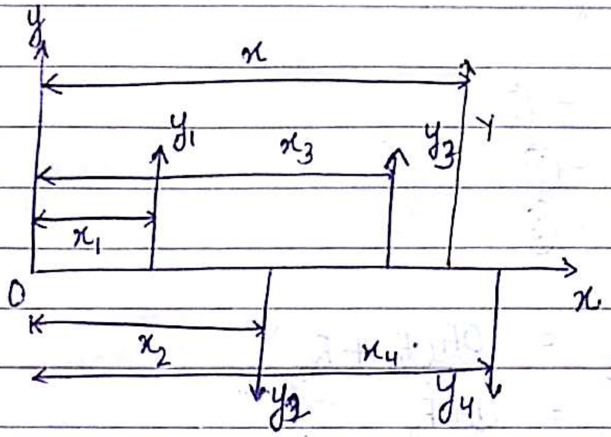
Everyone says hapiness starts from 'H'
How come my starts from 'D'.

Date:
Page No.

17/1/16

General case of Parallel forces in a plane →



$Y = y_1 - y_2 + y_3 - y_4$

$Y = \Sigma y_i$

OY

$Y.x = y_1 x_1 - y_2 x_2 + y_3 x_3 - y_4 x_4$

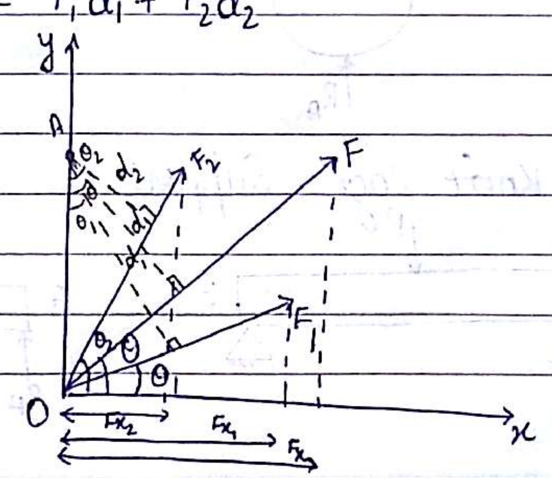
$$x = \frac{\Sigma y_i x_i}{Y} = \frac{\Sigma y_i x_i}{\Sigma y_i}$$

Principle of Moments / Varignon's Theorem →

Moment of a force about any axis is equal to the sum of moment of its components abt the same axis.

$F \rightarrow F_1, F_2$

$F.d = F_1 d_1 + F_2 d_2$



$F_x = F\cos\theta$

$F_{x_1} = F_1 \cos\theta_1$

$F_{x_2} = F_2 \cos\theta_2$

Moment abt. A

$F.d = F.OA\cos\theta$

$= OA.F\cos\theta$

$= OA.F_x$

$Fd = OA F_x$ — (1)

$F_1 d_1 = OA.F_{x_1}$ — (2)

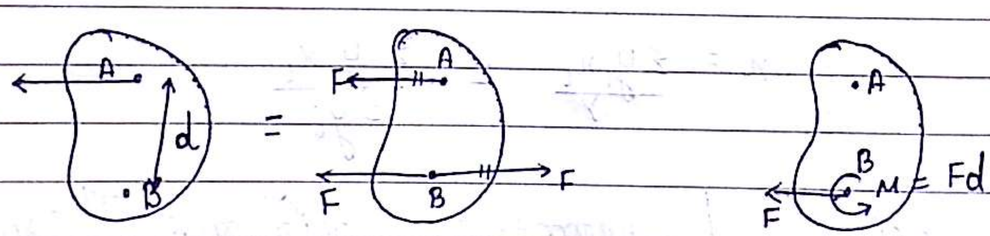
$F_2 d_2 = OA.F_{x_2}$ — (3)

(2) + (3)

$F_1 d_1 + F_2 d_2 = OA(F_{x_1} + F_{x_2})$

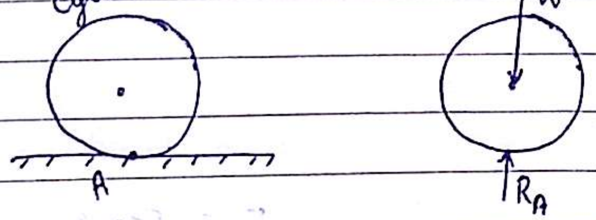
$= OA F_x$

Resolution of a Force into a force and couple

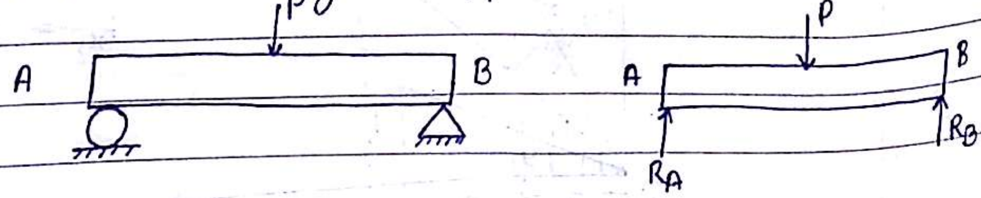


Supports and Reactions

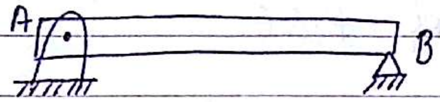
(1) Frictionless Support

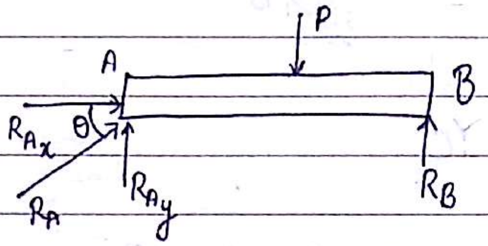


(2) Roller and Knife edge Support

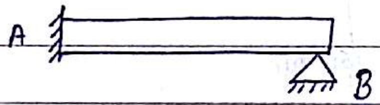


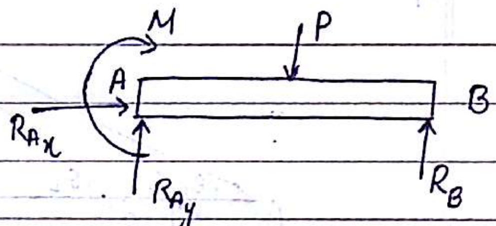
(3) Hinge / Pin Joint Support →



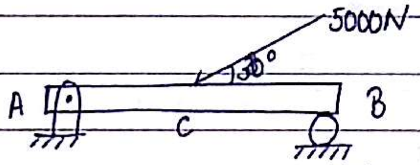


(4) Built in Support



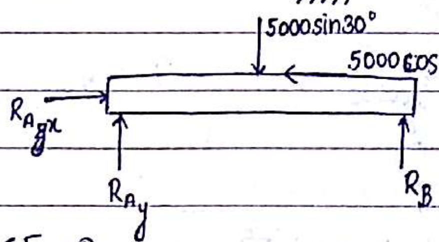


Q. 2.11



$AB = 5m$

Sol^n-



$\Sigma F_x = 0$

$$R_{A_x} = 5000 \times \frac{\sqrt{3}}{2}$$

$$= 2500\sqrt{3}\ N = 4330$$

$\Sigma F_y = 0$

$$R_{A_y} + R_B = 2500N$$

$$\Sigma M_A = 0$$

$$-2.5 \times 2500 + R_B \times 5 = 0$$

$$R_B = \frac{6250}{5}$$

$$= 1250N$$

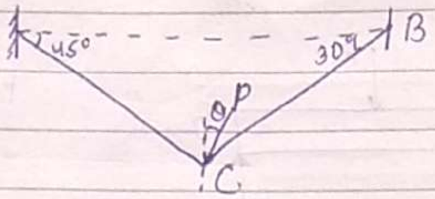
$$R_{A_y} = 2500 - 1250$$

$$= 1250N$$

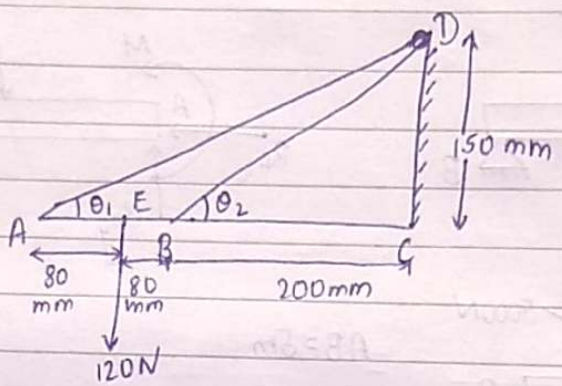
$$R_A = 4506.8N$$

Date:
Page No.

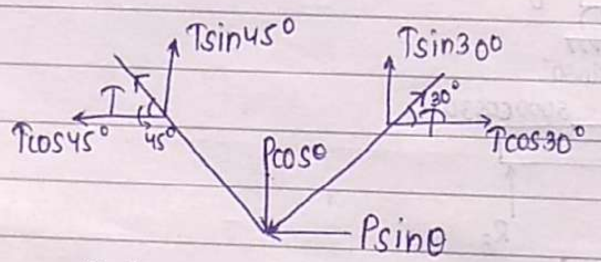
Q.① Force P is applied at point C of the cable ~~AB~~ ACB. If tension in each part is 50N. Find out the value of P & θ.



Q② Determine tension in cable ADB & reaction at pt. C



①



T = 50

$P\sin\theta = 50\cos 30^\circ - 50\cos 45^\circ$ — ①

$P\cos\theta = 50\sin 45^\circ + 50\sin 30^\circ$ — ②

①/②

$$\tan\theta = \frac{\frac{\sqrt{3}}{2} - \frac{1}{\sqrt{2}}}{\frac{1}{\sqrt{2}} + \frac{1}{2}}$$

$$= \frac{\sqrt{6} - 2}{2 + \sqrt{2}}$$

$$= 0.13$$

$$\theta = 7.4^\circ$$

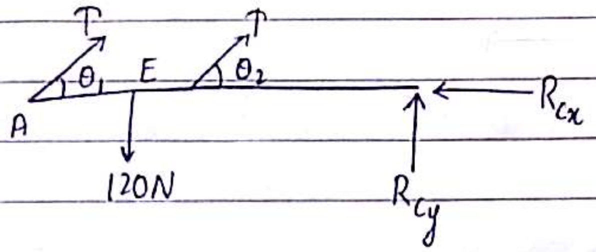
$P = 61.69\ N$

(2) $\theta_1 = \tan^{-1}\frac{150}{360}$

$= 22.6^\circ$

$\theta_2 = \tan^{-1}\frac{150}{200}$

$= 36.87^\circ$



$T\cos\theta_1 + T\cos\theta_2 = R_{cx}$

$T(\cos\theta_1 + \cos\theta_2) = R_{cx}$

$1.72\,T = R_{cx}$

$T(\sin\theta_1 + \sin\theta_2) + R_{cy} = 120$

$0.98T + R_{cy} = 120$

Moment abt. pt. C = 0

$\cancel{Tco}\ T\sin\theta_2 \times 200 \ \cancel{+} - 120 \times 280 + T\sin\theta_1 \times 360 = 0$

