DPP – 8 (COM)

Q 1. A tennis ball bounces down a flight of stairs striking each step in turn and rebounding to the height of the step above. The coefficient of restitution is:

(a) $\frac{1}{2}$ (b) $\frac{1}{\sqrt{2}}$ (c) $\frac{1}{4}$ (d) 1

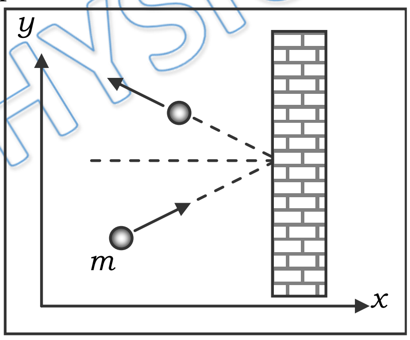
Q 2. A ball strikes a horizontal floor at an angle θ = 45°. The coefficient of restitution between the ball and the floor is e = $\frac{1}{2}$. The fraction of its kinetic energy lost in collision is :

(a) $\frac{5}{8}$ (b) $\frac{3}{8}$ (c) $\frac{3}{4}$ (d) $\frac{1}{4}$

Q 3. After perfectly inelastic collision between two identical particles moving with same speed in different directions, the speed of the particles become half the initial speed. The angle between the velocities of the two before collision is:

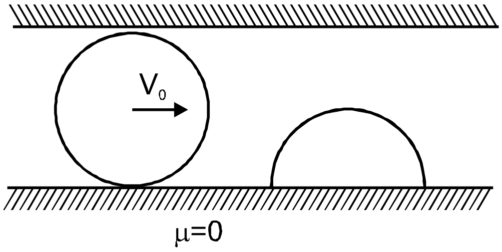
(a) 60° (b) 45° (c) 120° (d) 30°

Q 4. A ball of mass m moving with velocity $\vec{u} = u_x\hat{i} + u_y\hat{j}$ hits a vertical wall of infinite mass as shown in the figure. The ball slips up along the wall for the duration of collision and there is friction between the ball and the wall. Neglect the effect of gravity. Pick up the correct alternative.



(a) The net impulse of the wall on the ball must not be along the negative x-axis for the duration of collision.
(b) The collision changes only the x- component of velocity of the ball
(c) The collision changes only the y- component of velocity of the ball
(d) The impulse provided by frictional force to the ball for the duration of collision cannot be neglected in comparison to impulse provided by normal reaction.

Q 5. A smooth hemisphere of mass m and radius R is at rest. A smooth solid sphere of mass 2m and radius R moving with velocity V_0 between two horizontal smooth surfaces separated by a distance slightly greater than 2R as shown in figure. Solid sphere collides with the hemisphere. If coefficient of restitution is $\frac{1}{2}$, then :

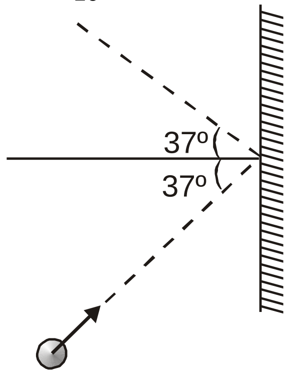


(a) The speed of hemisphere after collision is V_0
(b) The speed of solid sphere after collision is $\frac{V_0}{2}$
(c) The loss in kinetic energy of the system is $\frac{1}{4}mV_0^2$
(d) The final kinetic energy of hemisphere is $\frac{1}{4}$ th of initial kinetic energy of sphere

Q 6. A smooth sphere A of mass m collides elastically with an identical sphere B at rest. The velocity of A before collision is 8 m/s in a direction making 60º with the line joining the centres at the time of impact. Which of the following is/are possible:
(a) the sphere A comes to rest after collision
(b) the sphere B will move with a speed of 8 m/ after collision
(c) the directions of motion of A and B after collision are at right angles
(d) the speed of B after collision is 4 m/s.

Q 7. Two spheres A and B of masses m_1 and m_2 respectively collide. A is at rest initially and B is moving with velocity v along x-axis. After collision B has a velocity $\frac{v}{2}$ in a direction perpendicular to the original direction. The mass A moves after collision in the direction.
(a) same as that of B
(b) Opposite to that of B
(c) $\theta = \tan^{-1}(2)$ to the x-axis
(d) $\theta = \tan^{-1}(1/2)$ to the x-axis

Q 8. A particle moving on a smooth horizontal surface strikes a stationary wall. The angle of strike is equal to the angle of rebound & is equal to 37° and the coefficient of restitution with wall is e $=\frac{1}{5}$. Find the friction coefficient between wall and the particle in the form $\frac{x}{10}$ and fill value of :



Q 9. Two identical uniform solid smooth spheres each of mass m each approach each other with constant velocities such that net momentum of system of both spheres is zero. The speed of each sphere before collision is u. Both the spheres then collide. The condition of collision is given for each situation of column-I. In each situation of column-II information regarding speed of sphere(s) is given after the collision is over. Match the condition of collision in column-I with statements in column-II.

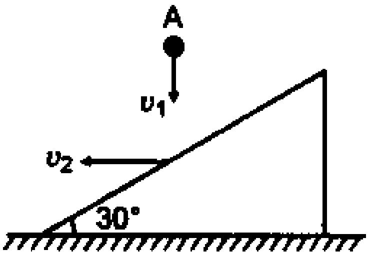
Column-I	**Column-II**
(A) Collision is perfectly elastic and head on	(p) speed of both spheres after collision is u
(B) Collision is perfectly elastic and oblique	(q) velocity of both spheres after collision is different
(C) Coefficient of restitution is $e = \frac{1}{2}$ and collision is head on	(r) speed of both spheres after collision is same but less than u.
(D) Coefficient of restitution is $e = \frac{1}{2}$ and collision is oblique	(s) speed of one sphere may be more than u.

