EUNOIA JUNIOR COLLEGE
JC1 Promotional Examination 2020
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME						
CIVICS GROUP	2	0	-			REGISTRATION NUMBER

PHYSICS

9749/02

Paper 2 Structured Questions

02 October 2020

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.

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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S.F.	
Total	

This document consists of **24** printed pages

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	=	$T/{}^{o}C + 273.15$
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	=	$v_o \cos \omega t$
		=	$\pm\, \omega\sqrt{\left(x_o^{\,2} - x^2\right)}$
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	=	$\dfrac{Q}{4\pi\varepsilon_o r}$
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	=	$\dfrac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant	λ	=	$\dfrac{\ln 2}{t_{\frac{1}{2}}}$

1 A water bomb is launched at ground level at a velocity of 20 m s^{-1} at an angle of 50° from the horizontal to hit a boy on top of a platform of height H at a position 32 m from the foot of the building. The boy is standing at a distance x from the edge of the platform.

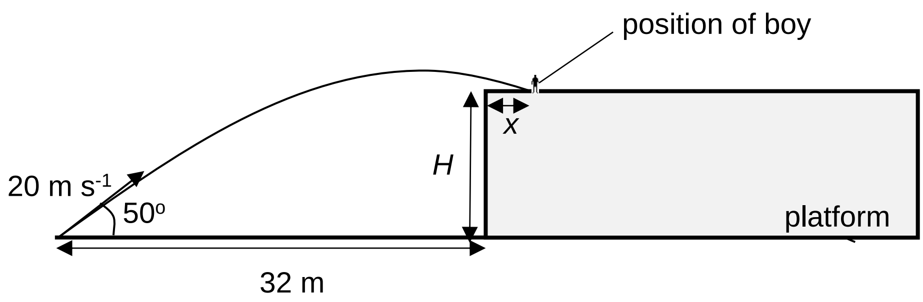

Fig. 1.1 (not drawn to scale)

The water bomb reaches the top of its trajectory and then fall towards the boy, hitting him 2.75 s after launch.

(a) Show that the height of the platform H is 5.0 m. [1]

(b) Determine the distance x of the boy from the edge of the building.

x = ……………………. m [1]

(c) Upon seeing the water bomb being launched at him, the boy runs away from the edge of the platform as soon as possible. Assuming that the water bomb (which explodes upon impact) has a 'splash radius' of 5.0 m and the boy's reaction time is 0.20 s, calculate the minimum constant acceleration at which the boy should run in order to avoid being splashed.

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

(d) State and explain the changes to your answers in **(b)** if a water bomb of a larger mass is being launched instead at the same velocity.

………

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………

……… [3]

[Total: 7]

2 Fig. 2.1 is a diagram of a human arm lifting an object.

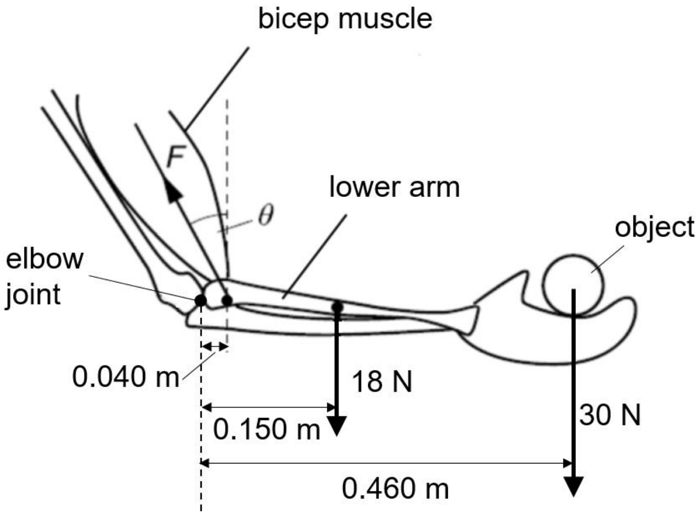

Fig. 2.1

The lower arm is horizontal and its centre of gravity is 0.150 m from the elbow joint. The weight of the lower arm is 18 N. The bicep muscle exerts a force F at an angle of θ to the vertical.