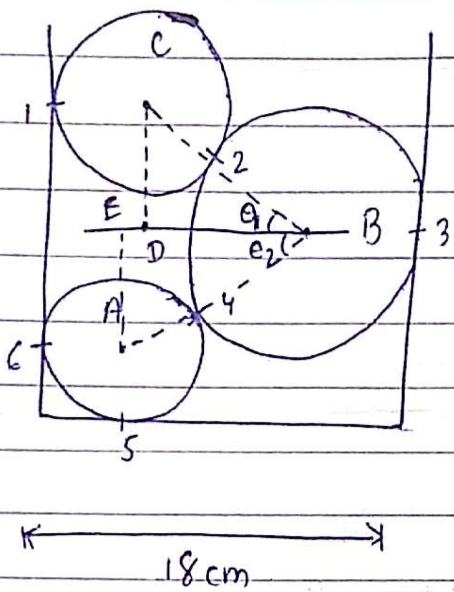
$T(120 + 138.35) = 33600$

$T = 130.056\ N$

$R_{cx} = 223.6N$

$R_{cy} = -7.4N$

3



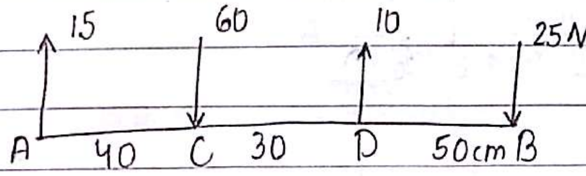
$r_a = 4cm$ $\quad$ $W_A = 15$

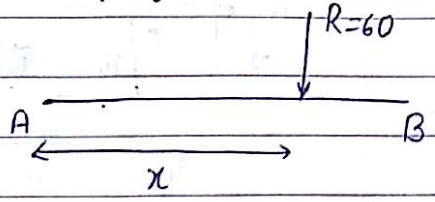
$r_b = 6$ $\quad$ $W_B = 40$

$r_c = 5$ $\quad$ $W_C = 20kg$

$$\cos\theta_1 = \frac{BD}{11} = \frac{7}{11}$$

① ⓐ Find out the resultant of the system.

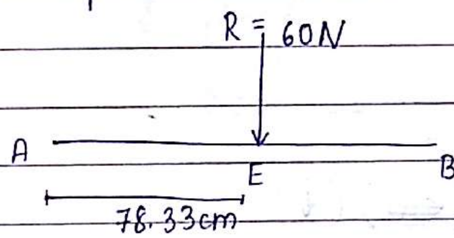




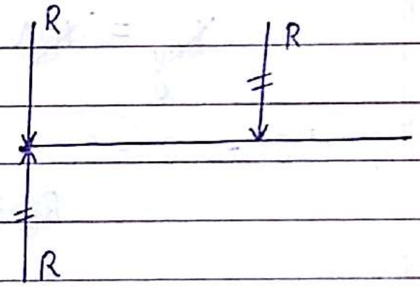
Sol^n– ~~F_{re}~~ $F_{net} = 15+10-60-25$
$= -60N$
$= 60N (\downarrow)$

$-60x = -60\times40 + 10\times70$ ~~$+$~~ -25×120
$x = 78.33cm$

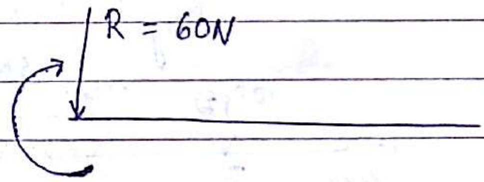
ⓑ Reduce the system into a single force and moment at pt. A.



≡

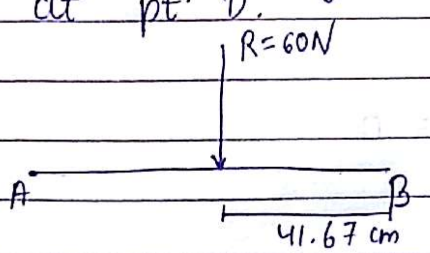


≡

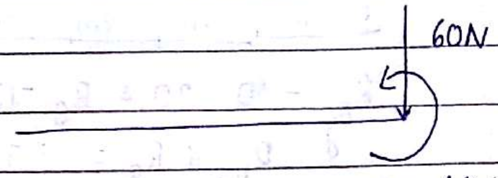


$M = F\times d = 60\times78.33$
$= 4699.8$ N-cm
$= 47$ N-m (cw)

Reduce the system into a single force & moment at pt. D.

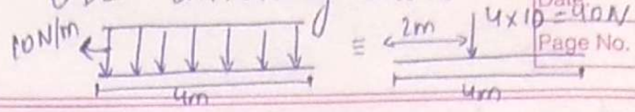


≡

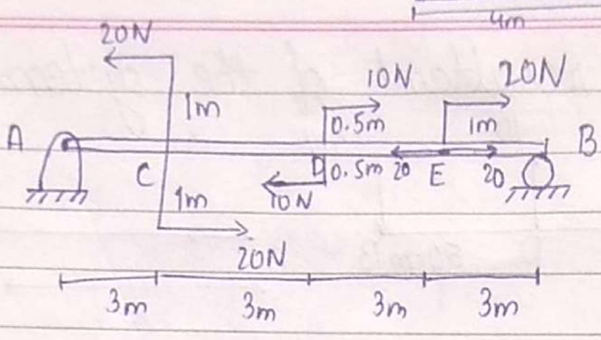


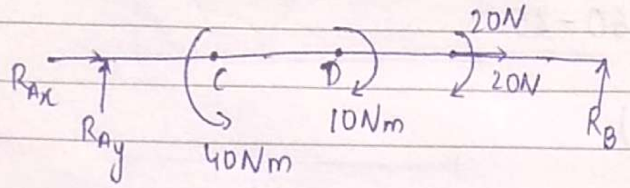
$M = 60\times41.67$
$= 2500.2$ N-cm

UDL - uniformly distributed load



Q.





$R_{Ax} = 20N$

$\cancel{R_{Ay} + R_B =}$

$\cancel{-40\times 3 + 10\times 6 + 20\times 9 - R_B\times 12 = 0}$

$R_B = \cancel{10N}(\uparrow)$

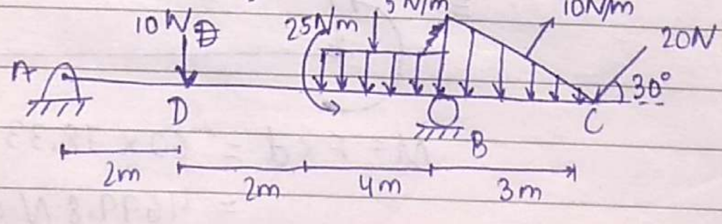
$\cancel{R_{Ay} = 10N (\downarrow)}$

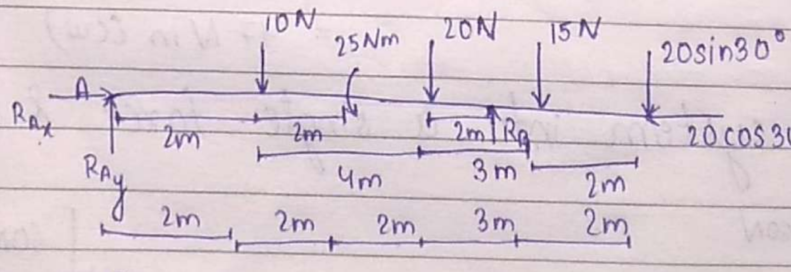
$40 - 10 - 20 + R_B\times 12 = 0$

$R_B = 0.833 (\cancel{cw}) (\downarrow)$

$R_{Ay} = 0.833 (\uparrow)$

Q.

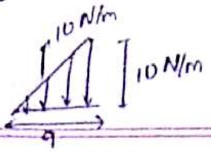




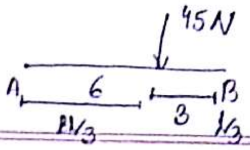
$R_{Ay} - 10 - 20 + R_B - 15 - 10 = 0$

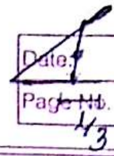
$R_{Ay} + R_B = 55N$

UVL → Uniformly varying load



$F = \frac{1}{2} \times 10 \times 9 = 45N$





$R_{Ax} = 20\cos 30°$

$= 20 \times \frac{\sqrt{3}}{2}$

$= 17.32\,N\,(\rightarrow)$

$\Sigma M_A = 0$

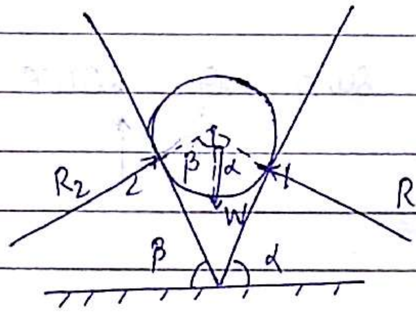
$-10 \times 2 + 25 - 20 \times 6 + R_B \times 8 - 15 \times 9 - 10 \times 11 = 0$

$R_B = 45\,N\,(\uparrow)$

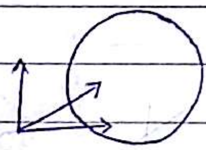
$R_{Ay} = 55 - 45$

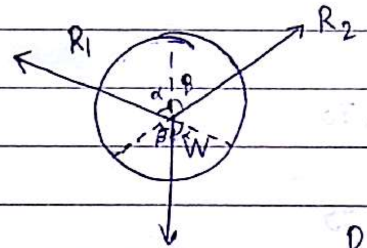
$= 10\,N\,(\uparrow)$

Q.



Find reaction at 1 & 2.





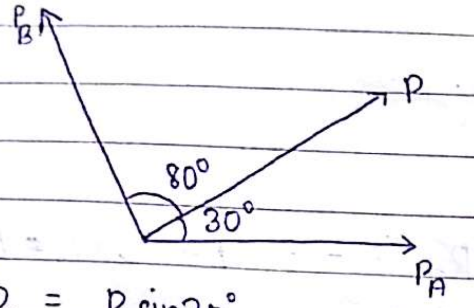
$$\frac{R_1}{\sin(180-\beta)} = \frac{R_2}{\sin(180-\alpha)} = \frac{W}{\sin(\alpha+\beta)}$$

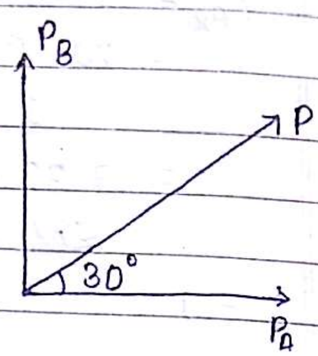
$$R_1 = \frac{W\sin\beta}{\sin(\alpha+\beta)} \qquad R_2 = \frac{W\sin\alpha}{\sin(\alpha+\beta)}$$

Date:
Page No.