Q 10. Two identical billiard balls are in contact on a table. A third identical ball strikes them symmetrically and remains at rest after impact. The coefficient of restitution is
(a) 2/3 (b) 1/3
(c) 1/6 (d) $\sqrt{(3/2)}$

Q 11. A gardener waters the plants by a pipe of diameter 1 cm. The water comes out at the rate of 20 cc/s. The reactionary force exerted on the hand of the gardener is:
(a) 2.54×10^{-5} N
(b) 1.62×10^{-3} N
(c) 5.1×10^{-3} N
(d) zero

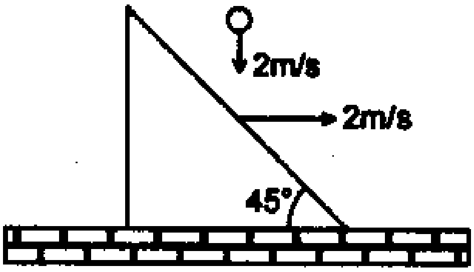
Q 12. A particle of mass m collides with a stationary particle and continues to move at an angle of 45° with respect to the original direction. The second particle also recoils at an angle of 45° to this direction. The mass of the second particle is: (collision is elastic)
(a) m (b) $\sqrt{2}$ m (c) $\frac{m}{\sqrt{2}}$ (d) $\frac{m}{2}$

Q 13. A ball A is falling vertically downwards with velocity v_1. It strikes elastically with a heavy wedge moving horizontally with velocity v_2 as shown in figure. What must be the ratio $\frac{v_1}{v_2}$, so that the ball bounces back in vertically upward direction relative to the wedge:



(a) $\sqrt{3}$ (b) $\frac{1}{\sqrt{3}}$ (c) $\frac{1}{\sqrt{2}}$ (d) $\frac{1}{2}$

Q 14. A small ball falling vertically downward with constant velocity 2 m/s strikes elastically an heavy inclined plane moving with velocity 2 m/s as shown in figure. The velocity of rebound of the ball with respect to ground is:



(a) 4 m/s (b) $2\sqrt{5}$ m/s (c) $2\sqrt{2}$ m/s (d) 2 m/s

Q 15. A girl throws a ball with Initial velocity v at an Inclination of 45°. The ball strikes a smooth vertical wall at a horizontal distance d from the girl and after rebouncing returns to her hand. What is the coefficient of restitution between the wall and the ball?

(a) $v^2 - gd$ (b) $\frac{gd}{v^2-gd}$

(c) $\frac{gd}{v^2}$ (d) $\frac{v^2}{gd}$

COMPREHENSION

When the mass of a system is variable, a thrust force has to be applied on it in addition to all other forces acting on it. This thrust force is given by:

$$\vec{F} = \vec{V}_r\left(\pm\frac{dm}{dt}\right)$$

Here $\vec{V}_r$ is the relative velocity with which the mass dm either enters or leaves the system. A box with a jet engine has total mass 50 kg. Gases are ejected from this backwards with relative velocity 20 m/s . The rate of ejection of gas is 2kg/s. Total mass of gas is 20 kg. Coefficient of friction between the box and road is $\mu = 0.1$.

Q 16. Box will start moving after time t = ………….. seconds:

(a) 4 (b) 10 (c) 5 (d) 8

Q 17. Maximum speed of box will be v = ……………. m/s: (Take in $\frac{4}{3}$ = 0.28)

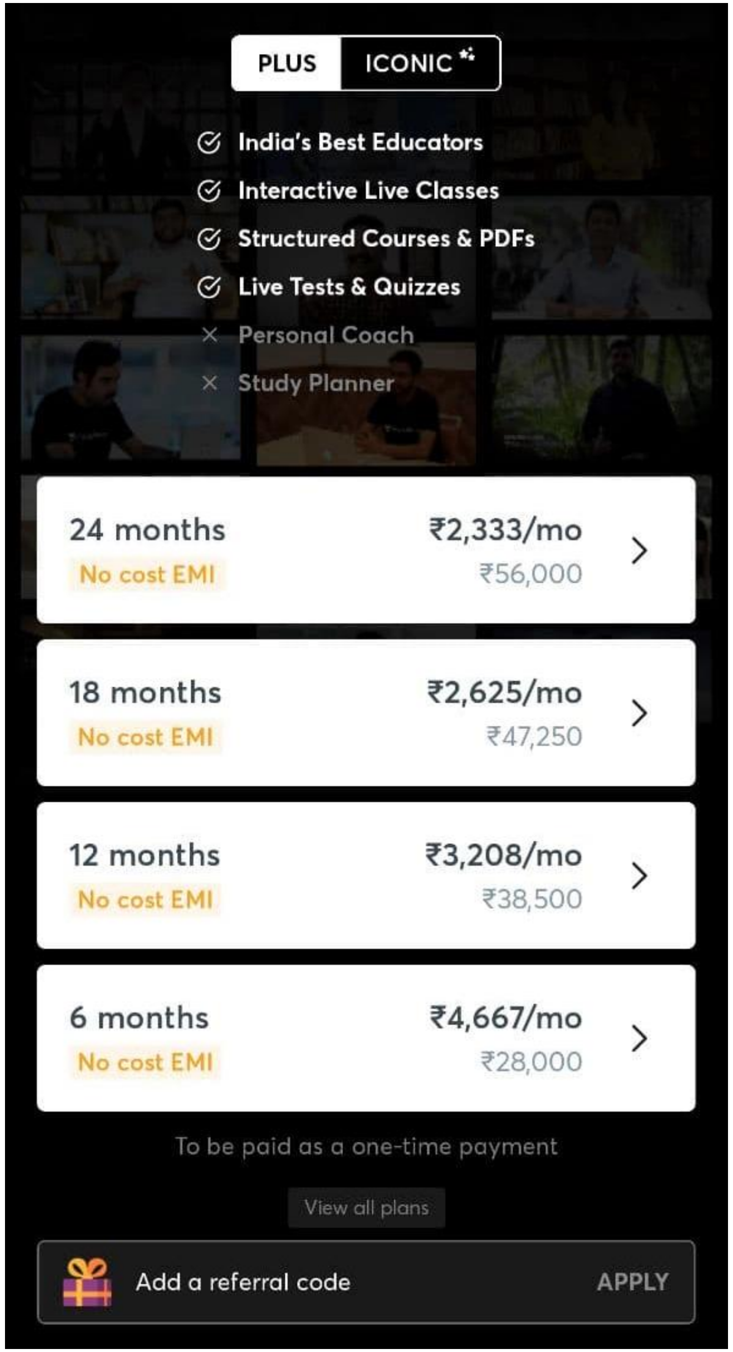
(a) 0.6 (b) 0.8 (c) 1.0 (d) 1.2

Q 18. box will stop after time (from starting) t = ……………….. seconds:

(a) 12.2 (b) 6.4 (c) 10.6 (d) 5.8.

