Roll No : [U19CS012 (D-12)]

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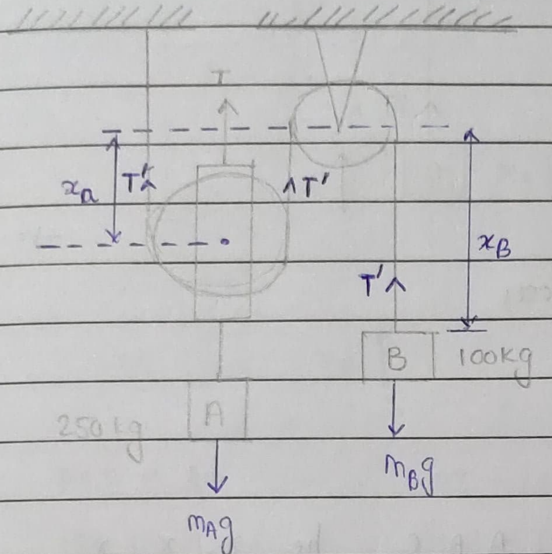
KINETICS ASSIGNMENT

1.Y



$2x_a + x_b = l$ (length of rope) ↓ constant

$\frac{d}{dt}(2x_a + x_b) = \frac{dl}{dt}$

$2V_A + V_b = 0$ — (1)

$2a_a + a_b = 0$ diff w.r.t time

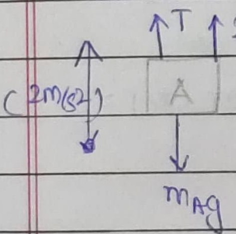
$[a_B = -2a_A]$

$= -2(2)$ $(a_A = 2m/s^2 (\uparrow))$

$= -4 m/s^2$

$[a_B = 4 m/s^2$ (downwords) $(\downarrow)]$

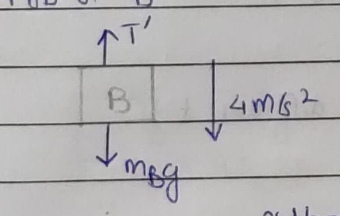
FBD of A



$2T' + T - 250g = 250(2)$

$2T' + T = 500 + 250g$ — (1)

FBD of B



$2(m_Bg - T' = (100)(4))$ — (2)

$\cancel{T' = (100g - 400)}$

$\cancel{(2T' = 200g - 800)}$ — (2)

subbract (1) + (2)

$\cancel{T = 500 + 800 - 450g}$ $T + 2(100)g = 500 + 250g + 800$

$= 1300 -$ $T = 1300 + 50g$

ANS: $[T = 1790.5 N]$

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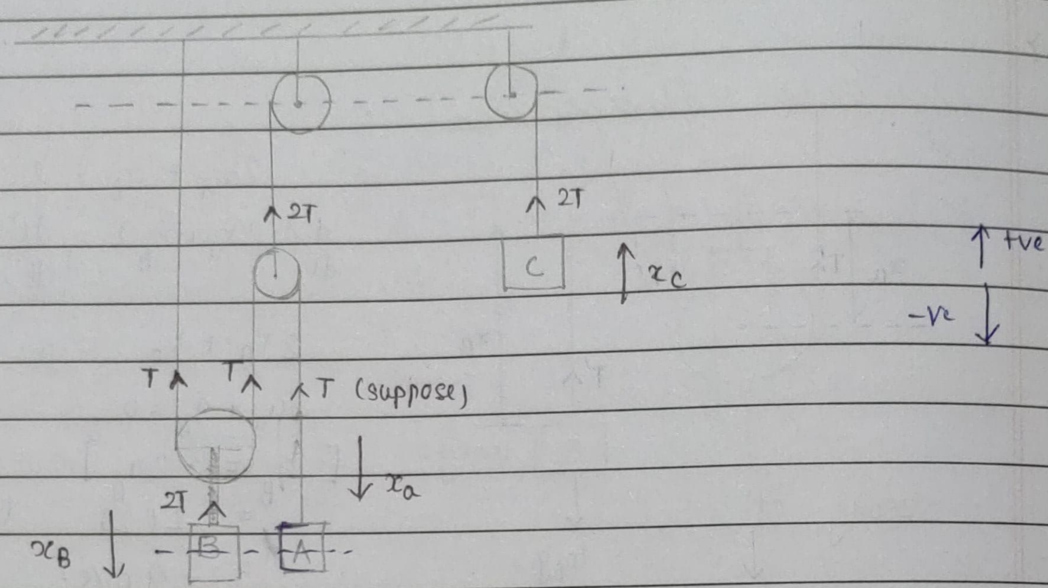
2>



(1) Let the displacement of blocks A, B, C be x_A, x_B, x_C.

