H

NATIONAL JUNIOR COLLEGE

SENIOR HIGH 1 PROMOTIONAL EXAMINATION

Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS **9749/02**

Paper 2 Structured Questions

Candidate answers on the Question Paper.

29 September 2021

2 hours

No Additional Materials are required.

READ THE INSTRUCTION FIRST

Write your subject class, registration number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answers **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	**/ 6**
2	**/ 7**
3	**/ 7**
4	**/ 7**
5	**/ 13**
6	**/ 10**
7	**/ 10**
8	**/ 20**
Total (80m)	

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[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\mathrm{K} = T/{}^\circ\mathrm{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm \omega \sqrt{x_0^2 - x^2}$
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	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

1 A small wooden block is held stationary on a rough slope at a distance of 2.0 m from the bottom of the slope. At time t = 0, it is projected up the slope with an initial speed of 5.0 m s^{-1} as shown in Fig. 1.1.

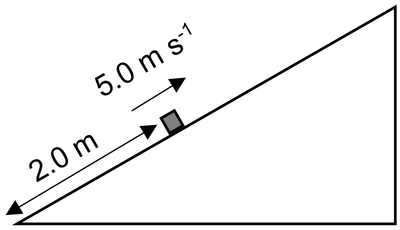


Fig. 1.1

The deceleration of the block is 6.0 m s^{-2}.

(a) Show that the distance travelled by the block, relative to its initial position at t = 0, before it comes to rest momentarily at the top of the slope is 2.1 m.

$$v^2 = u^2 + 2as$$

$$0 = 5.0^2 + 2(-6.0)s$$

$$s = \frac{25}{12} = 2.08 \approx 2.1 \text{ m (shown)}$$

[1]

Comments:
Most students got this part correct.

(b) Determine the time taken for the block to travel to the top of the slope.

$$v = u + at \quad \Rightarrow \quad 0 = 5.0 - 6.0t$$

$$t = \frac{5.0}{6.0} = 0.83 \text{ s}$$

time = ... s [1]

Comments:
Most students got this part correct.

(c) After reaching the top of the slope, the block starts to slide down with an acceleration of 3.8 m s^{-2}.

Determine

(i) the time taken for the block to travel from the top of the slope to the bottom of the slope.

$$s = ut + \frac{1}{2}at^2$$

$$4.1 = \frac{1}{2}(3.8)t^2$$

$$t = 1.47 \text{ s}$$

t = ... s [1]

Comments:
Most students got this part correct. Those who got it wrong, mostly substitute s = 2.1 m instead of 4.1 m as shown in the solution above. Other methods to solve are accepted.

(ii) the speed of the block on reaching the bottom of the slope.

$v = u + at = 0 + 3.8(1.47) = 5.6$ m s^{-1}

speed = ... m s^{-1} [1]

Comments:
Most students got this part correct. There were error-carried-forward marks awarded from (c)(i).

(d) On Fig. 1.2, sketch the variation with time, of the displacement of the block (relative to the start point) for the entire motion starting from t = 0 to the instant the block reaches the bottom of the slope. Take displacement upslope to be positive.

Fig. 1.2

[2]

Correct shape B[1]

t = 0.83 s OR 2.30 s labelled B[1]

Comments:

There is acceleration, clearly the graph cannot be straight lines. There were graphs showing “teleportation” as well. Many students also didn’t add the duration up to get about t = 2.3 s.

2 **(a)** Derive, from the definitions of pressure and density, the equation for pressure due to a column of liquid is given by

$$p = h\rho g$$

Definition: Pressure is given by force per unit area, where the force is acting at right angles to the area.

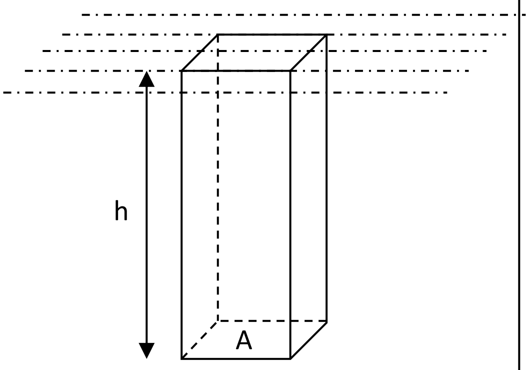
$$p = \frac{F}{A}$$

Definition: Density is the mass per unit volume of the substance.

$$\rho = m/V$$

Consider a column of liquid of cross-sectional area A and depth h from the surface, in a container. The pressure, p, at the base would be given by the definition of pressure,

$$p = \frac{F}{A}$$



where F is the force acting on the base due to the weight of the column of the liquid. (Since the block of liquid is stationary)

That is, $F = mg$

But from the definition of density,
$m_{liquid} = \rho_{liquid} V_{liquid}$, thus

$$p = \frac{\rho_{liquid} V_{liquid}\, g}{A} = \frac{\rho_{liquid} (h\,A)\, g}{A} = \rho_{liquid}\, h\, g$$

So, the pressure due to a column of liquid is given by

$p = h\rho g$ h: depth from the surface

ρ : density of the liquid

[3]

(b) Fig. 2.1 shows a simplified catapult used to hurl projectiles a long way.

