M.M. : 70

CLASS-XI (ANNUAL EXAM) (2023-24)
PHYSICS
Marking Scheme/Hints to Solution

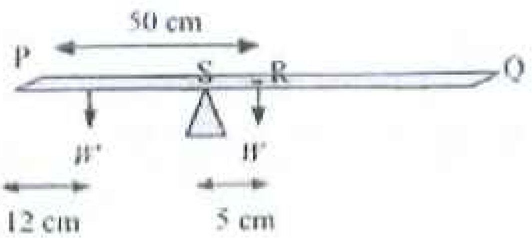
Note : Any other relevant answer, not given herein but given by the candidate be suitably rewarded.

S. No.	Value Points/Key Points	Marks Allotted to each value point/key point	Total Marks
	Section-A		
1.	(b) $[L^{-1/2}T^2]$ $\because$ Dimensions of $\left(a\sqrt{x}\right)$ = Dimensions of (bt^2)	1	1
2.	(c) increases by 800 J $\because$ $\Delta Q = \Delta U + \Delta W$, $\Delta Q = 200$ cal $= 200 \times 4.2 = 840$ J, $\Delta W = 40$ J $\Delta Q = 840 - 40 = 800$ J	1	1
3.	(d) zero Since no external forces act on the system, the center of mass keeps moving just as it did before the two objects started to exert forces on each other. And since the objects were at rest, their center of mass will remain at the same place. That is the speed of center of mass of the bodies is zero.	1	1
4.	(a) 0.2 kg ms^{-1} Here $u = 0$ m/s and $v = 2$ m/s (slope) $I = m(v - u) = 0.1 \times (2 - 0) = 0.2$ kg ms^{-1}	1	1

5.	(c) $10\sqrt{10}$ Here $T^2 \propto r^3$ and $T = r^{3/2}$	1	1
6.	(a) $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$	1	1
7.	(b) A and B are the kinetic energy and potential energy respectively and C the total energy of the satellite.	1	1
8.	(a) 16 : 9 Work done to blow a soap bubble = change in surface energy = Surface Tension × Area Hence work done α Area α r^2	1	1
9.	(d) zero	1	1
10.	(b) lift is moving up with acceleration equal to g Because when lift is moving up, apparent weight = m (g + a)	1	1
11.	(a) $\frac{n}{n+2}$ $C_v = \frac{nR}{2}, C_p = \frac{(n+2)R}{2} \left(\because C_p - C_v = R\right)$	1	1
12.	(d) 3 π Nm $\omega = 2\pi\nu = 2\pi\frac{150}{60} = 5\pi,$ $\alpha = (\omega - \omega_0)/t = \pi/2, \quad \tau = I\alpha$	1	1
13.	(d) If both Assertion and Reason are false.	1	1
14.	(a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.	1	1

15.	(b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.	1	1
16.	(d) If both Assertion and Reason are false.	1	1
	Section-B		
17.	(i) Average speed is greatest in time interval 3	½	
	(ii) The magnitude of average acceleration is greatest for time interval 2	½	2
	(iii) During time interval 1	½	
	(iv) During time interval 2	½	
18.	On comparing the given equation with the general equation of wave		
	$y(x, t) = 0.001 \sin(2x + 50t + \pi/3)$		
	$y(x, t) = A \sin(kx + \omega t + \phi)$	½	
	$k = 2$ rad/m, $\omega = 50$ rad/s	½	
	Wave is propagating along negative x-axis		
	$v = \frac{\omega}{k}$	$\frac{1}{2}$	
	$v = \frac{50}{2} = 25$ m/s	½	2
19.	Given : $I_A > I_B$ and $L_A = L_B$ (angular momentum)		
	$L = I\omega$ and $KE = \frac{1}{2} I \omega^2 = (I\omega)^2/(2I)$	½	
	Hence $KE = L^2 / (2I)$		
	i.e. $KE \propto (1/I)$	½	
	Hence $(KE_B / KE_A) = (I_A / I_B)$	½	
	As $I_A > I_B$		
	Hence $KE_B > KE_A$	½	2

