Anglo-Chinese Junior College

A Methodist Institution
(Founded 1886)

Physics Promotional Examination
Higher 2

CANDIDATE NAME		CLASS	
CENTRE NUMBER		INDEX NUMBER	

PHYSICS **9745/02**

Paper 2 Structured Questions

6 October 2008

2 hours

Candidates answer on the Question Paper
No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your Name and Index number in the spaces on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in **Section A**.
Answer **any two** questions in **Section B**.

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 Examiners' use only	
Section A	
1	/ 9
2	/ 10
3	/ 7
4	/ 7
5	/ 7
6	/ 6
7	/ 4
Section B	
8	/ 15
9	/ 15
10	/ 15
Total	/ 80

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	=	$-\dfrac{Gm}{r}$
displacement of particle in s.h.m.,	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega \sqrt{x_o^2 - x^2}$
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	=	$x_o \sin \omega t$
transmission coefficient,	T	$\propto$	$\exp(-2kd)$
	where k	=	$\sqrt{\dfrac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\dfrac{0.693}{t_{1/2}}$

Section A
Answer **all** questions in this section.

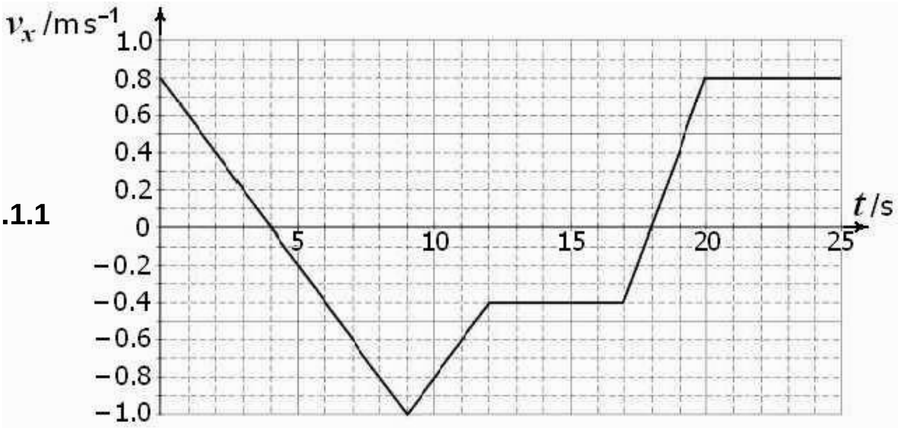
1 (a) Define *acceleration.*

....

[1]

(b) A 0.50 kg cart moves on a straight horizontal track. The graph of horizontal velocity v_x against time t for the cart is as shown in Fig.1.1.

Fig.1.1



(i) Show that the total distance travelled by the cart from 0 to 9.0 s is 4.1 m.

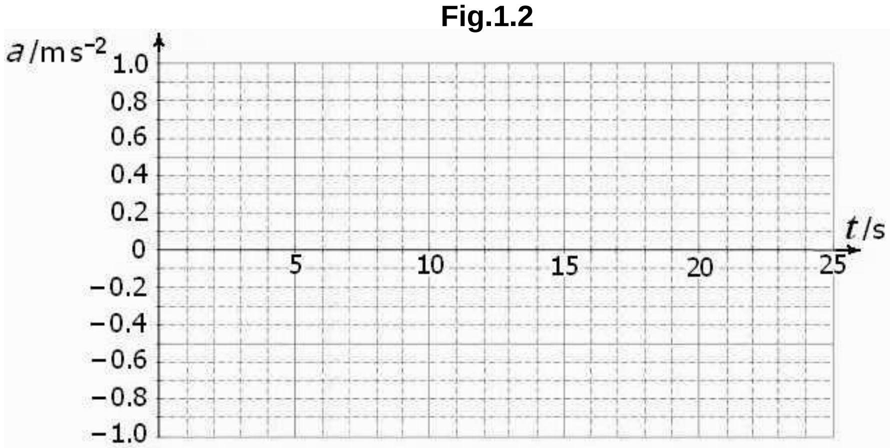
(ii) Determine the magnitude of the displacement of the cart after 9.0 s from its starting point at 0 s.