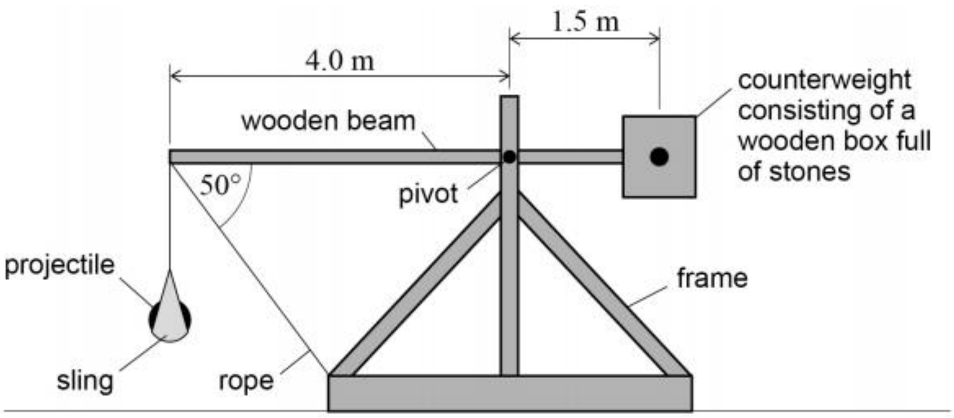


Fig. 2.1

The counterweight is a wooden box full of stones to one end of the uniform beam. The projectile, usually a large rock, is in a sling hanging vertically from other end of the beam. The weight of the sling is negligible.

The beam is held horizontal by a rope attached of the frame.

The stones and the wooden box in the counterweight have a total mass of 1000 kg, the mass of the beam is 500 kg and the projectile weighs 250 N.

Calculate the tension in the rope. Explain your working clearly.

Taking moments about the pivot, B1

Clockwise moments = 1000 x 9.81 x 1.5 = 14715 B1

Anti-Clockwise moments = 250 x 4 + Tsin50°(4) + 1.25(500)(9.81)

1000 x 9.81 x 1.5 = 250 x 4 + Tsin50°(4) + 1.25(500)(9.81) B1 - 250 x 4+1.25(500)(9.81)

T = 2475 N = 2480 N A1

tension = ... N [4]

[Turn over

3 **(a)** Two masses, 2.5 kg and 4.5 kg, are connected by an inextensible cord that runs over a frictionless and massless pulley as shown in Fig. 5.1.

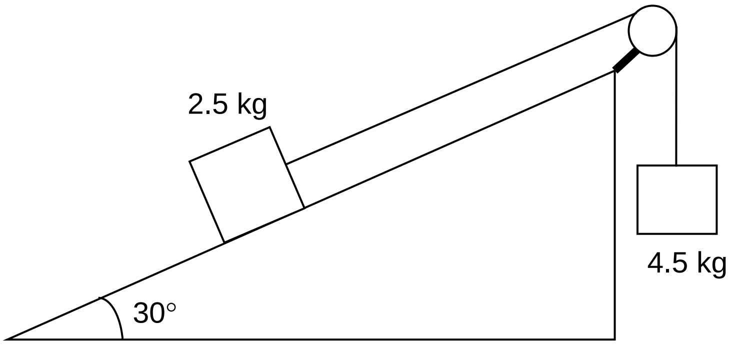


Fig. 5.1

Both masses are released from rest and they moved a distance of 0.50 m.

(a) Determine the final speed of the system after travelling 0.50 m.

Loss in GPE by 4.5 kg = Gain in GPE by 2.5 kg + Total Gain in KE

[C1 - GPE] [C1 – KE]

$4.5 \times 9.81 \times 0.50 = 2.5 \times 9.81 \times 0.50 \sin 30 + ½ (4.5 + 2.5) v^2$

$v = 2.13$ m s^{-1} [A1]

speed = ... m s^{-1} [3]

Comments:
Some students uses 2.5 kg for the mass for KE. Many also made mistake for the Gain/Loss in GPE. In the above method, the "Loss" in energy is all placed in the LHS, while all the "Gain" in energy is placed on the RHS. Students should stay focus on one method and stick to it. There were also students solving this using kinematics correctly.

(b) The power of the engine of a sports car of mass 1500 kg is 200 kW in normal driving mode. It can cruise at speed of 90 km h^{-1}.

(i) Show that the force that is delivered by the engine to the car is 8000 N.

90 km h^{-1} = 25 m s^{-1} [B1]

P = F v
200 000 = F (25) [M1]

F = 8000 N [A0]

[2]

Comments:
By now, students should not have issue recognizing the speed were given in km h^{-1}. There were also a handful of students who did not remember the formula.

(ii) When the car suddenly switches to turbocharging mode, the power doubles. Assuming the resistive force remains the same at that instant, determine the acceleration.

Force doubled since the power doubles. [C1]
Thus resultant force, F_R = 16000 – 8000 = 1500 a
a = 5.33 m s^{-2} [A1]

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

Comments:
Many students didn't calculate the resultant, thus only got half of the marks.

4 A circus performer is riding his motorcycle with uniform speed such that its period is 20.0 s in a horizontal circle of radius 83 m on the inner surface of a cylindrical wall, as shown in Fig. 4.1.

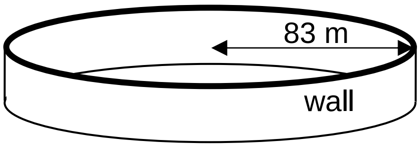


Fig. 4.1

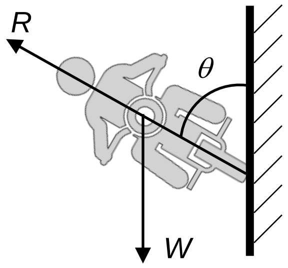


Fig. 4.2

The orientation of his motorcycle is shown in Fig. 4.2. The two forces acting on the motorcycle-man system are the reaction force *R* acting at an angle θ with the vertical and the weight *W*.

(a) *R* is the resultant of two forces. They are perpendicular to each other. State the two forces.

Normal contact force and friction. [B1 for both to be stated correctly] .... [1]

Comments:
Component of R is NOT weight, or centripetal force!

(b) One of forces in (a) points to the left of the Fig 4.2, show that this force is

$$F = 0.835\,W$$

The normal contact force, F, provides the centripetal force

F $= m\,r\,\omega^2$ [C1]

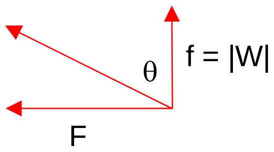
$= (W/g)\,r\,(2\pi/T)^2$

$= (W/g)\,(83)\,(2\pi/20)^2 = 0.835\,W$ [A1]

[2]

Comments:
Some students did not realized that W = mg. Thus couldn't get full credit. Note that initially, 1 mark was allocated for the statement "The normal contact force, F, provides the centripetal force". Students should always write this statement.