10/1/17

Force System





$$P_A = \frac{P\sin 30^\circ}{\sin(30^\circ + 80^\circ)}$$

$$P_B = \frac{P\sin 80^\circ}{\sin(30^\circ + 80^\circ)}$$

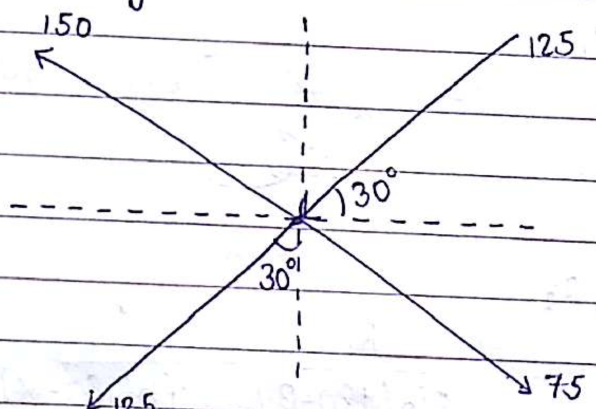
$$P_A = \frac{P\sin 30^\circ}{\sin(90^\circ)} = P\sin 30^\circ$$

$$P_B = \frac{P\sin 60^\circ}{\sin 90^\circ} = P\sin 60^\circ$$

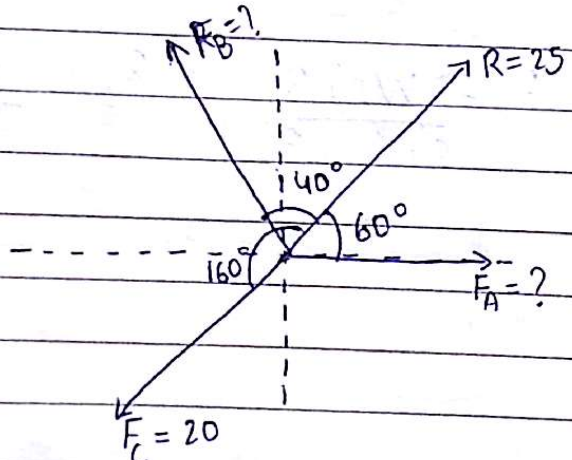
12/01/17

Determine the algebraic sum of force components in x & y direction

1.)

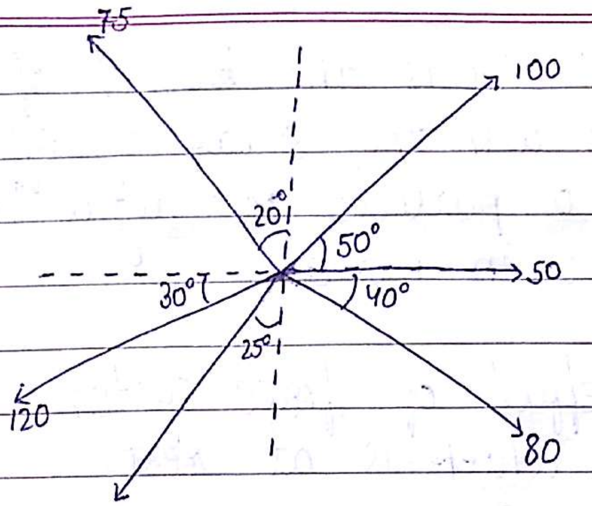


2.)



Date:
Page No.

3.)



13/01/17

Engineering Mechanics- It is the branch of physical science that deals with the study of effect of force system acting on a particle or rigid body which may be at rest or in motion.

Statics- Study of effect of force system acting on a particle or body which is at rest.

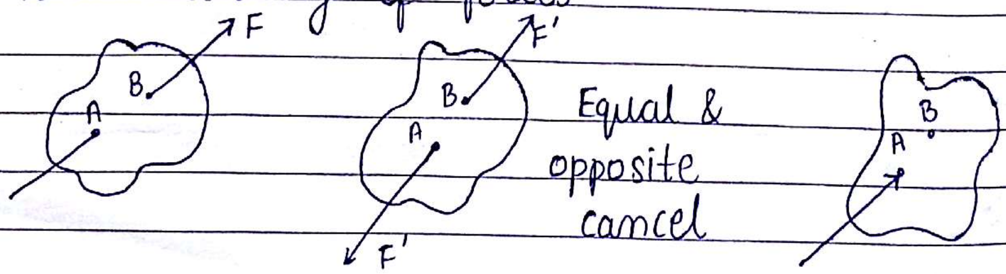
Dynamics- Study of effect of force system acting on a particular rigid body which is at rest.

Kinematics- Study of effect of force system without reference of cause of motion i.e. relationship b/w velocity, displacement, acceleration are defined.

Kinetics- Study of effect of force system with reference to the cause of motion i.e. force and mass are considered.

Law of Mechanics-

1. Newton's law of inertia
2. F ∝ rate of change of momentum
3. Equal & opposite reaction
4. Newton's gravitation law $F = \frac{Gm_1m_2}{r^2}$
5. Parallelogram law
6. Transmissibility of forces



The cond^n of equilibrium of a body will remain unchanged if point of application of a force acting on a rigid body is shifted to any other point acting along its line of action.

7.) Δ law

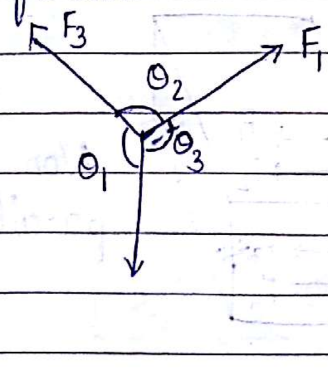
If two forces acting on a pt. are represented by two sides of a triangle taken in order, then their resultant is represented by the 3rd side taken in an opposite order.

8.) Polygon law of forces

If n no. of concurrent forces acting on a body are represented in magnitude & dir^n by the side of a polygon taken in an order, then the resultant is represented in magnitude and direction by the closing side of the polygon taken ~~to~~ in opposite order.

9.) Lami's Theorem

If three concurrent forces acting on a body ~~are represented in magnitude and direction by the~~ ~~&~~ having same nature (push or pull) are in equilibrium then each force is proportional to the sine of angle included b/w the other two forces.



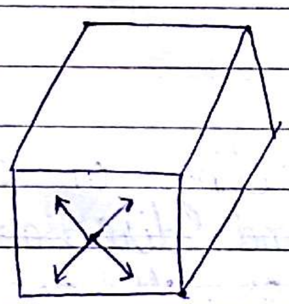
$$\frac{F_1}{\sin\theta_1} = \frac{F_2}{\sin\theta_2} = \frac{F_3}{\sin\theta_3}$$

Scanned by CamScanner

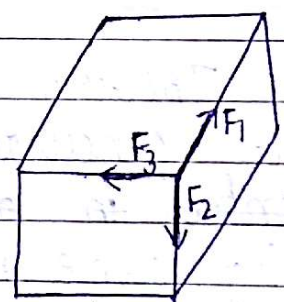
Force System

It is the combination of different forces acting on a body.

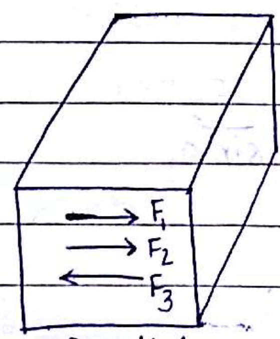
- Force System
  - Coplanar Force System
    - Concurrent Force system
    - Parallel F.S.
      - Like Parallel F.S.
      - Unlike Parallel F.S.
    - Non-concurrent & non-parallel F.S.
  - Non-Coplanar Force System
    - (Same)



Coplanar concurrent F.S.
(meeting at one pt.)

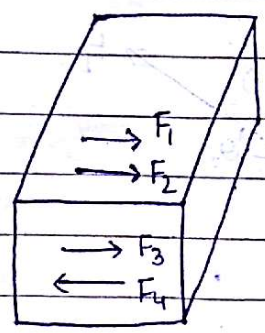


Non-coplanar concurrent F.S.

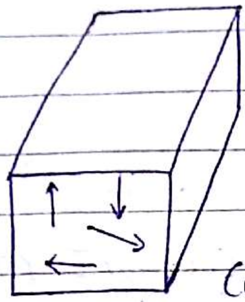


Parallel

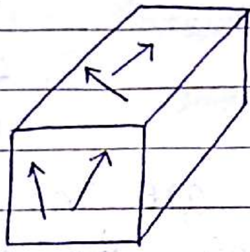
- F_1 & F_2 parallel FS
- F_2 & F_3 non-parallel FS



Non coplanar parallel forces



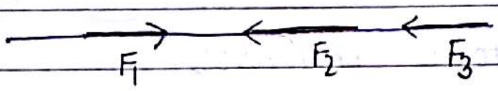
Coplanar Non-concurrent & non-parallel



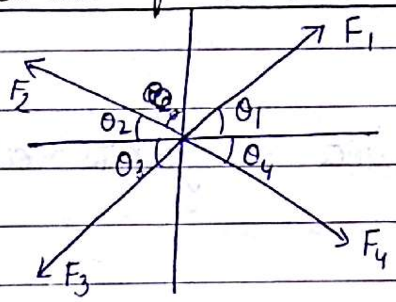
Non-everything

Collinear F.S.

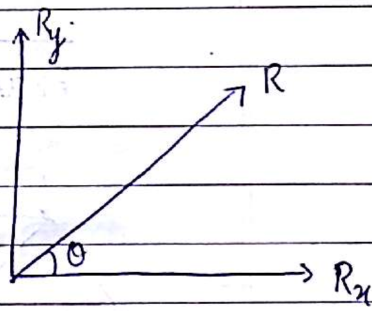
Lie in one line



Resultant of several Concurrent Forces



$$R_x = F_{x_1} + F_{x_2} + F_{x_3} + F_{x_4}$$
$$R_y = F_{y_1} + F_{y_2} + F_{y_3} + F_{y_4}$$



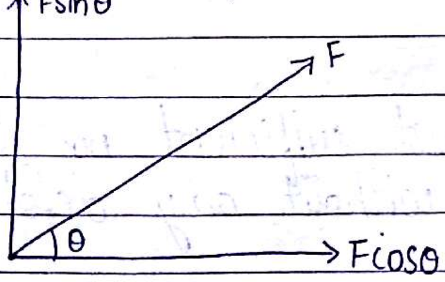
$F_{x_1} = F_1 \cos\theta_1$ $\quad$ $F_{x_2} = -F_2 \cos\theta_2$

$F_{x_3} = -F_3 \cos\theta_3$ $\quad$ $F_{x_4} = F_4 \cos\theta_4$

$$R = \sqrt{R_x^2 + R_y^2}$$

Resolution of Force

Process of breaking the force into a no. of forces which are equivalent to the given force.



Date:
Page No.

24/01/17

Unit-2

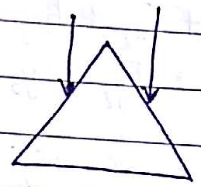
~~Thrus~~ Truss

~~Thr~~ Truss are the structures of straight members that are joined together at their ends by riveting & welding.

Load applied at joints only.

Truss is a ~~true~~ two force member.

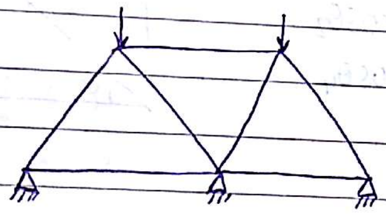
Eg.- Mobile tower, transmission tower



Frame

Load applied on joints as well as members.