Displacement = ... m

[4]

(c) On the axes in Fig.1.2, sketch the acceleration a against time t graph for the motion of the cart from t = 0 to t = 25 s. Show all essential workings in the space provided below.

Fig.1.2



[4]

[Turn over

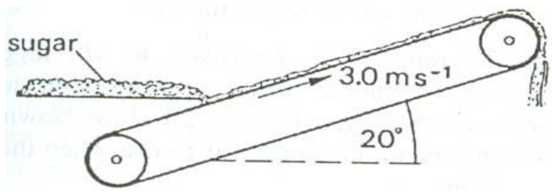
2 (a) In what way is the momentum of a body affected by the resultant force acting on it?

....

.... [2]

(b) A conveyor belt travelling at a speed of 3.0 m s^{-1} and at an angle of 20° to the horizontal has 18 kg of sugar dropped onto it each second as shown in Fig.2.

Fig.2



Assuming that the sugar has negligible speed before reaching the belt,

(i) show that momentum gained in each second by the sugar is 54.0 kg m s^{-1},

[2]

(ii) deduce the force which the belt must exert on the sugar to accelerate it to the speed of the belt,

required force = ... N [2]

(iii) determine the work done per second by the force found in (b)(ii) on the sugar,

work done per second = ... [2]

(iv) find the potential energy gained in each second by all the 36 kg of the sugar which is on the belt.

Potential energy gained in each second = ... [2]

3 (a) State Archimedes' principle.

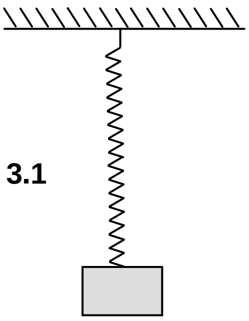
....

....

.... [1]

(b) A block of platinum alloy of mass 0.50 kg and density 2.77×10^4 kg m^{-3} is suspended in air from a spring of spring constant k = 50 N m^{-1}as shown in Fig. 3.1.

Fig 3.1

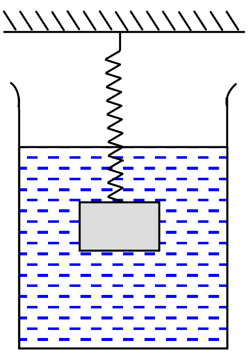


Assuming that air has negligible density and that the spring obeys Hooke's Law, show that the equilibrium extension of the spring when the block is hung in air is 9.81 cm.

[2]

(c) The platinum block is then completely immersed in a beaker of unknown fluid as shown in Fig.3.2. After being immersed in the unknown liquid, it is observed that the equilibrium extension of the spring decreases to 5.0 cm.

Fig 3.2



Assuming that the unknown liquid is non-viscous, by drawing a free-body-diagram for the forces acting on the block, or otherwise, determine the density of the liquid.

[4]

4 (a) Define gravitational field strength.

....

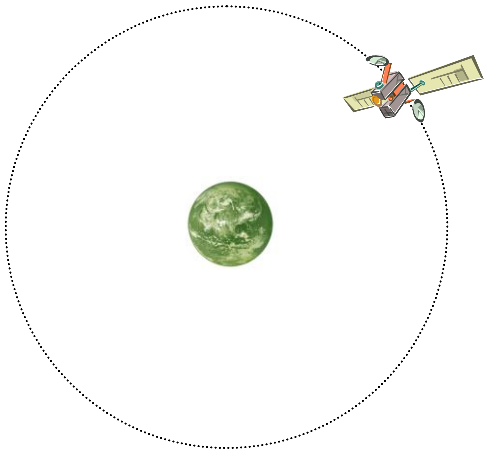
....

....

.... [2]

(b) Fig 4 shows the Voyager 1 space probe revolving round a newly discovered planet at constant speed in a circular orbit.
Sketch and label on Fig.4 the force F acting on the space probe. [1]

Fig 4



(c) More precise measurements using Voyager 1's on-board instruments indicate that it is orbiting with an orbital radius of 4.35×10^8 m with a period of 1.84 Earth-days.
(1 Earth-day = 24 hours)
Find the planet's gravitational field strength at the probe's orbit.

gravitational field strength = ... N kg^{-1} [4]

5 (a) State the two conditions necessary for the motion of an oscillating body to be simple harmonic.

....

....

....