(c) Hence, show that the angle θ is 39.9°



$R \sin \theta = F \quad = 0.835\ W$

and the vertical component of R should have a magnitude W.

$R \cos \theta = f = |W|$ [B1 – show both or correct diagram]

Thus $\tan \theta \quad = 0.835\ W / f$ [M1 to indicate clearly the tangent calculation, not equal to 0.835 W / W]

$= 0.835\ W / |W|$

$\theta \quad = 39.9°$ [A1]

[3]

Comments:
This question is 3 marks! While there's not a need for a very elaborated answer, but clear working/statement should **show** that the frictional force = magnitude of weight.

(d) Explain why is it not possible for θ to be 90°.

This would means R is parallel to the ground, thus frictional force would cause a moment about the C.G. of the system to topple.

OR

This would means R is parallel to the ground, thus there is no frictional force to keep the system in vertical equilibrium. [B1]

Comments:
θ is the angle between the vertical axis and R, not F! Thus some thought that F = 0. Some thought that W = 0, but it is frictional force = 0, or the lack of vertical component of R. Few students discussed about the moment about the C.G.
Note also that any object in circular motion is never in equilibrium. Why?!

5 **(a)** Define *simple harmonic motion.*

Acceleration is directly proportional to displacement from equilibrium position / a fixed point. B[1] ....

Acceleration is opposite in direction to displacement / directed towards the equilibrium position / fixed point. [B1] ....

.... [2]

(b) Fig. 5.1 shows the variation of amplitude of oscillation of a system with the frequency of an external source. The system is critically damped.

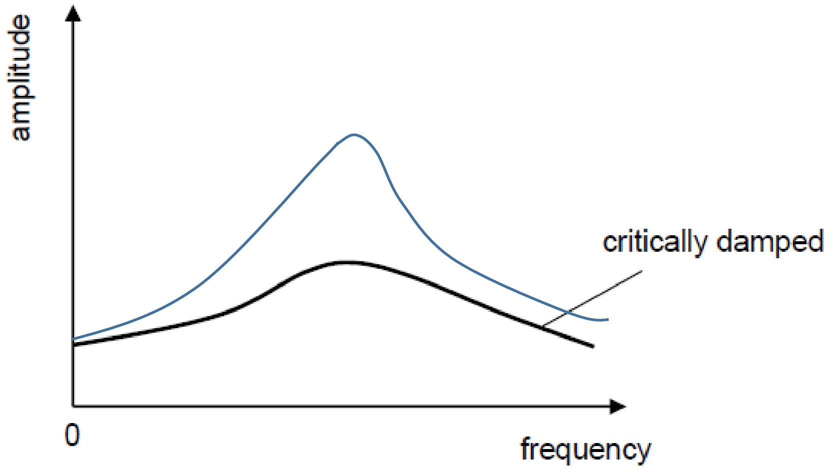


Fig. 5.1

(i) State the name of the phenomenon illustrated in Fig. 5.1.

Resonance B[1] .... [1]

(ii) Sketch, on Fig. 5.1, the variation of the amplitude with frequency for the same system that is lightly damped.

[3]

Curve above the original one [B1]

peak sharper [B1]

peak frequency > or equal to the one shown [B1]

(c) A motor car with a defective suspension system is driven at a steady speed over a series of road bumps. The road surface may be assumed to vary sinusoidally. At this speed the car's vertical oscillation becomes very large.

The following data is available.

Mass of car with passengers = 1850 kg

Mass of passengers = 320 kg

Vertical rise of car when passengers get out of car = 1.5 cm

Separation of two adjacent peaks of the road surface = 13 m.

The natural frequency *f* of the car is given by the following expression.

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

where *k* is the spring constant and *m* is the mass of car and passengers.

(i) Determine the natural frequency of the car.

$$k = \frac{3200 \times 9.81}{1.5 \times 10^{-2}} = 2.093 \times 10^{5} \text{ N m}^{-1}$$ [B1]

$$f = \frac{1}{2\pi}\sqrt{\frac{2.093 \times 10^{5}}{1850}} = 1.69 \text{ Hz}$$ [A1]

natural frequency = ... Hz [2]

(ii) Explain why the vertical oscillations of this car becomes very large.

The frequency of meeting each bump matches/is equal/coincides with the natural frequency of the suspension system. [B1]

Resonance occurs. [B1]

Since system is lightly damped/not critically damped [B1]

(so amplitude rises to very large)

.... [3]

(iii) Determine the speed of the car when the vertical oscillations is very large.

Let car's speed be v m s^{-1}.

Frequency of meeting bump = $\frac{v}{13}$ s^{-1} [M1]

(explanation required for driver frequency or period)

So, $\frac{v}{13} = 1.69$

v = 22 m s^{-1} [A1]

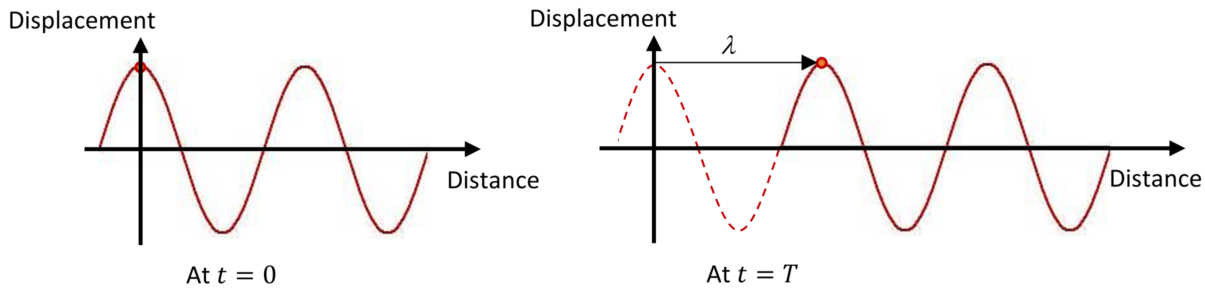
speed = ... m s^{-1} [2]

6 (a) A wave of frequency f and wavelength λ has speed v.

