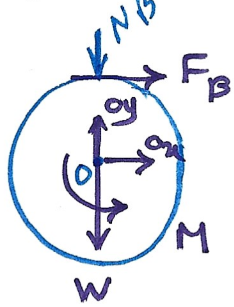
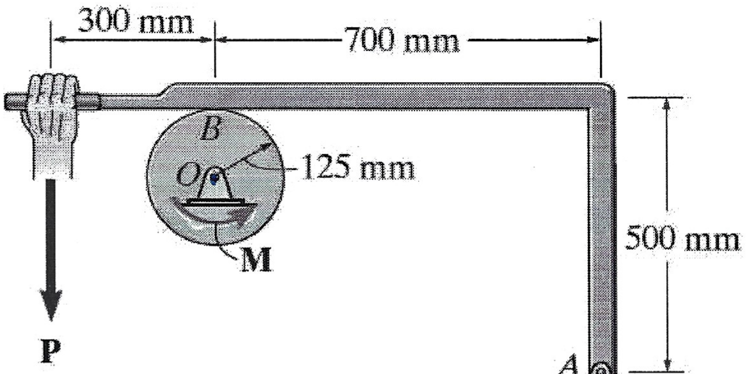
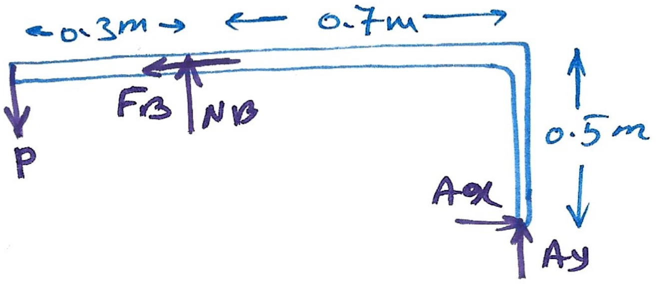
The coefficients of static and kinetic friction between the drum and brake bar are $\mu s = 0.4$ and $\mu k = 0.3$, respectively. If $M = 50$N.m and $P = 85$ N determine the horizontal and vertical components of reaction at the pin $O$. Neglect the weight and thickness of the brake. The drum has a mass of 25 kg.




(FBD I)




(FBD II)




Assume brake has stopped drum

In FBD(I) $\Sigma M_O \circlearrowleft^{+} = 0 \rightarrow$

$$\cancel{M}_{50\,N\cdot m} - F_B(0.125) = 0 \rightarrow F_B = \frac{50}{0.125} = 400\ N$$

$$\text{In FBD (II)} \rightarrow \Sigma M_A \circlearrowleft^{+} = 0 \rightarrow \overset{400}{\cancel{F_B}} \times 0.5 - N_B(0.7) + P(\overset{1}{\cancel{0.7+0.3}}) = 0 \rightarrow$$

$$N_B = \frac{\frac{400}{2} + 85}{0.7} = \frac{285}{0.7} = 407.14\ N \qquad F_{Bs} = \mu_s N_B = 0.4(407.14) =$$

$F_{Bs} = 162.9\ N$ $\quad$ $F_B > F_{Bs}$ $(400 > 162.9) \rightarrow$ Initial assumption was incorrect!

drum rotates $\rightarrow \mu_k$ $\quad$ $F_{Bk} = \mu_k N_B = 0.3\ N_B$ $(*)$

From FBD (II) $\Sigma M_A \circlearrowleft^{+} = 0 \rightarrow P - 0.7N_B + 0.3N_B \times 0.5 = 0 \rightarrow$

$$P - 0.7N_B + 0.15N_B = 0 \rightarrow N_B = 154.54\ N \rightarrow F_{Bk} = 0.3 \times 154.54 = 46.36\ N$$

$$\overset{+}{\rightarrow} \Sigma F_x = 0 \rightarrow -N_B + O_y - W = 0 \rightarrow O_y = 400\ N \ \checkmark$$

$$\Sigma F_y \uparrow^{+} = 0 \rightarrow F_B + O_x = 0 \rightarrow O_x = -F_B = -46.4N \ \checkmark$$