[2]

(b) A light spring is loaded with a mass and made to execute vertical oscillations. Fig.5 shows the force-extension graph of the spring.

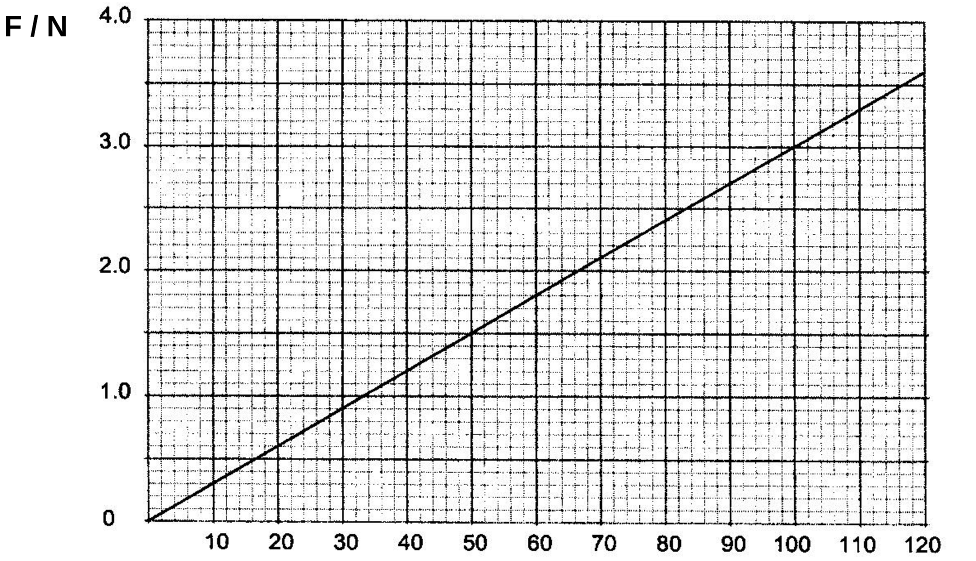
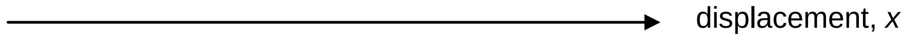


Fig 5

(i) By considering the restoring force on the mass, show that the angular frequency, ω, of oscillation is given by $\omega = \sqrt{\frac{k}{m}}$, where k is the spring constant and m is the loaded mass.

[2]

(ii) For a mass-spring system undergoing SHM, draw on the same set of axes
the 1 kinetic energy versus displacement graph,
2 elastic potential energy versus displacement graph,
and 3 total energy versus displacement graph.
{Note:- The displacement – axis is drawn below. You are to draw a suitable energy – axis before drawing the 3 graphs using the same set of axes}



[3]

6 (a) State two conditions necessary for the establishment of a well-defined interference pattern.

....

....

.... [2]

(b) Fig.6 shows an experimental arrangement for observing light wave interference fringes using a Young's Double Slit. The source s produces monochromatic light of wavelength λ. The separation of the double-slits is *a* and the spacing between the double slits and screen is D. y is the distance between a bright fringe and the central maximum along the screen. At this position, the eye-piece M is at the n^{th} bright fringe from the central maximum.

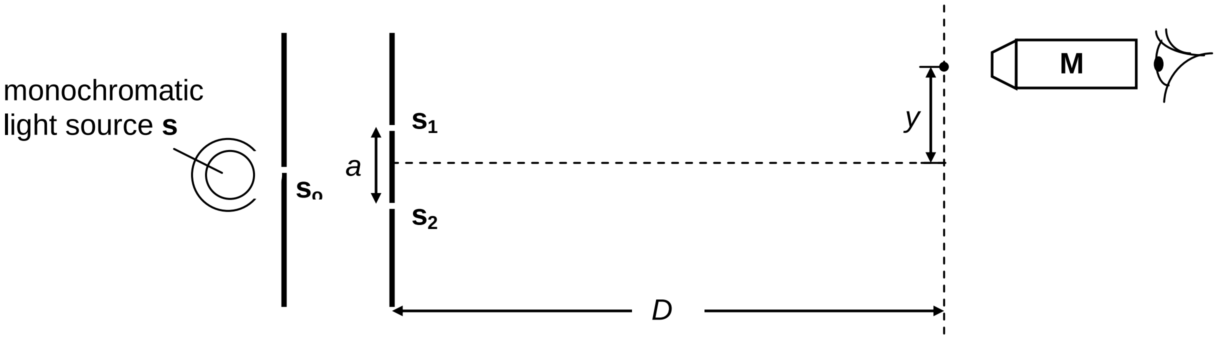


Fig. 6

(i) Explain why is the single slit s_o needed in the arrangement in Fig.6?