Using the definition of speed, deduce the equation $v = f\lambda$.

Speed is defined as the distance travelled **per** unit time

In a time of one period (T), a crest would have travelled a distance of one wavelength (λ) as shown in the diagrams below:



Hence, speed of the wave, $v = \frac{\text{Distance travelled}}{\text{time taken}} = \frac{\lambda}{T} = f\lambda$ since $\frac{1}{T} = f$

Examiner's comment:
Students did not score well for this qn. Common wrong phases used were "wavelength is the distance travelled by a particle in one period", "speed is distance over time" etc.
The particle does not travel a wavelength. The particle has a maximum displacement of amplitude. Amplitude $\neq \lambda$

[2]

(b) Fig. 6.1 shows the variation with time of the displacements X_A and X_B at a point P due to sinusoidal sound waves A and B.

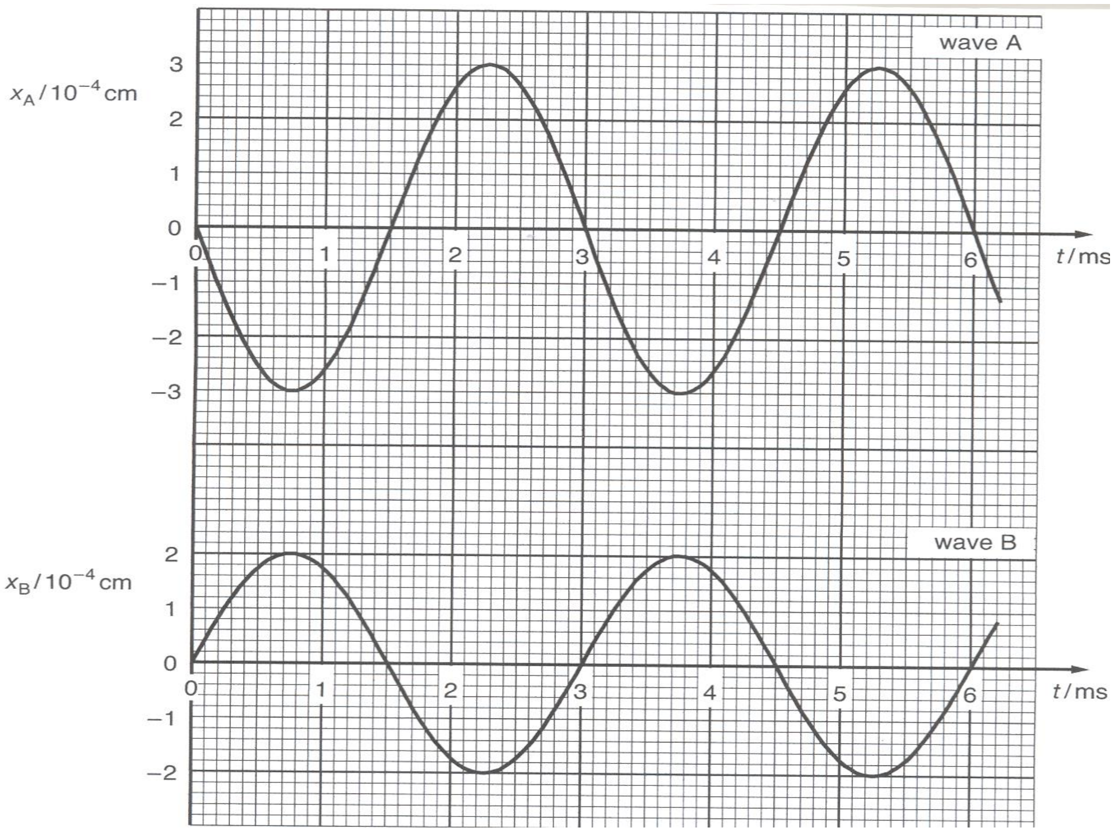


Fig. 6.1

(i) By reference to Fig. 6.1, state one similarity and one difference between these two waves.

Similarity: Same period [A1] ....

.... [1]

Difference: Different amplitude or particles vibrating in different directions [A1] ....

.... [1]

Examiner's comment:
Students scored well for this qn.
Students MUST NOT state answer that were already stated in the qn or not indicated on the Fig. 6.1
Common unacceptable phases used were "Both waves are sinusoidal", ""They are sound waves", "wavelength is same".
Student was awarded zero marks if student read and wrote the period of the waves wrongly.

(ii) The intensity of wave A alone at point P is I .

1. Show that the intensity of wave B alone at P is $\frac{4}{9}I$.

Amplitude of wave A is 3.0 x 10^{-4} cm and intensity $I_A = I$

Amplitude of wave B is 2.0 x 10^{-4} cm and intensity I_B

Intensity of wave is proportional to square of amplitude of wave.

Hence, $I_B / I_A = (2/3)^2$, B1

$I_B = (4/9)\ I$

[1]

Examiner's comment:
Students scored well for this qn.
Student MUST state the relation, Intensity of wave is proportional to square of amplitude of wave Or $Intensity \alpha (Amplitude)^2$ or $I = kA^2$
Some common poor presentation were as follow:

(1) $I_B = (2/3)^2\ I_A$,
$= (4/9)\ I$

(2) $I_A = (3.0 \times 10^{-4})^2$
$I_B = (2.0 \times 10^{-4})^2$
$= (4/9)\ I$

2. Calculate the resultant intensity, in terms of I , of the two waves at point P.

Resultant amplitude at P = 1.0 x 10^{-4} cm A1

Hence, $I_P / I_A = (1/3)^2$, $I_P = (1/9)\ I$ A1

Examiner's comment:
Students did not score well for this qn.
Common mistakes were students add or subtract intensity of I_A and I_B to calculate resultant velocity.