3 members



7 Members
5 joints

Mathematical condn for perfect truss

$m = 2j - 3$

m = No. of member of truss
j = No. of joints

A truss which has just sufficient no. of members to resist the load without any deformation.

Date:
Page No.

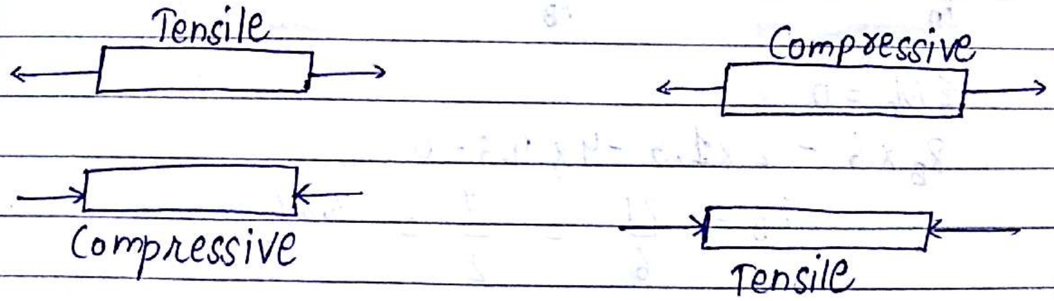
→ $m > 2j-3$ Over rigid / Redundant / Statically indetermin-ate
However truss is stable we cannot solve the ~~$m < 2j-3$~~ truss by using eq^{n}s of static eq^m.
Truss contains more member than required.

→ $m < 2j-3$ Under rigid / collapsible condition / Deficient truss. statically determinate, it means eq^n of static eq^m are sufficient to determine the axial force in the members of a truss.

Assumptions of a perfect truss

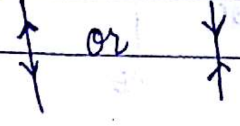
→ Load applied at joints only ~~neglib~~
→ Negligible weight of members
→ Pin-joint connections
→ Joints are frictionless
→ ~~f~~ Truss is statically determinate

External Force   Internal Force

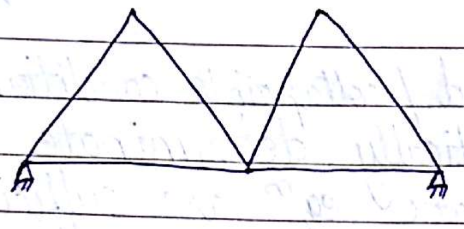


(1) Method of joints

→ First of all find out the support r_x^ns R_A & R_B.
→ Mark the internal forces in the members of the truss



→ Eq^m of each joint is considered. If the magnitude of force comes out to be -ve it means assumed dir^n is simply reversed.



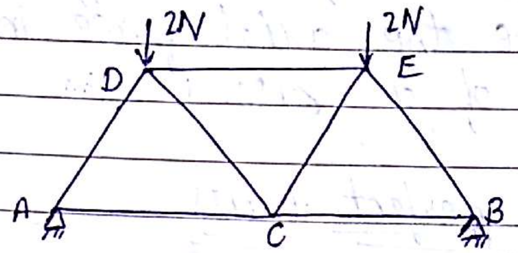
$m = 2j-3$

$6 = 2 \times 5 - 3$

$= 10-3$

$6 < 7$

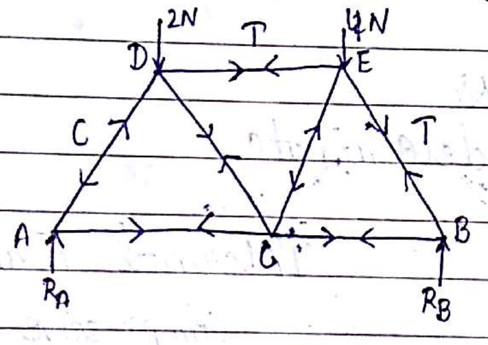
Q.



Find out the magnitude & nature of internal force in member DE.

Length of each member is 3m & every member is inclined to each other at an angle of 60°.

Sol^n



$\Sigma F_y = 0$

$R_A + R_B - 2 - 4 = 0$

$R_A + R_B = 6 \quad -(1)$

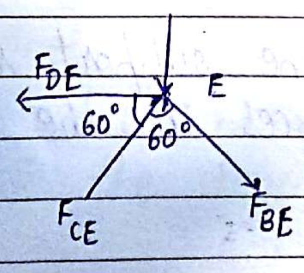
$\Sigma M_A = 0$

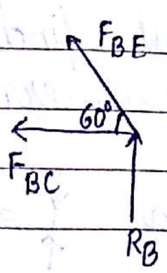
$R_B \times 6 - 2 \times 1.5 - 4 \times 4.5 = 0$

$R_B = \frac{21}{6} = \frac{7}{2} = 3.5N$

$R_A = 6 - 3.5$

$= 2.5 N$

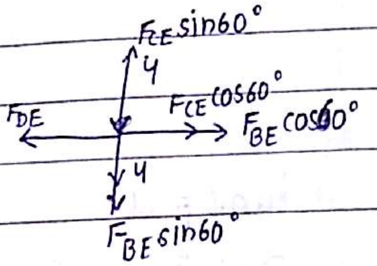




$F_{BE} \sin 60^\circ = R_B$

$F_{BE} = R_B \times \frac{2}{\sqrt{3}}$

$= 4.04N$



$F_{DE} = F_{CE} \cos 60^\circ + F_{BE} \cos 60^\circ$

$F_{DE} = 6.35N$ (✗)

$F_{CE} \sin 60^\circ = 4 + F_{BE} \sin 60^\circ$

$F_{DE} = 1.732$

$F_{CE} \sin 60^\circ = 4 + 3.5$

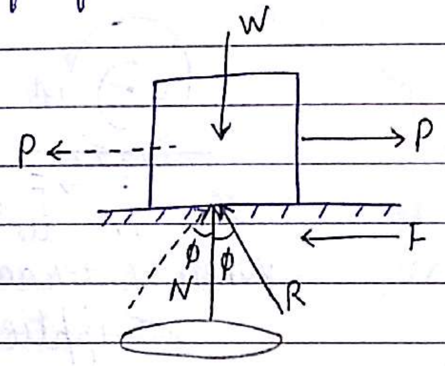
$F_{CE} = 8.66\,N$ (✗)

27/01/17

Friction

Friction force

Cone of friction



If R is within the cone, it is self locking condition i.e. the motion does not occur.

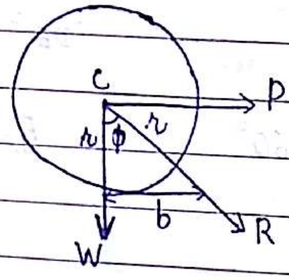
Angle of friction - Angle made by the resultant of normal reaction and frictional force with the normal reaction.

31

Thakna mana hai
Revital

Angle of repose - Min^m angle of inclination of a plane with horizontal surface at which the body will just slide down on it without any external force.

Rolling friction -



$\tan\phi = \mu$

$\Sigma M_0 = 0$

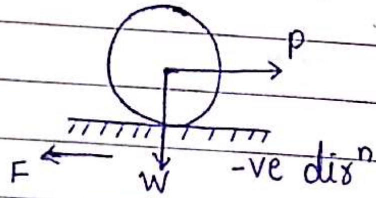
$P.r\cos\phi = W.r\sin\phi$

$\frac{P}{W} = \tan\phi$

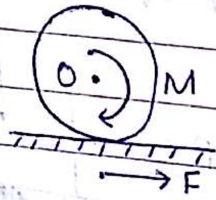
$$\frac{P}{W} = \frac{b}{r} \Rightarrow \tan\phi = \frac{b}{r}$$

Force of friction on a wheel

i When a force is applied on a wheel



When ext. force is applied



When external torque is applied

31/01/17

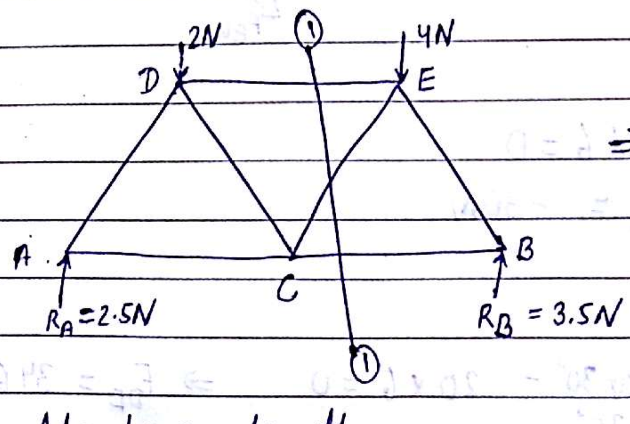
Truss (cont.)

Method of section

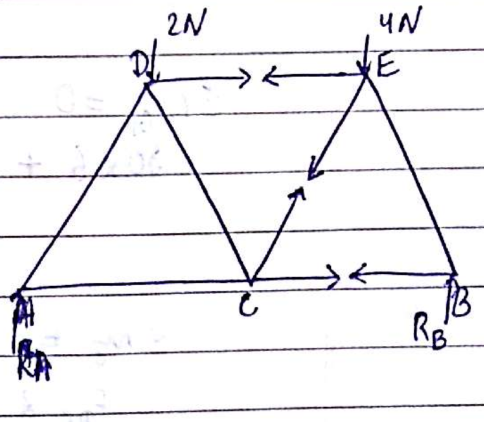
1.) Find out the support reaction.
2.) Cut the truss into 2 separate portions by passing a section through those members where forces are to be determined.
3.) Internal force of the members which are cut by section become external force.
4.) Now every portion of truss ~~is~~ ~~in~~ is in eqⁿ. We can apply eqⁿ of eqᵐ to solve the particular truss.

Note:
→ Section should pass through members, not joints.
→ A section should cut three members only.
→ Consider either right hand portion or left hand portion after cutting.
→ While using moment eqⁿ moment can be taken about any point which may or may not lie on the portion of the truss under consideration.
→ Do not consider the effects of uncut members in the truss.

Q.

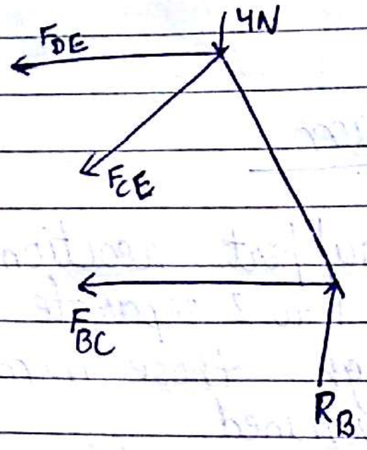


⇒



Members length = 3m

Date:
Page No.



