EUNOIA JUNIOR COLLEGE
JC1 Promotional Examination 2018
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME						
CIVICS GROUP	1	8	-			REGISTRATION NUMBER

PHYSICS

9749/02

Paper 2 Structured Questions

02 October 2018

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	10
2	10
3	10
4	10
5	20
6	20
S.F.	
Total	80

This document consists of **20** printed pages and **2** blank 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	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{(x_o{}^2 - x^2)}$
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 A ball is thrown from the top of a building at point A with a velocity of 10.8 m s^{-1}, at an angle 40.0° to the horizontal as shown in Fig. 1.1.

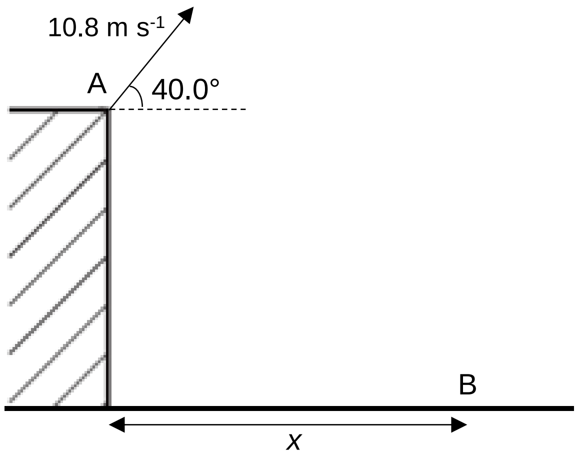


Fig. 1.1

The ball hits the ground at point B, and the velocity of the ball just before it hits the ground is 60.0° above the horizontal.

(a) Determine the horizontal component of the ball's velocity, u_x, at point A.

u_x = ……………….. m s^{-1} [1]

(b) Show that the vertical component of the ball's velocity, v_y, at point B is 14.3 m s^{-1}, taking downwards as positive. [1]

(c) Determine the horizontal distance, x, from the bottom of the building to point B.

x = ……………….. m [3]

(d) Determine the height, h, of the building.

h = ……………….. m [1]

At a later time, a rock is thrown horizontally to the right at A such that it also lands at B at the same time as the ball thrown earlier.

(e) (i) At what time after throwing the ball is the rock thrown?

time = ……………….. s [3]

(e) (ii) Determine the speed at which the rock is thrown.

speed = ……………….. m s^{-1} [1]

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

....

....

.... [1]

(b) A ball B of mass 1.2 kg travelling at constant velocity collides head-on with a stationary ball S of mass 3.6 kg, as shown in Fig. 2.1.

Fig. 2.1

The variation with time t of the velocity v of ball B before, during and after colliding with ball S is shown in Fig. 2.2.

