Physicsaholics

DPP – 4 (COM)

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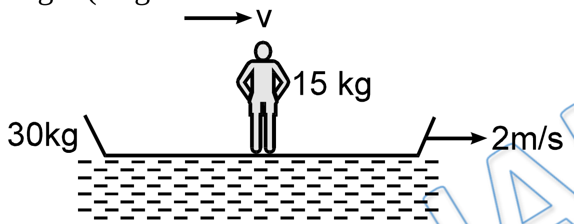
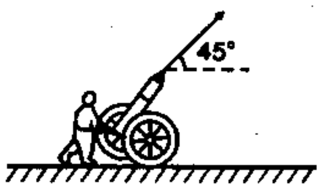
Q 1. In the figure shown the initial velocity of boat (30 kg) + person (15 kg) is 2 m/s. Man starts moving on boat. Find velocity of person w.r.t. boat so that velocity of boat will be 1 m/s in right (Neglect friction between boat and water)



(a) 3 m/s towards right
(b) 3 m/s towards left
(c) 4 m/s towards right
(d) 4 m/s towards left

Q 2. The resultant force on a system of particles is zero.
(a) The centre of mass of the system must be at rest.
(b) Acceleration of each particle may be in the same direction.
(c) Velocity of each particle may be in the same direction at some instant of time.
(d) If only one particle has initially non-zero velocity, then it is possible that all the particles have zero velocity simultaneously, later on.

Q 3. A gun fires a bullet as shown in figure. The barrel of the gun is inclined at an angle of 45^0 with horizontal. When the bullet leaves the barrel, it will be travelling at an angle to the horizontal, of:

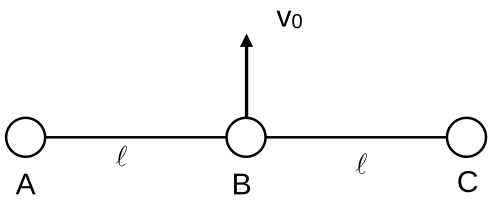


(a) 45° (b) less than 45° (c) more than 45° (d) zero

Q 4. A block of mass 1kg is pushed on a movable wedge of mass 2kg and height h = 30 cm with a velocity u = 6m/sec. Before striking the wedge it travels 2 m on a rough horizontal portion. Velocity is just sufficient for the block to reach the top of the wedge. Assuming all surfaces are smooth except the given horizontal part and collision of block and wedge is jerkless, the friction coefficient of the rough horizontal part is **:**

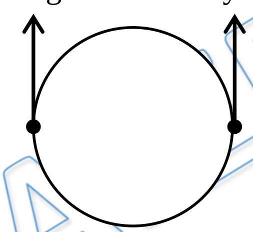
(a) 0.125 (b) 0.377 (c) 0.675 (d) 0.45

Q 5. Three identical balls each are connected by light inextensible strings with each other as shown and rest over a smooth horizontal table. At moment t = 0, ball B is imparted a velocity. Calculate the velocity of A when it collides with ball C.



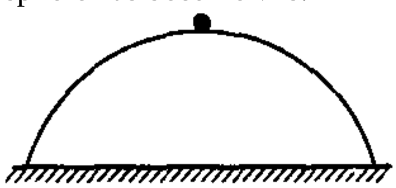
(a) $\frac{2v_0}{3}$ (b) $\frac{v_0}{3}$ (c) $\frac{v_0}{2}$ (d) $\frac{2v_0}{5}$

Q 6. On a smooth horizontal surface, a ring of mass M lies with two insects of mass m, on its diametrically opposite points. The insects move with velocity v in same direction relative to the ring. The velocity of the ring as the insects meet is



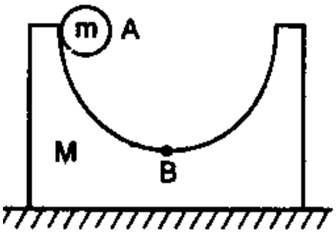
(a) $\frac{Mv}{2m}$ (b) $\frac{M-m}{M+m}$
(c) zero (d) $\frac{2m}{M}v$

Q 7. A hemisphere of radius R and of mass 4m is free to slide with its base on a smooth horizontal table. A particle of mass m is placed on the top of the hemisphere. The angular velocity of the particle relative to hemisphere at an angular displacement θ when velocity of hemisphere has become v is:



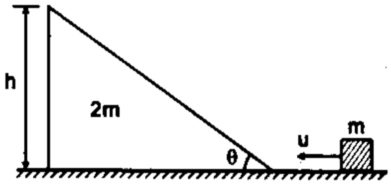
(a) $\frac{5v}{R\cos\theta}$ (b) $\frac{2v}{R\cos\theta}$ (c) $\frac{3v}{R\sin\theta}$ (d) $\frac{5v}{R\sin\theta}$

Q 8. A block of mass M = 2 kg with a semicircular track of radius R = 1.1 m rests on a horizontal frictionless surface. A uniform cylinder of radius r = 10 cm and mass m = 1.0 kg is released from rest from the top point A. The cylinder slips on the semicircular frictionless track. The speed of the block when the cylinder reaches the bottom of the track at B is :(g = 10 m/s^2)



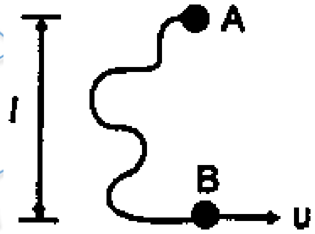
(a) $\sqrt{\frac{10}{3}} m/s$ (b) $\sqrt{\frac{4}{3}} m/s$ (c) $\sqrt{\frac{5}{2}} m/s$ (d) $\sqrt{10} m/s$

Q 9. A block of mass m in is pushed towards a movable wedge of mass 2 m and height h with a velocity u. All surfaces axe smooth. The minimum value of a for which the block will reach the top of the wedge is:



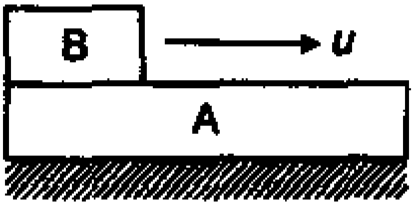
(a) $2\sqrt{gh}$ (b) $\sqrt{3gh}$ (c) $\sqrt{6gh}$ (d) $\frac{\sqrt{32}}{gh}$

Q 10. Two particles A and B each of mass m are attached by a light inextensible suing of length 2 L The whole system lies on a smooth horizontal table with B initially at a distance *l* from A. The particle at end B is projected across the table with speed is perpendicular to AB. Velocity of ball A just after the string Is taut, is :



(a) $\frac{u\sqrt{3}}{4}$ (b) $u\sqrt{3}$ (c) $\frac{u\sqrt{3}}{2}$ (d) $\frac{u}{2}$

Q 11. A horizontal block A is at rest on a smooth horizontal surface. A small block B, whose mass is half of A, is placed on A at one end and projected along other end with some velocity is given. The coefficient of friction between blocks is μ. Then:



(a) the blocks will reach a final common velocity u/3
(b) the work done against friction is two-third of the initial kinetic energy of B
(c) before the blocks reach a common velocity the acceleration of A relative to B is (2/3)μg

(d) before the blocks reach a common velocity, the acceleration of A relative to B is (3/2)μg

Q 12. A man of mass m is stationary on a stationary flat car. The car can move without friction along horizontal rails. The man starts walking with velocity v relative to the car. Work done by him:

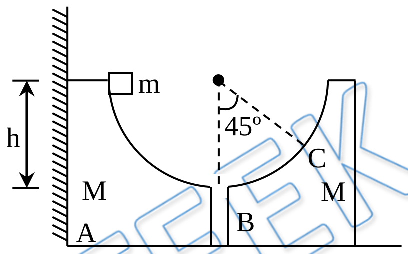
(a) is less than $\frac{1}{2}mv^2$, if he walks along the rails

(b) is equal to $\frac{1}{2}mv^2$, if he walks normal to rails

(c) can never be less than $\frac{1}{2}mv^2$

(d) is greater than $\frac{1}{2}mv^2$, if he walks along the rails

Q 13. Two identical blocks having mass M each are smoothly conjugated and placed on a smooth horizontal floor as shown in figure. On left of block A, there is a wall. A small block of mass m is released from the position shown in figure. Velocity of block B is maximum –



(a) when m is at highest position on B

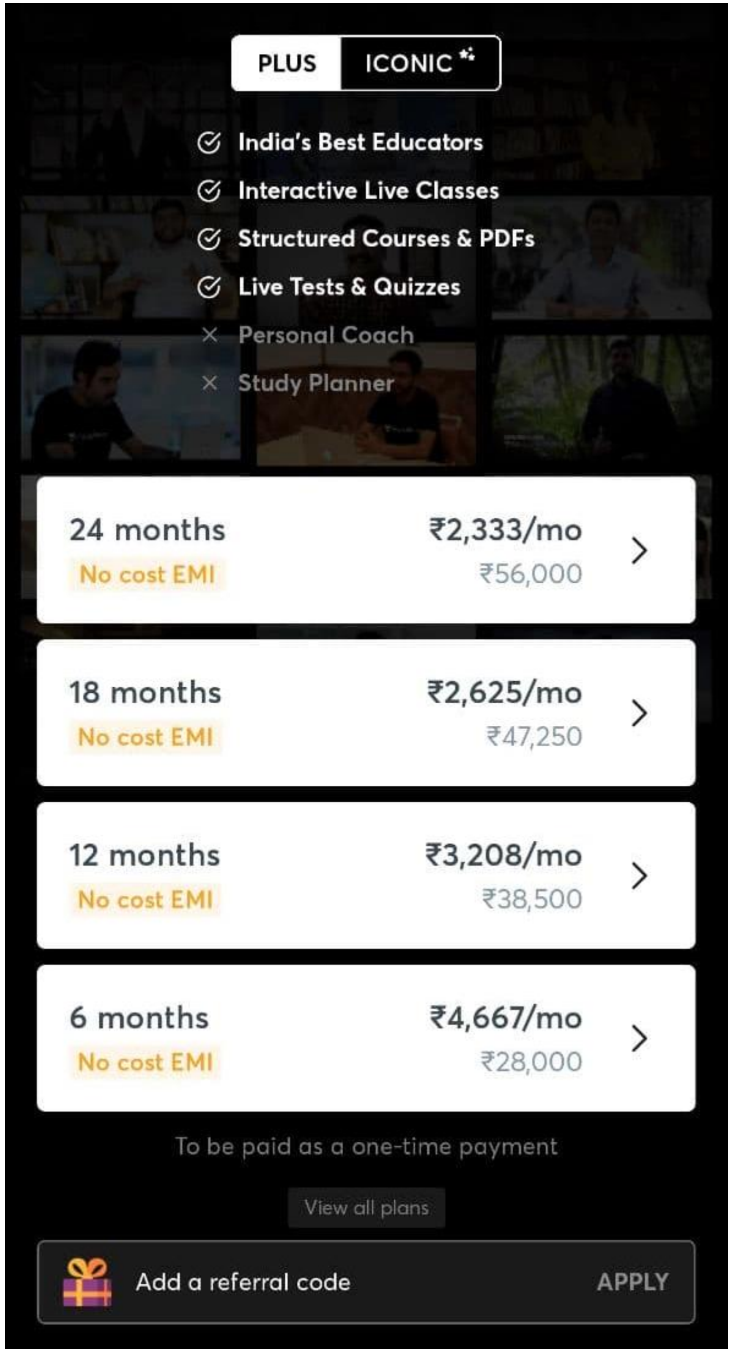
(b) when m is at lowest position and moving towards left