20.	Consider a system of two bodies 1 & 2 and there is no external force acting.		
	Let $\mathbf{F}_{12}$ be the force acting on 2 by 1 & $\mathbf{F}_{21}$ be the force acting on 1 by 2.	½	
	The rate of change of momentum of body 1 = $d\mathbf{p}_1/dt$ and rate of change of momentum of body 2 = $d\mathbf{p}_2/dt$		
	Thus, according to Newton's second law of motion		
	$\mathbf{F}_{12} = d\mathbf{p}_2 / dt$ and $\mathbf{F}_{21} = d\mathbf{p}_1 / dt$	½	
	Adding both the above equations, we get		
	$\mathbf{F}_{12} + \mathbf{F}_{21} = (d\mathbf{p}_2 / dt) + (d\mathbf{p}_1 / dt) = d(\mathbf{p}_2 + \mathbf{p}_1)/dt$		
	Since no force is applied therefore momentum change will also be zero.	½	
	Thus $d(\mathbf{p}_1 + \mathbf{p}_2)/dt = 0$		
	Therefore, $\mathbf{F}_{12} + \mathbf{F}_{21} = 0$		
	$\mathbf{F}_{12} = -\mathbf{F}_{21}$		2
	Thus, Newton's third law is proved with Newton's second law.	½	
21.	Escape velocity of a projectile from the Earth,		
	$V_{esc} = 11.2$ km/s		
	Projection velocity of the projectile, $V_P = 3\ V_{esc}$		
	Mass of projectile = m		
	Velocity of the projectile far away from the Earth = v_f		
	Total energy of the projectile on the Earth =		
	$\frac{1}{2} mv_p^2 - \frac{1}{2} mv_{esc}^2$	½	
	Total energy of the projectile far away from the Earth		
	$= \frac{1}{2}mv_f^2$		

From the law of conservation of energy, we have		
$\frac{1}{2}mv_p^2 - \frac{1}{2}mv_{esc}^2 = \frac{1}{2}mv_f^2$	½	
$v_f = \sqrt{v_p^2 - v_{esc}^2}$	½	
$= \sqrt{(3v_{esc})^2 - (v_{esc})^2}$		
$= \sqrt{8}\ V_{esc}$	½	2
$= \sqrt{8} \times 11.2$ km/s		
OR		
	½	
The mass of the metre stick is concentrated at its mid-point, i.e., at the 50 cm mark.		
Mass of the meter stick = m		
Mass of each coin, m = 5 g		
When the coins are placed 12 cm away from the end P, the centre of mass gets shifted by 5 cm from point R toward the end P. The centre of mass is located at a distance of 45 cm from point P. The net torque will be conserved for rotational equilibrium about point R.	½ ½	
$10 \times g\ (45 - 12) - m\ g\ (50 - 45) = 0$		
Hence, the mass of the metre stick is 66 g.	½	

Section-C

22.	$h = [ML^2T^{-1}]$ $\quad c = [LT^{-1}]$ $\quad G = [M^{-1}L^3T^{-2}]$	½	
	$M \alpha h^a c^b G^d$	½	
	$M = k\, h^a c^b G^d$		
	$[M^1 L^0 T^0] = [M^0L^0T^0]\,[M^aL^{2a}T^{-a}]\,[L^bT^{-b}]\,[M^{-d}L^{3d}T^{-2d}]$	½	
	$a - d = 1$		
	$2a + b + 3d = 0$	½	
	$-a - b - 2d = 0$		
	On solving, $a = ½,\ d = -½,\ b = ½$	½	3
	Hence $M = k\, h^{1/2} c^{1/2} G^{-1/2}$	½	
23.	Vector perpendicular to both		
	$\vec{A} = \left(3\hat{i} + \hat{j} + 2\hat{k}\right)$ and $\vec{B} = \left(2\hat{i} - 2\hat{j} + 4\hat{k}\right)$ is given by		
	$\vec{C} = \vec{A} \times \vec{B}$	½	
	$\vec{C} = \left(3\hat{i} + \hat{j} + 2\hat{k}\right) \times \left(2\hat{i} - 2\hat{j} + 4\hat{k}\right)$	½	
	$\Rightarrow \quad \vec{C} = \left(8\hat{i} - 8\hat{j} - 8\hat{k}\right)$	½	
	Unit vector perpendicular to both $\vec{A}$ and $\vec{B}$ = $C = \dfrac{\vec{C}}{\lvert\vec{C}\rvert}$	½	
	$\Rightarrow \quad \lvert\vec{C}\rvert = \sqrt{8^2 + (-8)^2 + (-8)^2} = \sqrt{64 + 64 + 64} = 8\sqrt{3}$	½	
	$\Rightarrow \quad \vec{C} = \dfrac{\left(8\hat{i} - 8\hat{j} - 8\hat{k}\right)}{8\sqrt{3}}$	½	3
	$\Rightarrow \quad \vec{C} = \dfrac{\left(\hat{i} - \hat{j} - \hat{k}\right)}{\sqrt{3}}$		