Resultant intensity = ... [2]

(iii) Determine the resultant displacement for the two waves at point P at time t = 4.0 ms.

Resultant displacement at 4.0 ms = (-2.6 x 10^{-4}) + 1.8 x 10^{-4} = - 0.8 x 10^{-4} cm A1

Examiner's comment:
Students did not score well for this qn.
Students were careless and forget to include 10^{-4} in their answer. Student MUST read the axis clearly.

Resultant displacement = ... cm [1]

(c) A 10 W light bulb emits visible light uniformly in all directions. A person can see the light from a distance of 20 x 10^3 m on a dark night.

If the area of the pupil in the person's eye is 0.50 cm^2, calculate the power of light received by one eye.

$$Power = \frac{10}{4\pi(20000)^2} x(\frac{0.50}{100(100)})$$ M1

$$= 1.0x10^{-13} W$$

A1

Examiner's comment:

Students did not score well for this qn.

power = ... W [2]

Some students forgot the formula for surface area of sphere. Many students forget to convert 0.50cm^2 to m^2 in their calculation.

7 A stationary sound wave is formed in a tube with one closed end as illustrated in Fig. 7.1.

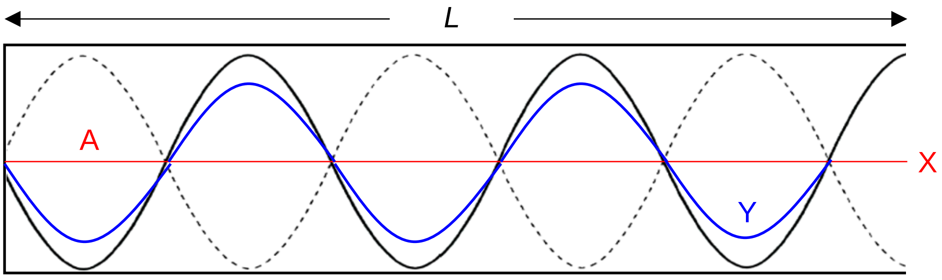


Fig. 7.1

The length of the tube is *L*.

The solid line represents the wave at time $t = 0$ and the dotted line represents the wave at time $t = \frac{T}{2}$, where *T*, the period of the wave, is 5.0×10^{-4} s. The speed of sound is 330 m s^{-1}.

(a) Calculate

(i) the frequency of the sound wave.

$\frac{1}{5.0\times10^{-4}} = 2000$ Hz

frequency = ... Hz [1]

Examiner's comment:
Students scored well for this qn.

(ii) the wavelength of the sound wave.

$\lambda = \frac{330}{2000} = 0.165$ m

wavelength = ... m [1]

Examiner's comment:
Students scored well for this qn. Only a few students used 300 instead of 330 in their calculation.

(iii) the length *L* of the tube.

$L = 5.5 \times \frac{\lambda}{2} = 0.454$ m M[1] A[1]

length = ... m [2]

(iv) On Fig. 7.1, label a point with the letter "A" where the amplitude of vibration of the air molecules is maximum.

[1]

A must be one of the anti-nodes.
Examiner's comment:
Students did not score well for this qn. There were few students labelled many "A" in fig 7.1. Students should follow the instruction in the qn to indicate only **a** point.

[Turn over

(b) On Fig. 7.1, sketch the shape of the stationary wave when

(i) $t = \frac{T}{4}$. Label this wave X. [1]

(ii) $t = \frac{7T}{8}$. Label this wave Y. Shape [1], Peak > half [1] [2]

Examiner's comment:

Students did not score well for this qn. Many students had no idea what they should be drawing. Many student failed to follow what the qn asked. Many students failed to label X and Y in the wave they drew or labelled the wave using their own symbols.

(c) Determine another resonant frequency that is higher than the one shown in Fig. 7.1.

$\frac{2000}{11} \times 13$ C[1]

$= 2360$ Hz or any higher harmonic A[1]

Note: for open pipe, for nth harmonic, $f_n = n\ f_o$ where n is odd number
$2000 = 11\ f_o$, n=11 , f_o is the fundamental frequency(lowest freq)

frequency = ... Hz [2]

Examiner's comment:
Students did not score well for this qn. Many students had no idea what they were calculating. Marks will be deducted if working is unclear.

8 When Ball 1 of mass m_1 and velocity u collides elastically with a stationary Ball 2 of mass m_2, the motion of the balls after the collision depends on the direction of impact. This can be solved completely by applying the laws of conservation of energy and linear momentum.

Fig. 8.1 shows the oblique collision of the two balls.