(c) when m is at point C

(d) is equal to $\frac{m\sqrt{2gh}}{m+M}$

Answer Key

Q.1 a	**Q.2 c**	**Q.3 c**	**Q.4 c**	**Q.5 a**
Q.6 c	**Q.7 a**	**Q.8 a**	**Q.9 b**	**Q.10 a**
Q.11 a, b, d	**Q.12 a, b**	**Q.13 b**		



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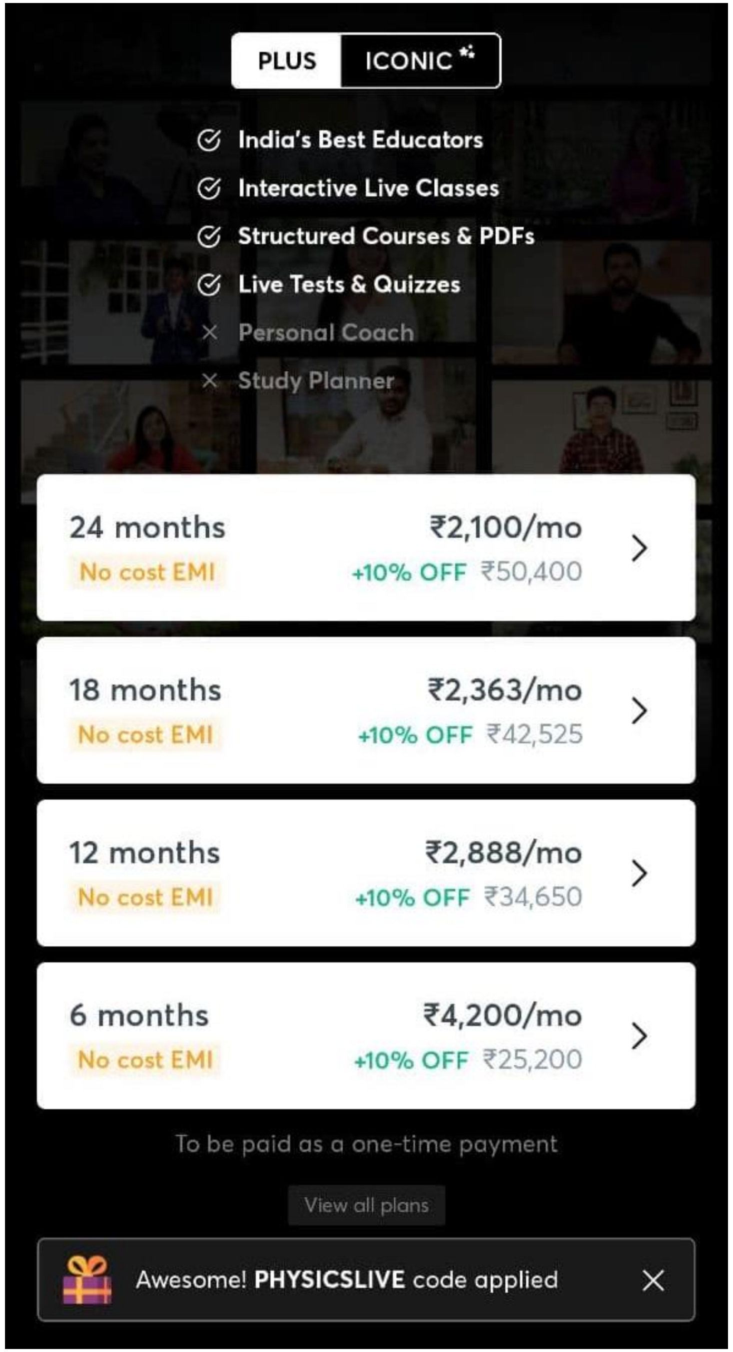


Written Solution

DPP- 4: Conservation of Momentum.

By Physicsaholics Team

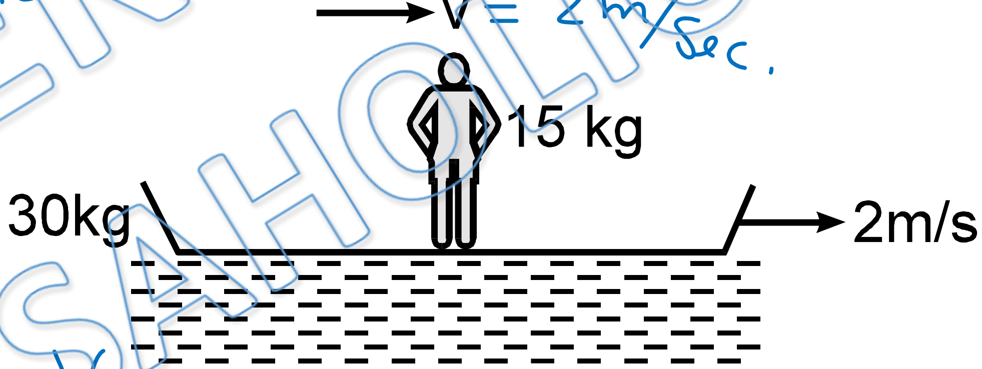
Q.1) In the figure shown the initial velocity of boat (30 kg) + person (15 kg) is 2 m/s. Man starts moving on boat. Find velocity of person w.r.t. boat so that velocity of boat will be 1 m/s in right (Neglect friction between boat and water)

by Conservation of momentum → +ve

$45 \times 2 = 30 \times 1 + 15 v$

$15 v = 60$

$v = 4 m/sec$



(a) 3 m/s towards right

(b) 3 m/s towards left

(c) 4 m/s towards right

(d) 4 m/s towards left

$V_{m,b} = V_{m,g} - V_{b,g}$

$= 4 - 1$

$= 3 m/sec$

V (w.r.t ground) 1 m/sec

Q.2) The resultant force on a system of particles is zero.