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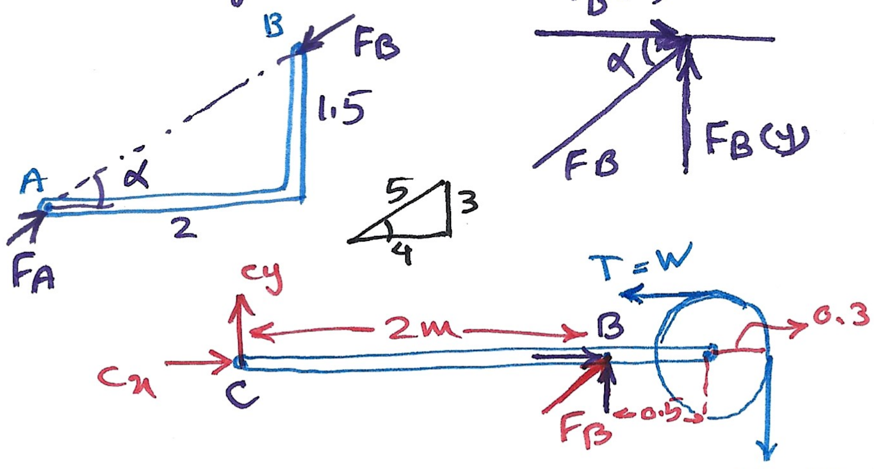
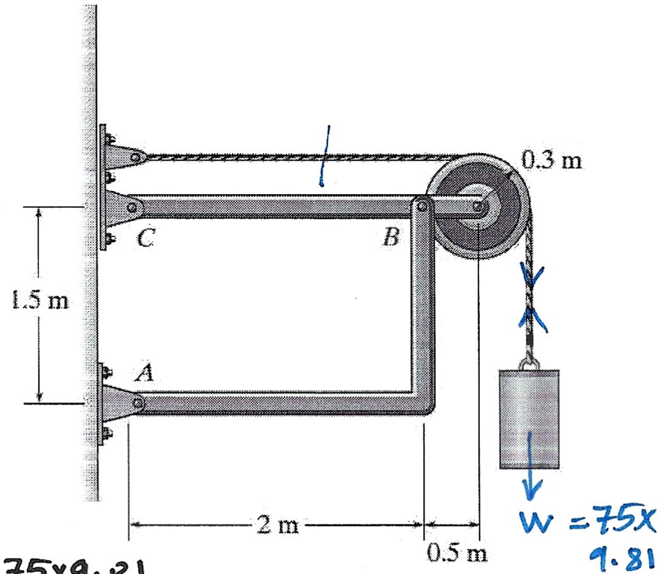
Determine the horizontal and vertical components of force at pins $B$ and $C$. The suspended cylinder has a mass of 75 kg.

$m = 75$ kg




$$\Sigma M_C \overset{+}{\circlearrowleft} = 0 \rightarrow + F_B(y)(2) - 75\times9.81\times(\underbrace{\cancel{2+0.5+0.3}}_{2.8}) + 75\times9.81\,(0.3) = 0$$

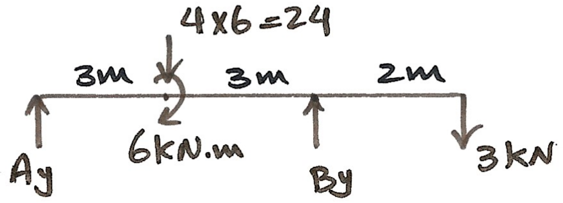
$$\alpha = \tan^{-1}\left(\frac{1.5}{2}\right) \rightarrow F_B(\sin\alpha)\times2 - 75\times9.81\times2.8 + 75\times9.81\times0.3 = 0$$

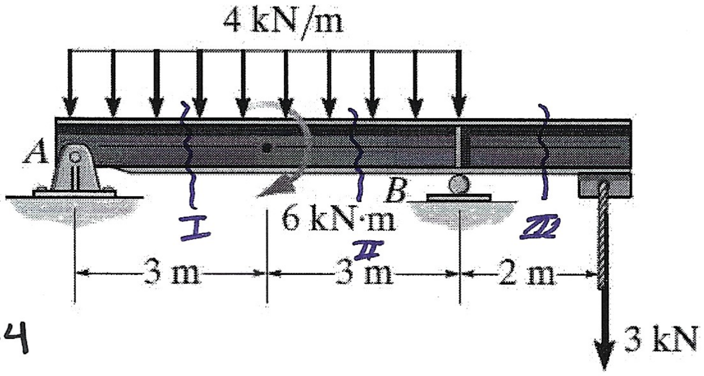
$$\rightarrow F_B = 1532.8 \text{ N} \rightarrow \begin{cases} F_B(y) = F_B \sin\alpha = F_B\left(\frac{3}{5}\right) = 1532.8\left(\frac{3}{5}\right) = 920 \text{ N} \\ F_B(x) = F_B\cos\alpha = F_B\left(\frac{4}{5}\right) = 1532.8\left(\frac{4}{5}\right) = 1226 \text{ N} \end{cases}$$