The horizontal distance between the elbow joint and the point of attachment of the muscle to the lower arm bone is 0.040 m. The weight of the object held in the hand is 30 N and its centre of gravity is 0.460 m from the elbow joint. The arm is in equilibrium.

(a) Determine the value of F when $\theta = 15^{\circ}$.

F = ………………………… N [2]

(b) For the lower arm to be in equilibrium, the elbow joint also needs to exert a force *R* on the lower arm bone.

(i) Draw a labelled arrow on Fig. 2.1 to represent the force *R* that the elbow exerts on the lower arm. [1]

(ii) Explain the direction of this force *R*.

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

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

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

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

(c) As the lower arm is slowly moved away from the body in the horizontal direction, the angle θ increases.

Sketch in Fig. 2.2 the graph of how *F* varies with θ. (You may assume that the lower arm remains horizontal and is in equilibrium at all times.) [1]

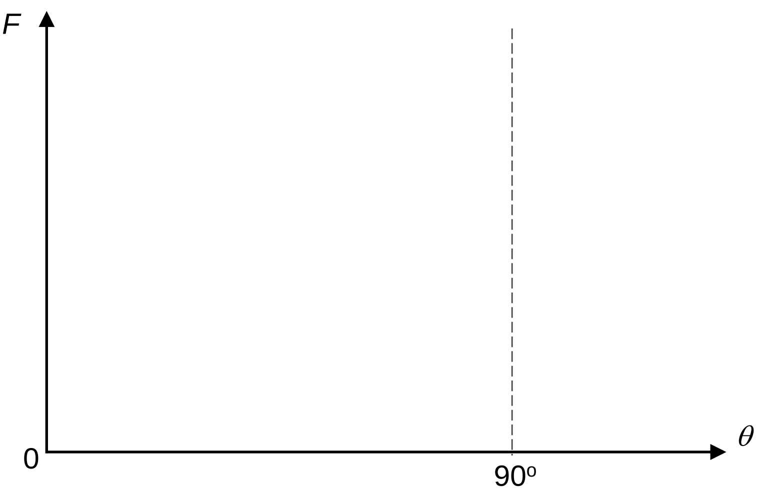

Fig. 2.2

(d) Suggest and explain what will happen to *F* if he has a longer lower arm that has the same weight.

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

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

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

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

[Total: 8]

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

………

………

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

(b) A particle A travelling with a velocity of 9.0×10^5 m s^{-1}, along a horizontal frictionless surface collides elastically with another particle B of identical mass, which was initially stationary, as shown in Fig. 3.1.

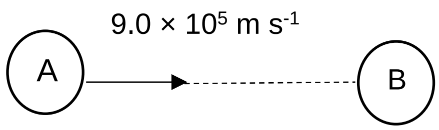

Fig.3.1

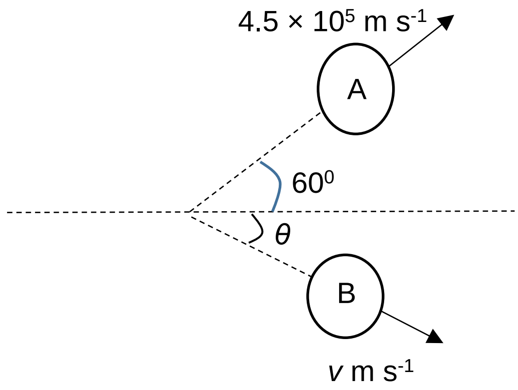

Fig.3.2

They then move apart as shown in Fig. 3.2.

Particle A has velocity 4.5×10^5 m s^{-1} at an angle of 60° to the direction of its initial path.

Particle B has velocity v m s^{-1} at an angle of θ to the direction of the initial path of particle A.

(i) Calculate

1. the magnitude of velocity v

v = ………………….. m s^{-1} [2]

2. the angle θ

θ = ………………° [2]

(ii) Using the principle of conservation of momentum, explain why the momentum of particle A cannot be conserved.

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

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

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

[Total: 8]

4 **(a)** A box of mass 4.0 kg, is pushed by a varying force *F* along a rough floor, with a constant frictional force of 2.5 N. The force *F* varies with the displacement *x* measured with respect to a fixed point, P on the ground as shown in Fig 4.1.