$\vec{F}_{net} = 0 \Rightarrow \vec{a}_{cm} = 0 \Rightarrow \vec{V}_{cm} = \text{Constant}$

$\vec{a}_{cm} = \frac{m_1\vec{a_1} + m_2\vec{a_2} + \cdots}{m_1 + m_2}$

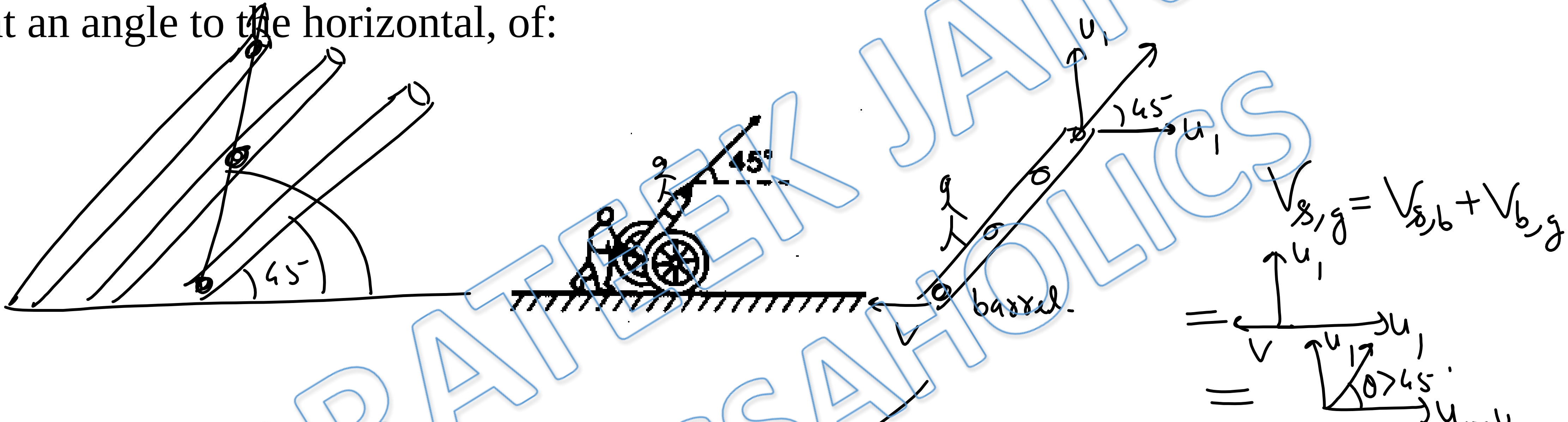
(a) The centre of mass of the system must be at rest.

(b) Acceleration of each particle may be in the same direction.

(c) Velocity of each particle may be in the same direction at some instant of time.

(d) If only one particle has initially non-zero velocity then it is possible that all the particles have zero velocity simultaneously, later on.

Q.3) A gun fires a bullet as shown in figure. The barrel of the gun is inclined at an angle of 45^0 with horizontal. When the bullet leaves the barrel, it will be travelling at an angle to the horizontal, of:



(a) 45° (b) less than 45° (c) more than 45° (d) zero

Q.4) A block of mass 1kg is pushed on a movable wedge of mass 2kg and height h = 30 cm with a velocity u = 6m/sec. Before striking the wedge it travels 2 m on a rough horizontal portion. Velocity is just sufficient for the block to reach the top of the wedge. Assuming all surfaces are smooth except the given horizontal part and collision of block and wedge is jerkless, the friction coefficient of the rough horizontal part is :

Using Conservation of momentum from A to B →

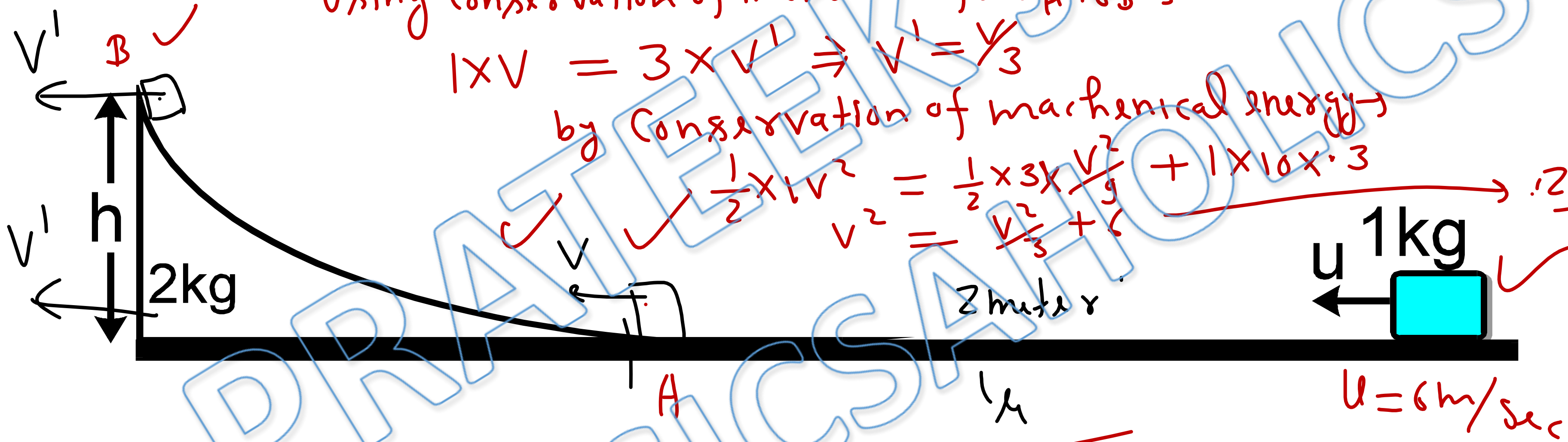
$1 \times V = 3 \times V' \Rightarrow V' = V/3$

by Conservation of mechanical energy →

$\frac{1}{2} \times 1 \times V^2 = \frac{1}{2} \times 3 \times \frac{V^2}{9} + 1 \times 10 \times .3$