$$\rightarrow \Sigma F_x \overset{+}{\rightarrow} = 0 \rightarrow C_x + F_B\cos\alpha - T = 0 \rightarrow C_x = T - F_B\cos\alpha = 75\times9.81 - 1532.8\left(4/5\right) = -490.5 \text{ N}$$

$$\rightarrow \Sigma F_y \overset{+}{\uparrow} = 0 \rightarrow C_y + F_B\sin\alpha - T = 0 \rightarrow C_y = -184 \text{ N}$$

Draw the shear and moment diagrams for the overhang beam.



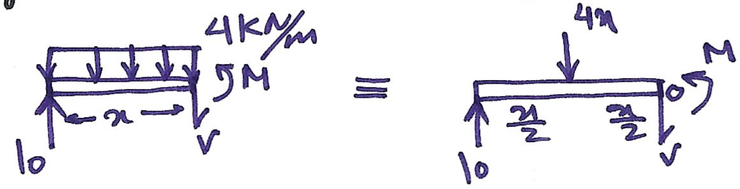




$\Sigma M_A \circlearrowleft^{+} = 0 \rightarrow 6 + \overset{72}{\cancel{24 \times 3}} - B_y \times 6 + 3 \times (3+3+2) = 0 \rightarrow 6B_y = 6 + 72 + 24$

$\rightarrow B_y = \frac{102}{6} = 17\ kN$

$\Sigma F_y \uparrow^{+} = 0 \rightarrow A_y - 24 + 17 - 3 = 0 \rightarrow A_y = 24 + 3 - 17 = 10\ kN$

3 cuts : I)




$\Sigma F_y \uparrow^{+} = 0 \rightarrow$

$10 - 4x - V = 0 \rightarrow V = 10 - 4x \rightarrow$ at $x = 0 \rightarrow V = 10 - 0 = 10\ kN$

V (equation) is the same for (I) and (II) $\rightarrow$ at $x = 6 \rightarrow V = 10 - 4 \times 6 = -14\ kN$

$\Sigma M_o \circlearrowleft^{+} = 0 \rightarrow M + 4x\left(\frac{x}{2}\right) - 10x = 0 \rightarrow M = 10x - 2x^2 \rightarrow$

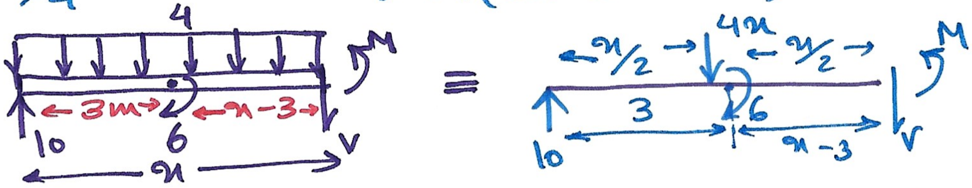
at $x = 0 \rightarrow M = 0\ kN.m$

at $x = 3 \rightarrow M = 30 - 2 \times 3^2 = 12$

Max / Min for M $\rightarrow \frac{dM}{dx} = 0 \rightarrow \frac{d}{dx}(10x - 2x^2) = 10 - 4x = 0 \rightarrow$

$x = 10/4 = 2.5\ m \rightarrow M(\text{at } x = 2.5m) = 10 \times 2.5 - 2 \times 2.5^2 = 12.5\ kN.m$

II)

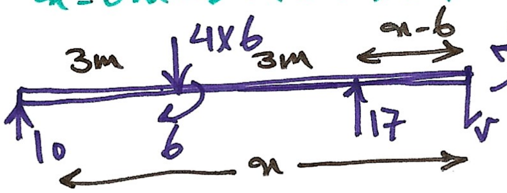



$\rightarrow \Sigma M \circlearrowleft^{+} = 0 \rightarrow$

$M + 4x\left(\frac{x}{2}\right) - 6 - 10 \times x = 0 \rightarrow M = 10x + 6 - 2x^2 \rightarrow$ at $x = 3 \rightarrow M = 18\ kN.m$

at $x = 6m \rightarrow M = 10 \times 6 + 6 - 2 \times 6^2 = 66 - 72 = -6\ kN.m$

III)




