig. 7.2, X and Y are two stars of equal mass *M*. The points A, B and C are equidistant from both X and Y. B is on the straight line joining the centres of mass of X and Y.

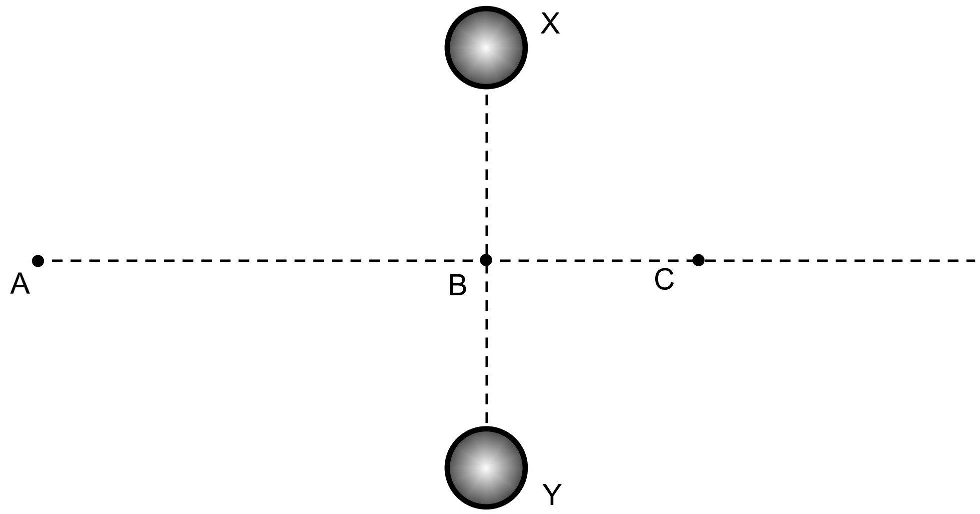

Fig. 7.2

(i) State Newton's Law of Gravitation.

....

....

.... [1]

(ii) Draw arrows on Fig. 7.2 to represent the gravitational forces due to the each of the stars acting on a small mass placed at points A, B and C. The length of the arrow should be relative to their respective magnitudes. [2]

(iii) Fig. 7.3 is another schematic of stars X and Y. The distance between the centres of mass of X and Y is 2*L*. P is a point equidistant from X and Y and is at a distance x from the straight line joining the centres of mass of X and Y.

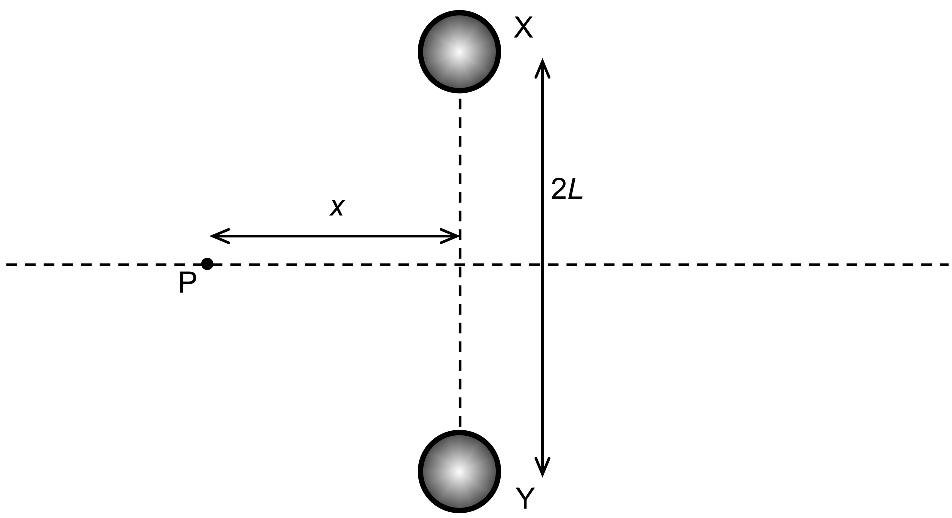

Fig. 7.3

1. Show that the magnitude of the resultant gravitational force acting on a mass *m* placed at P is

$$F_G = \frac{2GMmx}{\left(x^2 + L^2\right)^{\frac{3}{2}}}$$

[2]

2. Hence, state and explain if the subsequent motion of a mass placed at rest at point P is simple harmonic.

....

....

.... [2]

End of Paper

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