....

.... [1]

(ii) To make measurements, a sufficient number of well-spaced fringes must be observable by the observer through the eye-piece M. State the expression for the fringe spacing in terms of the parameters given in the question.

.... [1]

(iii) Using the fringe spacing expression in (b)(ii), describe two ways to increase the fringe spacing.

....

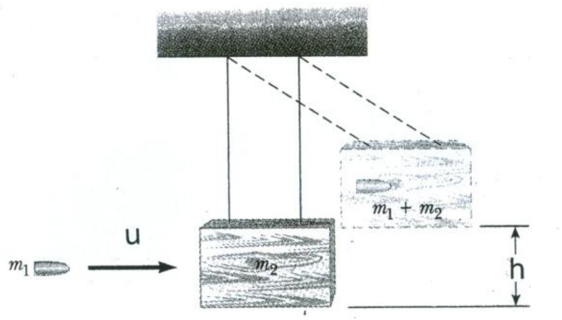
....

....

[2]

7 The ballistic pendulum was used to measure the speeds of bullets before electronic timing devices were developed. The version shown in Fig 7 consists of a large block of wood of mass m_2 hanging from two long cords.

Fig 7



A bullet of mass m_1 is fired into the block at a speed of u, and comes quickly to rest. The block (with bullet embedded inside) then swings upward, their centre of mass rising a vertical distance h before the pendulum comes momentarily to rest at the end of its arc.

Assuming that during the collision, the net external impulse on the *block (with embedded bullet)* is zero and its direction just after the collision is in the bullet's original direction of motion,

(a) identify the type of collision that has taken place between the bullet and the block.

....

.... [1]

(b)(i) find the speed V of the (block + bullet) system just after the collision in terms of m_1, m_2 and u.

(ii) hence express the speed of the bullet u just prior to the collision in terms of m_1, m_2 and h.

[3]

[Turn over

Section B

Answer **any two** questions in this section.

8 Fig 8 shows the pair of parallel plates with some dimensions of an ink-jet cartridge. On entering the space between the parallel plates, the ink droplet travels with a horizontal velocity of 20 m s^{-1}. Between the parallel plates the charged ink droplet is subjected to a constant downward force due to an electric field but the uncharged ink droplet is not subjected to this downward force. Outside the parallel plates, the ink droplets are not subjected to this constant downward force.

In order to land in the center of the gutter to be recycled for further use, the charged ink droplet must leave the plates at an angle of 35° to its direction of entry into the region between the plates. Droplets that are uncharged pass undeflected through the space between the parallel plates and reach the paper.

