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NAME Yash Kapoor Branch C.S. SEC B_2 ROLL NO. 54

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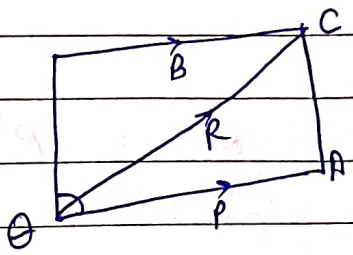
Tutorial - 1

Q-1. एक ~~बल~~ कण पर क्रियाशील दो बल P व Q का परिणामी बल P के लम्बवत है, तो सिद्ध कीजिए कि बलो के मध्य $\cos^{-1}\left(\frac{P}{Q}\right)$ है।



Ans- अतः $\tan\theta = \frac{Q\sin\alpha}{P+Q\cos\alpha}$

$\tan\theta = \frac{Q\sin\alpha}{P+Q\sin\alpha}$

तथा $\infty = \frac{1}{0} = \frac{Q\sin\alpha}{P+Q\cos\alpha}$

$\Rightarrow P+Q\cos\alpha = 0$

$\cos\alpha = -P/Q$

या $\alpha = \cos^{-1}\left(\frac{P}{Q}\right)$ Ans

Q-2. Point the magnitude of two force from following data –

(i) angle between the Force = 75°

(ii) angle between the resultant one Force = 45°

(iii) Magnitude of = 2000 N resultant.

Ans – P or Q = ?

$\theta = 75°$

$\alpha = 45°$

$R = 2000$ N

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$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta} \quad - (1)$$

$$\tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta} \quad - (2)$$

$$R^2 = P^2 + Q^2 + 2PQ\cos\theta$$

$$(2000)^2 = P^2 + Q^2 + 2PQ\cos 75^\circ$$

$$4000000 = P^2 + Q^2 + 2PQ\cos 75^\circ \quad - (3)$$

$$\tan 45^\circ = \frac{Q\sin 75^\circ}{P + Q\cos 75^\circ} \qquad \left\{\because \tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta}\right\}$$

$$1 = \frac{Q\sin 75^\circ}{P + Q\cos 75^\circ} \qquad \{\tan 45^\circ = 1\}$$

$$P + Q\cos 75^\circ = Q\sin 75^\circ \quad \Rightarrow P = Q\sin 75^\circ - Q\cos 75^\circ$$

$$\Rightarrow P = Q[\sin 75^\circ - \cos 75^\circ] \quad \Rightarrow P = Q[0.707].$$

समी (1) से $- R^2 = P^2 + Q^2 + 2PQ\cos\theta$

$$4000000 = Q^2(0.5) + Q^2 + 2PQ\cos 75^\circ$$

$$4000000 = Q^2(0.5) + Q^2 + 2Q(0.707)Q\cos 75^\circ$$

$$4000000 = Q^2(0.5) + 1 + 2 + 0.1829$$

$$4000000 = Q^2(1.8659)$$

$$Q^2 = 4000000 / 1.8659$$

$$Q^2 = 2143737.60 \qquad Q = 14.64\ N$$

$$P = 1464 \times 0.707$$

$$P = 10.350\ N.$$

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Q-3. Two Forces of Equal magnitude P act angle θ to each other what will be resultant if :-

(i) Resultant of 2 equal force is equal to either of them find angle between them.

(ii) The resultant of 2 Forces (P+Q) & (P-Q) is equal to $\sqrt{3P^2+Q^2}$. Show that forces are inclined to each other at angle 60°

$60° = \theta/2$

Ans. (i) When two forces are equal $P = Q$ then

$$R = \sqrt{P^2+Q^2 \quad 2PQ\cos\theta}$$ put $P = Q$

then

$$R = \sqrt{P^2+P^2+2P^2\cos\theta}$$

$$R = \sqrt{2P^2+\theta 2P^2\cos\theta}$$

$$R = \sqrt{2P^2(1+\cos\theta)}$$

$$R = \sqrt{2P^2\ 2\cos^2\theta/2} \qquad R = 2P\cos\theta/2$$

(ii) Given $P = R$

$$R = 2P\cos\theta/2 \qquad \Rightarrow P = 2P$$

$$\left(\frac{P}{2P}\right)\cos^{-1} = \theta/2$$

$$\therefore \left(\frac{1}{2}\right)\cos^{-1} = \theta/2 \qquad \therefore 60° = \theta/2$$