$\Sigma F_y = 0 \rightarrow -V + 17 - 24 + 10 = 0 \rightarrow$

$V = +3\ kN$

$\Sigma M \circlearrowleft^{+} = 0 \rightarrow M - 17(x - 6) + 24(x - 3) - 6 - 10 \times x = 0 \rightarrow M = 3x - 24$

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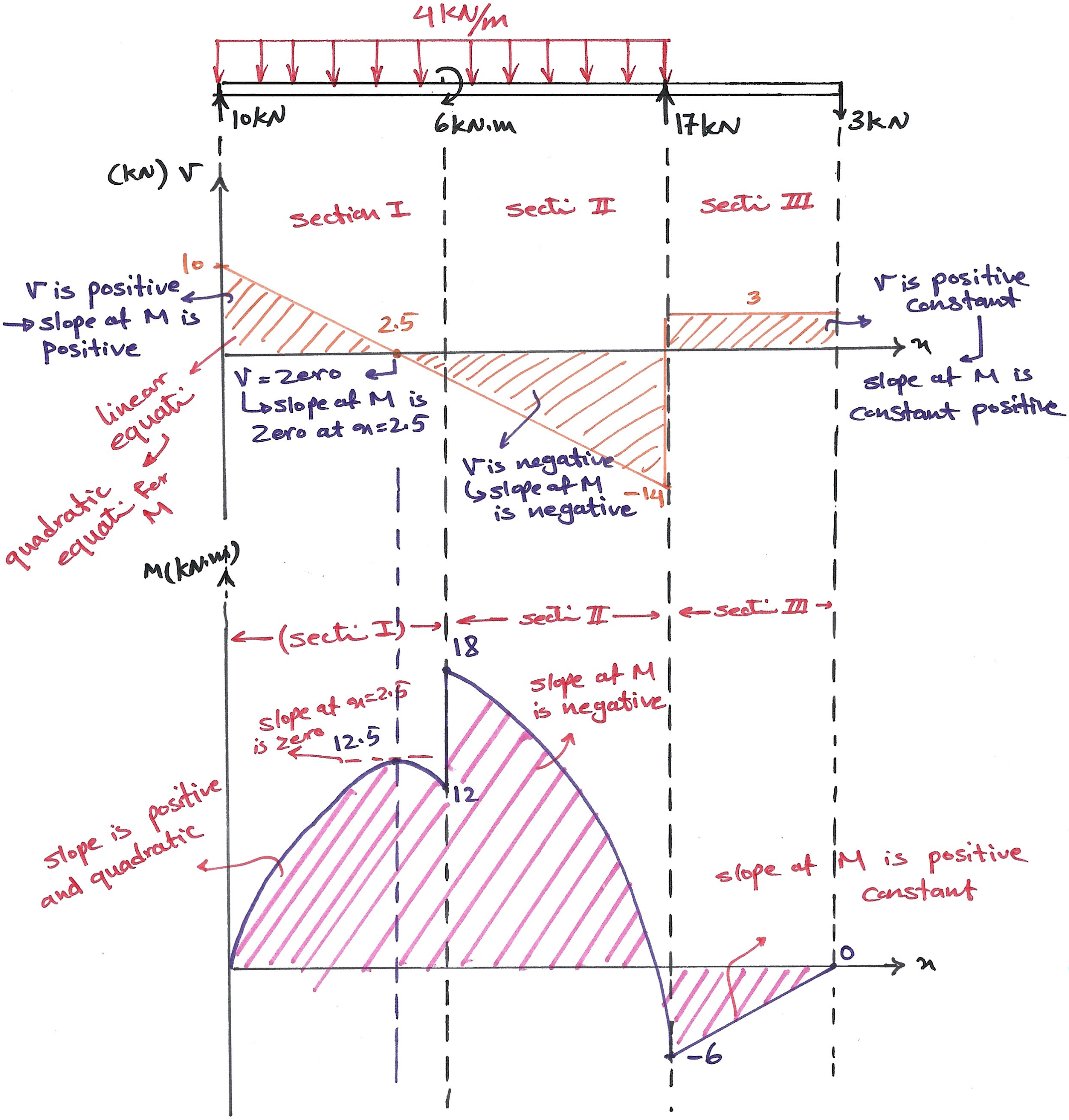
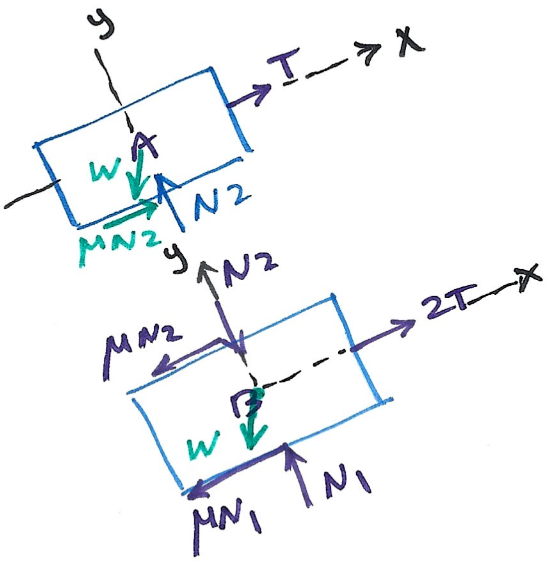
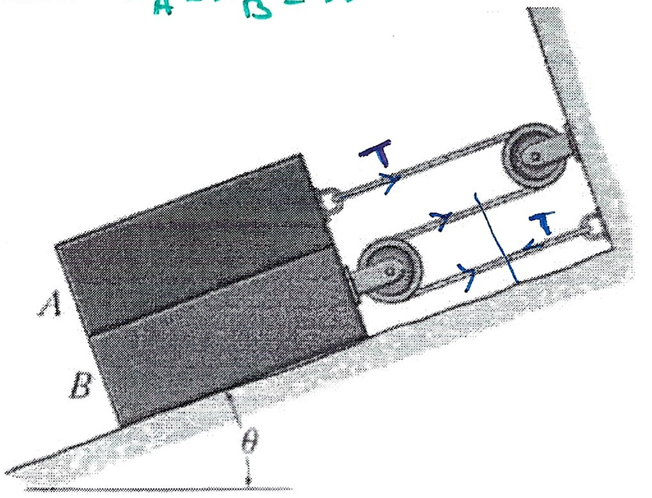
$x = 6m \rightarrow \quad M = 3\times6-24 = -6 \text{ kN.m}$