Answer Key

Q.1 b	Q.2 b	Q.3 c	Q.4 a, d	Q.5 a, b, c
Q.6 c, d	Q.7 d	Q.8 5	Q.9 (A) p,q (B) p,q (C) q,r (D) q,r	Q.10 a
Q.11 c	Q.12 a	Q.13 b	Q.14 b	Q.15 b
Q.16 c	Q.17 a	Q.18 c		



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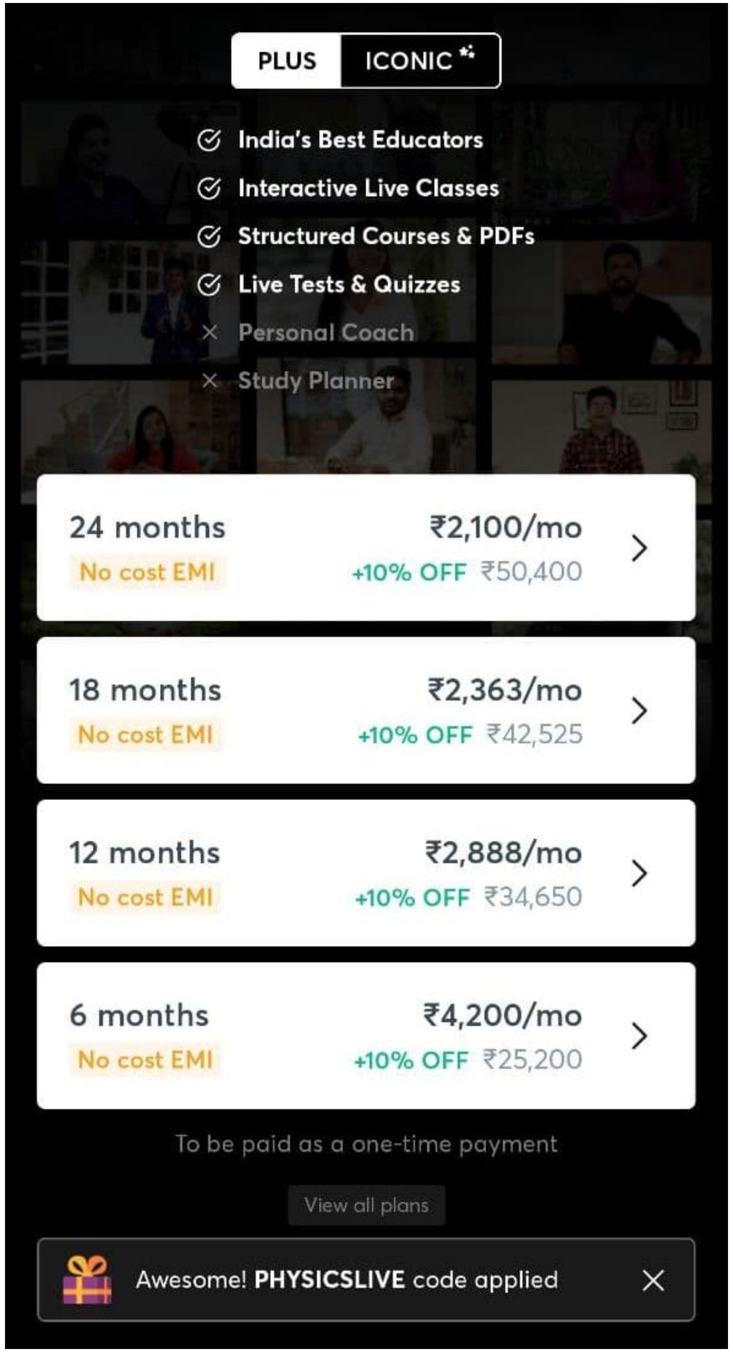

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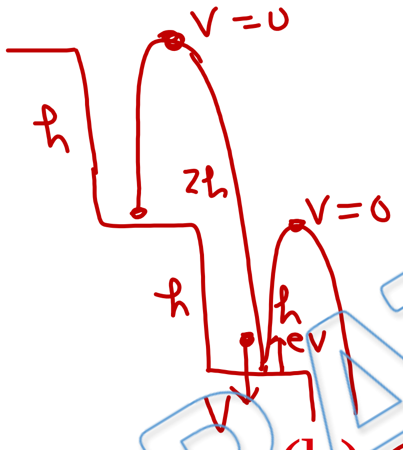
Written Solution

DPP- 8 : Oblique Collision,Variable Mass System

By Physicsaholics Team

Q.1) A tennis ball bounces down a flight of stairs striking each step in turn and rebounding to the height of the step above. The coefficient of restitution is:



$$V = \sqrt{2g \times 2h}$$

$$h = \frac{e^2 V^2}{2g}$$

$$h = \frac{e^2}{2g} \times 4gh$$

$$\Rightarrow e^2 = \frac{1}{2}$$

$$e = \frac{1}{\sqrt{2}}$$

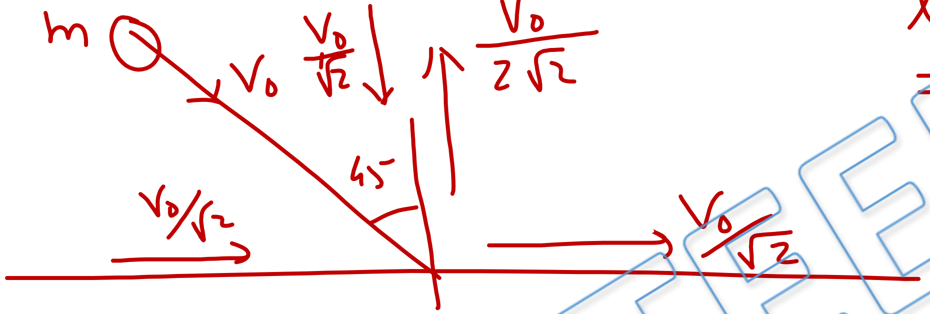
(a) $\frac{1}{2}$

(b) $\frac{1}{\sqrt{2}}$

(c) $\frac{1}{4}$

(d) 1

Q.2) A ball strikes a horizontal floor at an angle $\theta = 45°$. The coefficient of restitution between the ball and the floor is $e = \frac{1}{2}$. The fraction of its kinetic energy lost in collision is :



loss in KE

$$= \frac{1}{2} m V_0^2 - \frac{1}{2} m \left[\frac{V_0^2}{2} + \frac{V_0^2}{8} \right]$$

$$= \frac{1}{2} m V_0^2 - \frac{1}{2} m \left[\frac{4V_0^2 + V_0^2}{8} \right]$$

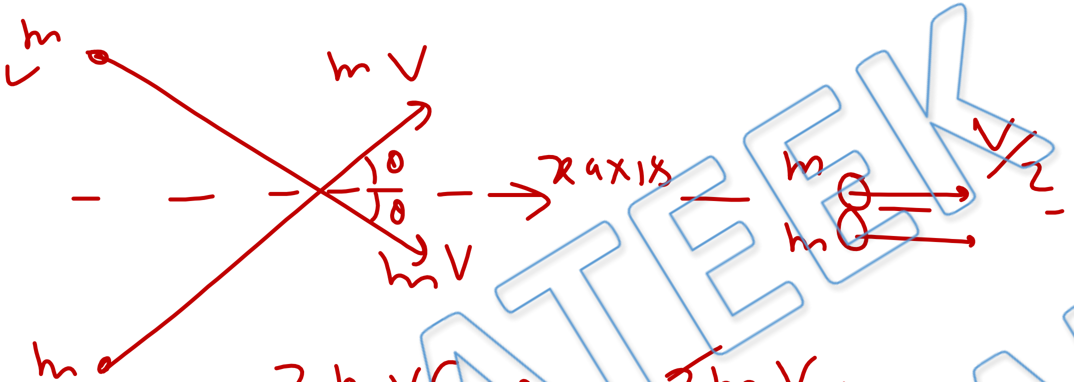
$$= \frac{mV_0^2}{2} \left[1 - \frac{5}{8} \right] = \frac{3}{16} m V_0^2$$