(iii) $P = P+Q$

$Q = P-Q$

$R = \sqrt{3P^2+Q^2}$

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$$R = \sqrt{P^2+Q^2+2PQ\cos\theta}$$

$$3P^2+Q^2 = (P+Q)^2+(P-Q)^2+2(P+Q)(P-Q)\cos\theta$$

$$2(P^2-Q^2)\cos\theta$$

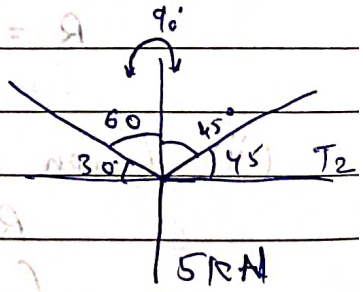
$$\Rightarrow 3P^2+Q^2 = 2P^2+Q^2+2(P^2-Q^2)\cos\theta$$

$$P^2-Q^2 = 2(P^2-Q^2)\cos\theta$$

$$\frac{P^2-Q^2}{2(P^2-Q^2)} = \cos\theta$$

$$\Rightarrow \frac{1}{2} = \cos\theta \quad \Rightarrow \cos\theta = 60^\circ$$

Q-4. A machine weight 5 kn is supported by two chain attached to some point on machine one chain has in clination of 45° with horizontal and other chain has in clination of 30° with horizontal find tension in chain.



Ans. $\frac{T_1}{\sin(90+45^\circ)} = \frac{T_2}{\sin(90+30^\circ)} = \frac{5}{\sin 105^\circ}$

$$T_1 = \frac{5\sin(90+45)}{\sin 105}$$

$$T_1 = \frac{5\cos 45^\circ}{\sin 105} \Rightarrow T_1 = \frac{5\times 1/\sqrt{2}}{\sin(180-75^\circ)} \Rightarrow \frac{5/\sqrt{2}}{\sin 75^\circ}$$

$$T_1 = \frac{5/\sqrt{2}}{0.965} \qquad \because \sin 75^\circ = 0.965$$

$$T_1 = \frac{3.536}{0.966} = 3.66$$

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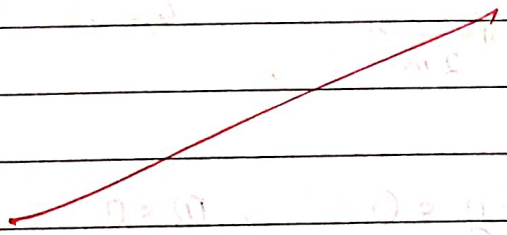
$$T_2 / \sin(90+30) = \frac{5}{\sin 105}$$

$$T_2 = \frac{5(\sin 90+30)}{\sin 105} \Rightarrow T_2 = \frac{5\cos 30^\circ}{\sin 105^\circ}$$

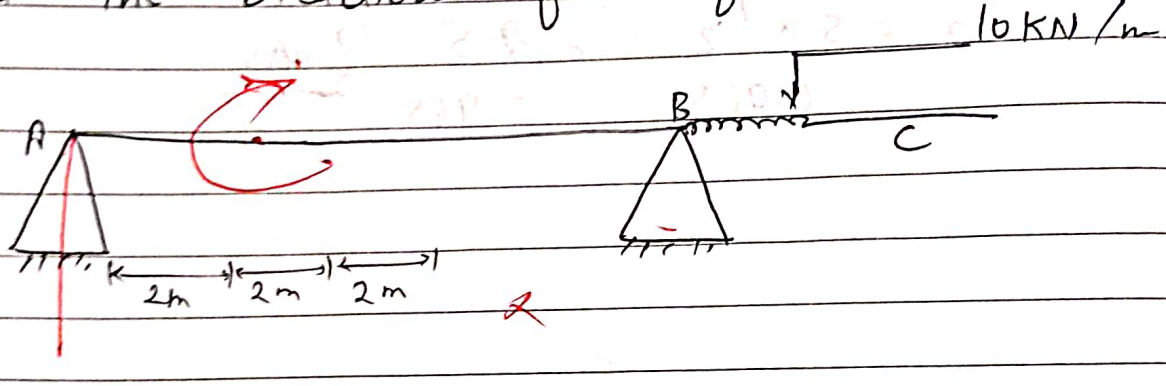
$$T_2 = \frac{5 \times 1/2}{0.965} = \frac{2.5}{0.965}$$? kN

∴



Tutorial - 2

Q-1. Find the reaction force of A & B



$f_x = 0$, $f_y = 0$, $m = 0$

सभी Reaction force का योग सदैव 0 होता है।

FBD

$R_A - 10 - 20 + R_B - 30 = 0$ — समी (1)

$R_A + 10 \times 2 + 20 \times 4 - 12\ B \times 6 + 30 \times 7.5 = 0$

$20 + 80 - 6R_B + 225 = 0$

$100 - 6R_B + 225 = 0$

$325 - 6R_B = 0$

$R_B = \frac{325}{6} = 54.16$ kN

समी (1) में R_B का मान रखने पर।

$R_A - 10 - 20 + 54.16 - 30 = 0$

$R_A - 30 + 54.16 - 30 = 0$

$R_A - 60 + 54.16 = 0$

$R_A = 16 - 54.16 = 5.84$ kN Ans

Q-2 Determine the reaction at A and B for the beam as shown in fig.