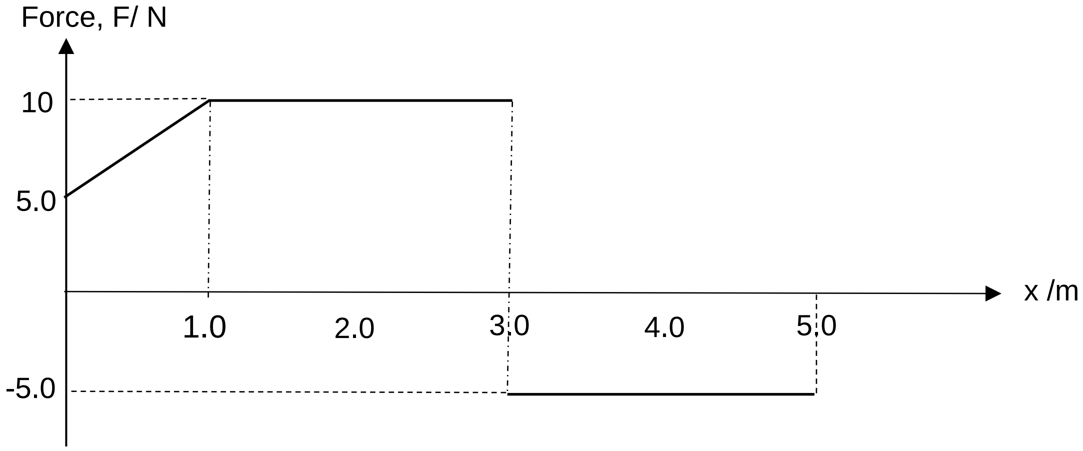

Fig. 4.1

(i) Determine the work done by the force *F* after it has travelled a displacement of 3.0 m from P.

work done by *F* = …………………. J [1]

(ii) Assuming that the box started from rest at P, find the speed of the box at *x* = 5.0 m.

speed of box = ……………..… m s^{-1} [3]

(b) A spring, which obeys Hooke's Law, with an unstretched length L_1 and force constant k experiences a tension that extends its length to L_2. By sketching an appropriate graph, derive an expression for the elastic potential energy stored in the spring in terms of k, L_1 and L_2. [3]

[Total: 7]

5 The *Globe of Death* in Fig. 5.1 is a popular circus act where stunt riders ride motorcycles inside a mesh sphere ball. The riders can loop vertically as well as horizontally.

Fig 5.1

(a) In one performance, the stunt rider rides his motorcycle in a horizontal circle with constant speed at an angle of 30° above the equatorial plane of the sphere as shown in Fig. 5.2.

The sphere has a radius of 5.0 m.

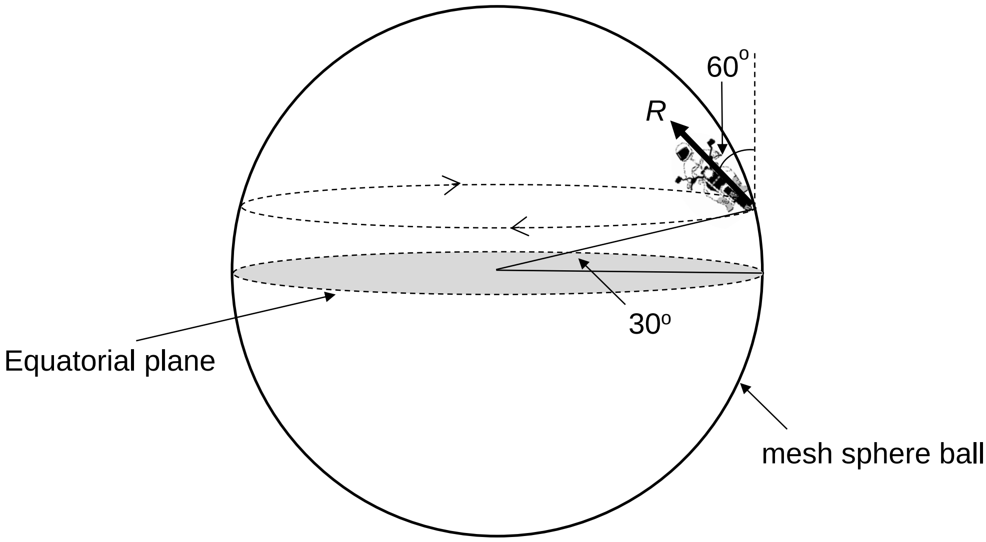

Fig. 5.2

The force R exerted by the sphere on the rider and motorcycle makes an angle of 60° with the vertical.