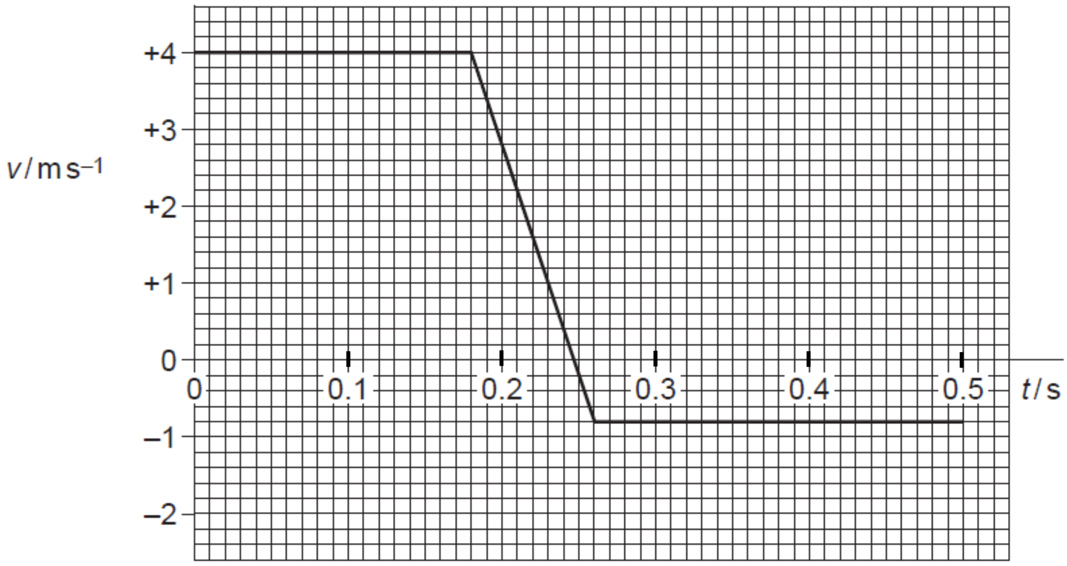


Fig. 2.2

(i) Using Fig. 2.2, determine the change in momentum of ball B, Δp_B, during the collision.

magnitude of Δp_B = ... kg m s^{-1}

direction of Δp_B = ... [2]

(ii) Calculate the speed of ball S after the collision.

speed = ……………….. m s^{-1} [1]

(iii) Complete Fig. 2.2 to show the variation with time of the velocity of ball S before, during and after the collision with ball B. [2]

(iv) Determine the force acting on ball S during the collision.

magnitude of force = ………………….……..…….. N

direction of force = ………………………………… [2]

(v) Using your answer in **b(ii)** and information from Fig. 2.2, deduce quantitatively whether the collision is elastic or inelastic.

....

....

.... [2]

3 A technician placed a block with dimensions 0.20 m × 0.20 m × 0.10 m in a pool of water as shown in Fig. 3.1. She then measured the depth of immersion *h* of the block in water. The densities of the block and water are 560 kg m^{-3} and 1000 kg m^{-3} respectively.

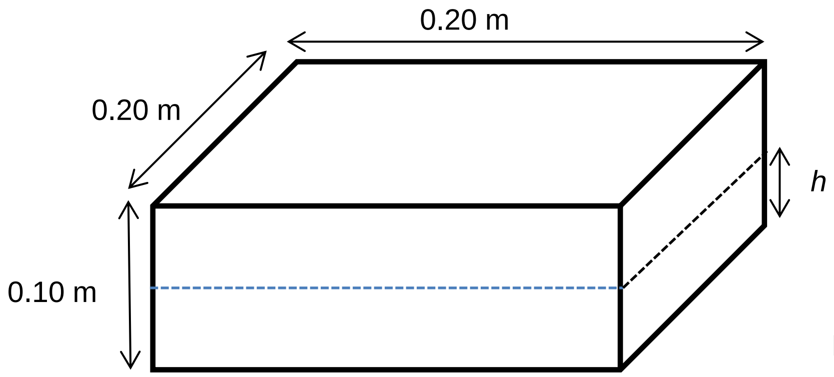


Fig. 3.1

(a) Calculate the value of *h.*

h = ………………………… m [2]

(b) The technician took a 1.0 m long uniform plank of mass 1.5 kg and placed it on the same floating block in Fig. 3.1. When she is standing at 0.010 m from the pivot, the plank becomes horizontal.