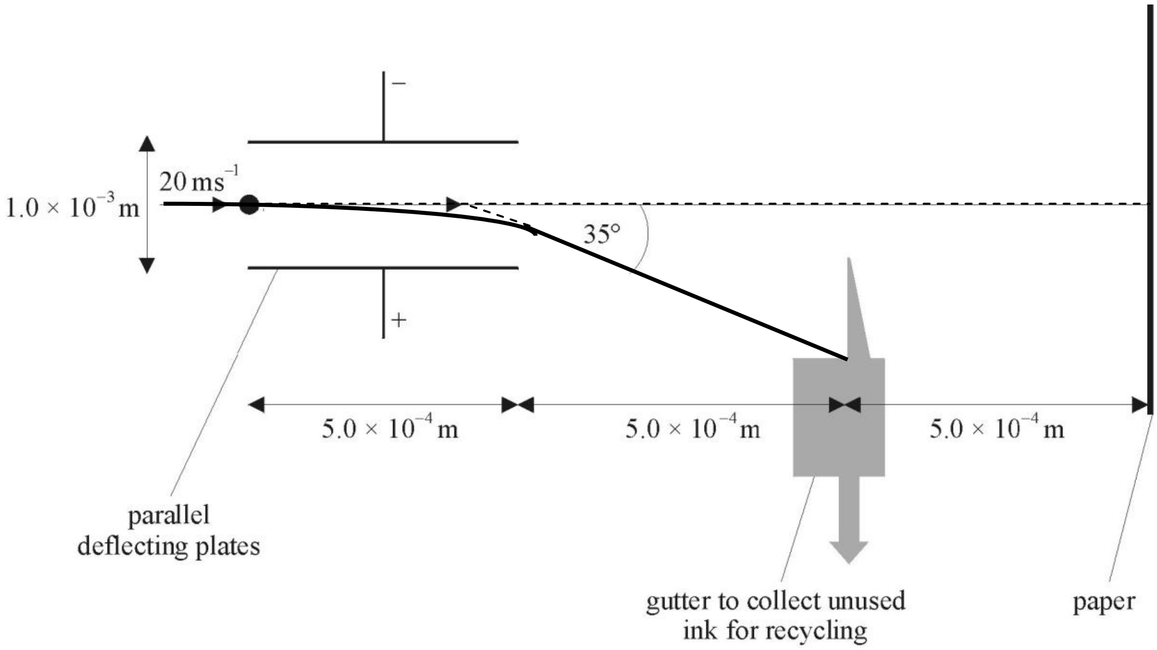


Fig 8

(a) Ignore the effect of gravitational force, state and explain the path of a charged ink droplets from the time it enters the pair of parallel plates until it reaches the gutter. {Hint:- Consider two parts of the path of the charged ink droplets
(1) within the space between the parallel plates and
(2) outside the parallel plates from the end of the parallel plates to the gutter. }

....

....

....

....

....

....

.... [4]

(b) Ignore the effect of gravitational force,

(i) **Draw to scale a vector diagram** to show the components and the resultant of the velocity of the charged ink droplet as it leaves the parallel plates. Hence determine the magnitude of the vertical component of its velocity.

vertical resultant velocity = ... $m\ s^{-1}$ [2]

(ii) Find the time for which the ink droplet is between the parallel plates and hence calculate its vertical acceleration during this time.

time = ... s

vertical acceleration = ... $m\ s^{-2}$

[3]

(iii) For an ink droplet of mass 2.9×10^{-10} kg, calculate the downward force acting on the ink droplet whilst it is between the parallel plates.

downward force = ... N [2]

(c) The uncharged, undeflected ink droplets travel beyond the parallel plates towards the paper. With the aid of a suitable calculation, discuss whether or not the printer manufacturer needs to take into consideration the droplet falling under gravity in the specification of the resolution of the printer. The radius of an ink droplet is 40 μm.
{Hint: Consider the vertical displacement of the ink droplet by the time it reaches the paper}

[4]

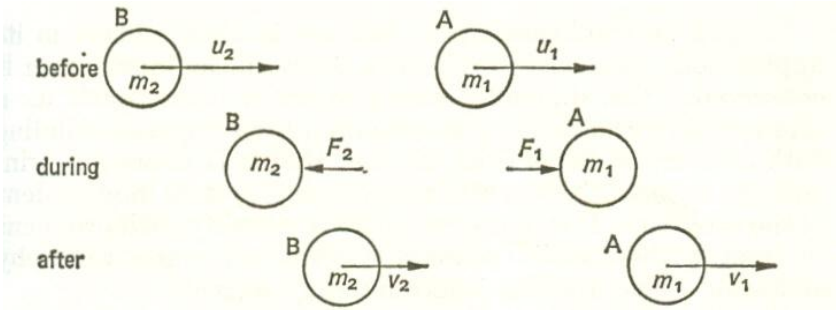
9(I) (a) Define *linear momentum* of an object.

....

[1]

(b) A sphere B of mass m_2 travelling in a straight line with a speed u_2 collides head-on with another sphere A of mass m_1 , which has a speed of u_1 in the same direction. The final speeds of the spheres just after the collision are $v_2$and v_1 respectively as shown in the Fig 9.1.

Fig 9.1



(i) If F_1 is the average contact force that acts on m_1 by m_2 and F_2 is the average contact force that acts on m_2 by m_1 for a short time t, write down equations relating (1) F_1 to m_1, u_1, v_1

Equation (1): ....

and (2) F_2 to m_2, u_2, v_2.