$V^2 = \frac{V^2}{3} + 6 \rightarrow \frac{2V^2}{3} = 6$

$V = 3\ m/sec$



(a) 0.125 (b) 0.377 (c) 0.675 (d) 0.45

Using Work-Energy theorem :-

$-\mu \times 1 \times 10 \times 2 = \frac{1}{2} \times 1 (9 - 36)$

$20\mu = -\frac{27}{2}$

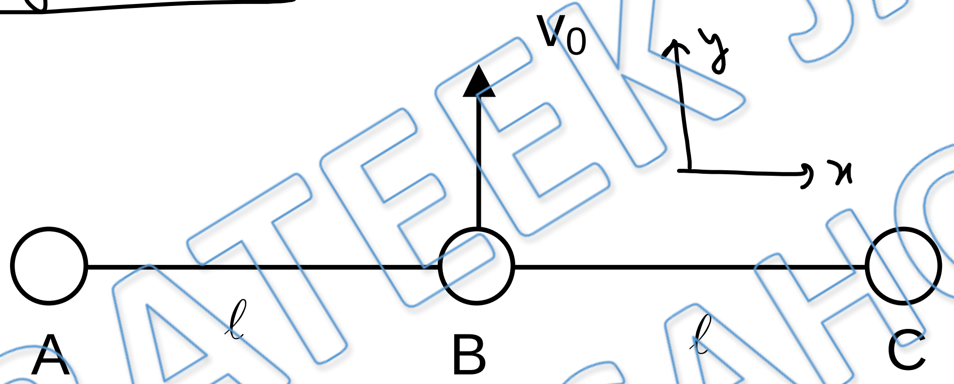
$\mu = \frac{27}{40}$

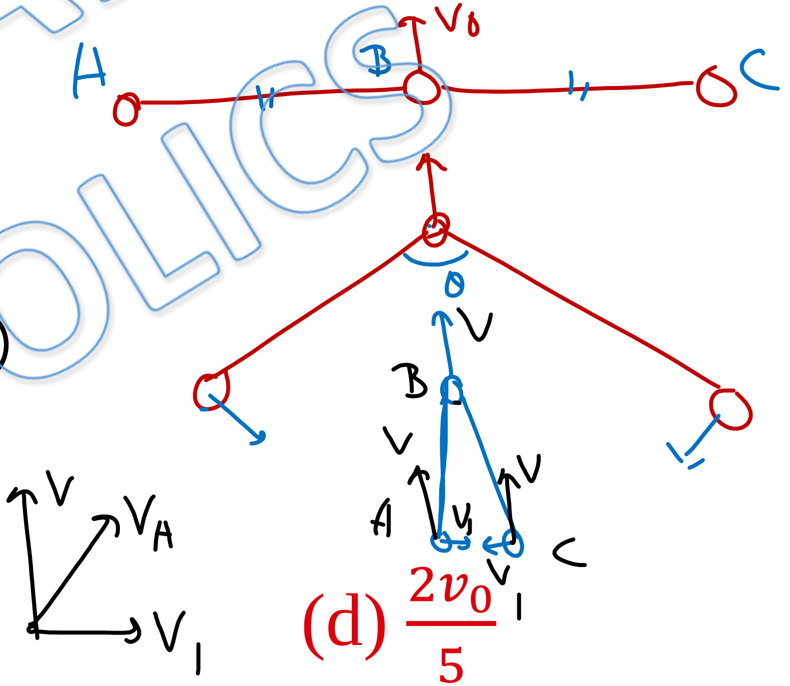
Q.5) Three identical balls each are connected by light inextensible strings with each other as shown and rest over a smooth horizontal table. At moment t = 0, ball B is imparted a velocity. Calculate the velocity of A when it collides with ball C.

by COM in y direction

$mV_0 = 3mV$

$V = V_0/3$





(a) $\frac{2v_0}{3}$ (b) $\frac{v_0}{3}$ (c) $\frac{v_0}{2}$ (d) $\frac{2v_0}{5}$

by Conservation of Mechanical Energy →

$\frac{1}{2}mV_0^2 = \frac{1}{2}m\left(\frac{V_0}{3}\right)^2 + \frac{1}{2}mV_A^2 \times 2$

$\frac{1}{2}mV_0^2 \times \frac{8}{9} = mV_A^2 \Rightarrow V_A = \frac{2V_0}{3}$

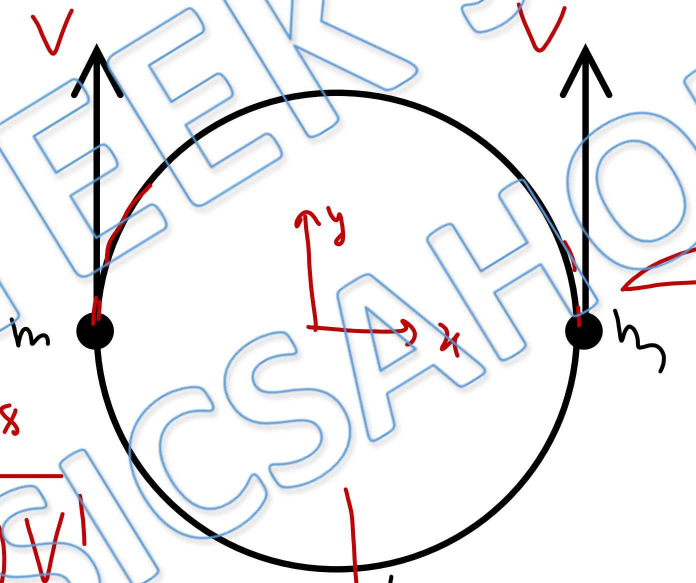
Q.6) On a smooth horizontal surface, a ring of mass M lies with two insects of mass m, on its diametrically opposite points. The insects move with velocity v in same direction relative to the ring. The velocity of the ring as the insects meet is