(i) Assuming that the rider and motorcycle can be considered as a point mass, show that the speed of the rider and motorcycle is 8.6 m s^{-1}. [3]

(ii) State and explain whether work is done by R on the rider and motorcycle.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(b) The stunt rider changes to a vertical loop in the sphere as shown in Fig.5.3.

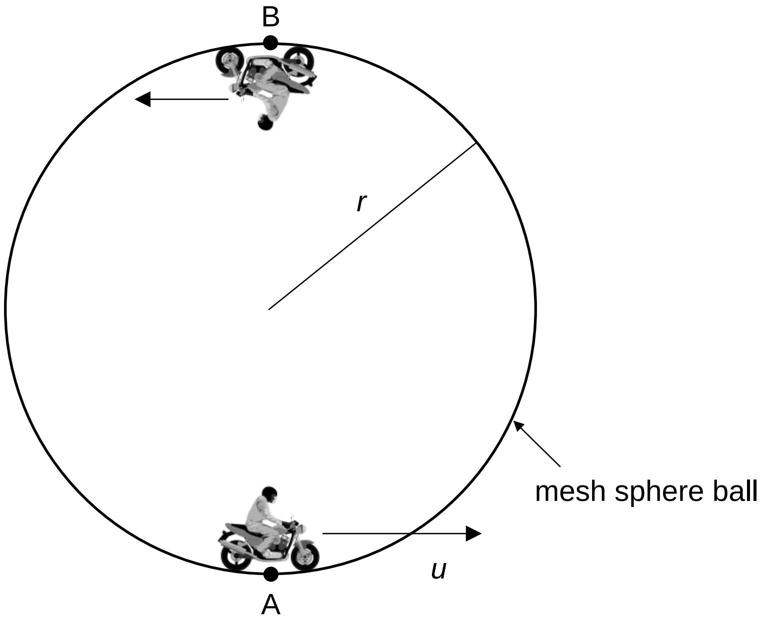

Fig. 5.3

As the rider passes the bottom of the vertical loop at point A, he switches off the engine. The unpowered motorcycle continues in a vertical loop to reach the top at point B and finally back to point A.

The radius of the sphere is *r*. Assume the rider and motorcycle can be considered as a point mass.

Derive an expression for the minimum speed *u* of the rider at A, in terms of *r* and the acceleration of free fall *g*, so that he can complete the vertical loop.

Explain your working. [3]

[Total: 8]

6 **(a)** A satellite of mass m is in a circular orbit of radius r about the Earth. The Earth may be considered to be an isolated uniform sphere with its mass M concentrated at its centre.

(i) Show that the kinetic energy E_k of the satellite is given by the expression

$$E_k = \frac{GMm}{2r}$$

where G is the gravitational constant. Explain your working. [3]

(ii) The variation with orbital radius r of the gravitational potential energy of the satellite is shown in Fig. 6.1.

On the figure, draw the variation with orbital radius of the kinetic energy of the satellite. [1]