24.	Let mass of A = m_1, mass of B = m_2		
	Let minimum mass of C is m		
	Here net force on each body is zero		
	For A : $R = (m + m_1)\,g$	½	
	and $T = f_s = \mu R = \mu\,(m + m_1)\,g$	½	
	for B : $T = m_2\,g$	½	
	$\mu\,(m + m_1)\,g = m_2\,g$	½	
	$0.2\,(m + 10)\,g = 5\,g$	½	3
	Hence m = 15 kg	½	
25.	Gravitational potential energy of a body at a point in a gravitational field of another body is defined as the amount of work done in bringing the given body from infinity to that point without acceleration.	½	
	Suppose the Earth is a uniform sphere of Mass M and radius R. Gravitational potential energy of a body of mass m at a point P in a gravitational field of Earth is equal to the amount of work done in bringing m from infinity to point P without acceleration.		
	 	½	

	A small amount of work done in bringing it without acceleration through a very small distance (dx) is given by		
	dw = Fdx	½	
	$dw = (GMm/x^2)dx$	½	
	Integrating on both sides		
	$w = \int_{\infty}^{r} \frac{GMm}{x^2}\, dI$		
	$w = \left[\frac{GMm}{x}\right]_{\infty}^{r}$	½	
	$w = \left[\frac{GMm}{r}\right] - \left(\frac{GMm}{\infty}\right)$		
	$w = \frac{-GMm}{r}$	½	3
	Since the work done is stored as its gravitational potential energy U		
	Hence $U = -\frac{GMm}{r}$		
26.	If B is the bulk modulus of the air, P is the pressure of the air, v is velocity and ρ is the density, then, Newton's formula for velocity of sound in air is given by		
	$v = \sqrt{B/\rho} = \sqrt{P/\rho}$	½	
	At NTP (Normal Temperature and Pressure)		
	Pressure (P) = 1.1013×10^5 N/m^2		
	Density of air (ρ) = 1.293 kg/m^3		
	Thus velocity, $v = \sqrt{\frac{P}{\rho}} = \sqrt{\frac{1.013 \times 10^5}{1.293}} = 280$ m/s	½	

Experimentally it has been found that the velocity of sound in air is 332 m/s. Hence there is some error in Newton's assumption and it needs correction. According to Newton, sound waves propagate through an isothermal process.	½	
Laplace provide a correction for Newton's formula. He assumed that, the process of compression and rarefaction occur very fast and no exchange of heat takes place. Thus, the temperature doesn't remain constant and the propagation of sound in gas is an adiabatic process.	½	
In adiabatic process PV^{γ} = constant where $\gamma = C_P/C_V$ C_P = Specific heat for constant pressure C_V = Specific heat for constant volume γ = adiabatic index Differentiating the equation, we get $v = \sqrt{\frac{B}{\rho}}$ $v = \sqrt{\frac{PY}{\rho}}$ where B = YP	½	
Pressure (P) = 1.1013×10^5 N/m^2 Density of air (ρ) = 1.293 kg/m^3 adiabatic index (γ) = 1.4 This gives v = 332.5 m/s. This value is very close to the experimental value. Hence, Laplace provides correction to the Newton's formula.	½	3