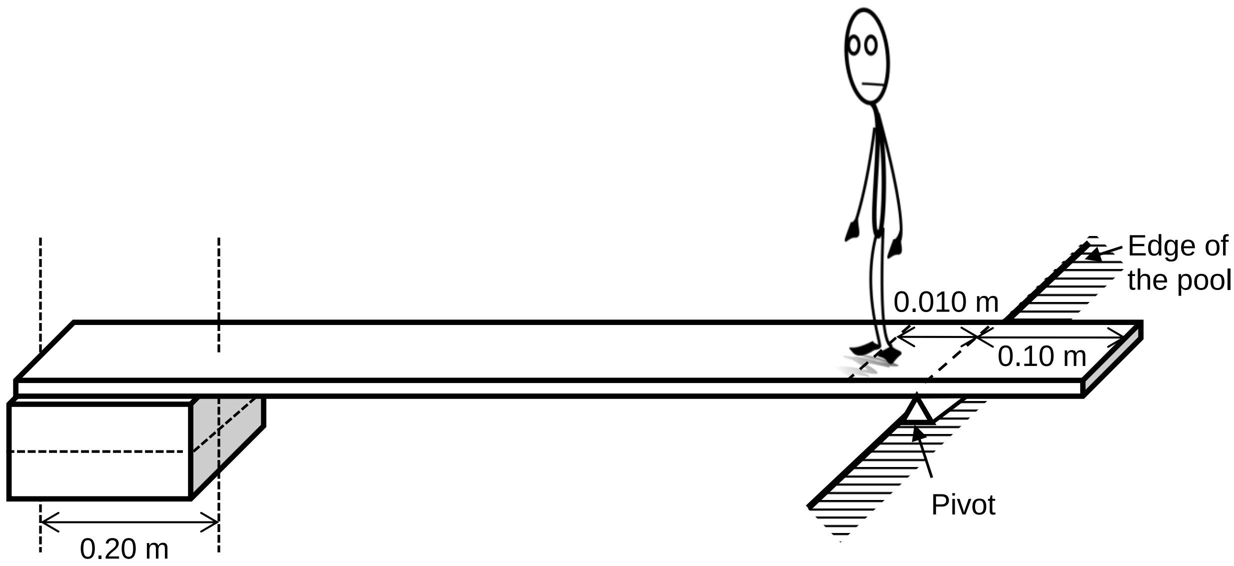


Fig. 3.2

(i) Draw and name the forces acting on the plank in Fig. 3.2. [3]

(ii) Given that the mass of the technician is 40.0 kg, calculate the normal contact force exerted by the block on the plank.

Normal contact force = ………………………… N [2]

(iii) Determine the new depth of immersion *h'* of the block in water, assuming that the block stays upright in the water.

h' = ………………………… m [3]

4 **(a)** State the definition of *Simple Harmonic Motion*.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(b) An old motor car travels at steady speed over a rough road on which the height varies in a sinusoidal way. The car's shock absorber mechanism which normally damps vertical oscillation is not working, and as a result, the car experiences rapid vertical oscillations.

Fig. 4 below shows the variation with vertical displacement x from the equilibrium position of the acceleration a, for the vertical motion of the car.

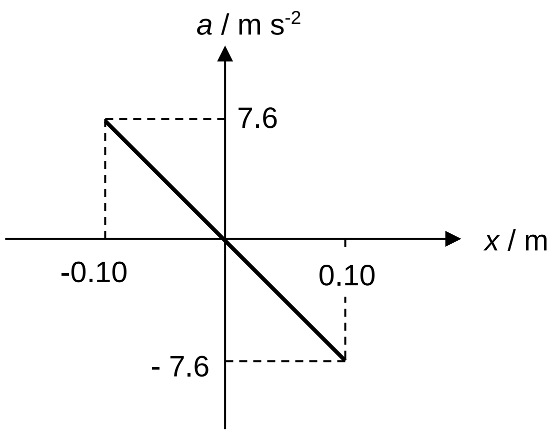


Fig. 4

(i) Show that the angular frequency of the vertical oscillation is 8.7 rad s^{-1}. [2]

(ii) Hence, or otherwise, calculate the period of the vertical oscillation.

period = …………….………… s [1]

(iii) The car is at the lowest point of the vertical oscillation at t = 0 s. Write down an equation to represent the variation with time t of the vertical displacement x from the equilibrium position, in terms of x, amplitude x_o, angular frequency ω and t.

[1]

(iv) Determine the shortest time taken t needed for the car to oscillate from its lowest point to a point 0.025 m below its equilibrium position.

time = ……………………….. s [2]

(v) If the car travels at a certain speed along this rough road, the amplitude of the vertical oscillations may become very large. Explain why this is so.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

5 **(a)** Define *radian*.

……

……[1]

(b) A uniform sphere of radius R has mass M. The mass of the sphere may be assumed to be a point mass at the centre of the sphere, as illustrated in Fig. 5.1.