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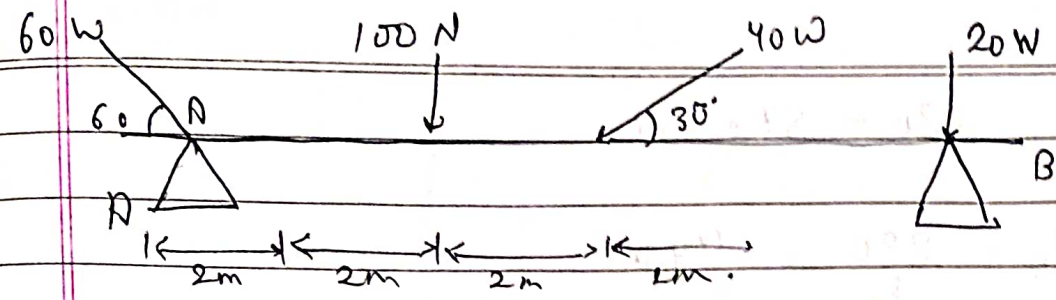
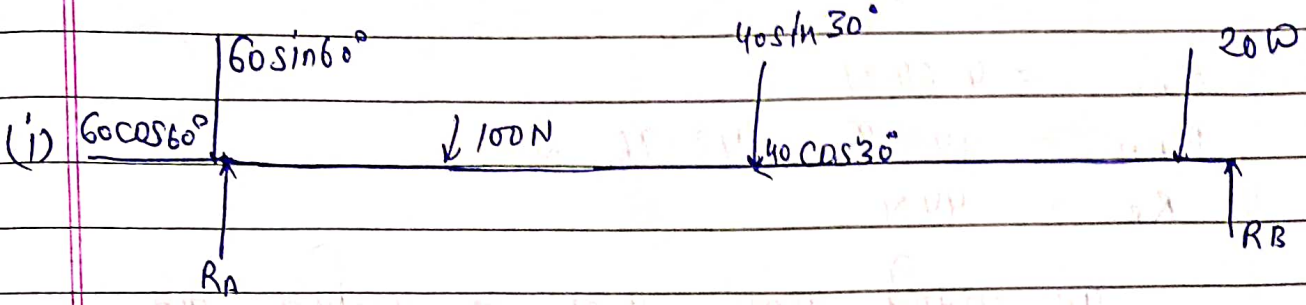


(i)



R_A

$\Sigma f_x = 0 \Rightarrow R_{fx} + 60\cos 60° - 40\cos 30° - ①$

$R_{Ax} + 60 \times \frac{1}{2} - 40 \times \frac{\sqrt{3}}{2} = 0$

$R_{Ax} + 30 - 20\sqrt{3} = 0$

$R_{Ax} = -30 + 20\sqrt{3}$

$R_{Ax} = -30 + 34.64$

$R_{Ax} = 4.64\ N$

(ii) $\Sigma f_y \Rightarrow R_{AN} - 60\sin 60° - 100 - 40\sin 30° - 20 + R_B = 0$

$\Rightarrow R_{AN} - 60 \times \frac{\sqrt{3}}{2} - 100 - 20 - 40 \times \frac{1}{2} - 20 + R_B = 0$

$R_{AN} - 30\sqrt{3} - 100 - 20 - 20 + R_B = 0$

$R_{AN} - 30\sqrt{3} - 140 + R_B = 0$

$R_{AN} - 51.96 - 140 + R_B = 0$

$R_{AN} = 191.96 - 44 = 147.96\ N$

$M = 0$

$100 \times 1 + 40\sin 30° \times 2 + 20 \times 4 - R_B \times 5 = 0$

$100 + 40 \times \frac{1}{2} \times 2 + 80 + R_B \times 5 = 0.$

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$$220 - 5R_B = 0$$

$$R_B = \frac{220}{5} = 44\ N$$

$R_{Ax} = 4.64\ N$

$R_{AN} = 147.96\ N$

$R_B = 44\ N$

R_A पर लगने वाला फल ~~ल~~ कार्यरत बल

$$R_A = \sqrt{(R_{Ax})^2 + (R_{AN})^2}$$

$$\theta = \tan^{-1}\left(\frac{R_{AN}}{R_{Ax}}\right)$$

$$R_A = \sqrt{(4.64)^2 + (147.96)^2}$$

$$R_A = \sqrt{21.52 + 21892.16}$$

$$R_A = \sqrt{21913.68}$$

$$R_A = 148.03$$

$$\theta = \tan^{-1}\left(\frac{147.96}{4.64}\right)$$

$$\theta = 88.20°$$

Q-4. A machine weight 50 N hangs from point C by two strings AC and CB as shown in fig.