$\Sigma M_C = 0$

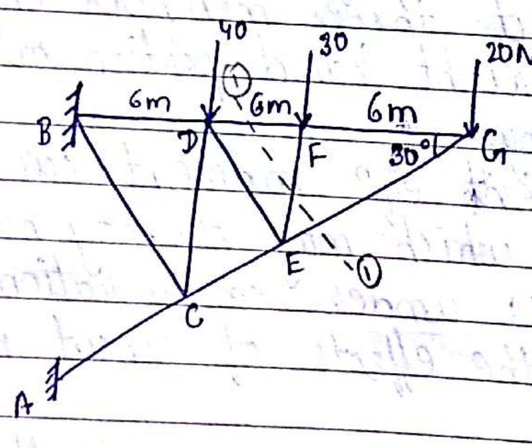
$F_{DE} \times 2.6 - 4 \times 1.5 + 3.5 \times 3 = 0$

$F_{DE} = -1.73 N$

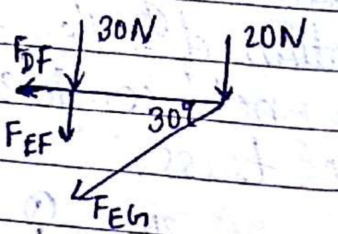
$\Sigma M_B = 0$

$+4 \times 1.5 + F_{DE}(2.6) + F_{CE}\cos 60^\circ (2.6) + F_{CE}\sin 60^\circ (1.5) = 0$

#



F_{DE}, F_{EG}, F_{EF} = ?



$\Sigma M_G = 0$

$30 \times 6 + F_{EF} \times 6 = 0$

$F_{EF} = -30N$

$\Sigma M_E = 0$

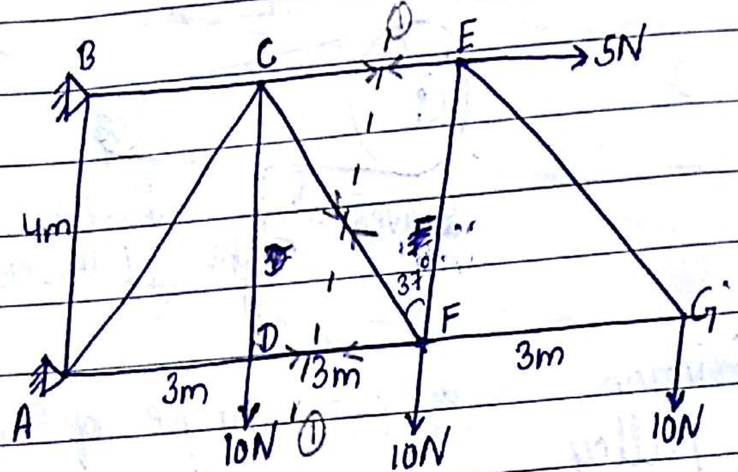
$F_{DF} \times \frac{6\tan 30^\circ}{\cancel{\tan 30^\circ}} - 20 \times 6 = 0 \quad \Rightarrow F_{DF} = 34.64N$

Date:
Page No.

$F_{EG}\sin 30^\circ + 20 + 30 - 30 = 0$

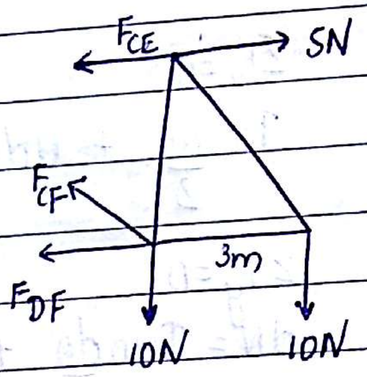
$F_{EG} = -40\,N$

Q.



$F_{CF} = ?$

$F_{CE} =$



$\Sigma M_F = 0$

$F_{CE} \times 4 - 5\times 4 - 10\times 3 = 0$

$F_{CE} = \frac{50}{4} = 12.5\,N$

$\Sigma M_D = 0$

$\Sigma F_y = 0$

$-10 - 10 + F_{CF}\cos 37^\circ = 0$

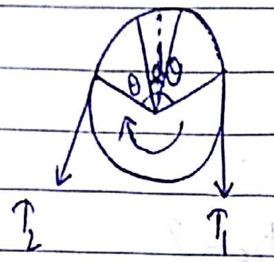
$F_{CF} = \frac{20}{\cos 37^\circ} = 25.04\,N$

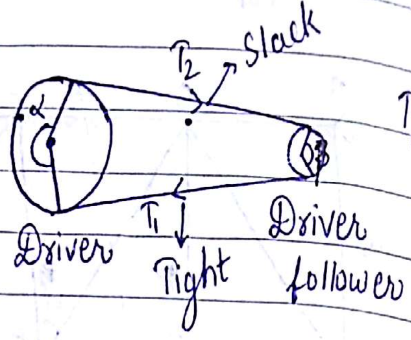
Q.

Scanned by CamScanner

3/2/17

Belt Friction : Ratio of Tensions

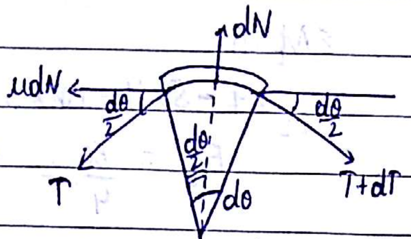




$T_1 > T_2$

$\mu \rightarrow$ ~~Angle~~ coeff. of friction b/w belt & pulley

$\alpha, \beta \rightarrow$ Angle of lap/wrap



$\Sigma F_x = 0$

$T\cos\frac{d\theta}{2} + \mu dN = (T+dT)\cos\frac{d\theta}{2}$

$\Sigma F_y = 0$

$dN = T\sin\frac{d\theta}{2} + (T+dT)\sin\frac{\theta}{2}$ - ②

$\cos\frac{d\theta}{2} \simeq 1$

$\sin\frac{d\theta}{2} \simeq \frac{d\theta}{2}$

$T + \mu dN = T + dT$

$\boxed{\mu dN = dT}$ - ③

$dN = T\frac{d\theta}{2} + (T+dT)\frac{d\theta}{2}$

$dN = T.d\theta + \underbrace{dT.\frac{d\theta}{2}}_{\text{negligible}}$

$\boxed{dN = Td\theta}$ - ④

$\mu.Td\theta = dT$

$\int_{T_2}^{T_1} \frac{dT}{T} = \int_0^\theta \mu.d\theta$ - ⑤

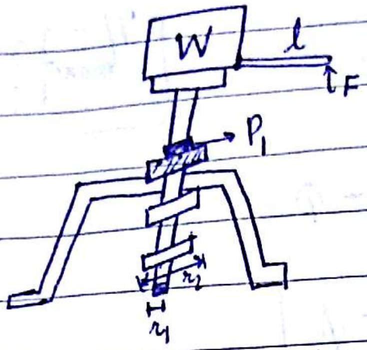
$\ln\frac{T_1}{T_2} = \mu\theta$

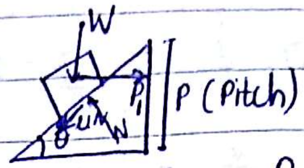
$\boxed{T_1 = T_2 e^{\mu\theta}}$

Scanned by CamScanner

Date:
Page No.

Friction in a Screw Jack:

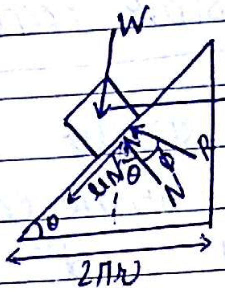




$P \rightarrow$ dist. b/w two consecutive threads

$P_1 \rightarrow$ Force applied on thread to raise the load

r = Mean radius of r_1 & r_2



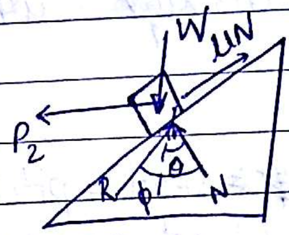
$\Sigma F_x = 0$ $\quad P_1 = R\sin(\theta+\phi)$

$\Sigma F_y = 0$ $\quad W = R\cos(\theta+\phi)$

$P_1 = W\tan(\theta+\phi)$

$R \rightarrow$ Resultant of Normal R_x^n & frictional force

To lower the load



$P_2 = W\tan(\theta - \phi)$

$$\eta = \frac{\text{Ideal Effort}}{\text{Actual Effort}}$$

In case of ideal friction is absent $\phi = 0$

$$= \frac{\tan\theta}{\tan(\theta+\phi)}$$

$$\frac{d\eta}{d\theta} = \frac{\sec^2\theta\tan(\theta+\phi) - \sec^2(\theta+\phi)\tan\theta}{(\tan(\theta+\phi))^2} = 0$$

$$\Rightarrow \sec^2\theta\tan(\theta+\phi) = \sec^2(\theta+\phi)\tan\theta$$

$$\frac{1}{\cos^2\theta}\frac{\sin(\theta+\phi)}{\cos(\theta+\phi)} = \frac{1}{\cos^2(\theta+\phi)}\frac{\sin\theta}{\cos\theta}$$

Date:
Page No.

$$2\sin(\theta+\phi)\cos(\theta+\phi) = 2\sin\theta\cos\theta$$

$$\sin 2(\theta+\phi) = \sin 2\theta$$

$$2(\theta+\phi) = \pi - 2\theta$$

$$\theta+\phi = \frac{\pi}{2} - \cancel{2}\theta$$

$$\boxed{\eta_{max.} = \frac{1-\sin\phi}{1+\sin\phi}}$$

$$\cancel{\phi} = \cancel{\pi} \quad 2\theta = \frac{\pi}{2} - \phi$$

$$\boxed{\theta = \frac{\pi}{4} - \frac{\phi}{2}}$$

Self Locking or non-reversible condition

When load W on the screw remains in place even if effort is removed i.e. effort = 0 that is called self locking condⁿ.

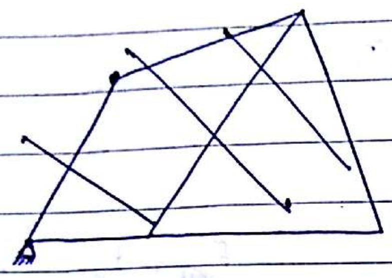
① $\phi' > \theta$

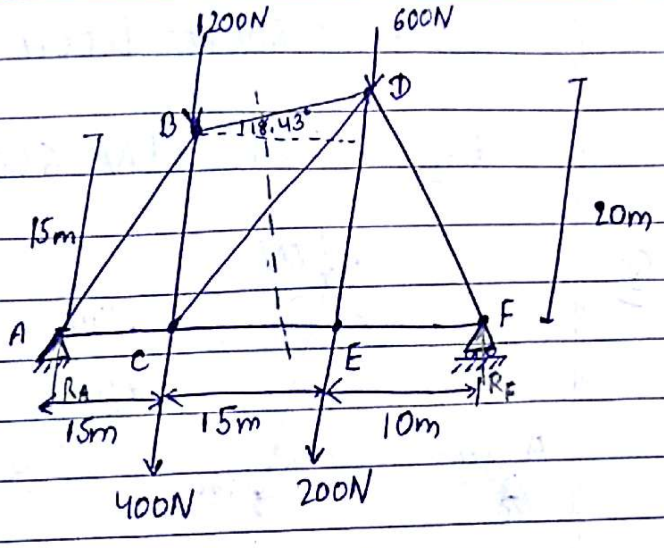
② $\eta < 50\%$

Lead is the axial dist. through which screw advance in one turn.