(2) Tension T in string connected to block 'A'.

(3)

$$\sum \text{Workdone by internal force} = 2T(-x_B) + T(-x_A) + 2T(x_C) = 0$$

$$[2x_B + x_A = 2x_C]$$

$x_B = x_A$ (∵ elevation is same)

$$\Rightarrow 3x_B = 2x_C \quad \text{(diff wrt t)}$$

$$(V_B) = \frac{2(V_C)}{(3)}$$

$$= \frac{2}{3} \times (8\ m/s) \quad \text{(Given)}$$

ANS: $V_A = V_B = 5.33\ m/s$

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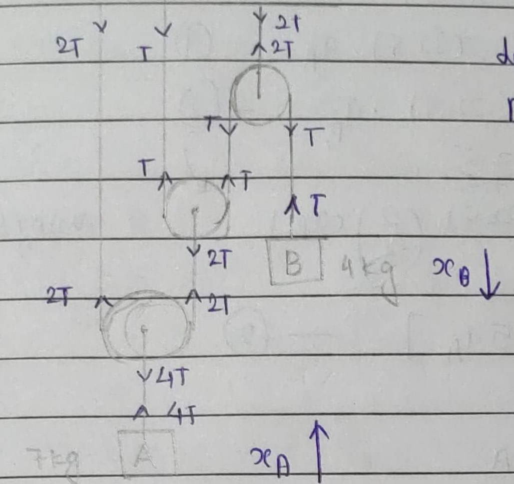
3.)



Let the displacement of ~~plect~~ block A & B be x_A & x_B.

Σ Work done by internal force $= 0$

$4T(x_A) - T x_B = 0$

$4x_A = x_B$

$[4a_A = a_B] - ①$ (double diff wrt t)

FBD of A $\quad 4T - (7g) = 7(a_A) \quad$ — (i) $\quad$ —①

FBD of B $\quad (4g) - T = 4(a_B) \quad$ — (ii)

$4 \times [(4g - T) = (16 a_A)]$ —— ③

Adding ① & ③

$9g = a_A(64 + 7)$

$\left[a_A = \frac{9 \times 9.81}{71} = 1.243 \text{ m/s}\right]$

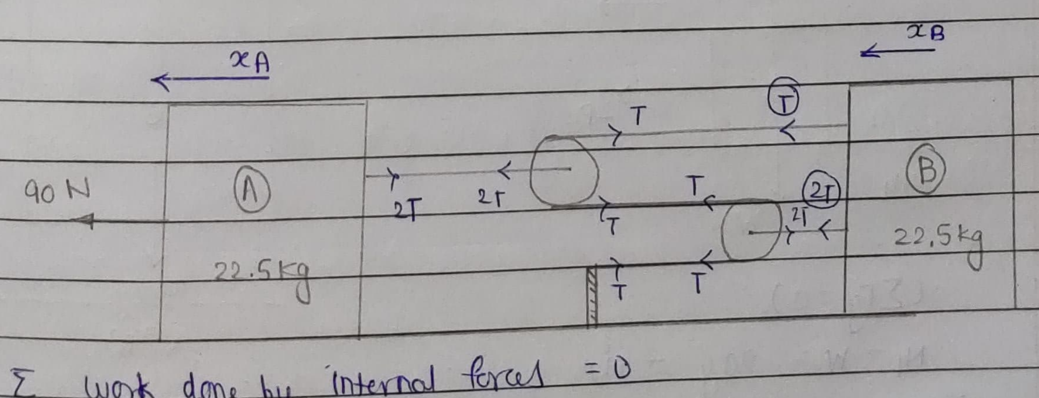
$a_B = 4 \times (1.243)$ m/s

$[a_B = 4.974 \text{ m/s}]$

ANS:

$\left[\begin{array}{l} T_B = 4g - 16(a_A) = 4g - 16(1.243) = 19.35 \text{ N} \\ T_A = 4T_B = 77.4 \text{ N} \end{array}\right]$

4.)