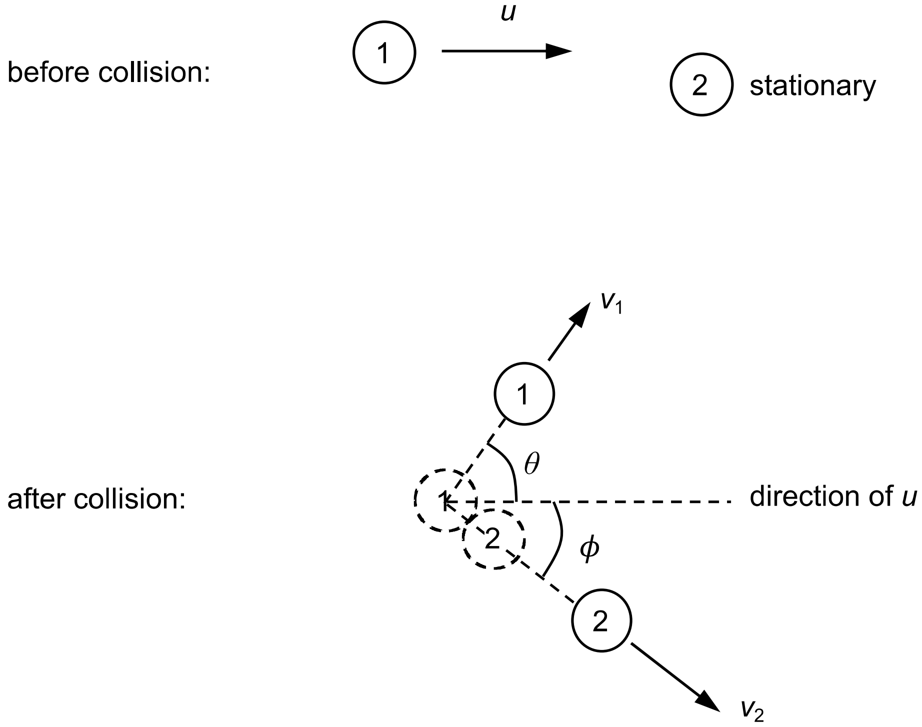


Fig. 8.1

After the collision, Ball 1 acquires velocity v' at angle θ to u and Ball 2 acquires velocity v at angle ϕ to u.

The variation with $\cos\phi$ of the ratio $\frac{v}{u}$ of Ball 2 for the different ratios of the masses $\frac{m_2}{m_1}$ of Ball 1 and Ball 2 are shown in Fig. 8.2.

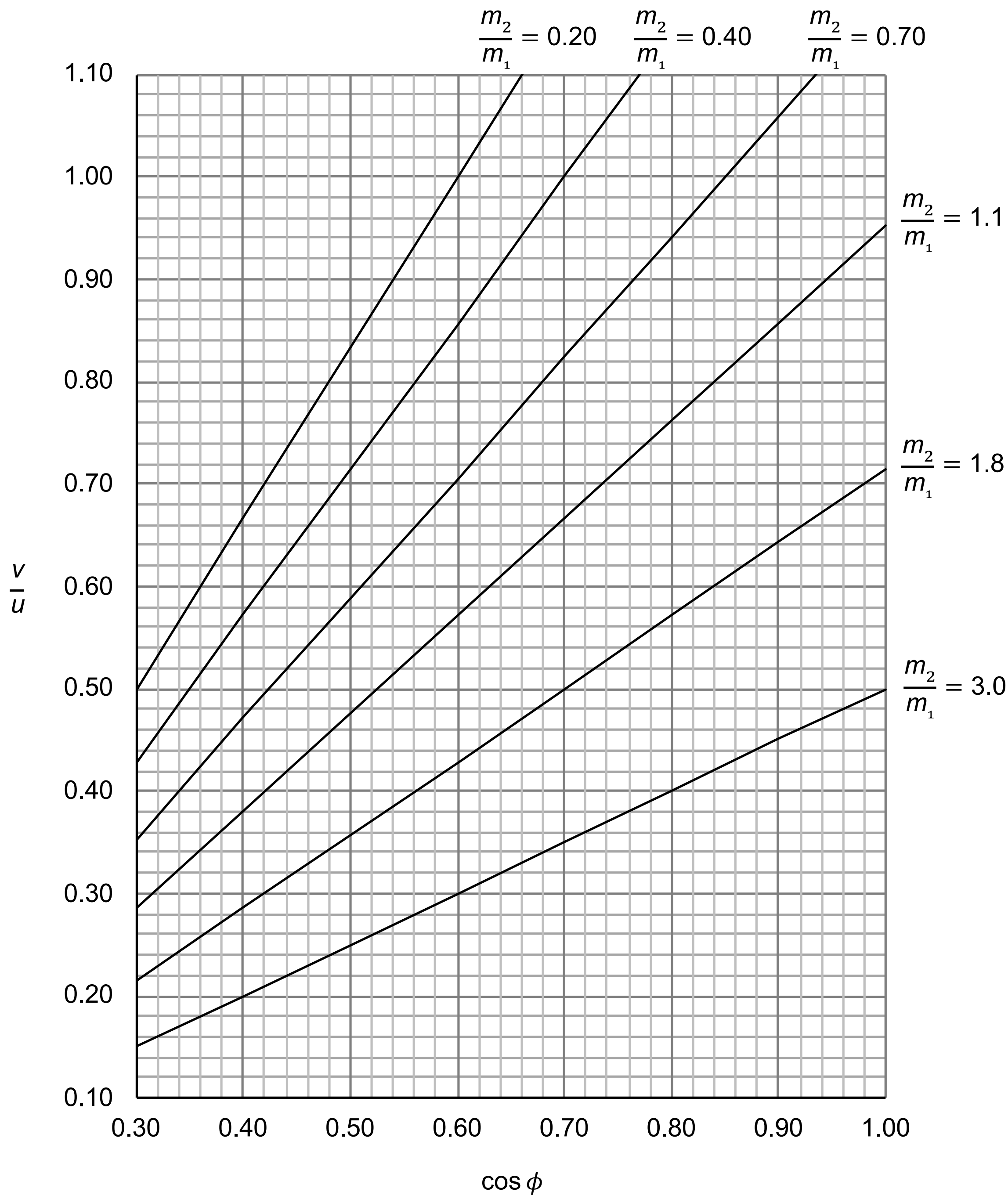


Fig. 8.2

(a) The graphs in Fig. 8.2 are described by the expression

$$\frac{v}{u} = k \cos \phi \qquad \text{(equation 8.1)}$$

where k is a constant.

Without drawing a graph, use the data for $\frac{m_2}{m_1} = 0.70$ to verify the expression.

evidence of calculation of $k = \frac{v/u}{\cos \phi}$ using 3 points on the line	M1
appropriate comment(s) based on the closeness of k–values	A1

Examiner's Comments:
It is good to use at least 3 points to verify the relationship. If more marks are given, then more points should be used.