$x = 8m \rightarrow \quad M = 3\times8-24 = 0 \text{ kN.m}$



If the coefficient of static friction at all contacting surfaces is μs, determine the inclination θ at which the identical blocks with weight W, begin to slide. $W_A = W_B = W$




For (A): $\sum F_y \uparrow^{+} = 0 \rightarrow N_2 - W\cos\theta = 0 \rightarrow \boxed{N_2 = W\cos\theta}$

$\sum F_x \nearrow^{+} = 0 \rightarrow T + \mu N_2 - W\sin\theta = 0 \rightarrow T = W\sin\theta - \mu N_2 =$
$= W\sin\theta - \mu W\cos\theta$ (*)

From (B): $\sum F_x \nearrow^{+} = 0 \rightarrow 2T - \mu N_1 - \mu N_2 - W\sin\theta = 0 \rightarrow$

$\boxed{2T = \mu(N_1 + N_2) + W\sin\theta}$ (**) $\quad 2\times(*) \rightarrow$

$2T = 2(W\sin\theta - \mu W\cos\theta)$
$2T = W\sin\theta + \mu(N_1 + N_2)$ $\rightarrow 2T = 2T \rightarrow$

$2W\sin\theta - 2\mu W\cos\theta = W\sin\theta + \mu N_1 + \mu N_2$

$W\sin\theta = \mu(N_1 + N_2) \rightarrow \mu = \dfrac{W\sin\theta}{N_1 + N_2}$ $\quad$ 2Wcosθ $\quad$ Wcosθ

$\dfrac{W\sin\theta}{\cos\theta} - 2\mu\dfrac{W\cos\theta}{\cos\theta} = \dfrac{\mu(N_1 + N_2)}{\cos\theta} \rightarrow W\tan\theta - 2\mu W = \dfrac{\mu(N_1 + N_2)}{\cos\theta}$