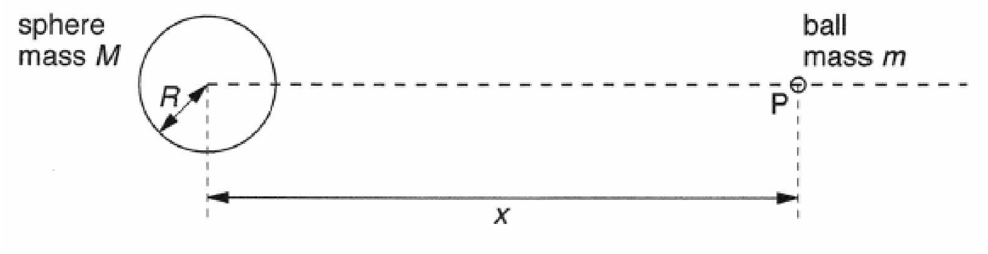


Fig. 5.1

A small ball of mass m is situated at point P, a distance x from the centre of the large mass. The sphere and the ball may be considered to be isolated in space.

State expressions (one in each case) in terms of M, m, x and the gravitational constant G for

(i) the gravitational field strength at point P,

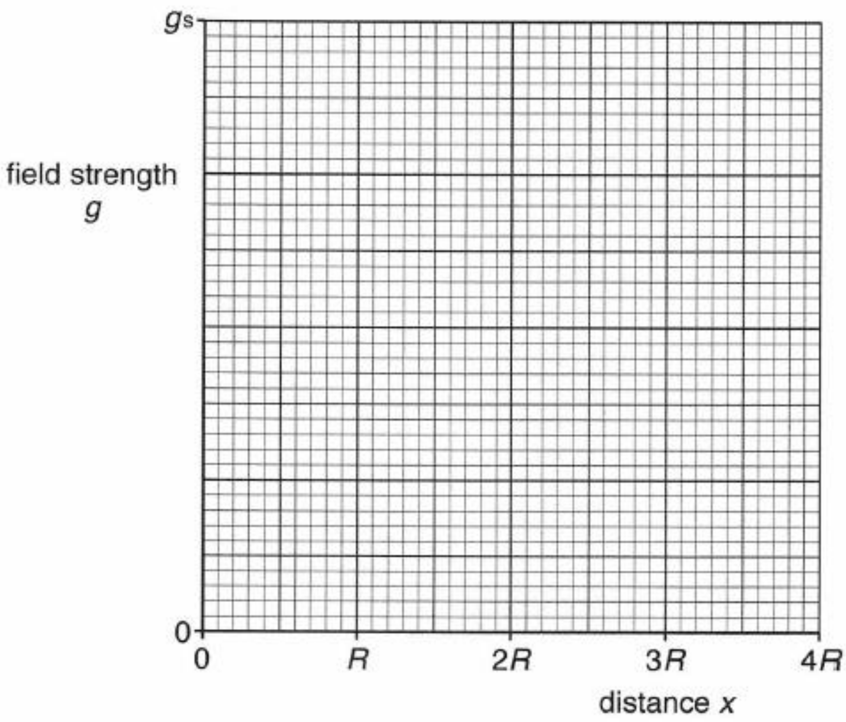
……………………………………………………[1]

(ii) the gravitational potential due to mass M at a distance $\frac{x}{2}$ from the centre of mass M.

……………………………………………………[1]

(iii) The gravitational field strength at the surface of the sphere illustrated in Fig. 5.1 is g_S.

On the axes of Fig. 5.2, sketch a graph to show the variation with distance x of the gravitational field strength g of the sphere of mass M for values of x from $x = R$ to $x = 4R$.



[2]

Fig. 5.2

(iv) Prove that the minimum speed v needed at the surface of sphere of mass M in order to escape from the influence of its gravitational field strength is given by the expression

$$v = \sqrt{2 g_S R}$$

[2]

(c) A binary star consists of two stars A and B. The two stars may be considered to be isolated in space. The centres of the two stars are separated by a constant distance d, as illustrated in Fig. 5.3.