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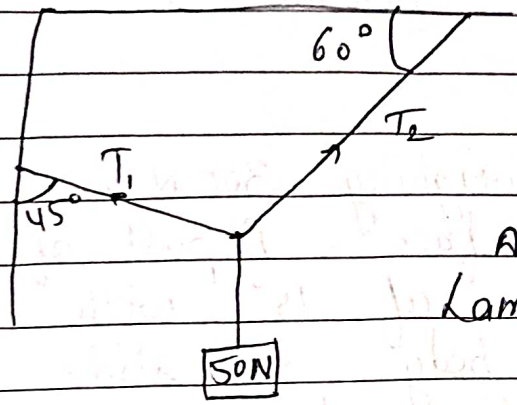
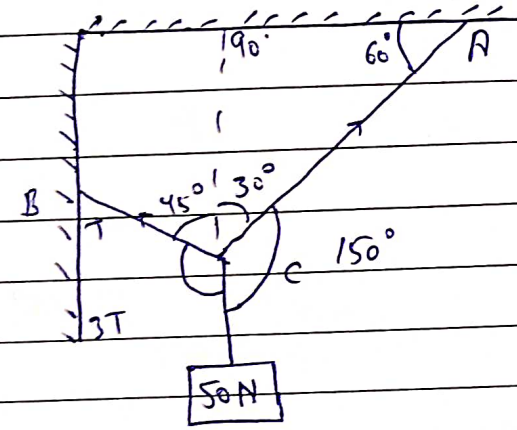


Find force in strain AC and CB using Lami's theorm.

Ans



$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$

$$\frac{T_1}{\sin 150^\circ} = \frac{T_2}{\sin 135^\circ} = \frac{50}{\sin 75^\circ}$$

$$\frac{T_1}{\sin 150} = \frac{50}{\sin 75^\circ} \Rightarrow T_1 = \frac{50 \sin 150}{\sin 75^\circ}$$

$$T_1 = \frac{50 \times 0.5}{0.965} = \frac{25000}{0.965} = 25.90 \text{ N}$$

$$\frac{T_2}{\sin 135} = \frac{50}{\sin 75} \Rightarrow T_2 = \frac{50 \sin 135}{\sin 75^\circ} \Rightarrow T_2 = \frac{50 \times 0.707}{0.965}$$

$$T_2 = \frac{35.35}{0.965} = 34.11 \text{ N}$$

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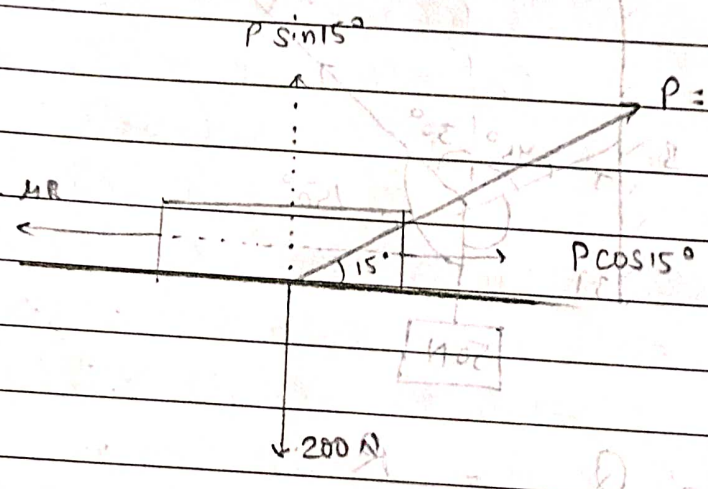
Tutorial - 3

Q-1. A body weighing 300 N is resting on rough horizontal surface. A pull of 100 N is applied at an angle of 15° with horizontal just cause a body to slide over a table. Make calculation for normal reaction & coefficient of friction.