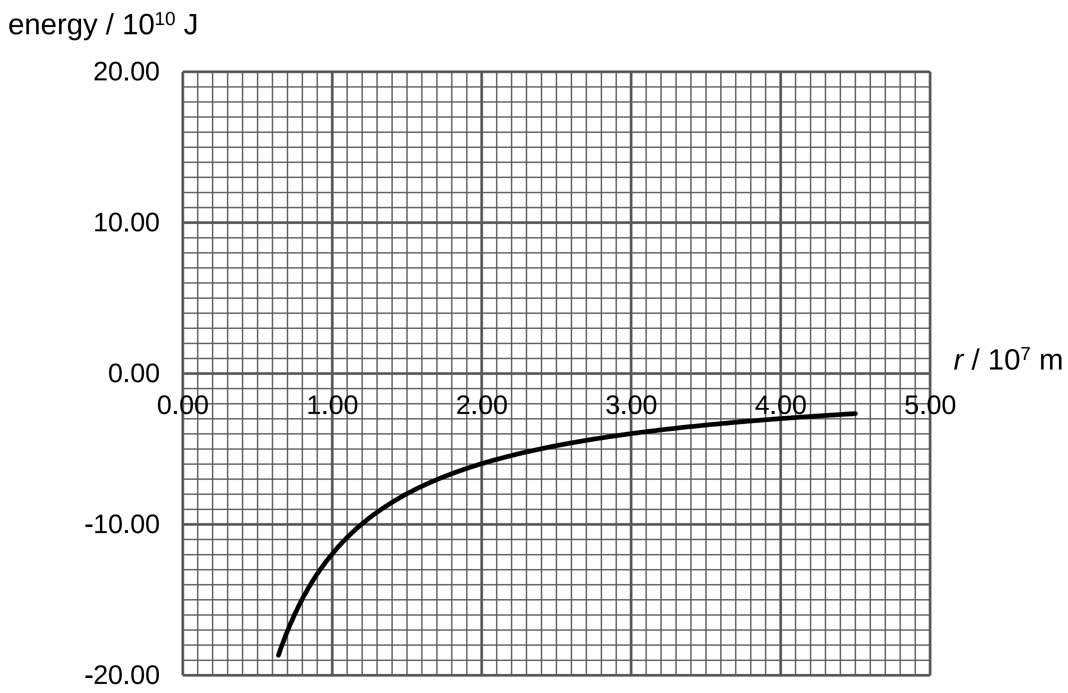

Fig. 6.1

(b) A satellite is originally in polar orbit and passes over the North and South poles of the Earth in each of its revolution. The polar orbit is a low-altitude orbit of about 1000 km above the surface of the Earth.

The satellite is to be re-deployed as a geostationary satellite. To achieve this, it must change its orbit to a high-altitude orbit of about 3.6×10^4 km above the equator by using on-board rocket engines.

(i) The first stage of the manoeuvre changes the satellite's orbit from a low-altitude polar orbit to a high-altitude polar orbit of 3.6×10^4 km. This happens in the same orbital plane.

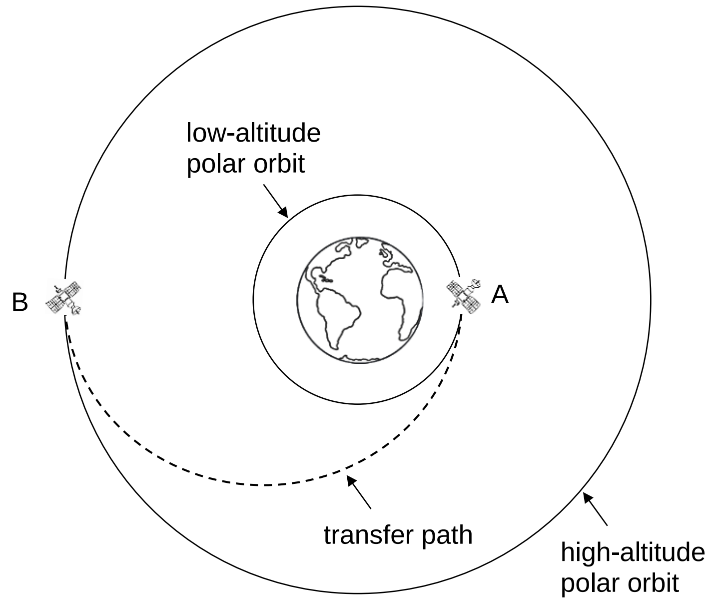

Fig. 6.2

Rocket engines are fired for short durations at point A (start of manoeuvre) and point B (end of manoeuvre) as shown in Fig. 6.2.

1. State with reasons how the kinetic energy and gravitational energy of the satellite have changed from the start to the end of the manoeuvre.

....

....

....