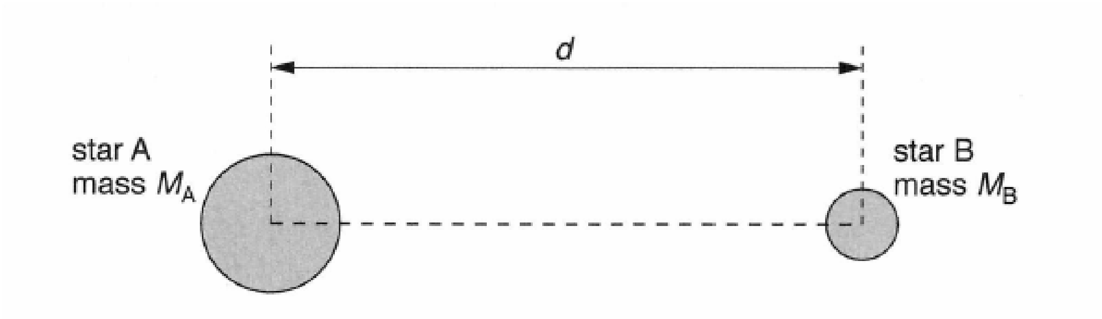


Fig. 5.3

Star A, of mass M_A, has a larger mass than star B of mass M_B, such that $\frac{M_A}{M_B} = 4.0$.

The stars are in circular orbits about each other such that the centre of their orbits is at a fixed point.

Viewed from Earth over a period of time equal to the period T of the orbits, the appearance of the stars is shown in Fig. 5.4.

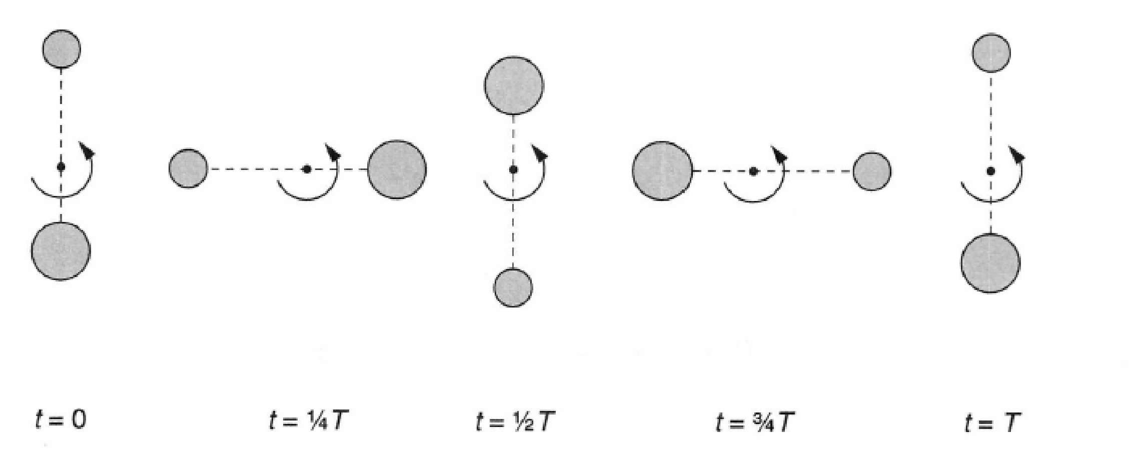


Fig. 5.4 **(Not drawn to scale)**

The period T of each orbit is 3.5 years.

The separation d of the centres of the stars is 5.0×10^{11} m

(i) Explain why the centripetal forces acting on the two stars are equal in magnitude.

……

……

……[2]

(ii) Calculate the angular speed ω of star A.

ω = ………………………………….. rad s^{-1} [2]

(iii) Determine the radius of the orbit of star A. Explain your working.

radius = ………………………………….. m [4]

(iv) Determine the mass of each star.

mass M_A of star A = …………………………………. kg

mass M_B of star B = …………………………………. kg [3]

(v) The plane of the orbits of the binary star is normal to the line of sight from Earth to the binary star.

A second binary star has the plane of its orbits parallel to the line of sight from Earth. This binary star is so far from Earth that the individual stars cannot be distinguished.

Suggest and explain what observation can be made to determine the period of the orbits of the stars.

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

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

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

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

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

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

(ii) A vertically polarized light of intensity I is incident on a polarizer with its polarizing plane tilted 30^{o} from the vertical as shown in Fig 6.1. The wave then passes through another polarizer with its polarizing plane tilted 30^{o} from the vertical in the other direction.