$\Sigma F_x = 0$

$P\cos 15° - F = 0$

$F = 100 \cos 15°$

$F = 96.59\ N$

$\Sigma F_y = 0$

$R + 100 \sin 75° - 300 = 0$

$R = -100 \sin 15° + 300$

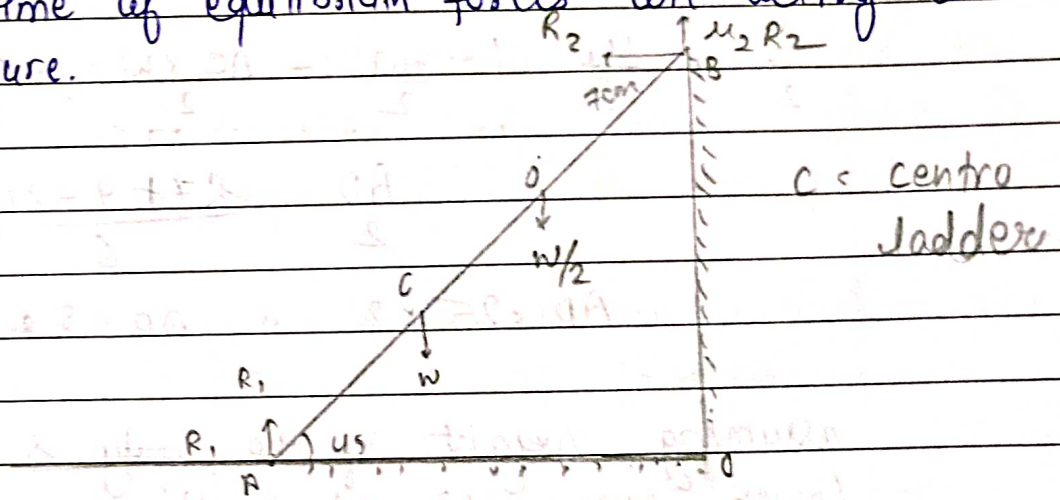
$R = -25.88 + 300$

$R = 274.12$

$$\mu = \frac{F}{R} = \frac{96.59}{274.12} = 0.352\ N$$ Ans

Q-2. A ladder 7m long is placed against a vertical wall making an angle 45° with horizontal. The coefficient of friction between wall & ladder is 1/3 & that between ladder & ground is 1/2. If a man whose weight is half of that of ladder ascends it. How high will be with ladder slips. If a body stands at bottom rung of ladder. The man ascends to the top of the ladder. Find weight of the body.

Ans- At the time of equilibrium forces are acting as shown in figure.



Equilibrium in horizontal direction

$$\mu_1 R_1 = \mu_1 R_2 = \frac{1}{2} \quad \therefore \quad R_2 = R_1/2$$

Equilibrium in vertical direction

$$\mu_2 = 1/3$$

$$R_1 + \mu_2 R_2 = W + W/2$$

$$R_1 + 1/3 \times R_1/2 = 3W/2$$

$$R_1 = 5W/7$$

So, $R_2 = R_1/2 = W/14$.

Let us assume the man can go upto point 'O' of the ladder without slipping.

$R_2 \times 7\sin 45° + \mu_2 \frac{R}{2} \times 7(\cos 45° - w \times 7/2 \cos 45°)$

$(-\frac{w}{2} AD \cos 45° = 0)$

$\frac{9w}{14} \times 7 \times \frac{1}{\sqrt{2}} + \frac{1}{3} \times \frac{9w}{14} \times 7 \times \frac{1}{\sqrt{2}} - \frac{7w}{2} \times \frac{1}{\sqrt{2}}$

$(\frac{AD}{2} \times w \times \frac{1}{\sqrt{2}} = 0)$

$\frac{9w}{2} + \frac{9w}{6} 1 - \frac{7w}{2} - \frac{AC \times w}{2} = 0$

$\frac{AD}{2} = \frac{27+9-21}{6} = \frac{15}{6}$

$AD = 2.5 \times 2 \Rightarrow AD = 5$ cm.

assuming weight of the ~~body~~ boy standing at lower rung = w_1 at limiting equilibrium

$\mu_1 R_1 = R_2$ $[\because \mu_1 \leq \frac{1}{2}]$

$R_1 + \mu_2 R_2 = w_1 + w + w/2$

$2R_2 + 1/3 R_2 = w_1 + 3w/2$

$\frac{7R_2}{3} = w_1 + 3w/2$

$R_2 = \frac{3}{7}(w_1 + 3w/2)$ — ①

Taking moments about A

$R_2 \times 7 \sin 45° + \mu_2 R_2 \times 7\cos 45° - w \times 7/2 \cos 45°$

$(-w/2 \times 7\cos 45° = 0)$

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$$7R_2 + 7R_2/3 = \frac{7W}{2} + \frac{7W}{2}$$

$$R_2 = 3W/4$$

Put value of R_2 in equation-①

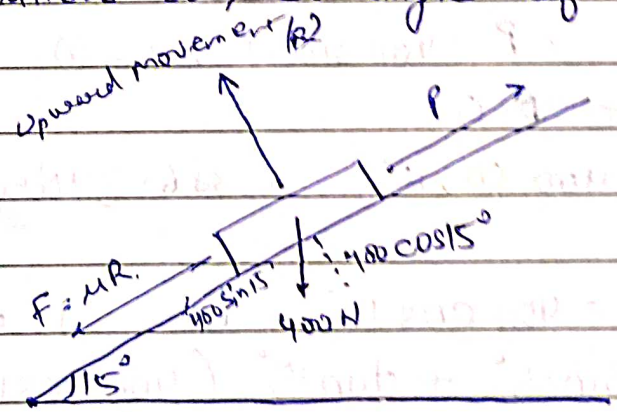
$$\frac{3W}{4} = \frac{3}{7} \quad (W_1 = 3W/2)$$

$$W_1 = W/4$$

Height of boy = $W_1 = W/7$

Q-3. A 400 N body is laying in limiting equilibrium on a rough inclined plane having an inclination of 30°. The inclination is now made equal to 45°. Find the force required to just the body up the plane, if force is applied at angle of 20° to the plane.