27.	(i) When a liquid is sprayed, the surface area of the liquid increases. Therefore, work has to be done in spraying the liquid, which is directly proportional to the surface tension. Because on adding soap, surface tension of water decreases, the spraying water becomes easy.	1	
	(ii) Heat carried away from a fire sideways mainly by radiation. Above the fire, heat is carried by both radiation and convection of air. But convection carries much more heat than radiation. So, it is much hotter above a fire than by its sides.	1	
	(iii) When we try to close the water tap with out fingers, the area of the outlet of the water eject gets reduced. Therefore, in accordance with the principle of continuity (av = constant), the velocity of the water will increase creating fast jets of water.	1	3
28.	(i) Work done during the process from A to B (expansion)		
	W_{AB} = + area ABKLA		
	= area of triangle ABC + area of rectangle BCLK	½	
	$= \left(\frac{1}{2} \times BC \times AC\right) + (KL \times LC)$		
	Now, $BC = KC = 4 - 1 = 3$ litres $= 3 \times 10^{-3}\ m^3$		
	$AC = 4 - 2 = 2\ Nm^{-2}$: $LC = 2 - 0 = 2\ Nm^{-2}$		
	Therefore, $W_{AB} = (½ \times 3 \times 10^{-3} \times 2) +$		
	$(3 \times 10^{-3} \times 2) = 9 \times 10^{-3}$ J	½	
	(ii) Work done during the process from B to C (compression) is		
	$W_{BC} = -$ area BCLK $= -$ KL × LC	½	
	$= 3 \times 10^{-3} \times 2 = -6 \times 10^{-3}$ J	½	

(iii) Work done during the process from C to A. As there is no change in volume of the gas in this process, therefore, $W_{CA} = 0$. ½

Net work done in the complete cycle

$W = W_{AB} + W_{BC} + W_{CA} = 9 \times 10^{-3} + (-6 \times 10^{-3}) + 0 = 3 \times 10^{-3}$ J ½ 3

OR

Let m kg be the mass of the stream required to just melt down 3200 g (or 3.2 kg) of ice at – 10°C

Heat gained by ice to raise its temperature from – 10°C to 0°C = $3.2 \times 2100 \times (0 - (-10)) = 67200$ J ½

Heat required to just melt down ice at 0 °C

$= 3.2 \times 336 \times 10^3 = 1075200$ J ½

Heat lost by steam while condensing to form water at 100°C

$= m \times 2260 \times 10^3$ J ½

Heat lost by water in cooling from 100°C to 0°C

$= m \times 4200 \times (100 - 0)$ J $= m \times 4200 \times 100$ J ½

Total heat lost = Total heat gained ½

$m \times 2260 \times 10^3 + m \times 4200 \times 100 = 67200 + 1075200$

$m = \frac{1142400}{2680000} = 0.426$ kg ½

Section-D

Case Study Based Questions

29. (i) (a) When a body falls through a viscous liquid, its velocity increases due to gravity but after some time its velocity becomes uniform because of viscous force becoming equal to the gravitational force. 1

	(ii) (c) P, Q, R Gravitational force remains constant. Therefore, P is the correct graph for the gravitational force. Viscous force will keep on increasing as the no. of layers of liquid will keep on increasing as the ball moves deeper inside the liquid. Therefore, Q is the correct graph for the viscous force. Net force acting on the ball will keep on decrease because the buoyancy force will keep on increasing as the ball achieves more and more depth. So, a time will come when the force become equal and the ball attains a constant velocity. Therefore, R is the correct graph for the net force.	1	
	(iii) (b) directly proportional to both radius 'R' and velocity 'v'. **OR** (d) r^2	1	
	(iv) (a) 0.1 m/s Terminal velocity, $v_r = 2\, r^2\, (\rho - \sigma)\, g/9\, \eta$ $v_r / 0.2 = (10.5 - 1.5)/(19.5 - 1.5)$ $v_r = 0.1$ m/s	1	4
30.	(i) (a) parabola Because $T = 2\pi\sqrt{L/g}$	1	
	(ii) (b) Amplitude of oscillation is small	1	
	(iii) (d) first increases and then decreases When water begins to drain out of the hollow sphere, its COM begin to shift below the centre of sphere. Hence equivalent length of pendulum increases and time period also increases. When entire water drains out COM again comes to centre of sphere. Hence equivalent length of pendulum decreases and time period also decreases.	1	