.... [2]

2. Explain why the magnitude of the change in kinetic energy is not equal to the magnitude of the change in gravitational potential energy.

....

.... [1]

(ii) In the second stage of the manoeuvre, the rocket engines are fired at point C to change the inclination of the polar orbit so that the satellite's orbital plane can become an equatorial plane that is necessary for geostationary orbit.

The altitude of the satellite remains constant at 3.6×10^4 km during the entire of the second stage.

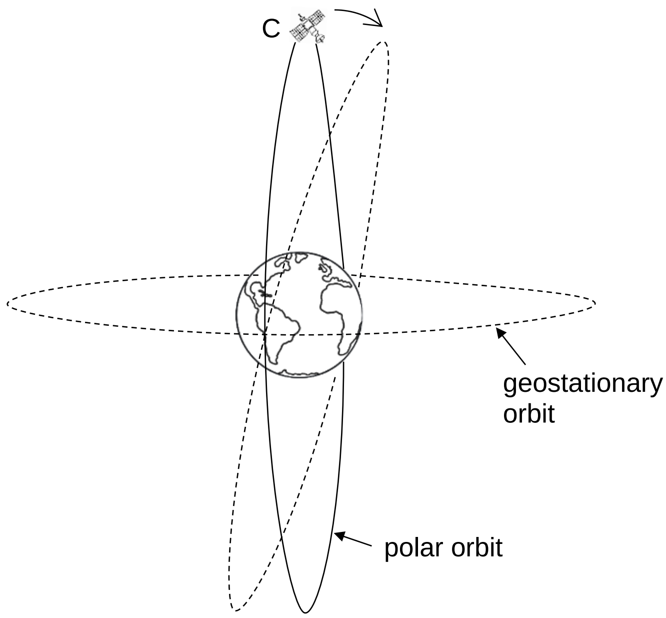

Fig. 6.3

1. Explain why the gravitational potential energy of the satellite remains constant during this second stage.

…………………………………………………………………………………………

………………………………………………………………………………….. [1]

2. Suggest why the tangential speed of the satellite in its orbit remains constant even though the rocket engines are fired at point C.

…………………………………………………………………………………………

………………………………………………………………………………….. [1]

[Total: 9]

7 **(a)** A spring-mass system is attached to a mechanical oscillator. The movable piston of the oscillator vibrates with a constant amplitude but with a frequency that can be varied.

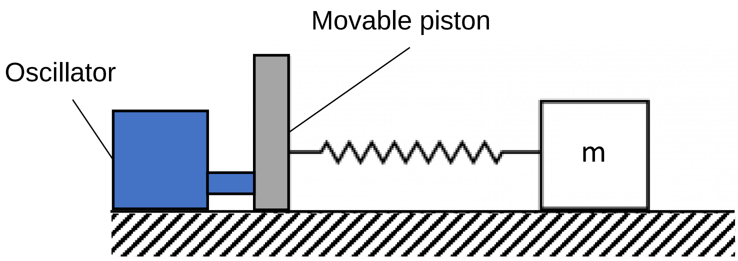

Fig. 7.1

Fig. 7.2 shows the frequency response graph of the mass m.