W, θ and μ

$\sum F_y \uparrow^{+} = 0 \rightarrow N_1 - N_2 - W\cos\theta = 0 \rightarrow N_1 = N_2 + W\cos\theta = W\cos\theta + W\cos\theta$
$= 2W\cos\theta$

$W\tan\theta - 2\mu W = \dfrac{3\mu W\cancel{\cos\theta}}{\cancel{\cos\theta}} \Rightarrow \cancel{W}\tan\theta = 5\mu\cancel{W} \rightarrow \boxed{\tan\theta = 5\mu}$

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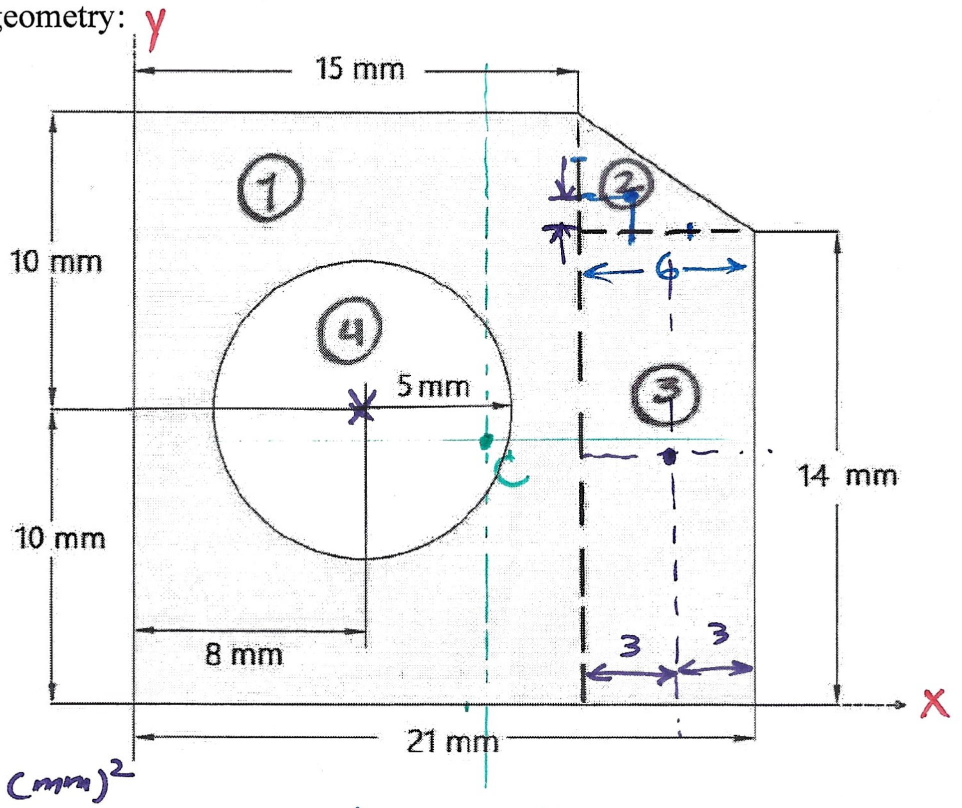
Determine the centroid of below geometry:




| part | $\bar{x}$ (mm) | $\bar{y}$ (mm) | A $(mm)^2$ | $\bar{x}A$ | $\bar{y}A$ |
|---|---|---|---|---|---|
| 1 | $\frac{15}{2}=7.5$ | 10 mm | $15\times20=300$ | 2250 | 3000 |
| 2 | $15+\frac{6}{3}=17$ | $14+\frac{6}{3}=16$ | $\frac{1}{2}\times6\times6=18$ | 306 | 288 |
| 3 | $15+3=18$ | $\frac{14}{2}=7$ | $14\times6=84$ | 1512 | 588 |
| 4 | 8 | 10 | $-\pi R^2=-78.5$ <br> $-\pi(5)^2$ | -628 | -785 |
| | | | $\Sigma A=323.5$ ✓ | 3440 ✓ | 3091 ✓ |

$\bar{x}=\frac{\Sigma \bar{x}A}{\Sigma A}=$

$3440/323.5=$

10.63 mm ✓

$\bar{y}=\frac{\Sigma \bar{y}A}{\Sigma A}=$

$3091/323.5=$

9.55 ✓