Ans. Body is in limiting equilibrium at an inclined rough plane of inclination 30°, So angle of friction



$P = 392.22\ N$ Ans

$\Sigma F_x = 0 \rightarrow P = 400 \sin 15^\circ + F$

$\rightarrow P = 400 \sin 15 + \mu R$ - (1)

$\Sigma F_y = 0 \rightarrow 0$

$R = 400 \cos 15^\circ = 386.37$ Newton

Put $R = 400 \cos 15^\circ$ in (1) equation

$P = 400 \sin 15^\circ + \tan 15^\circ (400 \cos 15^\circ)$

$P = 103.52 + 0.26 (386.37)$

$P = 103.52 + 103.52$

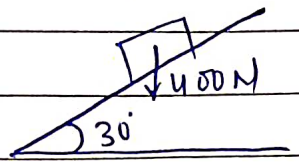
$P = 207.04$ Ans

$207.04\ N$

Tut -3

Q-4. A 400 N body is laying in limiting equilibrium on a rough in dired plane having a exclamation of 30°. The inclination is now made equal to 75° Find the force required to just move the body of the plane is the ~~for~~ force is applied at 20° of the plane.

Soln.

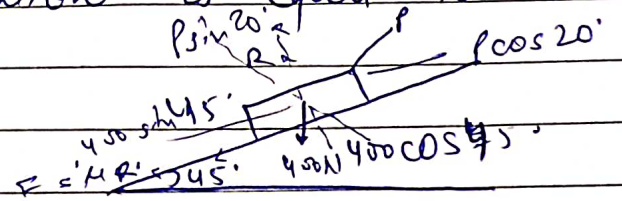


$\lambda = 30°$

$\mu = \tan\lambda$

$\mu = \frac{1}{\sqrt{3}}$

Now inclination is equal to 75°



$\Sigma F_x = 0 \rightarrow R + P\sin 20° = 400 \sin\cos 45°$

$R = 400\cos 45° - P\sin 20° - (1)$

$\Sigma F_y = 0 - P\cos 20° - 400\sin 45° + \mu R$

Put value of R in eq (1)

$P\cos 20° = 400\sin 45° + \tan 30° (400\cos 45° - P\sin 20°)$

$P\cos 20° = 400\sin 45° + 400\ 30° (\cos 45° - P\tan 30° \sin 20°)$

$P(\cos 20° + \tan 30° \sin 20°) = 400 (\sin 45° + \tan 30° \cos 45°)$

$P = 400(\sin 45 + \tan 30° \cos 45°) / \cos 20° + \tan 30° \times \sin 20°$

$P = 400 \frac{(0.707 + 0.577 \times 0.707)}{0.9397 + 0.577 \times 0.3420}$

$P = 8392.22 N$

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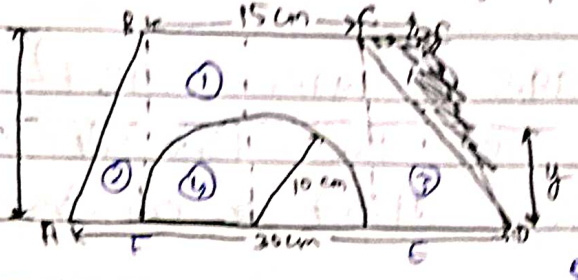
Tutorial - 4

Q-1 Find the centroid of plane fig. shown below :-



(1) आयत ~~EDHE~~ BCEF

(2) Δ ABF

(3) Δ CED

(4) अर्धवृत्त EFH

$\bar{x} = 0$

$$\bar{y} = \left(\frac{A_1y_1 + A_2y_2 + A_3y_3 - A_4y_4}{A_1 + A_2 + A_3 - A_4} \right) \quad \text{--- (1)}$$