(iv) (d) $2\pi^2$ m/s^2 1

As $g = 4\pi^2 (L/T^2)$

OR

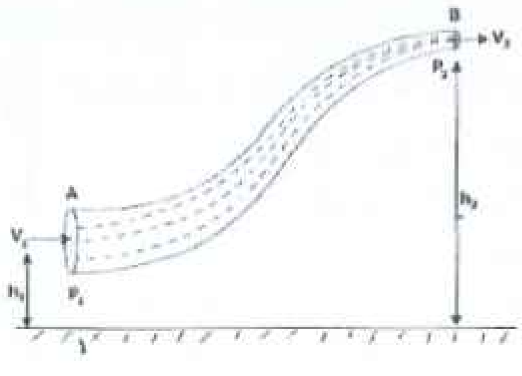
(c) $\sqrt{\frac{6}{7}}$ T

When lift accelerates with g/6 vertically upwards 4

then g is replaced by (g + a) in $T = 2\pi\sqrt{L/g}$

Section-E

31. (a) Statement– It states that for the streamline flow of an ideal liquid the total energy (the sum of the pressure energy, potential energy and kinetic energy) per unit mass or volume remains constant at every cross section throughout the liquid flow. 1



½

Consider a tube AB of varying cross-section through which an ideal liquid is in streamline flow.

Let P_1 = Pressure applied on the liquid at A

P_2 = Pressure at the end B, against which liquid is to move out.

a_1, a_2 = Area of cross section of the tube at A and B respectively.

h_1, h_2 = Mean height of section A and B from the ground or a reference level.	
v_1, v_2 = Normal velocity of the liquid flow at the section A and B respectively.	
ρ = Density of the ideal liquid flowing through the tube	
As a liquid flows from A to B, therefore $P_1 > P_2$	
The mass m of the liquid crossing per second through any section of the tube in accordance with the equation of continuity at point A and B is	
$a_1 v_1 \rho = a_2 v_2 \rho = m$	
$a_1 v_1 = a_2 v_2 = m/\rho = V$	½
$a_1 > a_2$ hence $v_2 > v_1$	
The work done by the pressure difference per unit volume	
= gain in K.E. per unit volume + gain in P.E. per unit volume	½
Now Work done = force × distance = Pressure × Volume	
Net work done per unit volume = $P_1 - P_2$	
K.E. per unit volume = $(½)\ mv^2 / V = (½)\ V \rho v^2 = (½)\ \rho v^2$	½
K.E. gained per unit volume = $\rho (v_2^2 - v_1^2)$	
P.E. per unit volume = $m g h / V = \rho g h$	
P.E. gained per unit volume = $\rho g (h_2 - h_1)$	
Therefore :	
$P_1 - P_2 = (½)\ \rho (v_1^2 - v_2^2) + \rho (h_2 - h_1) g$	½
$P_1 + (½)\ \rho v_1^2 + \rho g h_1 = P_2 + (½)\ \rho v_2^2 + \rho g h_2$	
Therefore :	
$P + (½)\ \rho v^2 + \rho g h$ is a constant.	½
(b) Limitations of Bernoulli's equation are as follows :	
1. The Bernoulli equation has been derived by assuming that the velocity of every element of the	

liquid across any cross-section of the pipe is uniform. Practically, it is not true. The elements of the liquid in the innermost layer have the maximum velocity. The velocity of the liquid decreases towards the walls of the pipe. Therefore, we should take into account the mean velocity of the liquid.

2. While deriving Bernoulli's equation, the viscous drag of the liquid has not been taken into consideration. The viscous drag comes into play, when a liquid is in motion. ½

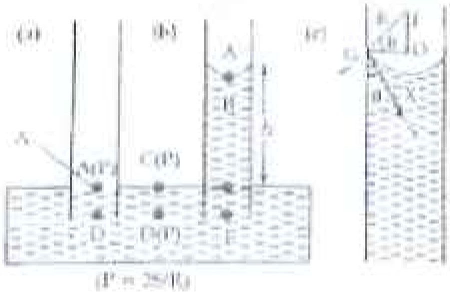
3. Bernoulli's equation has been derived on the assumption that there is no loss of energy, when a liquid is in motion. In fact, some kinetic energy is converted into heat energy and a part of it is lost due to shear force. ½ 4+1=5

4. If the liquid is flowing along a curved path, the energy due to centrifugal force should also be taken into consideration.