In single threaded screw, ~~P =~~ Lead = pitch
In double threaded - ~~After~~ 2 Lead = 1 Pitch
In triple threaded - 3 Lead = 1 Pitch

7/02/17





$F_{BD} =$

$F_{CD} =$

$F_{CE} =$

$\Sigma F_y = 0$

$R_A + R_F = 1200 + 600 + 400 + 200$

$= 2400N$

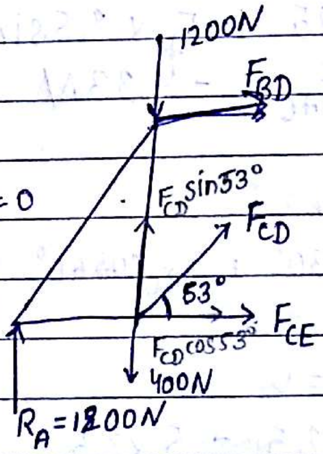
$\Sigma M = 0$

$-1200 \times 15 - 400 \times 15 - 200 \times 30 - 600 \times 30 + R_F \times 40 = 0$

$R_F = 1200\,N$

$R_A + R_F = 2400N$

$\Rightarrow R_A = 1200N$



$\Sigma F_y = 0$

$-400 + 1200 - 1200 + F_{CD} \times \frac{4}{5} + F_{BD} \times 0.316 = 0$

$F_{CD} \cdot \frac{4}{5} + F_{BD} \sin(18.43°) = \cancel{0}\ 400$ — (1)

$\Sigma F_x = 0$

$F_{CD} \cos 53° + F_{CE} + F_{BD} \cos 18.43° = 0$ — (2)

$\Sigma M_c = 0$

$1200 \times 15 + F_{BD}\ \cancel{\sin 18.43°}\ \cos 18.43° \times 15 = 0$

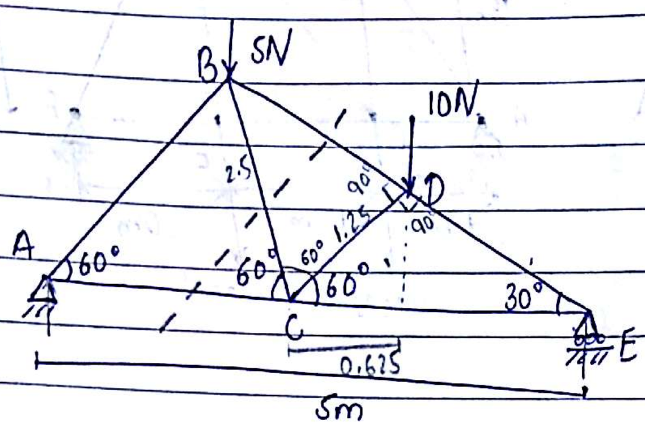
$\Rightarrow F_{BD} = \cancel{-3795.7N}\ -1265N\ (C)$

Date:
Page No.

$F_{CD} = \cancel{+1500N}\ 2000N\ (T)$

$F_{CE} = \cancel{2698.29N}\ 600N\ (T)$

Q:



F_{BD}, F_{BC}, F_{AC}

$AB = AC = CE$

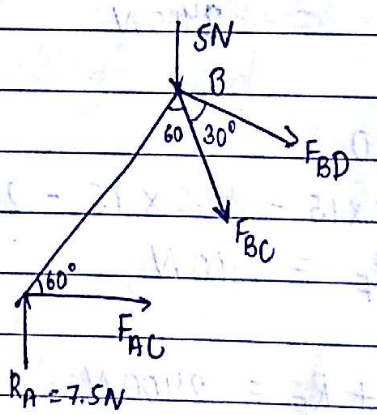
$R_A + R_E - 5 - 10 = 0$

$R_A + R_E = 15N$

$5 \times 1.25 + 31.25 - R_E \times 5 = 0$

$R_E = 7.5N$

$\Rightarrow R_A = 7.5N$



$AB = AC = CE$

$\cos 60° = \frac{b}{1.25}$

$b = 0.625$

$\Sigma M_B = 0$

$7.5 \times 1.25 + F_{AC} \times 2.5 \sin 60°$

$F_{AC} = -4.33N$

$\Sigma F_x = 0$

$F_{BD} \cos 30° + F_{BC} \cos 60° = 4.33$

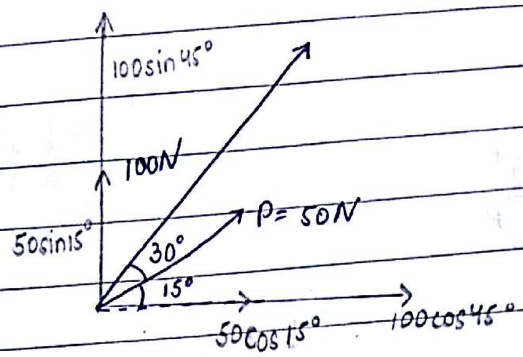
$\Sigma M_C = 0$

$7.5 \times 2.5 - 5 \times 2.5$

Date:
Page No.

Ex 2.1

2.2



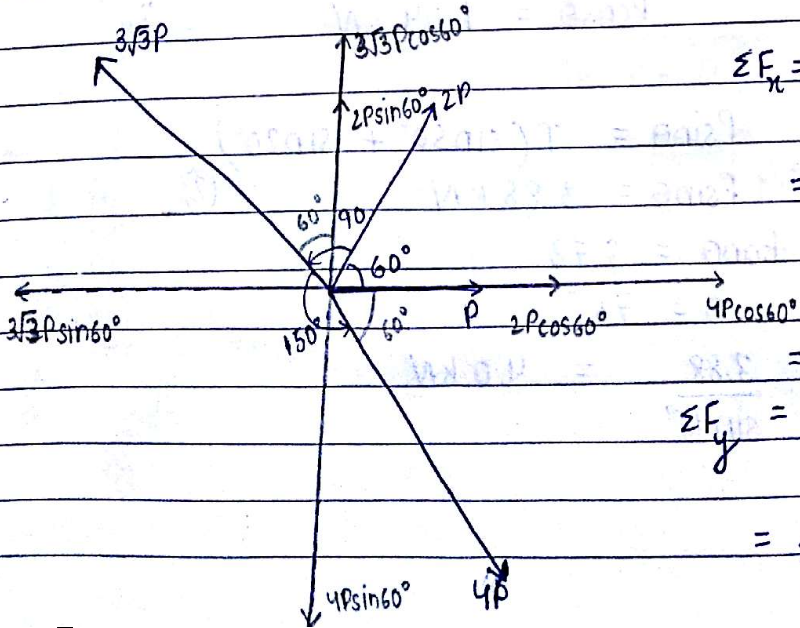
$$\Sigma F_x = \cancel{50\sin 15^\circ}\ 50\cos 15^\circ + 100\cos 45^\circ$$
$$= \cancel{83.65\ N}\ 119\,N$$

$$\Sigma F_y = 50\sin 15^\circ + 100\sin 45^\circ$$
$$= 83.65\,N$$

$$R = \sqrt{(F_x)^2 + (F_y)^2}$$
$$= \sqrt{(119)^2 + (83.65)^2}$$
$$= 145.46\,N$$

$$\tan\alpha = \frac{F_y}{F_x} = 0.703$$
$$= 35.1^\circ$$

2.3



$$\Sigma F_x = P + 2P\cos 60^\circ + 4P\cos 60^\circ - 3\sqrt{3}P\sin 60^\circ$$
$$= P\left[1 + 2\times\frac{1}{2} + 4\times\frac{1}{2} - 3\sqrt{3}\times\frac{\sqrt{3}}{2}\right]$$
$$= -P/2$$

$$\Sigma F_y = 3\sqrt{3}P\cos 60^\circ + 2P\sin 60^\circ - 4P\sin 60^\circ$$
$$= \frac{\sqrt{3}}{2}P$$

Date:

Page No.

$$R = \sqrt{\left(\frac{-P}{2}\right)^2 + \left(\frac{\sqrt{3}P}{2}\right)^2}$$

$$= \sqrt{\frac{4P^2}{4}} = P$$

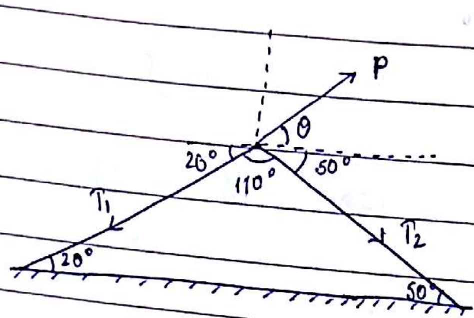
$$\tan\theta = \cancel{\frac{-\sqrt{3}/2}{1/\sqrt{2}}} \quad \frac{\sqrt{3}/2\, P}{-1/2\, P}$$

$$= -\sqrt{3}$$

$$\Rightarrow \theta = \pi - \frac{\pi}{3}$$

$$= \frac{2\pi}{3} = 120°$$

2.4



$T_1 = T_2 = T$

$$\cancel{\Sigma F_x = P\cos\theta + T_2\cos 50° + T_1\cos 20° = 0}$$

$$\cancel{\Rightarrow P\cos\theta + T\,1.58 = 0}$$

$$\cancel{\Rightarrow P\cos\theta = -}$$

$$\Sigma F_x = 0 \quad \Rightarrow \quad P\cos\theta + T(\cos 50° - \cos 20°) = 0$$

$$P\cos\theta = 1.04\ kN \qquad -(1)$$

$$\Sigma F_y = 0$$

$$\Rightarrow \quad P\sin\theta = T(\sin 50° + \sin 20°)$$

$$P\sin\theta = 3.88\ kN \qquad -(2)$$

$$(2)/(1) \quad \tan\theta = 3.73$$

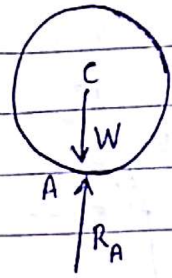
$$\theta = 75°$$

$$P = \frac{3.88}{\sin 75°} = 4.0\ kN$$

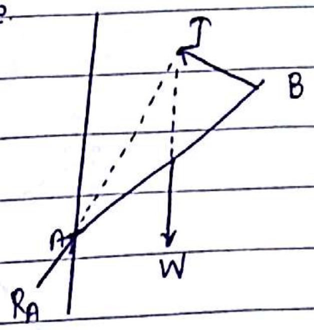
Date:

Page No.