[2]

(b) The constant k in **(a)** is related to the ratio of the masses by

$$\frac{2}{k} = \alpha \frac{m_2}{m_1} + \beta \qquad \text{(equation 8.2)}$$

where α and β are integers.

Fig. 8.3 shows the tables of values of $\frac{m_2}{m_1}$, k and $\frac{2}{k}$.

$\frac{m_2}{m_1}$	k	$\frac{2}{k}$
0.20	1.67	1.20
0.40	1.43	1.40
0.70	1.17	1.71
1.1	0.955	2.09
1.8	0.714	2.80
3.0	0.500	4.00

Fig. 8.3

(i) Complete Fig. 8.3 for $\frac{m_2}{m_1} = 1.1$

[1]

(ii) Fig. 8.4 is a graph of some of the data of Fig. 8.3.

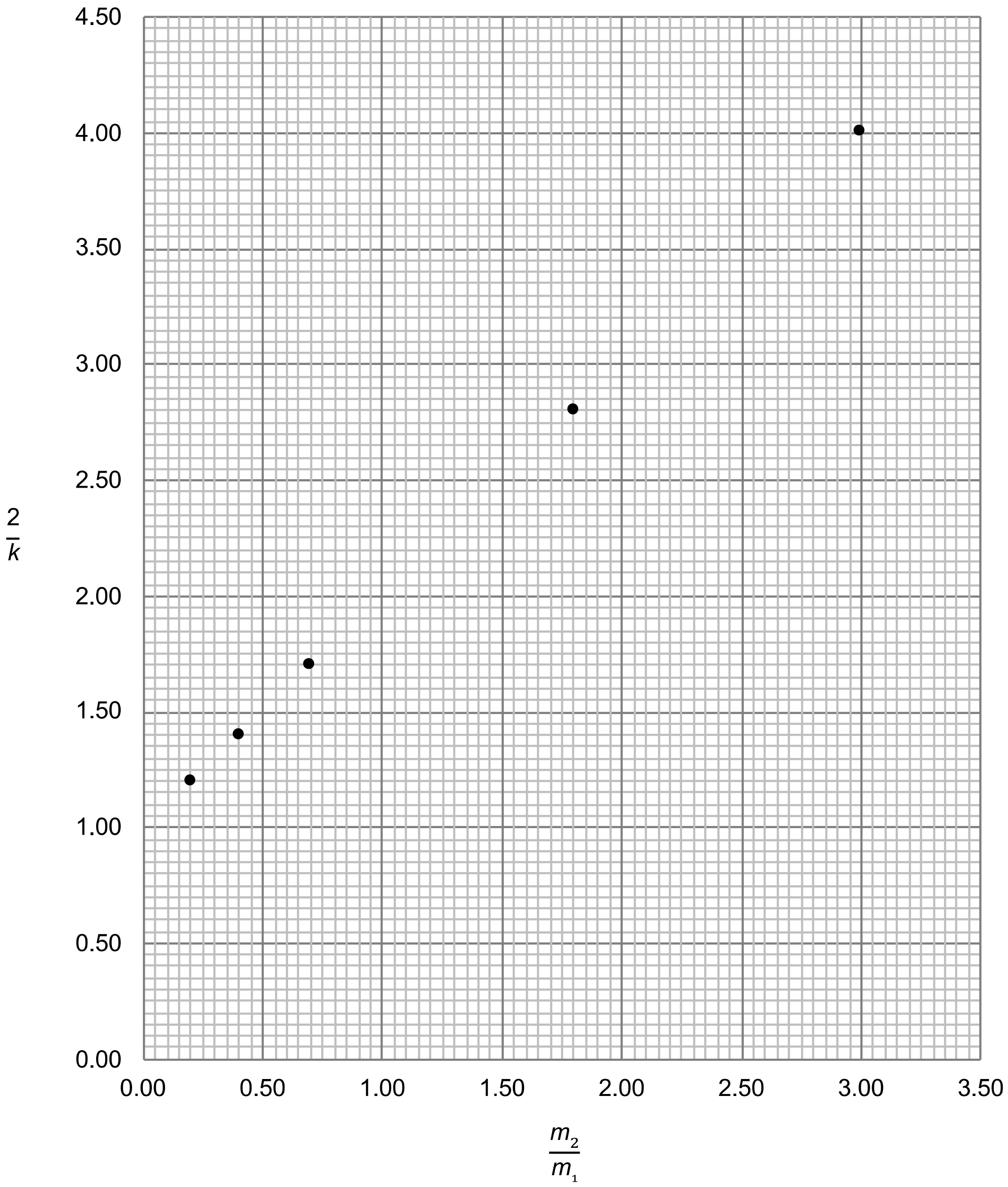


Fig. 8.4

On Fig. 8.4,

1. plot the point corresponding to $\frac{m_2}{m_1} = 1.1$,

2. draw the line of best fit for all the points.

[2]

Examiner's Comments:
Most students can complete this part with full credit.

(iii) Determine α and β from Fig. 8.4.

determine gradient using $\Delta y/\Delta x$		M1
either	read–off *y*–intercept from graph	
or	use $y = mx + c$ to calculate *y*–intercept	M1
$\alpha \approx \beta \approx 1$		A1
final value of α and β rounded to integer value (accept 1.0, 1.00, etc)		A1

$\alpha =$ ....

$\beta =$ .... [4]

Examiner's Comments:
It should be noted that both α and β are integers. And the method of getting β is often not explained in details.

(iv) By using equation 8.1 and equation 8.2 in **(a)** and **(b)**, write down an expression for the speed *v* of Ball 2 in terms *u*, $\frac{m_2}{m_1}$ and cos ϕ.

$v = \frac{2u}{1+\frac{m_2}{m_1}}\cos\phi$ B1

.... [1]

Examiner's Comments:
Such question only require the students to write the expression. Working is not needed.

(c) Fig. 8.5 shows Ball 1 colliding head–on ($\phi = 0°$) with the stationary Ball 2.