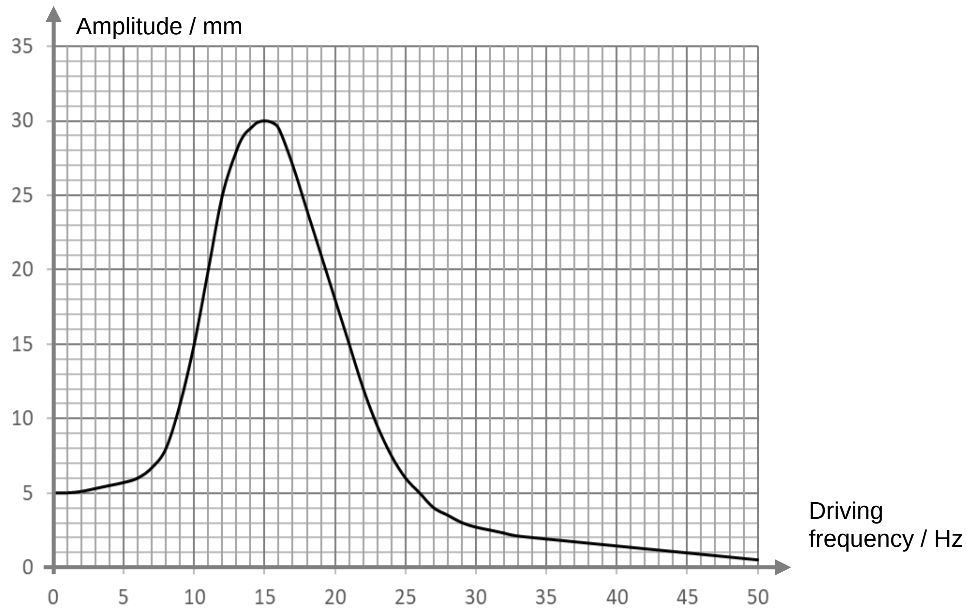

Fig. 7.2

(i) State the name of the phenomenon illustrated in Fig. 7.2.

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

(ii) Use Fig. 7.2 to determine

1. the natural frequency of the spring-mass system

natural frequency = ………………………… Hz [1]

2. the amplitude of vibration of the movable piston

amplitude = ………………………… mm [1]

(iii) On Fig. 7.2, sketch the frequency response graph if the damping effect is increased slightly. [1]

(b) Fig. 7.3 shows the same spring-mass system in Fig. 7.1 but with the oscillator switched off. The mass m is attached to the spring with spring constant *k*. The mass is displaced to the right and then released. The mass oscillates.

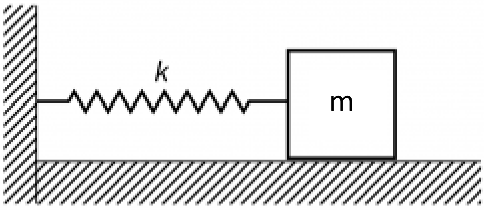

Fig. 7.3

(i) Determine the period of oscillation of the mass.

period = ………………………… s [2]

(ii) By considering the forces acting on the mass, show that the mass undergoes simple harmonic motion. [3]

[Total: 9]

8 **(a)** A guitar string is fixed at both ends. When the string is plucked, a stationary wave is set up in the string.

Explain how a stationary wave is formed on the string.

………

………

………

…………………………………………………………………………………………………… [3]

(b) A loudspeaker is held over a vertical tube of liquid, as shown in Fig. 8.1. A tap at the bottom of the tube is opened so that liquid drains out. The wavelength of the sound from the loudspeaker is 0.24 m. The sound that is heard first becomes much louder when the liquid surface reaches level A. The next time that the sound becomes much louder is when the liquid surface reaches level B, as shown in Fig. 8.2.

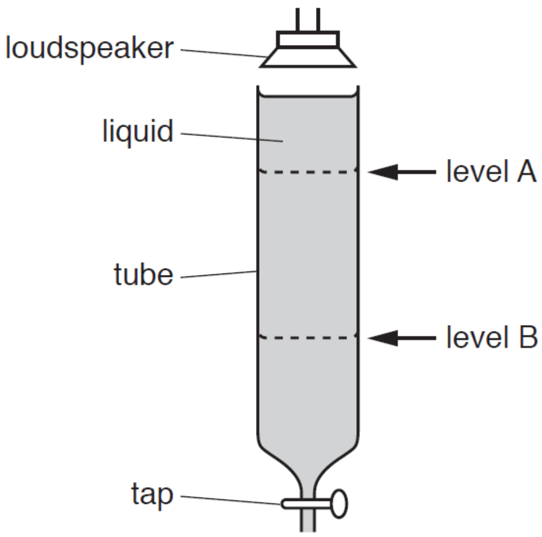

Fig. 8.1

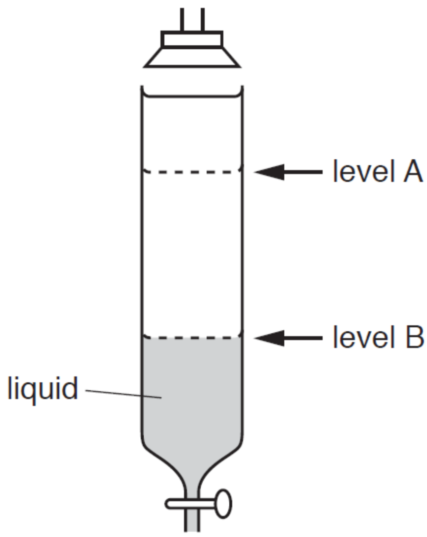

Fig. 8.2

(i) On Fig. 8.2, draw a representation of the stationary wave that is formed in the air column. [2]