(any two)

OR

(a) Let a capillary tube of uniform bore be dipped vertically in a wet liquid. Since liquid is wet, therefore, the meniscus is concave. Let r be the radius of capillary tube, R be the radius of meniscus and θ the angle of contact. ½



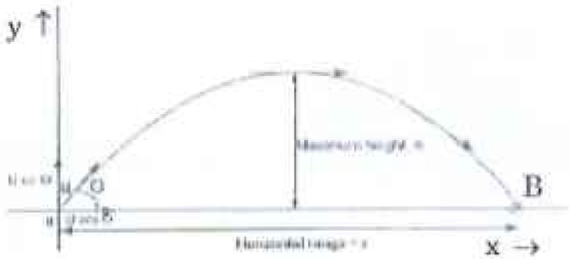
Let R = Radius of curvature of liquid meniscus P = Atmospheric pressure S = Surface tension of the liquid The pressure at point A just above the liquid meniscus in the capillary tube is atmospheric pressure = P	½
The pressure at point B, just below the liquid meniscus (on convex side) = P – 2S/R Pressure at E = pressure at B + pressure due to height h (= BE) of the liquid column $= \left(P - \frac{2S}{R}\right) + h\rho g$	1
As there is equilibrium, therefore Pressure at E = Pressure at D i.e., $P - \frac{2S}{R} + h\rho g = P$	½
or $h\rho g = \frac{2S}{R}$ or $h = \frac{2S}{R\rho g}$ ....(1)	½
Let I be the centre of curvature of liquid meniscus GXY in the tube and GS be the tangent to the liquid surface at point G. GI = R, GO = r $\angle IGO = \theta$ = angle of contact In ΔIGO $\cos\theta = \frac{GO}{GI} = r/R$	½
$R = \frac{r}{\cos\theta}$ Putting this value in (1) $h = \frac{2S\cos\theta}{r\rho g}$	½

(b) From equation (1)

$hR = 2S/\rho g$ = constant ½

When the tube is of insufficient length, a radius of curvature of the liquid meniscus increases, so as to maintain the product hR a finite constant, i.e., as h decreases, R increases and the liquqid meniscus becomes more and more flat, but the liquid does not overflow. ½ 4+1=5

32. (a) Any object that is given an initial velocity and the object subsequently follows a path determined by the gravitational force acting on it and by the frictional resistance of the atmosphere is called a projectile. ½



½

Motion along OX

$x = x_0 + u_x + (½)\, a_x t^2$ ½

$x = 4\cos\theta \,.\, t$

$t = x \,/\, u \cos\theta$ ½

Motion along OY

$y = y_0 + u_y + (½)\, a_y t^2$ ½

$y = (u \sin\theta)\, t + ½\, (-g)\, t^2$

$y = (u \sin\theta)\, (x/u \cos\theta) + (½)\, (-g)\, (x/u \cos\theta)^2$ ½

$y = x \tan\theta - (½)\, (gx^2/u^2\cos^2\theta)$

Which is an equation of a parabola

(b) Here $\theta = 90° - 30° = 60°$

Horizontal velocity $= u \cos 60° = 19.6\ ms^{-1}$ ½

$\therefore \quad u = \frac{19.6}{\cos 60°} = \frac{19.6}{0.5} = 39.2\ ms^{-1}$

$\therefore$ Maximum height,

$$H = \frac{u^2 \sin^2 60°}{2g} = \frac{(39.2)^2}{2 \times 9.8} \times \left(\frac{\sqrt{3}}{2}\right)^2 = 58.8\ m$$ ½