2.5

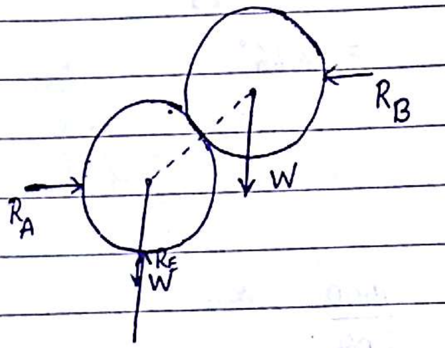


2.6

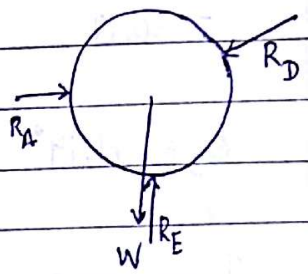


2.7)

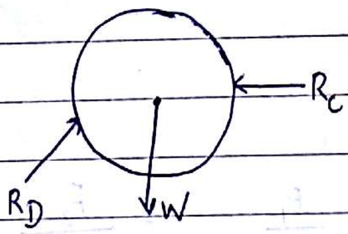
a)



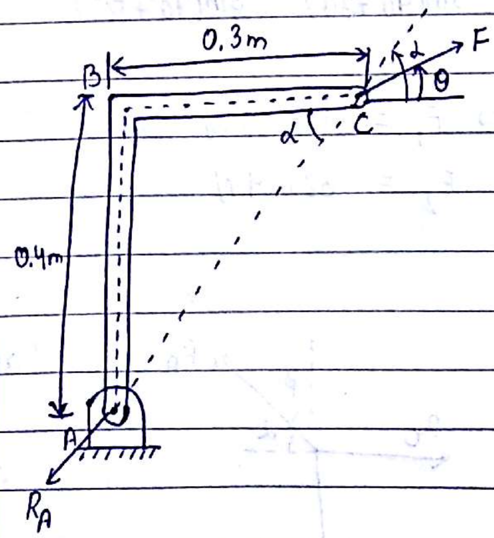
b)



c)



2.8

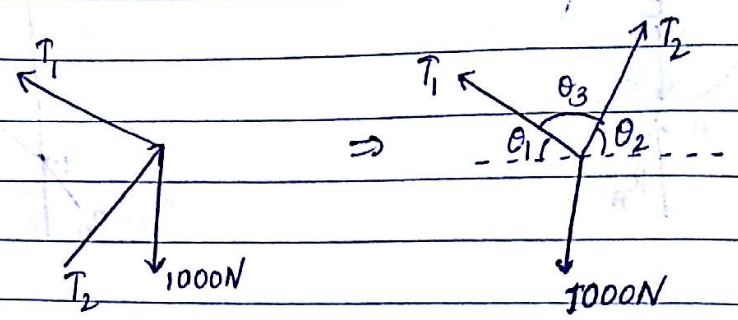


$\theta = \alpha$

$\tan \alpha = \dfrac{0.4}{0.3} = \dfrac{4}{3}$

$= 53.13^\circ$

2.9



$\theta_1 = \tan^{-1} \frac{30}{25}$

$= 50.19^\circ$

$\theta_2 = \tan^{-1} \frac{20}{25}$

$= 38.66^\circ$

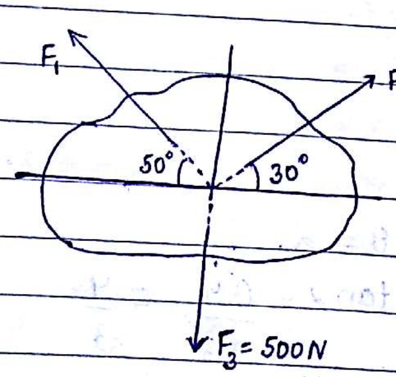
$\theta_3 = 91.14^\circ$

$$\frac{T_1}{\sin(90+\theta_2)} = \frac{T_2}{\sin(90+\theta_1)} = \frac{1000}{\sin\theta_3}$$

$T_1 = 780$

$T_2 = 640$

2.10

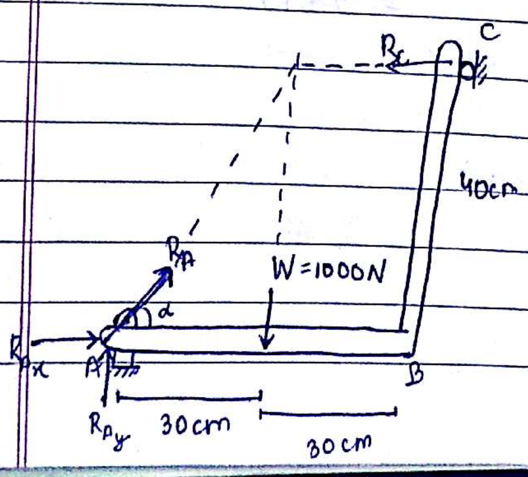


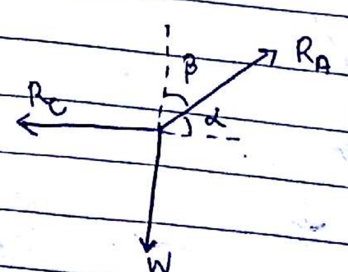
$$\frac{F_1}{\sin(90^\circ+30^\circ)} = \frac{F_2}{\sin(90^\circ+50^\circ)} = \frac{500}{\sin 100^\circ}$$

$\Rightarrow F_1 = 439.6\,N$

$F_2 = 326.4\,N$

2.12





$\tan\alpha = \frac{4}{3}$

$\alpha = 53.13^\circ$

$\cos\beta = \frac{4}{5}$

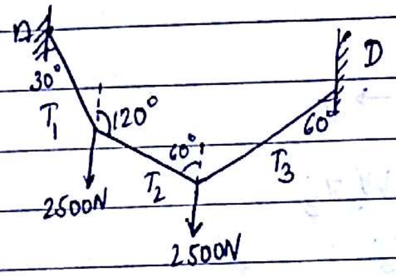
$$\frac{W}{\sin(90+36.87)} = \frac{R_A}{\sin 90} = \frac{R_C}{\sin(90+53.13)}$$

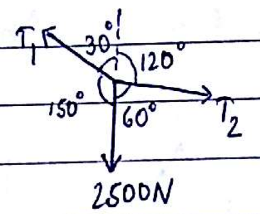
$$R_A = \frac{1000\times 5}{4} = 1250\,N$$

$$R_C = \frac{1000\times 5}{4} \times \frac{3}{5}$$

$$= 750\,N$$

2.13

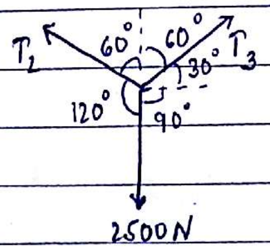




$$\frac{T_1}{\sin 60^\circ} = \frac{T_2}{\sin(150^\circ)} = \frac{2500}{\sin 150^\circ}$$

$$\Rightarrow T_2 = 2500$$

$$T_1 = 4330.13\,N$$



$$\frac{T_2}{\sin 120^\circ} = \frac{T_3}{\sin 120^\circ} = \frac{2500}{\sin 120^\circ}$$

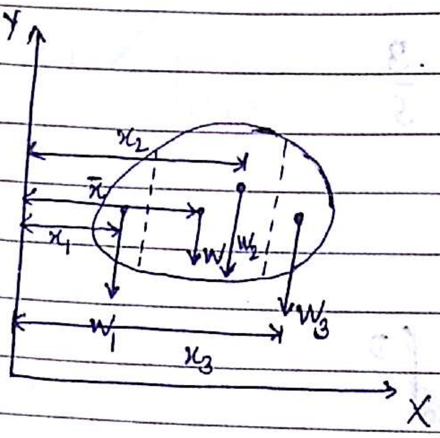
$$\Rightarrow T_2 = T_3 = 2500\,N$$

Happy Valentine's Day Cadbury ♡
14/2/17.

Date:
Page No.

Centre of Gravity

Centroid : Geometrical centre of plane body
COG → Centre of Gravity → 3D Bodies



$$W\bar{x} = \cancel{w} \; W_1x_1 + W_2x_2 + W_3x_3$$

$$\bar{x} = \frac{W_1x_1 + W_2x_2 + W_3x_3}{W}$$

① $$\bar{x} = \frac{W_1x_1 + W_2x_2 + \cdots + W_nx_n}{W_1 + W_2 + \cdots + W_n}$$

$$W = mg$$
$$W = \rho . V . g$$
$$W = \rho g V$$
$$= \rho g \, A . t$$

$$W_1 = \rho g t . A_1$$
$$W_2 = \rho g t . A_2$$
$$\vdots$$
$$W_n = \rho g t . A_n$$

② $$\bar{x} = \frac{A_1x_1 + A_2x_2 + \cdots + A_nx_n}{A_1 + A_2 + \cdots + A_n}$$

Date:
Page No.

$W = \rho A g l$

$W_1 = \rho A g l_1$

$W_2 = \rho A g l_2$

$\vdots$

$W_n = \rho A g l_n$

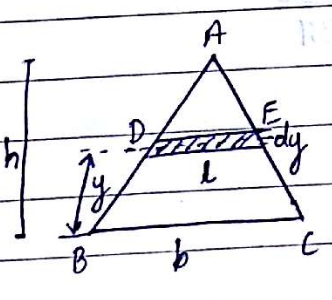
(3) $\bar{x} = \dfrac{l_1 x_1 + l_2 x_2 + \dots l_n x_n}{l_1 + l_2 + \dots l_n}$

$\bar{x} = \dfrac{\int x\,dl}{\int dl}$, $\bar{y} = \dfrac{\int y\,dl}{\int dl}$

$\bar{x} = \dfrac{\int x\,dA}{\int dA}$, $\bar{y} = \dfrac{\int y\,dA}{\int dA}$

dA - Small area under consideration.

(#)



$\dfrac{l}{b} = \dfrac{h-y}{h}$

$l = \left(\dfrac{h-y}{h}\right) b$

$\bar{y} = \dfrac{\int y\,dA}{\int dA}$

$\bar{y} = \dfrac{\int_0^h y\,l\,dy}{\int_0^h l\,dy}$

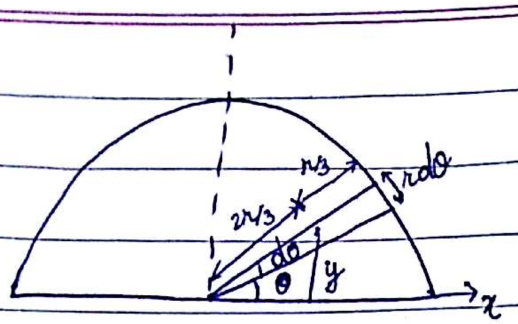
$\bar{y} = \dfrac{\frac{b}{h}\int_0^h (hy - y^2)\,dy}{\frac{b}{h}\int_0^h (h-y)\,dy}$

$= \dfrac{\left.\frac{hy^2}{2} - \frac{y^3}{3}\right]_0^h}{\left.hy - \frac{y^2}{2}\right]_0^h} = \dfrac{\frac{h^3}{2} - \frac{h^3}{3}}{h^2 - \frac{h^2}{2}} = \dfrac{h}{3}$

Date:

Page No.

#



$$\bar{y} = \frac{\int y\,dA}{\int dA}$$

$$y = \frac{2r}{3}\sin\theta$$

$$dA = \frac{1}{2}r^2 d\theta$$

(~~Semi-circular arc or wire~~)

Disc

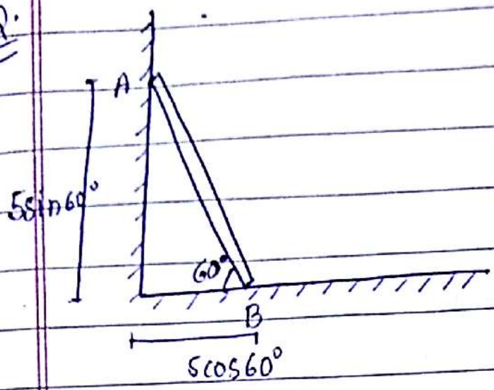
$$= \frac{\int_0^{\pi} \frac{2r}{3}\sin\theta \, \frac{1}{2}r^2 d\theta}{\int_0^{\pi} \frac{1}{2}r^2 d\theta}$$

$$= \frac{2r}{3} \frac{\int_0^{\pi} \sin\theta \, d\theta}{\int_0^{\pi} d\theta}$$

$$= \frac{2r}{3} \frac{[-\cos\theta]_0^{\pi}}{[\theta]_0^{\pi}}$$

$$= \frac{4r}{3\pi}$$

Q.