Initial KE $= \frac{1}{2} m V_0^2$

(a) $\frac{5}{8}$ (b) $\frac{3}{8}$ (c) $\frac{3}{4}$ (d) $\frac{1}{4}$

fractional loss $= \frac{3/16 \, m V_0^2}{\frac{1}{2} m V_0^2} = 3/8$

Q.3) After perfectly inelastic collision between two identical particles moving with same speed in different directions, the speed of the particles become half the initial speed. The angle between the velocities of the two before collision is:



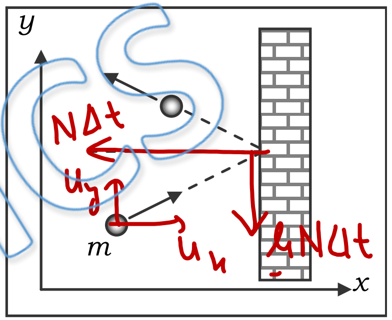
$2mv\cos\theta = 2mV/2$

(a) 60° (b) 45° (c) 120° (d) 30°

$\cos\theta = 1/2$

$\theta = 60$, $2\theta = 120°$

Q.4) A ball of mass m moving with velocity $\vec{u} = u_x\hat{i} + u_y\hat{j}$ hits a vertical wall of infinite mass as shown in the figure. The ball slips up along the wall for the duration of collision and there is friction between the ball and the wall. Neglect the effect of gravity. Pick up the correct alternative.



(a) The net impulse of the wall on the ball must not be along the negative x-axis for the duration of collision.

(b) The collision changes only the x- component of velocity of the ball

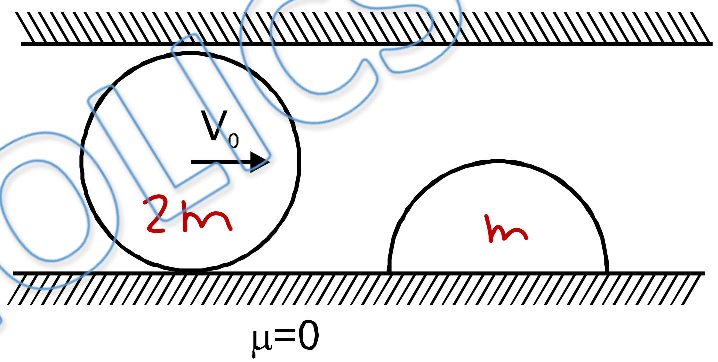
(c) The collision changes only the y- component of velocity of the ball

(d) The impulse provided by frictional force to the ball for the duration of collision cannot be neglected in comparison to impulse provided by normal reaction.

Q.5) A smooth hemisphere of mass m and radius R is at rest. A smooth solid sphere of mass 2m and radius R moving with velocity V_0 between two horizontal smooth surfaces separated by a distance slightly greater than 2R as shown in figure. Solid sphere collides with the hemisphere. If coefficient of restitution is $\frac{1}{2}$, then :

$$2mV_0 = mV_1 - 2mV_2$$

$$V_1 - 2V_2 = 2V_0 \quad --(1)$$



(a) The speed of hemisphere after collision is V_0

(b) The speed of solid sphere after collision is $\frac{V_0}{2}$

(c) The loss in kinetic energy of the system is $\frac{1}{4}mV_0^2$

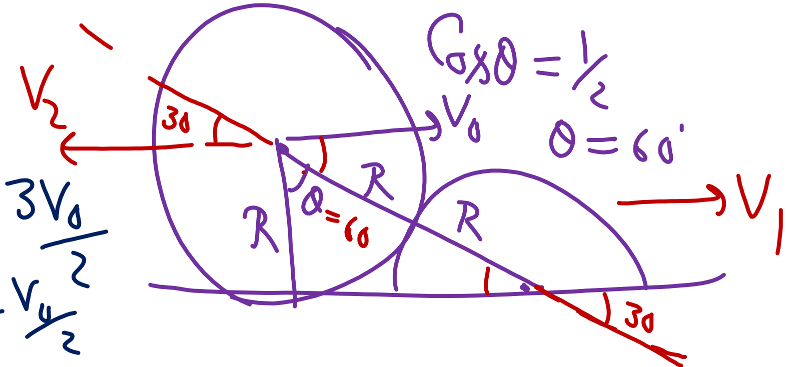
(d) The final kinetic energy of hemisphere is $\frac{1}{4}$ th of initial kinetic energy of sphere

$$e = \frac{1}{2} = \frac{V_1\cos 30 + V_2 \cos 30}{V_0 \cos 30}$$

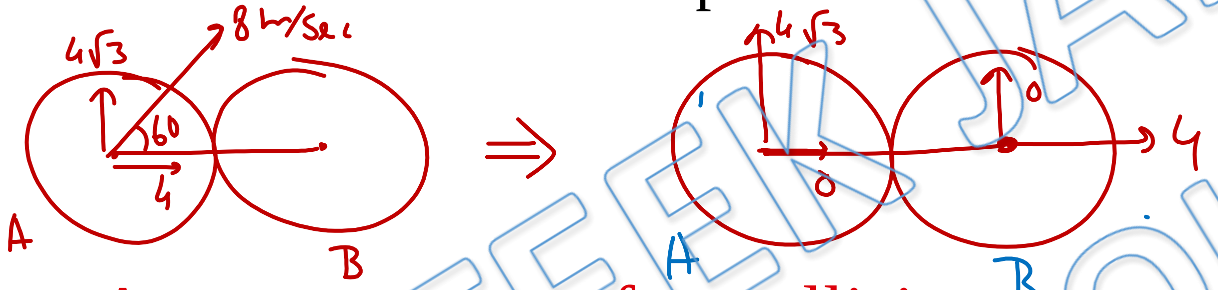
$$-V_1 + V_2 = -\frac{V_0}{2} \quad --(ii)$$

$$-3V_2 = \frac{3V_0}{2}$$

$$V_1 = V_0,\ V_2 = -\frac{V_0}{2}$$



Q.6) A smooth sphere A of mass m collides elastically with an identical sphere B at rest. The velocity of A before collision is 8 m/s in a direction making 60° with the line joining the centres at the time of impact. Which of the following is/are possible:



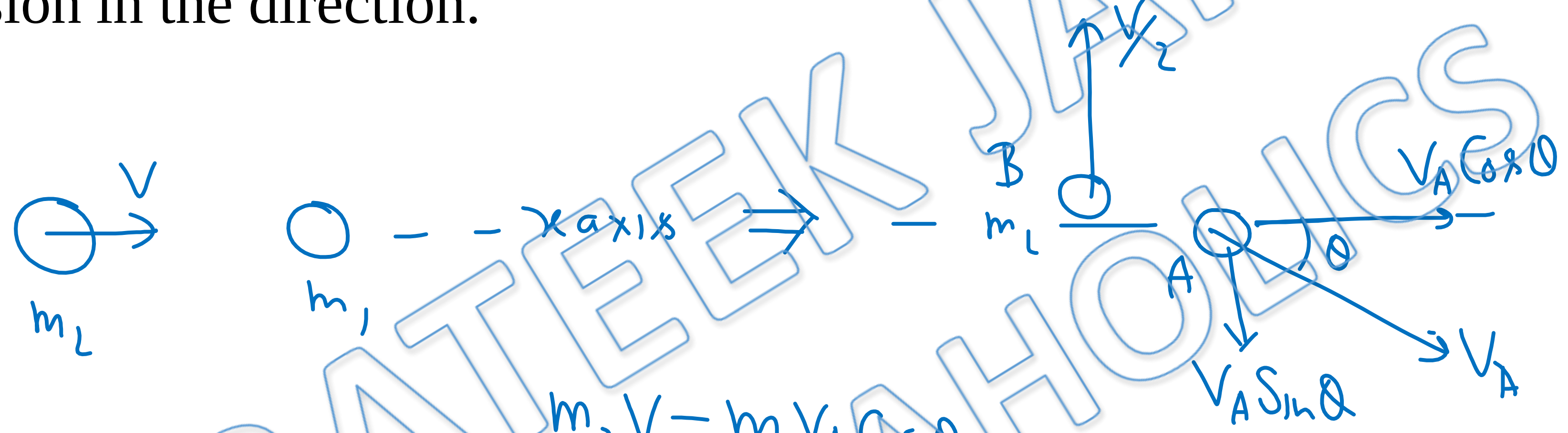
(a) the sphere A comes to rest after collision

(b) the sphere B will move with a speed of 8 m/ after collision

(c) the directions of motion of A and B after collision are at right angles

(d) the speed of B after collision is 4 m/s.

Q.7) Two spheres A and B of masses m_1 and m_2 respectively collide. A is at rest initially and B is moving with velocity v along x-axis. After collision B has a velocity $\frac{v}{2}$ in a direction perpendicular to the original direction. The mass A moves after collision in the direction.



$m_2 V = m_1 V_A \cos\theta$

(a) same as that of B

(b) Opposite to that of B

$m_2 \frac{V}{2} = m_1 V_A \sin\theta$

(c) $\theta = \tan^{-1}(2)$ to the x-axis

(d) $\theta = \tan^{-1}(1/2)$ to the x-axis

$\frac{1}{2} = \tan\theta$

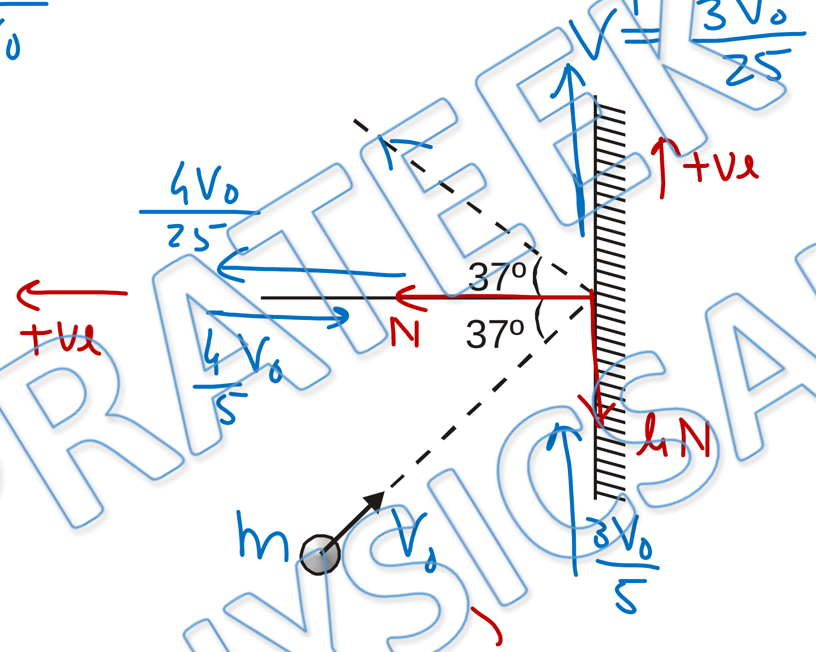
$\theta = \tan^{-1}\left(\frac{1}{2}\right)$

Q.8) A particle moving on a smooth horizontal surface strikes a stationary wall. The angle of strike is equal to the angle of rebound & is equal to 37° and the coefficient of restitution with wall is e $=\frac{1}{5}$. Find the friction coefficient between wall and the particle in the form $\frac{X}{10}$ and fill value of X.:

$e = 1/5$

$\tan 37 = \frac{3}{4} = \frac{V' \times 25}{4V_0}$

$V' = \frac{3V_0}{25}$



$N\Delta t = \frac{4mV_0}{25} - \left(-\frac{4mV_0}{5}\right)$

$N\Delta t = \frac{24}{25} mV_0 \quad -(1)$

$-\mu N\Delta t = \frac{3mV_0}{25} - \frac{3mV_0}{5}$

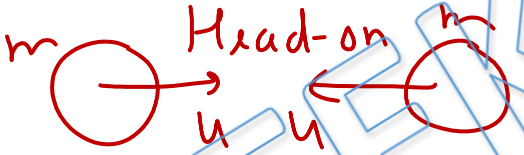
$\mu \times \frac{24}{25} mV_0 = \frac{12}{25} mV_0$