Horizontal range,

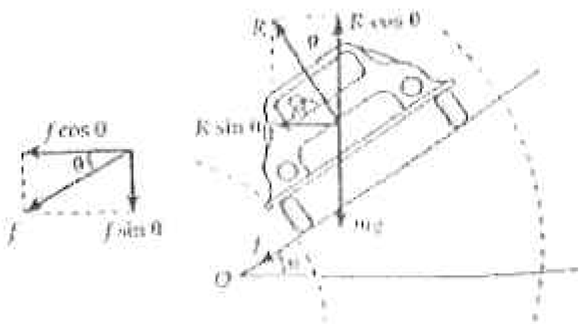
$$R = \frac{u^2 \sin 2\theta}{g} = \frac{(39.2)^2 \times \sin 120°}{9.8}$$ ½

$$= \frac{(39.2)^2}{9.8} \times \left(\frac{\sqrt{3}}{2}\right) = 135.8\ m$$ ½

3+2 = 5

OR

(a)

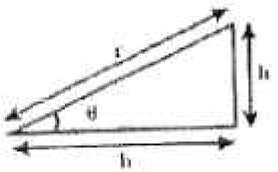


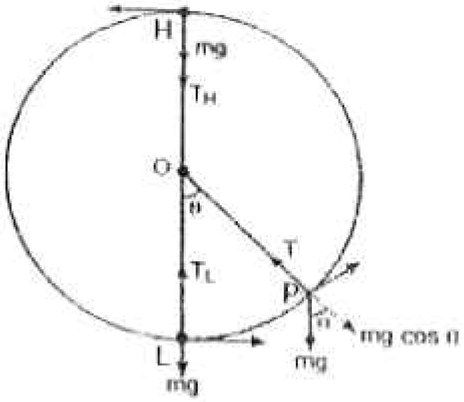
½

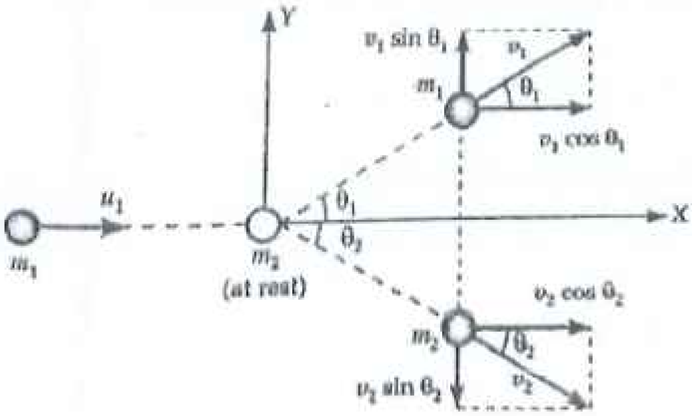
Consider a car of weight mg going along a curved path of radius r with speed v on a road banked at an angle θ. The forces acting on the vehicle are

1. Weight mg acting vertically downwards
2. Normal reaction R of the road acting at an angle θ with the vertical. ½
3. Force of friction f acting downwards along the incline plane.

Equating the forces along horizontal and vertical directions respectively, we get

	Marks	Total
$R \sin\theta + f \cos\theta = \frac{mv^2}{r}$ ......(1)	½	
$mg + f \sin\theta = R \cos\theta$, where $f = \mu R$ ....(2)	½	
$R \cos\theta - f \sin\theta = mg$		
Dividing equation (1) by equation (2), we get		
$\frac{R \sin\theta + f \cos\theta}{R \cos\theta - f \sin\theta} = \frac{v^2}{rg}$	½	
Dividing numerator and denominator of L.H.S. by $R \cos\theta$, we get		
$\frac{\tan\theta + \frac{f}{R}}{1 - \frac{f}{R}\tan\theta} = \frac{v^2}{rg}$		
$\frac{\tan\theta + \mu}{1 - \mu \tan\theta} = \frac{v^2}{rg}$		
$v^2 = rg\left[\frac{\mu + \tan\theta}{1 - \mu\tan\theta}\right]$ or $v = \sqrt{rg\left(\frac{\mu + \tan\theta}{1 - \mu\tan\theta}\right)}$	½	
(b) 	½	
Let the width of the path be b and h its height. Let v be the safe velocity		
$\tan\theta = \frac{v^2}{rg} = \frac{h}{b}$		
$\Rightarrow \quad h = \frac{v^2 b}{rg}$	½	
$= \frac{\left(48 \times \frac{1000}{3600}\right)^2 \times 1}{400 \times 9.8}$	½	
$= 0.0045$ m	½	3+2=5