(ii) Calculate the vertical distance between levels A and B.

distance = …………………………….... m [1]

(iii) Fig. 8.3 shows the instant when the liquid level is at B and a loud sound is heard.

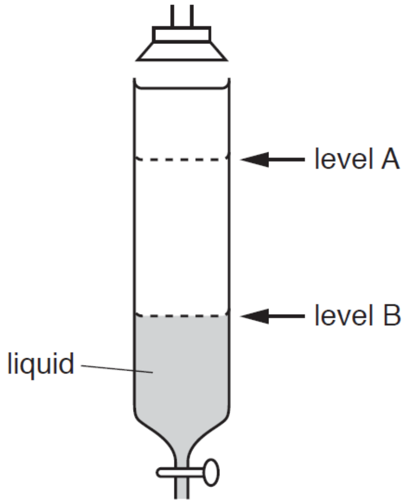

Fig. 8.3

On Fig. 8.3, mark a point which undergoes the maximum variation in pressure with a cross. [1]

(iv) The tap is now closed and the liquid level is kept at B. The wavelength of the sound produced by the loudspeaker is increased until the next time a loud sound is heard.

Determine the wavelength of the sound produced by the loudspeaker when this occurs.

wavelength = …………………….......... m [2]

[Total: 9]

9 A mass of 8.0 kg is attached to a spring with a spring constant of 200 N m^{-1} and an unstretched length of 0.80 m as shown in Fig. 9.1. The spring extends by 0.39 m due to the weight of the mass.

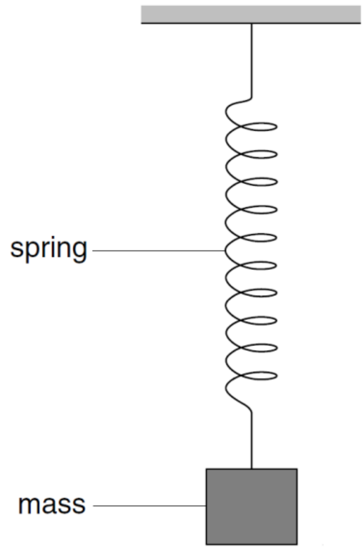

Fig. 9.1

(a) The mass is pulled down further by 0.15 m before letting it oscillate from rest at that position.

Given that the angular velocity of the oscillation is 5.0 rad s^{-1}, calculate the total energy of the oscillation.

total energy = …………………… J [2]

(b) At the lowest point of the oscillation, the spring broke and the mass falls a through a height of 20 m just before hitting into a pond of water.

(i) Calculate the speed of the mass just before it hits the water.

speed = ……………………….. m s^{-1} [3]

(ii) On hitting the water, the speed of the mass is reduced to 3.0 m s^{-1} in a time of 0.75 s.

Use momentum considerations to determine the average force on the mass during this time.

force = ……………………….. N [2]

(iii) Use energy considerations to suggest why, if the mass causes a large splash on hitting the sea, it will be slowed down in a shorter distance than when no splash is produced.

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

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

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

(c) The impact of the mass with the pond generates a circular wave that travels along the surface of the pond. Point A and point B are at distances of 0.50 m and 1.5 m away from the point of impact respectively.

(i) At point A, the amplitude of the wave is 4.0 cm. Determine the amplitude of the wave at point B.

amplitude = ……………………… cm [2]

(ii) Energy is not lost as the waves travel from point A to point B. Explain why there is a decrease in amplitude of the waves.

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

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

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

(iii) Given that the frequency and speed of the wave are 8.0 Hz and 2.0 m s^{-1} respectively, determine whether points A and B are in phase.

.... [3]

[Total: 15]