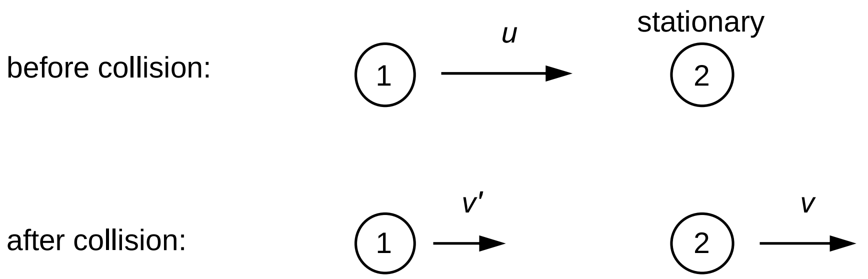


Fig. 8.5

By using information in **(a)** and **(b)**, show that $v = u$ and $v' = 0$ when the masses of the balls are equal.

either	deduce $k = 1$ from equation 8.2 and use equation 8.1	
or	use $v = \frac{2u}{1+\frac{m_2}{m_1}}\cos\phi$	M1
so, $v = u$		A0
use conservation of momentum or kinetic energy before and after collision is constant or relative speeds		M1
so, $0, v' = 0$		A0

Examiner's Comments:
Students should take note that they have to make use of (a) and (b) to show the values. Other methods will earn them no credit.

[2]

(d) During the time of impact, each ball exerts a normal force on the other. The normal forces on each ball are equal and oppositely directed. Through the action of these forces, momentum is exchanged between the two balls. Fig. 8.6 shows these forces when the balls collide head–on or obliquely.

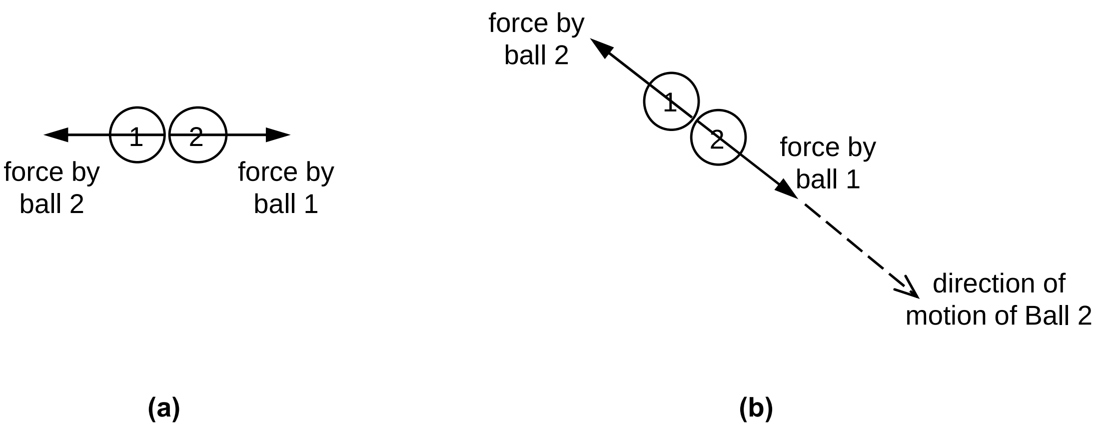


Fig. 8.6

Fig. 8.6(a) shows the forces lying along the line connecting the centres of the balls during a head–on collision.

Fig. 8.6(b) shows the forces parallel to the velocity of Ball 2 in an oblique collision.

(i) Explain why in a head–on collision, shown in Fig. 8.6(a), the direction of the velocities of the balls before and after the collision lie on the line connecting the centres of the balls.

resultant force on each ball M1

and change in momentum of balls along/parallel to line connecting the centres A1

so velocities of balls before and after collision along same line

[2]

Examiner's Comments:
Explanation must be clear and precise. Phrases like "horizontal direction", "passing through centre" are not clear.
In addition, mere quotes of Newton's Laws, without relating them to the question, will earn no credit.

(ii) Fig 8.7 shows the instant just before the oblique collision between two balls.

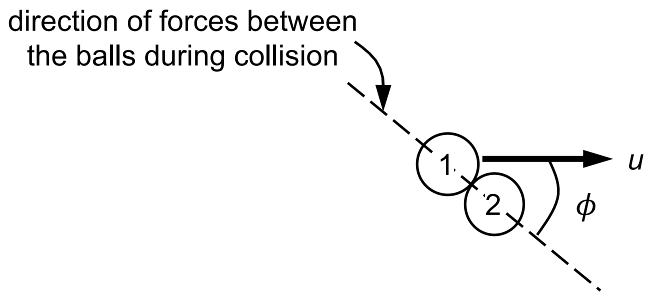


Fig. 8.7

The direction of the forces experienced by the balls during the collision is shown in the figure at angle ϕ to the initial velocity u of Ball 1.

1. Write down the component of the initial velocity u, in terms of u and ϕ,

along the direction of the forces: …………… $u \cos \phi$ ……………………........

perpendicular to the direction of the forces: .. $u \sin \phi$ ……………………......[1]

Examiner's Comments:
Most students can do this part.

…erpendicular when the masses of the balls are equal.

along (direction of) forces, velocity of Ball 2 equals $u \cos \phi$ B1

(for equal masses,) velocity of Ball 1 along direction of force is zero (after collision) M1

so, velocity of Ball 1 equals $u \sin \phi$ A1

therefore, velocities are perpendicular

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

3. Explain whether your answer to **(d)(ii)2.** will be different if the masses of the balls are not equal.

velocity of Ball 1 along direction of force is not zero after collision M1

resultant velocity of Ball 1 is not perpendicular to direction of forces (or direction of Ball 2) A1

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

Examiner's Comments:
Many students cannot understand this question. The explanation give is often confusing. The principle of conservation of momentum is often quoted without reference to direction and to the context of the question.

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