33.	(a) 		1
	(b) $T - mg\cos\theta = \frac{mv^2}{l}$		
	$T = \frac{mv^2}{l} + mg\cos\theta$		½
	T will be minimum when cos θ = min = – 1 and θ = 180° at the highest point H.		½
	$T_H \geq 0$		
	$T_H = \frac{m{v_H}^2}{l} - mg \geq 0$		
	$V_H \geq \sqrt{g\,l}$		
	According to law of conservation of energy		
	Total mechanical energy at L = Total mechanial energy at H		½
	$(½)\, m\, V_L^2 = (½)\, m\, V_H^2 + mg\,(2\,l)$		½
	$(½)\, m\, V_L^2 \geq (½)\, m\,(g\,l) + mg\,(2\,l)$		½
	$V_L^2 \geq 5\,g\,l$		
	$V_L \geq \sqrt{5\,g\,l}$		½
	At the lowest point L, θ = 0°		
	cos θ = cos 0° = 1		

$T_L \geq \frac{mv_L^2}{l} + mg \cos 0^\circ$	½	
$T_L \geq \frac{m(5gl)}{l} + mg$		
$T_L \geq 6\,mg$	½	5
OR		
(a) Suppose a particle of mass m_1 moving along X-axis with velocity u_1 collides with another particle of mass m_2 at rest. After the collision, let the two particles move with velocity v_1 and v_2, making angles θ_1 and θ_2 with X-axis.		
	1	
After the collision, the rectangular components of the momentum of m_1 are $m_1v_1 \cos\theta_1$ along +ve X-axis and $m_1v_1 \sin\theta_1$ along +ve Y-axis.	½	
After the collision, the rectangular components of the momentum of m_2 are $m_2v_2 \cos\theta_2$ along +ve X-axis and $m_2v_2 \sin\theta_2$ along –ve Y-axis.	½	
(b) (i) Glancing collision. For such collisions, $\theta_1 = 0^\circ$ and $\theta_2 = 90^\circ$.	½	

and $u_1 = v_1$ and $v_2 = 0$

$\therefore$ K.E. of the target particle $= \frac{1}{2} m_2 v_2^2 = 0$

Hence in a glancing collision the incident particle does not lose any kinetic energy and is scattered almost undeflected.

(ii) Head-on collision

In a head-on collision, the target particle moves in the direction of the incident particle i.e. $\theta_2 = 0°$. ½

$m_1 u_1 = m_1 v_1 \cos\theta_1 + m_2 v_2$ and $0 = m_1 v_1 \sin\theta_1$

Kinetic energy remains unchanged.

(iii) Elastic collision of two identical particles

As the two particles are identical so $m_1 = m_2 = m$ (say)

By conservation of kinetic energy for elastic collision.

$\frac{1}{2} m u_1^2 = \frac{1}{2} m v_1^2 + \frac{1}{2} m v_2^2$ or $u_1^2 = v_1^2 + v_2^2$ ½

By conservation of linear momentum

$m\vec{u}_1 = m\vec{v}_1 + m\vec{v}_2$ or $\vec{u}_1 = \vec{v}_1 + \vec{v}_2$ ½

$\therefore \vec{u}_1 \cdot \vec{u}_1 = \left(\vec{v}_1 + \vec{v}_2\right) \cdot (\vec{v}_1 + \vec{v}_2)$

$= \vec{v}_1 \cdot \vec{v}_1 + \vec{v}_1 \cdot \vec{v}_2 + \vec{v}_2 \cdot \vec{v}_1 + \vec{v}_2 \cdot \vec{v}_2$ ½

or $u_1^2 = v_1^2 + v_2^2 + 2\vec{v}_1 \cdot \vec{v}_2$

or $u_1^2 = u_1^2 + 2\vec{v}_1 \cdot \vec{v}_2$

or $\vec{v}_1 \cdot \vec{v}_2 = 0$ ½

This shows that the angle is 90°. Hence two identical particles moves at right angles to each other after elastic collision in two dimensions. 2+3=5