Equation (2): ....

(ii) Hence show that in the absence of a net external force on the colliding spheres as shown in Fig 9.1, the total linear momentum of the spheres is conserved in the collision.

....

....

[4]

(c) A truck of mass 2.2 x 10^4 kg and moving at a speed of 3.0 m s^{-1} catches up and collides with a trailer of mass 6.6 x 10^4 kg moving at a speed 1.0 m s^{-1} as shown in Fig 9.2. The velocity–time graph of the truck and trailer before, during and after the collision is shown in Fig 9.3.

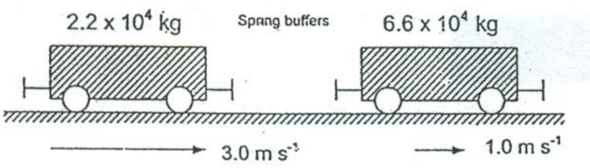


Fig 9.2

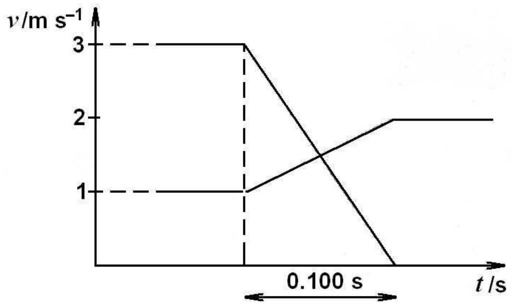


Fig 9.3

By finding the total kinetic energy before and after collision, identify and explain the type of collision that had occurred between the truck and the trailer.

[4]

(d) In an elastic one-dimensional head-on collision between an incoming body A of mass m_A and a body B of mass m_B initially at rest, their respective final velocities v_A and v_B after collision are given by

$$v_A = \left[\frac{(m_A - m_B)}{(m_A + m_B)}\right] u_A \qquad \text{and} \qquad v_B = \left[\frac{2m_A}{(m_A + m_B)}\right] u_A$$

where u_A is the velocity of body A before the collision.

State and explain how the mass of body B compares to the mass body A immediately after the collision, if body B has the greatest speed.

[2]

9(II) In a glass container which is 3.00 cm wide, two identical uniform glass spheres P and Q of weight W are held using tongs in the position as shown in Fig 9.4. Each sphere has a diameter of 2.00 cm and is marked with a black dot. The tongs are then removed. Assume that there is no friction between any two surfaces.

Draw (a) the final position of each sphere with the black dots included in Fig 9.5.
{Hint: if there is no friction, there is no rotation but there can be sliding.}

(b) a free body diagram of forces for each sphere in their final position in the diagrams provided in Fig 9.6.

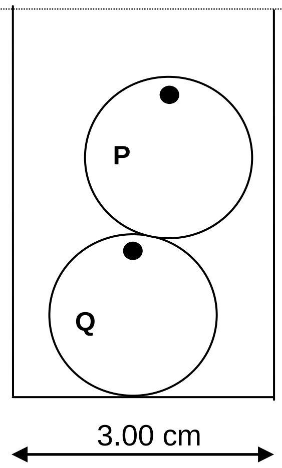


Fig 9.4
Just after tongs are removed

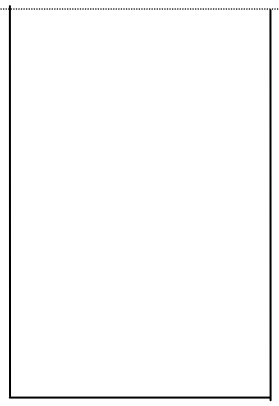


Fig 9.5
After the spheres have reached equilibrium

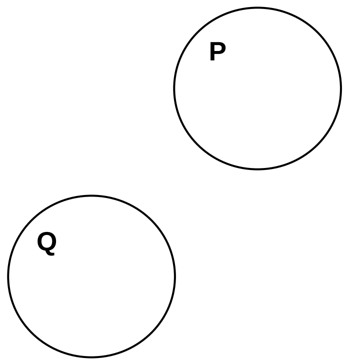


Fig 9.6
Free body diagram of forces for each sphere

[4]

10 (a) State the Principle of superposition of waves.