$\Rightarrow$

$A_1 = 15 \times 20 \Rightarrow 300 \text{ cm}^2$

$A_2 = A_3 = \frac{1}{2} \times 7.5 \times 20 = 75 \text{ cm}^2$

$A_4 = \frac{\pi \times 10^2}{2} \Rightarrow 50\pi \text{ cm}^2$

$y_1 = \frac{20}{2} \Rightarrow 10 \text{ cm.}$

$y_2 = y_3 = \frac{20}{3} = 6.66 \text{ cm.}$

$y_3 = \frac{4R}{\pi 3} \Rightarrow \frac{4 \times 10 \times 7}{3 \times 22} \Rightarrow 4.242 \text{ cm.}$

eq. (1) में सभी मान रखने पर।

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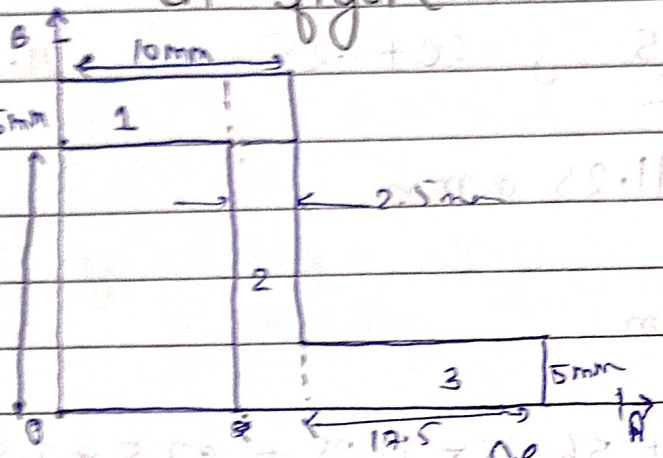
$$\bar{y} = \left(\frac{300 \times 10 + 75 \times 6.66 + 75 \times 6.66 - 157.14 \times 4.242}{300 + 75 + 75 - 157.14} \right)$$

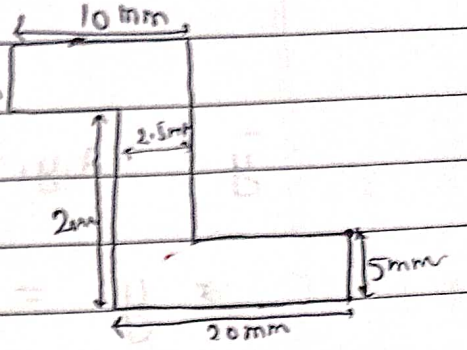
$$\Rightarrow \bar{y} = \left(\frac{3000 + 499.5 + 499.5 - 666.58}{450 - 157.14} \right)$$

$$= \frac{3332.42}{292.86} \Rightarrow 11.37 \text{ cm}$$

तो centroid of plane is on $(0, 11.37)$!

Q-2. Find the centroid of cross-sectional area of Z section shown in figure -





OA = OB और OC —

$A_1 = (10-2.5) \times 2.5 = 18.75 \text{ mm}^2$

$A_2 = (20+2.5) \times 2.5 = 56.25 \text{ mm}^2$

$A_3 = (20-2.5) \times 5 = 87.5 \text{ mm}^2$

$$\bar{x} = \frac{A_1x_1 + A_2x_2 + A_3x_3}{A_1 + A_2 + A_3}$$

$x_1 = \frac{10-2.5}{2}$ ⇒ $\frac{7.5}{2}$ ⇒ 3.75 mm

$x_2 = \frac{10-2.5}{2} = 10 - 1.25$ ⇒ 8.75 mm

$x_3 = 10 + \frac{17.5}{2} = 18.75$ mm

$$\Rightarrow \bar{x} = \left(\frac{18.75 \times 3.75 + 56.25 \times 8.75 + 87.5 \times 18.75}{18.75 + 56.25 + 87.5} \right)$$

$$\bar{x} = \frac{70.31 + 492.18 + 1640.62}{162.5}$$

$$\bar{x} = \frac{2203.11}{162.5} = 13.55 = \bar{x}$$

$$\bar{y} = A_1y_1 + A_2y_2 + A_3y_3 / A_1 + A_2 + A_3$$

$y_1 = 20 + \frac{2.5}{2}$ ⇒ $20 + 1.25$ ⇒ 21.25 mm

$y_2 = \frac{22.5}{2}$ ⇒ 11.25 mm

$y_3 = \frac{5}{2}$ ⇒ 2.5 mm

$$\bar{y} = \frac{18.75 \times 21.25 + 56.25 \times 11.25 + 87.5 \times 2.5}{162.5}$$

$$\bar{y} = \frac{398.43 + 632.81 + 218.75}{162.5} = \frac{1249.99}{162.5} = 7.69$$

$\therefore \bar{x} = 13.55$ mm & $\bar{y} = 7.69$ mm Ans

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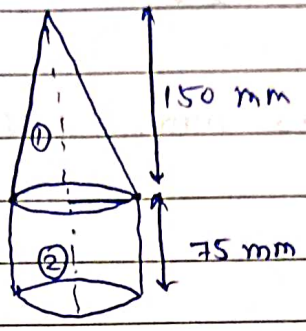
Q-2. A solid body is made up by joining the base of a right circular cone of height 150 mm of the equal base of a circular cylinder of height 75 mm. Calculate the c.g. of solid body from the base of cylinder.