Σ work done by internal forces $= 0$

$-x_A(2T) + 3T x_B = 0$

$2x_A = 3x_B$

$[2a_A = 3a_B]$ —① (double diff wrt t)

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$[\Sigma F_x = m_A a_A]$

Block A $\quad 90 - 2T = (22.5)\, a_A \quad$ — (1)

Block B $\quad 3T = (22.5)\, a_B \quad$ — (2)

$$3T = (\cancel{22.5}^{\cancel{7.5}\ 2.5})\left(\frac{2}{\cancel{3}}\right)(a_A) \qquad \text{using (i)}$$

$[T = 5a_A]$ — (2)

$90 - 10\,a_A = 22.5\,a_A$

$$\left[a_A = \frac{90}{32.5}\right]$$

for velocity of A, $\quad \Sigma F_s\,(S) = \frac{1}{2}m(v^2 - u^2)$

$\Sigma F_S = 90 - 2T = 22.5\,a_a = \left(22.5 \times \frac{90}{32.5}\right)$

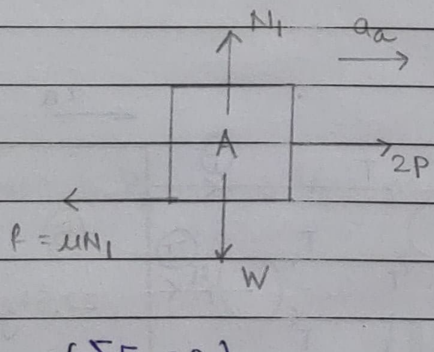
$[S = 2.7\ m]$

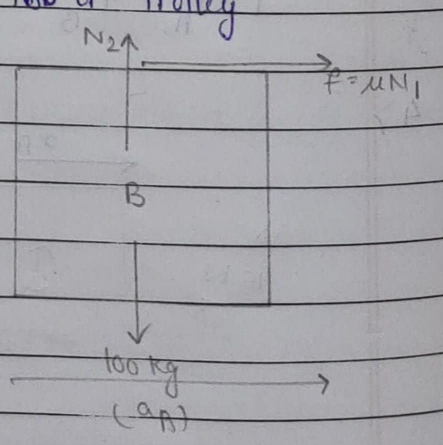
$$\frac{\cancel{22.5} \times 90}{32.5} \times (2.7) = \frac{1}{2}(\cancel{22.5})(v^2 - 0^2)$$

$v^2 = 14.95$

ANS : $\quad [\,v = 3.8665\ m/s\,]$

5.7 $\quad$ FBD of A $\qquad\qquad$ FBD of trolley





$(\Sigma F_y = 0)$

$N_1 = W = 20g \quad$ — (i)

$[N_1 = 20 \times 9.81 = 196.2\ N]$

$[f_{max} = \underset{(0.5)}{\mu} N_1 = 98.1\ N]$

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i) $F_x = m_a a_a \Rightarrow$ $2P - f = 20\, a_a$

$120 - 98.1 = 20\, a_A$

$[a_A = 1.095\ m/s^2]$

for Block B

$f = m_B a_B$

$98.1 = 100\, a_B$

$[a_B = 0.981\ m/s^2]$

ii) $2P = 80\ N < f_{max} = 98.1\ N$

$\therefore$ Both blocks will have same acceleration

$\therefore (2P) = (m_A + m_B)\, a$

$$\left[a = \frac{80}{120} = 0.67\ m/s^2 \right]$$

iii) 6.) By conservation of Energy Law,

Energy is constant (absence of external forces)