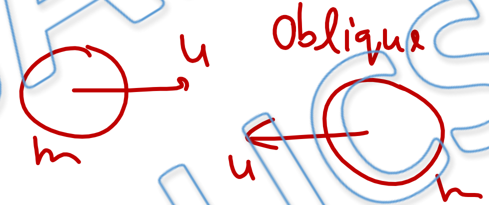
$\mu = 1/2$

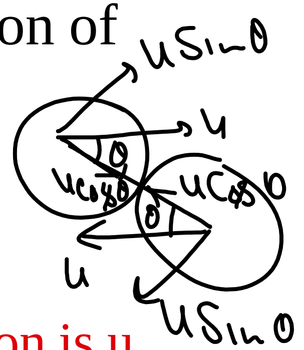
$\frac{1}{2} = \frac{X}{10}$

$X = 5$

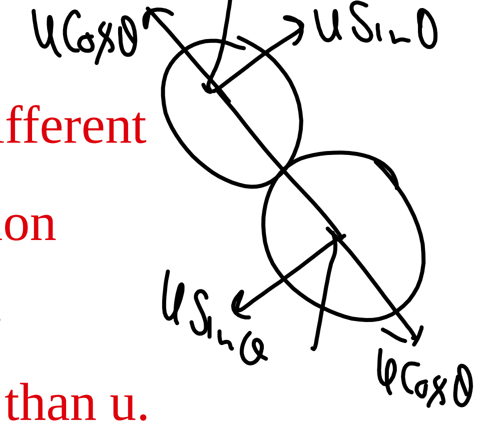
Q.9) Two identical uniform solid smooth spheres each of mass m each approach each other with constant velocities such that net momentum of system of both spheres is zero. The speed of each sphere before collision is u. Both the spheres then collide. The condition of collision is given for each situation of column-I. In each situation of column-II information regarding speed of sphere(s) is given after the collision is over. Match the condition of collision in column-I with statements in column-II.

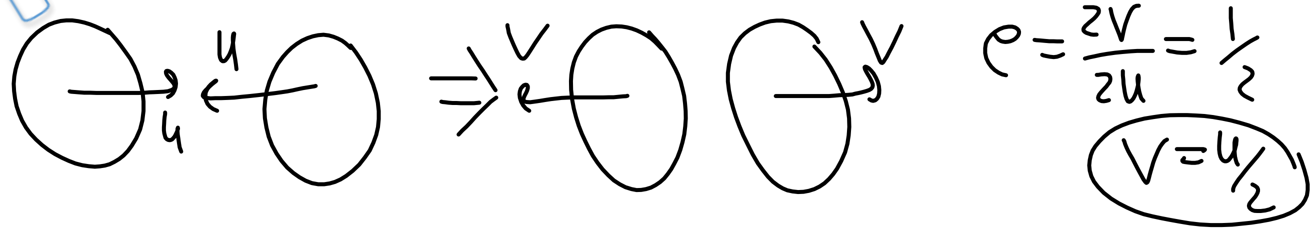






Column-I	**Column-II**
(A) Collision is perfectly elastic and head on	(p) speed of both spheres after collision is u
(B) Collision is perfectly elastic and oblique	(q) velocity of both spheres after collision is different
(C) Coefficient of restitution is $e = \frac{1}{2}$ and collision is head on	(r) speed of both spheres after collision is same but less than u.
(D) Coefficient of restitution is $e = \frac{1}{2}$ and collision is oblique	(s) speed of one sphere may be more than u.





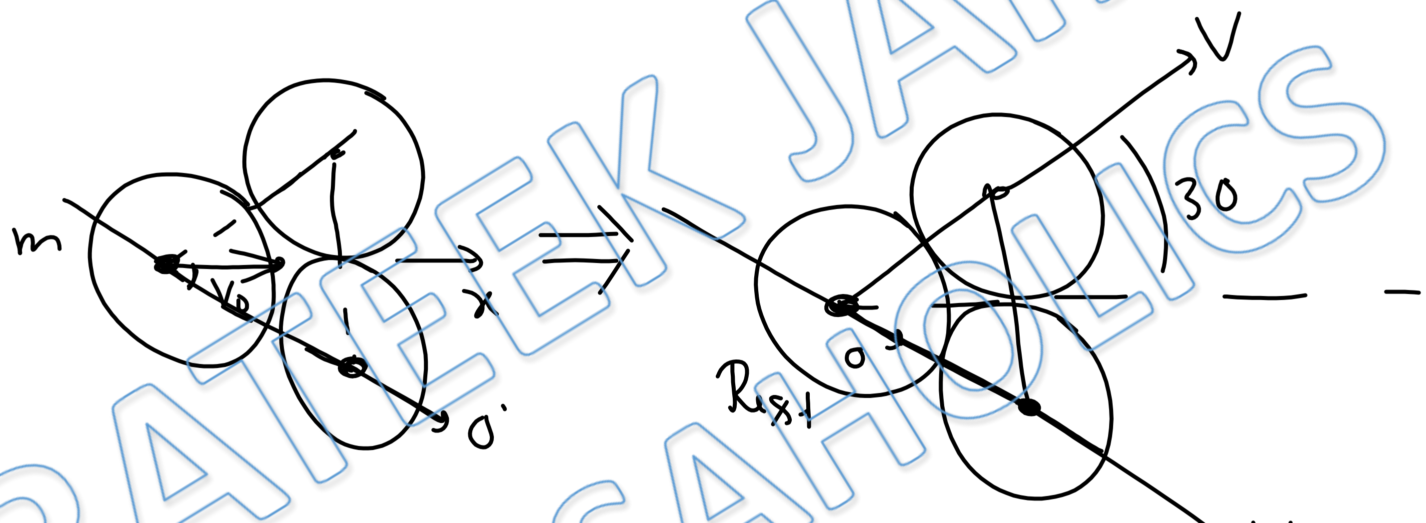
Q.10) Two identical billiard balls are in contact on a table. A third identical ball strikes them symmetrically and remains at rest after impact. The coefficient of restitution is

(a) 2/3

(b) 1/3

(c) 1/6

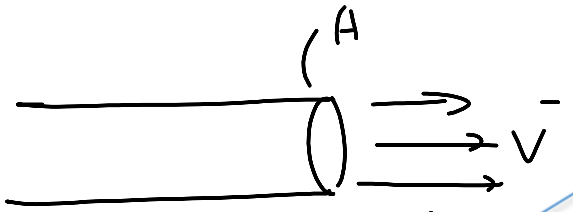
(d) √(3/2)



$$mV_0 = 2mV\cos 30 \Rightarrow V = \frac{V_0}{\sqrt{3}}$$

$$e = \frac{V}{V_0 \cos 30} = \frac{1}{\sqrt{3} \times \frac{\sqrt{3}}{2}} = \frac{2}{3}$$

Q.11) A gardener waters the plants by a pipe of diameter 1 cm. The water comes out at the rate of 20 cc/s. The reactionary force exerted on the hand of the gardener is:



Volume Rate of flow $= AV = 20\ cc/sec$

mass rate of flow $= \rho A V$

(a) 2.54×10^{-5} N

(b) 1.62×10^{-3}N

(c) 5.1×10^{-3} N ✓

(d) zero

Reaction by gardener

$$= \rho A V^2$$

$$= 1\left(\frac{A^2V^2}{A}\right) = \frac{20\times 20\times 4}{\pi \times 1^2}\ \text{dyne}$$

$$= \frac{16\times 10^2}{\pi}\ \text{dyne} = \frac{16}{\pi}\times 10^2 \times 10^{-5}\ \text{N}$$

$$= \frac{16}{\pi}\times 10^{-3}\ \text{N}$$

Q.12) A particle of mass m collides with a stationary particle and continues to move at an angle of 45° with respect to the original direction. The second particle also recoils at an angle of 45° to this direction. The mass of the second particle is: (collision is elastic)

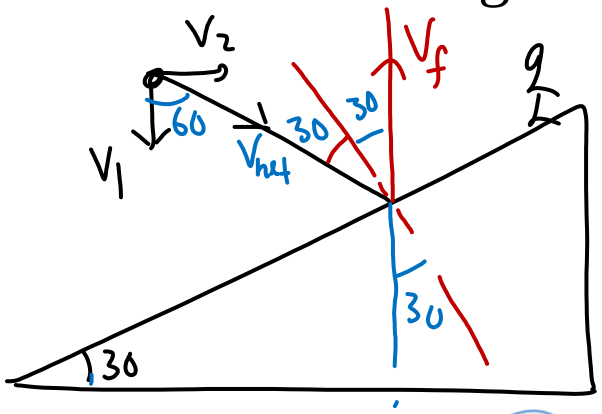
(a) m

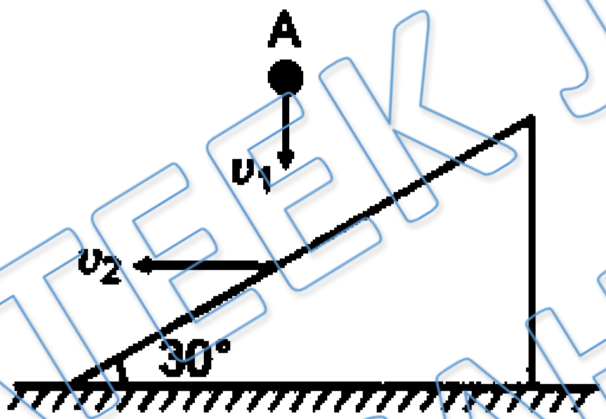
(b) $\sqrt{2}$ m

(c) $\frac{m}{\sqrt{2}}$

(d) $\frac{m}{2}$

Q.13) A ball A is falling vertically downwards with velocity v_1. It strikes elastically with a heavy wedge moving horizontally with velocity v_2 as shown in figure. What must be the ratio $\frac{v_1}{v_2}$, so that the ball bounces back in vertically upward direction relative to the wedge:



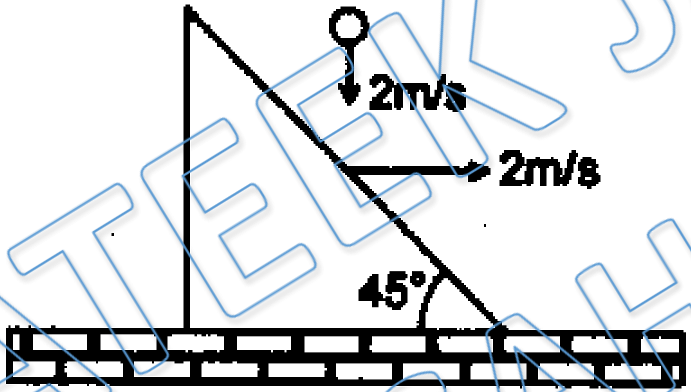


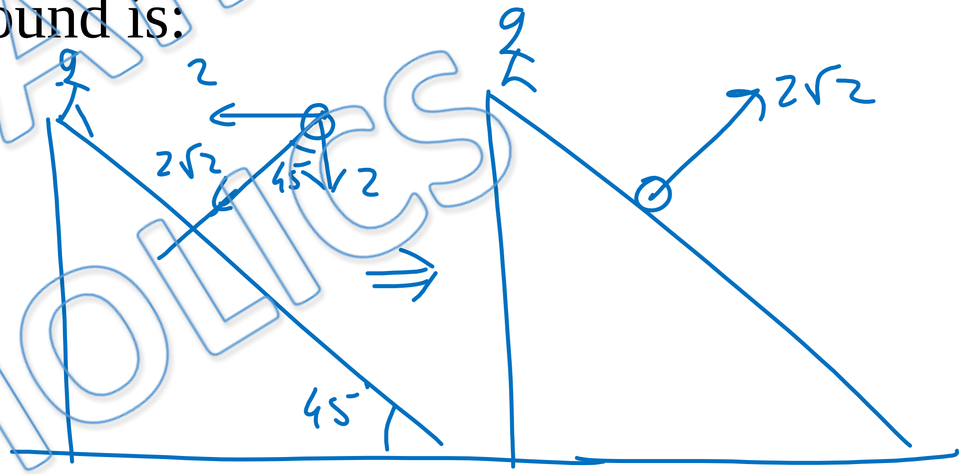
(a) $\sqrt{3}$ (b) $\frac{1}{\sqrt{3}}$ (c) $\frac{1}{\sqrt{2}}$ (d) $\frac{1}{2}$

$$\tan 60 = \frac{V_2}{V_1} = \sqrt{3}$$

$$\frac{V_1}{V_2} = \frac{1}{\sqrt{3}}$$

Q.14) A small ball falling vertically downward with constant velocity 2 m/s strikes elastically an heavy inclined plane moving with velocity 2 m/s as shown in figure. The velocity of rebound of the ball with respect to ground is:





(a) 4 m/s (b) $2\sqrt{5}$ m/s (c) $2\sqrt{2}$ m/s (d) 2 m/s

Velocity of ball w.r.t. ground after collision

$$\vec{V}_{b,g} = \vec{V}_{b,In} + \vec{V}_{In,g}$$

$$V_{b,g} = \sqrt{16+4} = 2\sqrt{5}$$

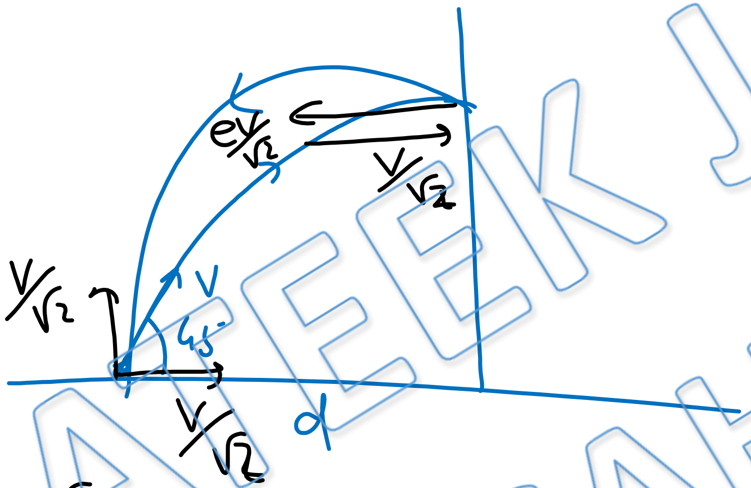
Q.15) A girl throws a ball with Initial velocity v at an Inclination of 45°. The ball strikes a smooth vertical wall at a horizontal distance d from the girl and after rebouncing returns to her hand. What is the coefficient of restitution between the wall and the ball?