(a) $\frac{Mv}{2m}$

(b) $\frac{M-m}{M+m}$

(c) zero

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



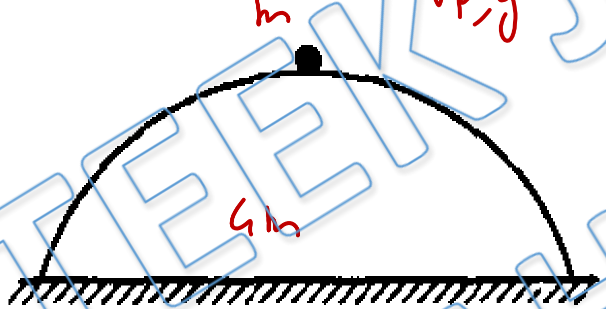
by COM along y axis

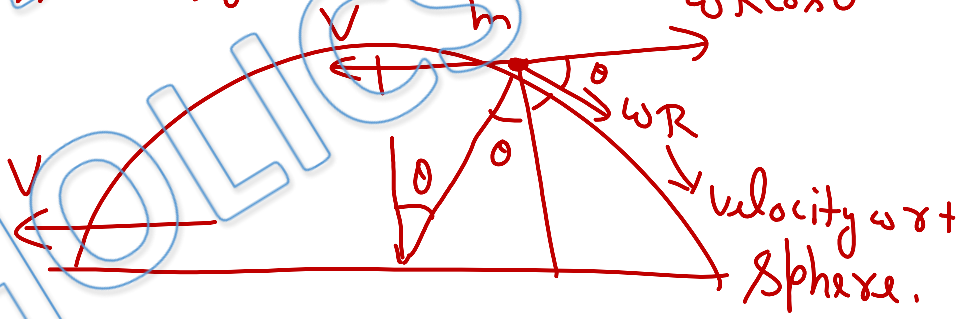
$0 = (M+2m)V'$

$V' = 0$

Q.7) A hemisphere of radius R and of mass 4m is free to slide with its base on a smooth horizontal table. A particle of mass m is placed on the top of the hemisphere. The angular velocity of the particle relative to hemisphere at an angular displacement θ when velocity of hemisphere has become v is:

$\vec{V}_{p,g} = \vec{V}_{p,s} + \vec{V}_{s,g}$





(a) $\frac{5v}{R\cos\theta}$ (b) $\frac{2v}{R\cos\theta}$ (c) $\frac{3v}{R\sin\theta}$ (d) $\frac{5v}{R\sin\theta}$

by Co Momentum in Horizontal direction →

$4mV = m(\omega R\cos\theta - V)$

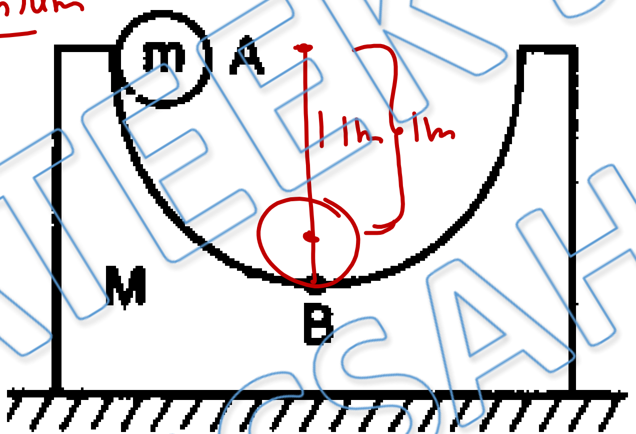
$5V = \omega R\cos\theta$

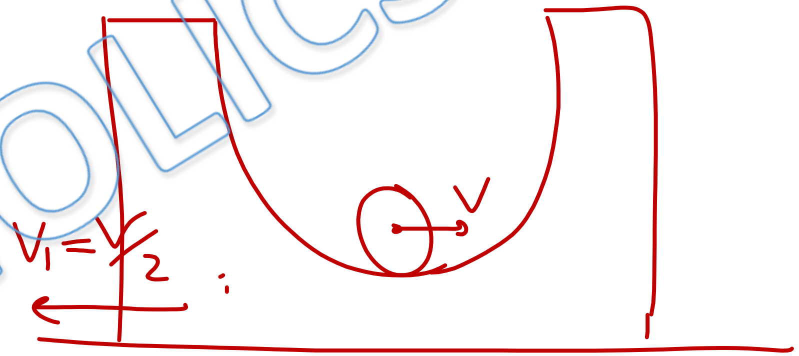
Q.8) A block of mass M = 2 kg with a semicircular track of radius R = 1.1 m rests on a horizontal frictionless surface. A uniform cylinder of radius r = 10 cm and mass m = 1.0 kg is released from rest from the top point A. The cylinder slips on the semicircular frictionless track. The speed of the block when the cylinder reaches the bottom of the track at B is :(g = 10 m/s^2)

by Conservation of momentum

$0 = 1 \times V - 2V_1$

$V_1 = V/2$





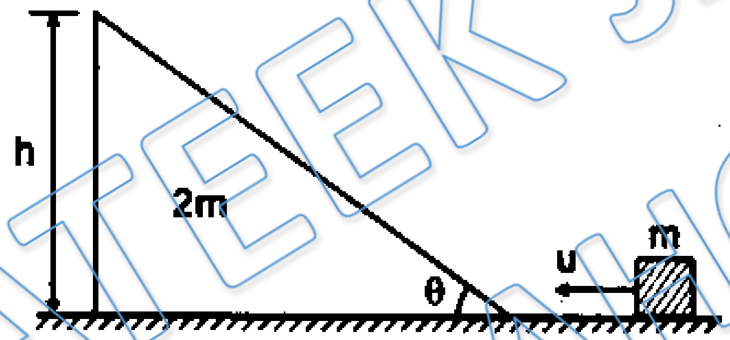
(a) $\sqrt{\frac{10}{3}} m/s$ (b) $\sqrt{\frac{4}{3}} m/s$ (c) $\sqrt{\frac{5}{2}} m/s$ (d) $\sqrt{10} m/s$