$\therefore$ (Potential Energy)$_1$ = (Kinetic Energy)$_2$

$$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$$

$$V_2 = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 15} = 17.15\ m/s \quad -①(i)$$

$$\frac{mv_2^2}{r} = \frac{(2mgh)}{(r)} \quad -①$$

FBD at point (2)

$$N - mg = \frac{mv_2^2}{(r)}$$

$$N = mg + \frac{2mgh}{(r)} = mg\left(1 + \frac{2h}{r}\right)$$

$$= 1500 \times 9.81 \left(1 + \frac{2(\cancel{15}^{3})}{(\cancel{5})}\right)$$

ANS: $= \left[\begin{array}{l} 103005\ N \\ 103.005\ KN \end{array}\right]$

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Energy at Point 2 = Energy at Point 3

$\frac{1}{2}m(v_2)^2 = \frac{1}{2}m(v_3)^2 + mg(3)$

$m(v_3)^2 = 2(2mg(15) - mg(3))$

$\cancel{m}(v_3)^2 = 54 \times \cancel{m} \times g$

$mgh_1 = \frac{1}{2}m(v_3)^2 + mg(h_2)$

$2\cancel{m}g(h_1 - h_2) = \cancel{m}(v_3)^2$ — ②

At point ③ (N = 0)

$mg = \frac{m(v_3)^2}{(r)}$

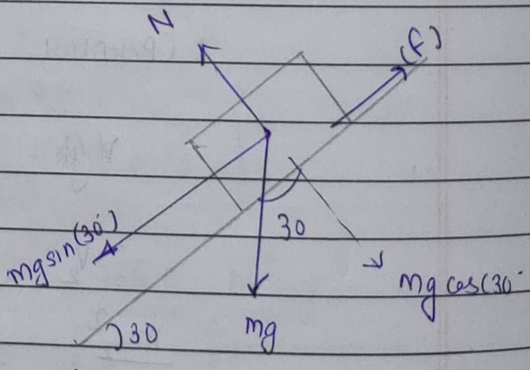
$r = \frac{(v_3)^2}{g} = \frac{(2g)(h_1 - h_2)}{g} = 2 \times (12)$

ANS: $= \boxed{24\,N}$

7.7 $\Sigma F_y = 0$

$N = mg\cos(30°)$

$\Sigma F_x = mg\sin(30°) - \mu(mg\cos(30°))$



Let maxm deformation be x_{max}

$\therefore \Sigma F_x(S) = \frac{1}{2}m(v^2 - u^2) + \frac{1}{2}k(x_{max})^2$

$\left(S = \frac{30}{100} + x_{max}\right)$ $(v = u = 0)$

$\therefore mg(\sin(30°) - \mu\cos(30°))(0.3 + x_{max}) = \frac{1}{2}k(x_{max})^2$

$100g(0.3268)(0.3 + x_{max}) = \frac{2500}{2}(x_{max})^2$

$[0.2564(0.3 + x_{max}) = (x_{max})^2]$

on solving; $[1250x_{max}^2 - 32.68x_{max} - 9.8 = 0]$

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$$x_{max} = \frac{(0.2564) \pm \sqrt{(0.2564)^2 - 4(0.2564)(0.077)}}{2(1)}$$

$$= 0.10258 \ m$$

$$= [10.26 \ m]$$

At maximum velocity $(a = 0)$

$(\Sigma F_x = 0)$ $\quad mg(\cos 60 - \mu \sin 60) - kx = 0$

$$\frac{32.68}{2500} = x$$

$$[x = 0.013]$$

$$mg(\sin 30 - \mu \cos 30)(0.3 + x) - \frac{1}{2}kx^2 = \frac{1}{2}\left(\frac{w}{g}\right)(V_{max}^2)$$

$$\therefore \ 9.8 + 32.68(0.013) - \frac{1}{2}(2500)(0.013)^2 = \frac{1}{2}\frac{(1000)}{(9.81)}(V_{max})^2$$