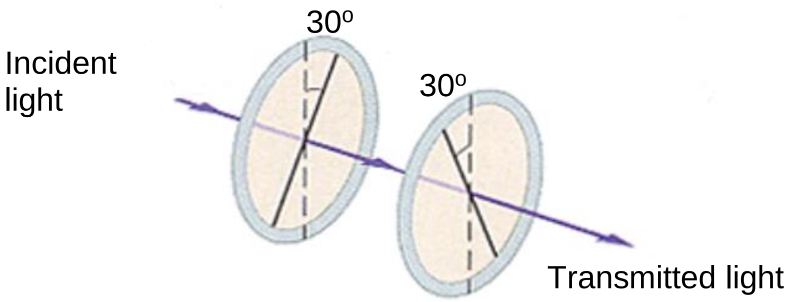

Fig. 6.1

Determine the intensity of the transmitted light in terms of I.

intensity = ……………….….. I [2]

(b) Fig. 6.2 illustrates a long tube, fitted with a tap, filled with water. As the water is allowed to run out of the tube, a tuning fork is sounded above its top.

Fig. 6.2 and Fig. 6.3 show the water levels when loud sounds are first heard and next heard respectively.

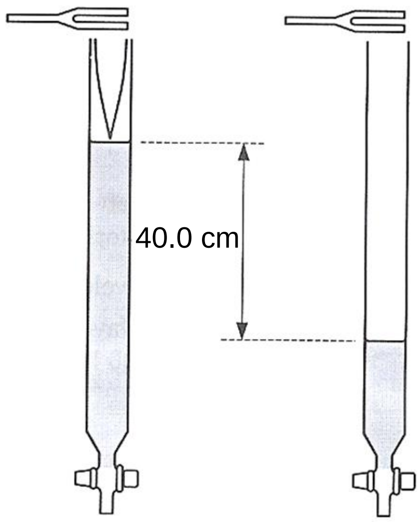

Fig. 6.2 **Fig. 6.3**

(i) Fig. 6.2 shows an illustration of the stationary wave produced in the tube.

On Fig. 6.3,

1. sketch an illustration of the stationary wave set up in the tube, [1]

2. indicate, with the letter N, the positions of any displacement nodes on the stationary wave. [1]

(ii) The tuning fork has a frequency of 413 Hz. The water levels for the two positions differs by 40.0 cm. Determine the speed of sound in the tube.

speed = ………………….. m s^{-1} [3]

(c) A diffraction grating, with 6.00×10^5 lines per metre, has a narrow beam of coherent light of wavelength 450 nm incident normally on it.

(i) Determine the maximum order of diffracted light that are visible on each side of the zero order.

maximum order = ………………… [2]

(ii) The incident beam is suspected to consist of two wavelengths of light, one at 449 nm and the other at 452 nm.

1. What is the order of diffracted light at which the two wavelengths are most likely to be distinguished?

order = ………………[1]

2. Given that the minimum angular separation of the diffracted light for which two wavelengths may be distinguished is 0.20°, determine whether two wavelengths could be observed as separate images. [3]

(d) Radar systems use waves of λ = 8.0 cm to detect incoming aircraft. The waves are passed along tubes called waveguides. One part of the system is shown in the Fig. 6.4 where it is rectangular in shape. The length of 1 side (AB & CD) is 18 cm while the length of the other side (BC & AD) is unknown. Assume no energy is lost by the waves in the waveguide and there is no phase change upon total internal reflection in the waveguide.

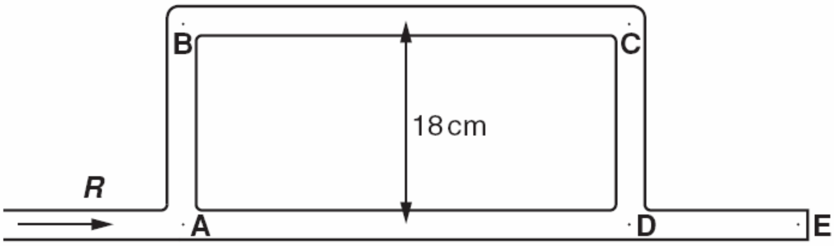

Fig. 6.4

(i) What type of electromagnetic wave does the wave corresponding to in the electromagnetic spectrum?

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

(ii) An electromagnetic wave R arriving at A can divide at A and reach C via the paths ABC and ADC.
State the whether constructive or destructive interference occurs at C.

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

(iii) By explaining your working clearly, determine whether the signal detected at D is a maximum or minimum. [3]

End of Paper

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