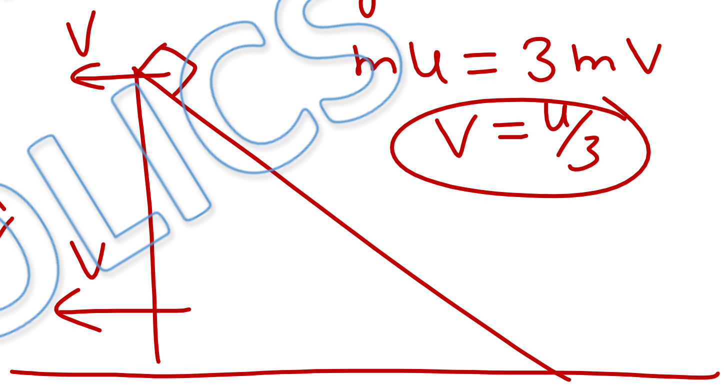
by COME →

$1 \times 10 \times 1 = \frac{1}{2} \times 1 V^2 + \frac{1}{2} \times 2 \times \frac{V^2}{4} \Rightarrow 10 = \frac{3V^2}{4}$

$V = \sqrt{\frac{40}{3}} \Rightarrow V_1 = \sqrt{\frac{10}{3}}$

Q.9) A block of mass m in is pushed towards a movable wedge of mass 2 m and height h with a velocity u. All surfaces axe smooth. The minimum value of a for which the block will reach the top of the wedge is:





by COM →

$mu = 3mV$

$V = u/3$

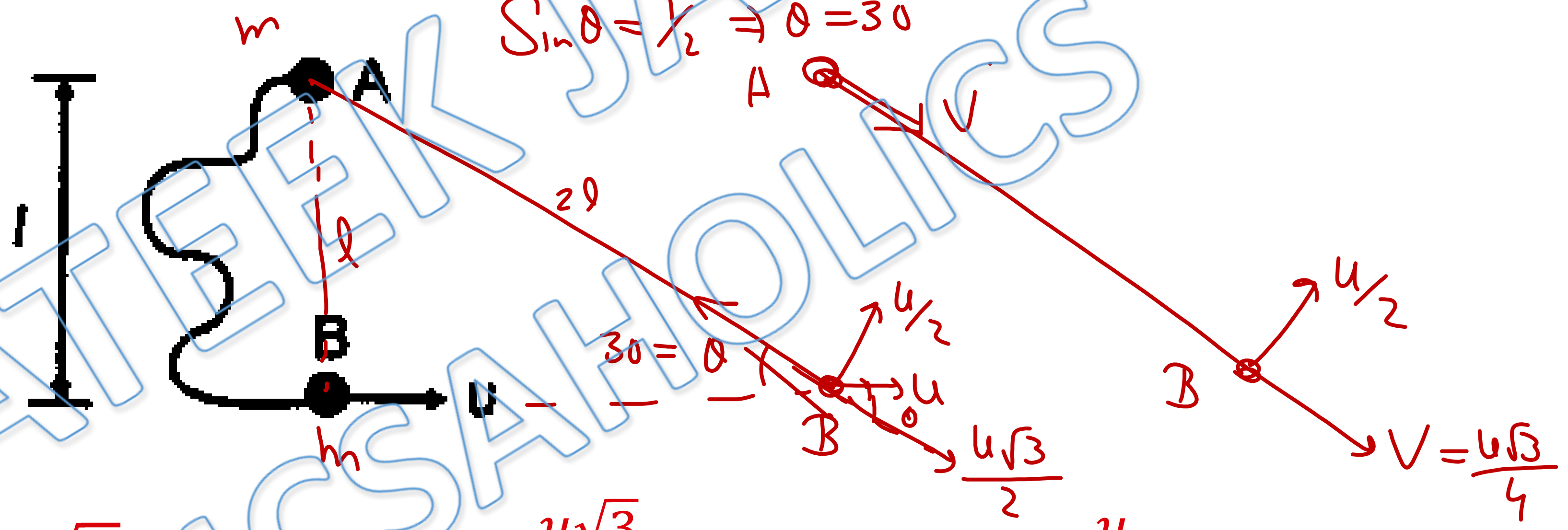
(a) $2\sqrt{gh}$ (b) $\sqrt{3gh}$ (c) $\sqrt{6gh}$ (d) $\frac{\sqrt{32}}{gh}$

by Conservation of mechanical energy

$\frac{1}{2}mu^2 = \frac{1}{2}\times 3m\frac{u^2}{9} + mgh$

$mu^2 - \frac{mu^2}{3} = 2ghm \Rightarrow \frac{2mu^2}{3} = 2ghm$

Q.10) Two particles A and B each of mass m are attached by a light inextensible suing of length 2 L The whole system lies on a smooth horizontal table with B initially at a distance *l* from A. The particle at end B is projected across the table with speed is perpendicular to AB. Velocity of ball A just after the string Is taut, is :

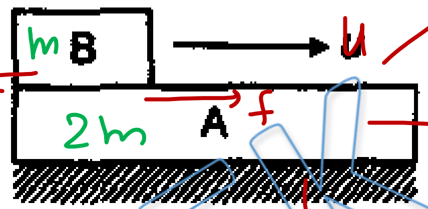


(a) $\frac{u\sqrt{3}}{4}$ (b) $u\sqrt{3}$ (c) $\frac{u\sqrt{3}}{2}$ (d) $\frac{u}{2}$

$m\frac{u\sqrt{3}}{2} = 2mV$

$V = \frac{u\sqrt{3}}{4}$

(Q.11) A horizontal block A is at rest on a smooth horizontal surface. A small block B, whose mass is half of A, is placed on A at one end and projected along other end with some velocity is given .The coefficient of friction between blocks is μ. Then:



(a) the blocks will reach a final common velocity u/3

(b) the work done against friction is two-third of the initial kinetic energy of B