Soln. The body is symmetrical so $\bar{x} = 0$

For right circular cone

$$V_1 = \frac{1}{3}\pi r^2 h$$

$$= \frac{1}{3}\pi r^2 \times 150 \text{ mm}$$

$$V_1 = 50\pi r^2 \text{ mm}^3$$

$$y_1 = \frac{150}{4} \Rightarrow y_1 = 37.5$$

For circular cylinder –

$$V_2 = \pi r^2 h$$

$$V_2 = 75\pi r^2 \text{ mm}^3$$

$$y_2 = 150 + 37.5$$

$$= 187.5$$

$$\bar{y} = V_1 y_1 + V_2 y_2 / V_1 + V_2$$

$$\bar{y} = \frac{(50\pi r^2 \times 37.5) + (75\pi r^2 \times 187.5)}{50\pi r^2 + 75\pi r^2}$$

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$$\bar{y} = \frac{50 \times 37.5 + (75 \times 187.5)}{50 + 75}$$

$$\bar{y} = \frac{187.5 + 14062.5}{125}$$

$$\bar{y} = 127.5 \text{ mm}.$$

Tutorial - 5

Q-1 In a experiment test conducted on lifting machine it was observed that an effort of 20 KN is applied to lift the load of 90 KN, where as an effort of 16 KN is required to lift the load of 70 KN, determine the following. (Taking V.R = 25)

(a) The law of machine
(b) The limiting machine advantage
(c) The limiting efficiency
(d) Effort required to lift the load of 15 KN.

Soln. (a) According to law of machine → $P = mW + C$

When Effort = 20 KN and load = 90 KN

$$20 = m \times 90 + C \quad \text{— (1)}$$

When Effort = 16 KN and load = 70 KN

$$16 = m \times 70 + C \quad \text{— (2)}$$

(1) − (2) $\quad 4 = 20m$

$$0.2 = m$$

Put $m = 0.2$ in (1) equation −

$$C = 2$$

So, $\boxed{P = 0.2W + 2}$

(b) $M.A_{max} = \frac{1}{m} = \frac{1}{0.2}$ $\quad \boxed{M.A_{max} = 5}$

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(c) $\eta_{max} = \frac{1}{m \times V.R} = \frac{1}{0.2 \times 25}$ $\boxed{\eta_{max} = 0.2}$

(d) When load = 15 KN then effort is

$P = 0.2(15) + 2$

$\boxed{P = 5 \text{ KN}}$

Q-2. In the case of lifting machine efforts required to lift the load 50 N and 80 N were 12 N and 18 N respectively, Find the –

(a) law of machine
(b) Efficiency of m/c & the effort loss in friction at 50 N load.
(c) Max. efficiency, If the velocity Ratio is 6.

Soln. (a) When $P_1 = 12$ and $W_1 = 50$ N

$12 = m \times 50 + c$ — (1)

When $P_2 = 18$N and $W_2 = 80$N

$18 = m \times 80 + C$ — (2)

(1) − (2)

$-6 = -30m$

$0.2 = m$

$12 = (0.2)\,50 + C$

$C = 2$

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So, $P = 0.2 \times W + 2$

(b) $\eta = \frac{M.A}{V.R} \times 100$

$= \frac{50}{12} \times \frac{1}{6} \times 100$

$\eta = 0.6944$

$P_f = \frac{W}{V.R}\left(\frac{1}{\eta} - 1\right)$

$P_f = 3.67$

(c) $\eta_{max} = \frac{1}{m \times V.R.} \times 100$

$= \frac{1}{0.2 \times 6} \times 100$

$\eta_{max} = 0.833 \times 100$

$\eta_{max} = 83\%$

Q-3. In a lifting m/c 25% of effort applied to raise a load is lost in friction, What does can be lifted through a height of 0.8 m if an effort of 200 N is moved through 10 m. Also determine M.A. and η if m/c

Soln. $V.R = \frac{10}{0.8} = 12.5$

$P_f = P \times 25\%$

$P_f = 200 \times 25\%$ $\quad P_f = 50\%$

$P_f = P_t - P_a$

$50 = \frac{W}{12.5} - 200$ $\quad W = 1875$ N

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$M.A = W/P \quad \Rightarrow M.A = \frac{1875}{200} \quad \Rightarrow \boxed{M.A = 9.375}$

$\eta = \frac{M.A}{V.R} = \frac{9.375}{12.5} \quad \boxed{\eta = 0.75}$ Ans