(a) $v^2 - gd$

(b) $\frac{gd}{v^2 - gd}$ ✓

(c) $\frac{gd}{v^2}$

(d) $\frac{v^2}{gd}$



from horizontal motion

$t_1 = \frac{d\sqrt{2}}{v}$

$t_2 = \frac{d\sqrt{2}}{ev}$

Total time of motion

$t_1 + t_2 = \frac{2u_y}{g} = \frac{2v}{g\sqrt{2}}$

$\frac{d\sqrt{2}}{v}\left(1 + \frac{1}{e}\right) = \frac{2v}{g\sqrt{2}}$

$1 + \frac{1}{e} = \frac{v^2}{dg}$

$\frac{1}{e} = \frac{v^2}{dg} - 1$

COMPREHENSION

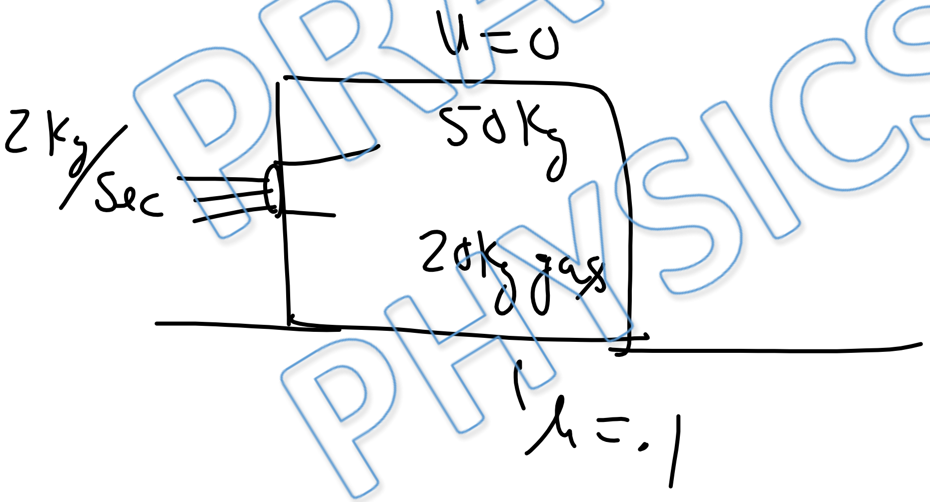
When the mass of a system is variable, a thrust force has to be applied on it in addition to all other forces acting on it. This thrust force is given by:

$$\vec{F} = \vec{V_r}\left(\pm\frac{dm}{dt}\right)$$

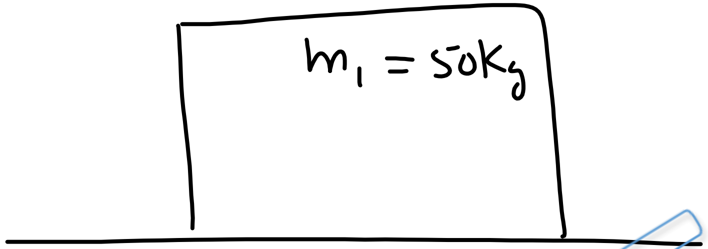
Here $\vec{V_r}$ is the relative velocity with which the mass dm either enters or leaves the system . A box with a jet engine has total mass 50 kg. Gases are ejected from this backwards with relative velocity

20 m/s . The rate of ejection of gas is 2kg/s.

Total mass of gas is 20 kg. Coefficient of friction between the box and road is $\mu = 0.1$.



Q.16) Box will start moving after time t = ………….. seconds:



(a) 4 (b) 10 (c) 5 (d) 8

mass of box at $t = t$, $m = 50 - 2t$

Limiting friction at $t = t$, $f = .1(50 - 2t)g = 50 - 2t$

Thrust force $= \lambda V_{rel} = 2 \times 20 = 40$

To just start motion $50 - 2t = 40$

$t = 5$ sec

Q.17) Maximum speed of box will be v = ……………. m/s: (Take in $\frac{4}{3}$ = 0.28)

$$a = \frac{40 - (50-2t)}{50-2t}$$

$$a = \frac{40}{50-2t} - 1$$

(a) 0.6 (b) 0.8 (c) 1.0 (d) 1.2

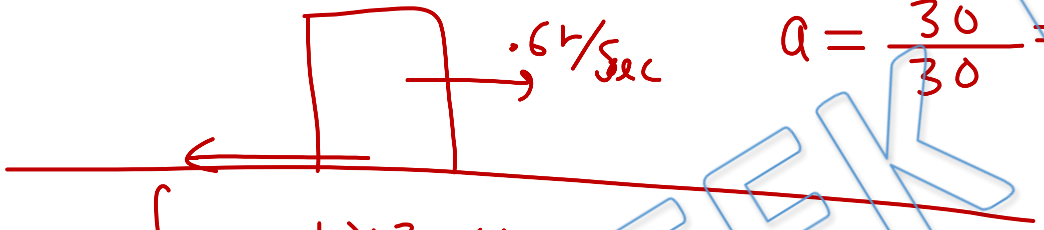
$$\int_0^V dv = \int_5^{10} \left(\frac{40}{50-2t} - 1\right) dt$$

$$V = \frac{40}{-2}\left[\ln(50-2t)\right]_5^{10} - \left[t\right]_5^{10} = -20\left[\ln \tfrac{3}{4}\right] - 5$$

$$= 20 \times .28 - 5 = .6$$

Q.18) box will stop after time (from starting) t = ………………….. seconds:

$t = 10\ \text{sec}$



$a = \frac{30}{30} = 1\ \text{m/sec}^2$

$f_r = .1 \times 30 \times 10 = 30\ \text{N}$

(a) 12.2 (b) 6.4 (c) 10.6 (d) 5.8

$v = u + at$

$0 = .6 - 1t$

$t = .6\ \text{sec}$

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Chalo Niklo