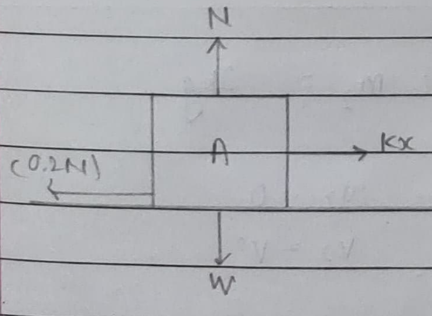
$$10.224 - 0.21125 = \frac{50}{9.81}(V_{max}^2)$$

$$(10.01275) = 5.097 \ V_{max}^2$$

$$V_{max}^2 = 1.964$$

$$[V_{max} = 1.402 \ m/s]$$

8->



$K = 500 \ N/m \qquad x = 0.15 \ m$

$$\Sigma F(s) + \frac{1}{2}kx^2 = \frac{1}{2}m(v^2 - 0^2)$$

$$(-1.6g)0.3 + \frac{1}{2}(500)(0.15)^2 = \frac{8}{2}(v^2)$$

$$V^2 = \frac{0.9162}{4}$$

$$V = 0.479$$

$\Sigma F_y = 0 \quad [N = W = 8g]$

$\Sigma F_x = 0 \quad f = 0.2 N$

$= (1.6g)$ ANS: $[V_D = 0.48 \ m/s]$

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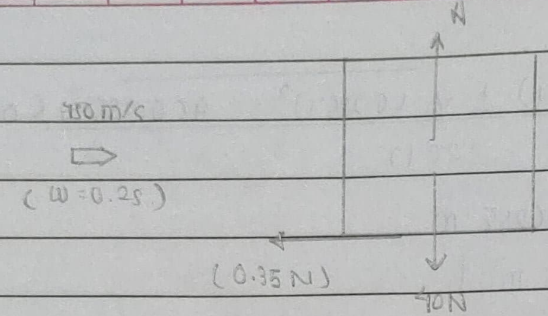
9.)



~~Bullet~~ Block

$m_1 = (40/g)$

$U_1 = 0$

$V_1 = (V')$

~~Block~~ Bullet

$m_2 = (0.25/g)$

$U_2 = 750\, m/s$

$(V_2 = V')$

① Conservation of Linear momentum

$$m_1 U_1 + m_2 U_2 = (m_1 + m_2) V'$$

$$\left[V' = \frac{\left(\frac{0.25}{g}\right)(750)}{\left(\frac{40}{g} + \frac{0.25}{g}\right)} = 4.66\, m/s \right]$$

$M = m_1 + m_2$

$= \left[\frac{40.25\, N}{g}\right]$

$\therefore N = W = 40.25\, N$

$\therefore f = 0.35 \times W = 14.0875\, N$

$\Sigma F = -14.0875$

$$\Sigma F(S) = \frac{1}{2}(M)(V^2 - U^2)$$

$V (V = 0)$

$V (U = V')$

$$-14.0875 (S) = -\frac{1}{2}\frac{(40.25)}{(g)}(4.66 \times 4.66)$$

ANS:

$$\left[(S) = \frac{31.02}{9.81} = 3.16\, m \right]$$

10.) i) $m_1 = \frac{10}{100}\, kg$ $\quad m_2 = 2\, kg$

$U_1 = 100\, m/s$ $\quad U_2 = 0$

$V_1 = (V')$ $\quad V_2 = V'$

[Conservation of momentum]

$$\therefore m_1 U_1 + m_2 U_2 = (m_1 + m_2)(V')$$

$$(0.01 + 2)\, V' = (0.01)(100)$$

$$\left[V' = 0.4975\, m/s \right]$$

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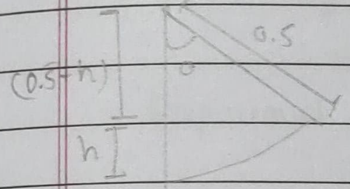
Energy is Conserved

$$\frac{1}{2}\cancel{(m_1+m_2)}(v')^2 = \cancel{(m_1+m_2)}gh$$

$$h = \frac{(0.4975)^2}{2\times 9.81}$$

$$[h = 0.0126\ m]$$



$$\cos\theta = \frac{0.5-h}{0.5} = 0.9748 \qquad [\theta = 12.89°]$$

ii)