(c) before the blocks reach a common velocity the acceleration of A relative to B is (2/3)μg

(d) before the blocks reach a common velocity, the acceleration of A relative to B is (3/2)μg

Using Work Energy theorem →

$W_{fr} = \frac{1}{2}(3m)\frac{u^2}{9} - \frac{1}{2}mu^2 = \frac{1}{2}\frac{mu^2}{3} - \frac{1}{2}mu^2 = K_1/3 - K_1 = -2K_1/3$

by Conservation of momentum

$mu = 3mV \Rightarrow V = u/3$

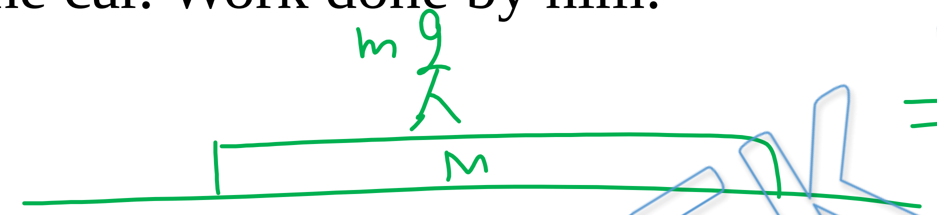
Work done against friction $= -W_{fr} = 2K_1/3$

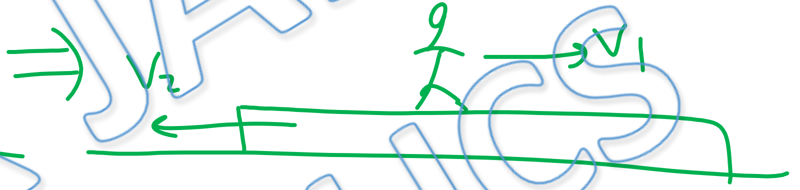
$a_B = \leftarrow \frac{\mu mg}{m} = \mu g \leftarrow$

$a_A = \rightarrow \frac{\mu mg}{2m} = \frac{\mu g}{2} \rightarrow$

$a_{rel} = \frac{3}{2}\mu g$

Q.12) A man of mass m is stationary on a stationary flat car. The car can move without friction along horizontal rails. The man starts walking with velocity v relative to the car. Work done by him:





(a) is less than $\frac{1}{2}mv^2$, if he walks along the rails

(b) is equal to $\frac{1}{2}mv^2$, if he walks normal to rails

(c) can never be less than $\frac{1}{2}mv^2$

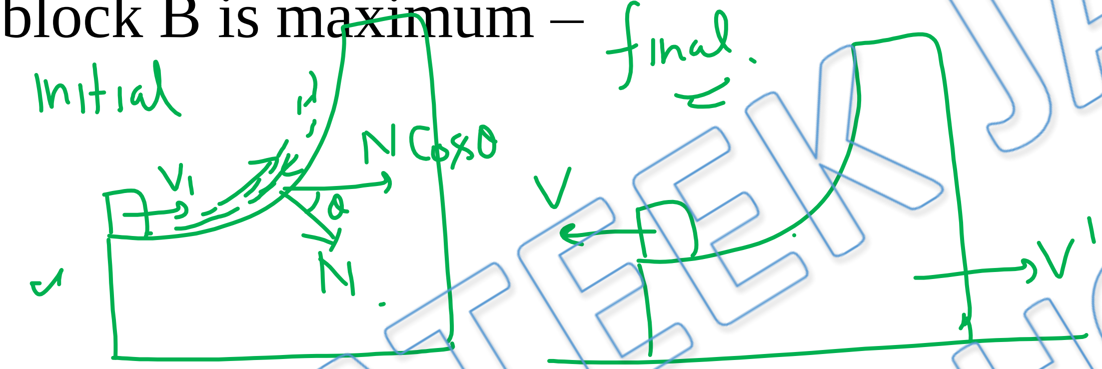
(d) is greater than $\frac{1}{2}mv^2$, if he walks along the rails

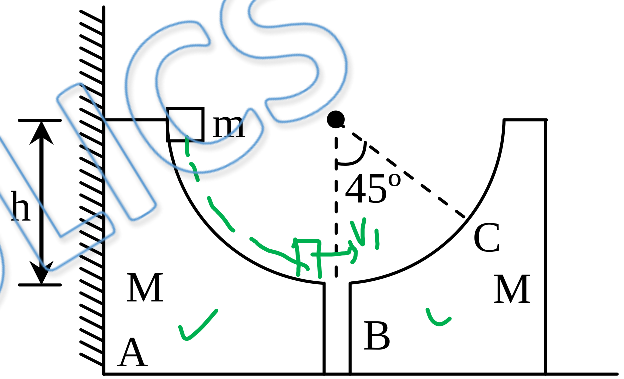
$V = V_1 + V_2$

work done by man
= KE of system w.r.t ground
= ,, ,, ,, CM
(Since CM is at rest)
$= \frac{1}{2}\mu V_{rel}^2$
$= \frac{1}{2}\mu V^2 < \frac{1}{2}mV^2$

$W = \frac{1}{2}mV^2$ if man moves normal to rails (car does not move)

Q.13) Two identical blocks having mass M each are smoothly conjugated and placed on a smooth horizontal floor as shown in figure. On left of block A, there is a wall. A small block of mass m is released from the position shown in figure. Velocity of block B is maximum –





(a) when m is at highest position on B

(b) when m is at lowest position and moving towards left

(c) when m is at point C

(d) is equal to $\frac{m\sqrt{2gh}}{m+M}$

$V_1 = \sqrt{2gh}$

by COM

$m(V_1+V) = MV'$

$mV_1 = MV' - mV \quad \text{---} (1)$

$\frac{1}{2}mV_1^2 = \frac{1}{2}mV^2 + \frac{1}{2}MV'^2$

$\frac{1}{2}m(V_1-V)(V_1+V) = \frac{1}{2}MV'^2$

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