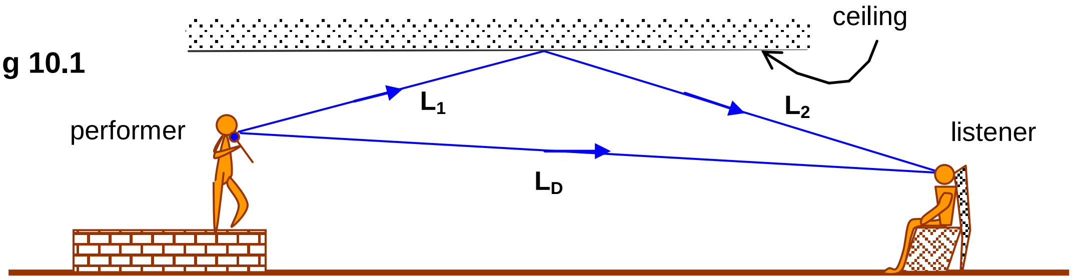
....

....

.... [1]

(b) An concert patron receives the sound of wavelength λ from the performer directly as well as reflected from the ceiling of a hall, as shown in Fig 10.1.

Fig 10.1



The distance travelled by the sound directly from the performer to the audience is L_D, and the distance travelled by the sound before hitting the ceiling is L_1 and distance between the ceiling and listener is L_2 as shown in Fig 10.1.

Write down a relationship between the distances L_D, L_1 and L_2 travelled by the sound wave and its wavelength λ, for constructive interference at the listener. In this case, there is no change of phase when sound waves are reflected from the ceiling.

Relationship :- .... [1]

Explain how the relationship would give a constructive interference at the listener.

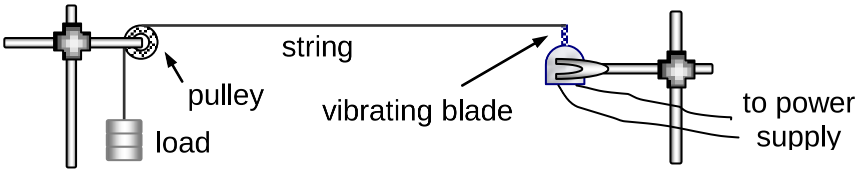
....

....

.... [2]

(c)(i) A long stretched string placed horizontally such that a load is hung over a pulley at one end and attached to a vibrating blade at the other as shown in Fig 10.2.

Fig 10.2



The blade when switched on, will cause the string to vibrate in a direction perpendicular to the string and at a suitable frequency, a stationary wave of wavelength λ is produced.

Explain how the stationary wave is formed in the string.

....

....

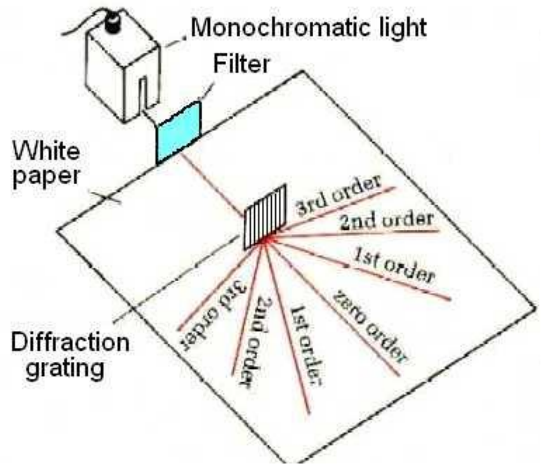
.... [2]

(ii) A 96 cm pipe closed at one end has 3 nodes in the pipe when air is blown into it from the open end. Find the frequency of the sound produced. The speed of sound may be taken to be 340 m s^{-1}.

frequency of sound = ... Hz [3]

(d)(i) Fig 10.3 shows a monochromatic light being incident normally on a diffraction grating.

Fig 10.3



Explain how the first order bright fringe in Fig 10.3 is formed.

....

....

....

....
[2]

(ii) The monochromatic light is now replaced by a source emitting white light and the diffraction grating used has 6000 lines per cm. Assume the zero order position is the zero angle location, determine the range of angles at which you would observe the first order spectrum.

Range = ... [4]

End of paper