$m_1 = 0.01\ kg$ $\qquad$ $m_2 = 2\ kg$

$U_1 = 100\ m/s$ $\qquad$ $U_2 = 0$

$V_2 = 10\ m/s$ $\qquad$ $V_2 = V_2$

(conservation momentum ~~Energy~~)

$$m_1U_1 + m_2U_2 = m_1V_1 + m_2V_2$$

$$1 = 0.1 + 2V_2$$

$$[\therefore V_2 = 0.45\ m/s]$$

Energy is conserved,

$$\therefore \frac{1}{2}m_2V_2^2 = m_2gh$$

$$\left[h = \frac{(0.45)^2}{2\times 9.81} = 0.01032\right]$$

$$\cos\theta = \frac{0.5-h}{h} = 0.9793$$

$$[\theta = 11.66°]$$

11.7

$m = 0.11\ kg$ $\qquad$ $F_I = \frac{m\Delta v}{t}$

$U = -24\hat{i}\ m/s$

$v = 36(\cos 40°\hat{i} + \sin(40)\hat{j})$ $\quad = \frac{0.11}{0.015}\left((36\cos 40 + 24)\hat{i} + 36\sin(40)\hat{j}\right)$

$t = 0.015$ sec

$$= \left[378.24\hat{i} + 169.69\hat{j}\right]$$

ANS: $[|F| = 414.564\ N]$

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$$\left[\theta = \tan^{-1}\left(\frac{169.69}{378.24}\right) = 24.16^\circ \right]$$

12.) $M_m = 68\ kg$ $\qquad m_c = 79.8\ kg$

$M_b = 57 \times 10^{-3}\ kg$ $\qquad m_s = 45\ kg$

$l_r = 0.91\ m$

$h = 30.5\ mm$

Energy of (Sand + Bullet Bag) is conserved

$$\therefore \frac{1}{2}(m_s + m_b)v^2 = (m_s + m_b)gh$$

$$v^2 = (2gh) \qquad [h = 30.5\ m]$$

$$[v = 0.77357\ m/s]$$

Let the initial velocity of bullet before striking sand bag is 'u'.

$\therefore$ By conservation of linear momentum

$$m_b(u) + m_s(0) = (m_s + m_b)(v)$$

$$(57 \times 10^{-3})\ u = (45.057)(0.778557)$$

$$[u = 611.486\ m/s]$$

Initial velocity of (Canoe + man + bullet) is zero.

By linear momentum conservation;

$$0 = (M_m + M_c)v' + m_b(u)$$

$$v' = \frac{-m_b u}{(m_m + m_c)} = \frac{-(57 \times 10^{-3})(611.487)}{(68 + 79.8)}$$

$$= -0.236\ m/s$$

ANS: $\left[v' = 0.236 \leftarrow (m/s) \right]$

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13.) $m_b = 60\,kg$ $m_g = 50\,kg$

$m = 30\,kg$

Intial centre of mass x_i from Left corner of boat

$$x_i = \frac{(60 \times 0) + (0.75 \times 30) + (1.5 \times 50)}{(60 + 30 + 50)}$$

Final centre of mass x_f from Left corner of boat

$$x_f = \frac{(50 \times 0) + (0.75 \times 30) + (1.5 \times 60)}{(60 + 30 + 50)}$$

Displacement of Boat $= \Delta(COM) = x_f - x_i$

$$= \frac{(60 - 50) \times (1.5)}{(140)}$$

(Back word) (for boat) ($\leftarrow$)

ANS: $= \frac{15}{140} = \boxed{0.107\ m}$

(shift)

14.) COM_{inital} (left corner) of Boat $x_i = \frac{(5 \times 60) + (90 \times 2.5)}{(150)}$

COM_{final} (left corner) of Boat $x_f = \frac{(90 \times 2.5)}{(150)}$

Displacement of Boat (towards right) $= \Delta COM$

$= x_f - x_i$

$$= \frac{\cancel{60} \times \cancel{5}}{(\cancel{150})\,30}$$

$= [2\,m]$ ($\rightarrow$)

Intially Left corner was 10 m away from pier:

Now, $10 + 2 = 12\,m$ away from pier

ANS: 12m.

Roll No: (D-12) U19CS012