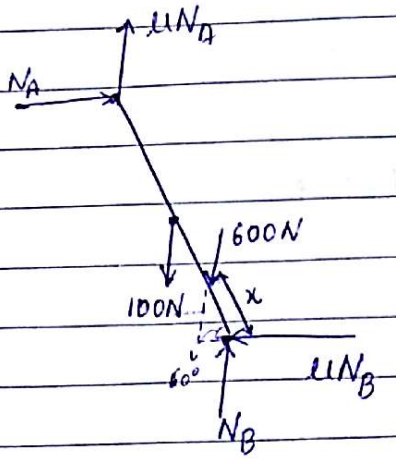
$AB = 5m$

Weight of ladder $= 100N$

Weight of man $= 600N$

$\mu = 0.25$

Determine how much distance along the ladder a man of 600N can ~~cover~~ ascend w/o causing it to slip.



$F_x = 0$

$N_A - \mu N_B = 0$

$N_A = \mu N_B$ —(1)

$F_y = 0$

$\mu N_A + N_B - 700 = 0$

$\mu N_A + N_B = \cancel{0}\ 700$

$N_A = 164.7N$

$\Sigma M_B = 0$

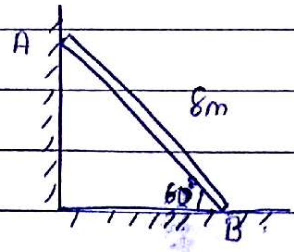
$N_A \times 5\sin 60 + \mu N_A 5\cos 60° - 100 \times 2.5\cos 60° - 600 \times x \cos 60° = 0$

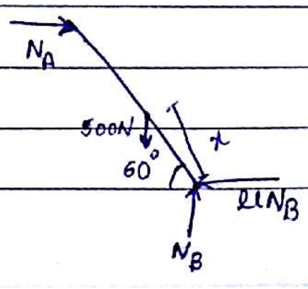
~~$\mu (N_B \times 5\sin 60° +$~~

$x = 2.3m$

Q. A weightless ladder is resting against smooth vertical wall. Coeff. of friction is 0.25. A man of weight 500N wants to climb up the ladder w/o slip. A second person of wt 800N wants to climb the same ladder. Would he climb less than the earlier person? Find the distance covered. $L = 8m$

Sol^n –





$N_A = \mu N_B$

$N_B = 500\ N$

$N_A = 125N$

$N_A \times 8\sin 60^\circ = 500 \times x \cos 60^\circ$

$x = 3.46\ m$

For 2nd man

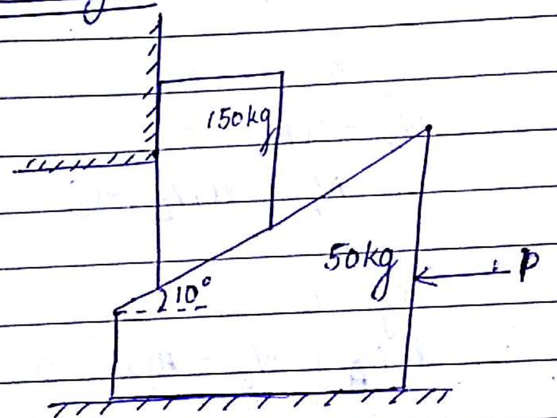
$N_B = 800N \qquad N_A = 200N$

$\cancel{8}\ 200 \times 8 \sin 60^\circ = 800 \times x \cos 60^\circ$

$x = 3.46m$

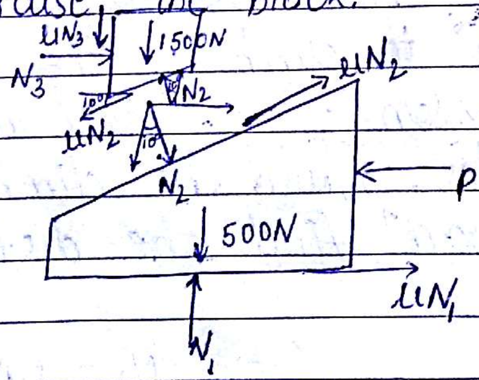
Wedge

③



A tapper shaped block with very less angle which are used for lifting ~~or~~, holding or shifting the heavy block by very less effort is called wedge.

Q③ Find the min^m force applied at wedge to raise the block.



$F_x = 0$

$\mu N_1 + \mu N_2 \cos 10^\circ + \cancel{\mu} N_2 \sin 10^\circ = P$

$F_y = 0$

$N_1 = 500 + \cancel{\mu N}\ N_2 \cos 10^\circ$ — ②

Date:

Page No.

Block

$N_3 - \mu N_2 \cos 10° \cancel{+} - N_2 \sin 10° = 0$

$N_2 \cos 10° = 150g + \mu N_3 + \mu N_2 \sin 10°$

$N_3 = \dfrac{N_2 \cos 10° - 150g \mp \mu N_2 \sin 10°}{\mu}$

$N_2 \left(\dfrac{\cos 10°}{\mu} - \mu \cos 10° - \sin 10° - \cancel{+} \dfrac{\mu \sin 10°}{\mu} \right) = \dfrac{150g}{\mu}$

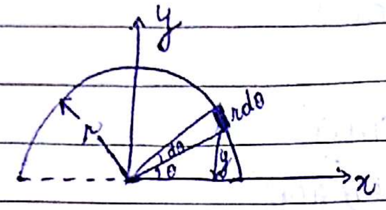
$N_2 = \dfrac{\cancel{5000}\ 4900}{\cancel{2.81}\ 2.6399}$

$= \cancel{1777.08N}\ \cancel{1673.78N}\ 1856.13$

$N_3 = \cancel{833.62N}\ \cancel{785.15}$

/

Semicircular wire/arc



$dl = rd\theta$

length of wire $= l$

$\pi r = l$

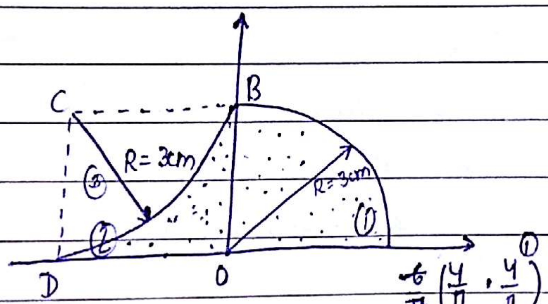
$r = \frac{l}{\pi}$

$$\bar{y} = \frac{\int y\,dl}{\int dl}$$

$$= \frac{\int_0^{\pi} r\sin\theta\, r\,d\theta}{\int_0^{\pi} r\,d\theta}$$

$$= \frac{r\,[-\cos\theta]_0^{\pi}}{\pi} = \frac{2r}{\pi}$$

#



Find CG of shaded portion.

$\frac{6}{\pi}$ ① $\left(\frac{4}{\pi}, \frac{4}{\pi}\right)$

① + ② − ③

$x_1 = 4/\pi \quad x_2 = -3/2$

$y_1 = 4/\pi \quad y_2 = 3/2$

$A_1 = 7.06 \quad A_2 = 9$

$x_3 = -(3 - 4/\pi)$

$y_3 = 3 - 4/\pi$

$A_3 = 7$

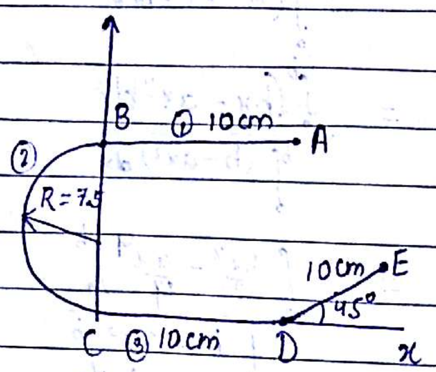
$$CG_x = \frac{7.06 \times 4/\pi + 9\,(-3/2) - 7.06(-3 + 4/\pi)}{\cancel{14+9}\ 7.06 + 9 - 7.06} = \cancel{0.326}\ 0.856$$

$$CG_y = \frac{7.06 \times 4/\pi + 9 \times (3/2) - 7.06(3 - 4/\pi)}{\cancel{14+9}\ 7.06 + 9 - 7.06} = 1.147$$

Date:

Page No.

Q. A uniform wire is bent into a shape as shown in figure. Calculate the CG of wire.



AB

$x_1 = 5cm$ $\quad y_1 = \cancel{10cm}\ 15cm$

$l_1 = 10cm$

BC

$x_2 = \dfrac{-2r}{\pi}$ $\quad y_2 = 7.5$

$l = \pi \times 7.5$

CD

$x_3 = 5\,cm$ $\quad y_3 = 0$

$l_3 = 10\,cm$

DE

$x_4 = 10 + 5\cos 45°$ $\quad y_4 = 5\sin 45°$

$l_4 = 10\,cm$

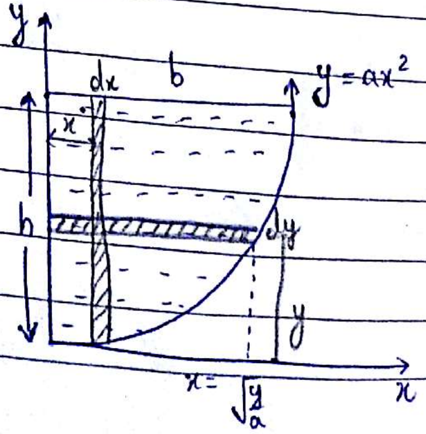
$$x_{CG} = \frac{5\times 10 - \frac{2\times(7.5)}{\pi}\times\pi\times 7.5 + 5\times 10 + 10\times(10+5\cos 45°)}{30 + \pi\times 7.5}$$

$= 2.29\,cm$

$$y_{CG} = \frac{15\times 10 + 7.5\times\pi\times 7.5 + 10\times 5\sin 45°}{30 + \pi\times 7.5}$$

$= \cancel{6.23cm}\ 6.75\,cm$

Q.



$dA = \sqrt{\dfrac{y}{a}} \times dy$

$$\bar{y} = \frac{\int_0^h y\sqrt{\frac{y}{a}}\,dy}{\int_0^h \sqrt{\frac{y}{a}}\,dy} = \frac{\int_0^h y^{3/2}\,dy}{\int_0^h y^{1/2}\,dy}$$

$$= \frac{\frac{2}{5}\left[y^{5/2}\right]_0^h}{\frac{2}{3}\left[y^{3/2}\right]_0^h} = \frac{3}{5}h$$

Date:
Page No.

$dA = (h - ax^2)dx$

$\bar{x} = \cancel{\dfrac{\int_0^b ax^3 dx}{\int_0^b ax^2 dx}}$ $\dfrac{\int_0^b (h - ax^2) x\, dx}{\int_0^b (h - ax^2) dx}$

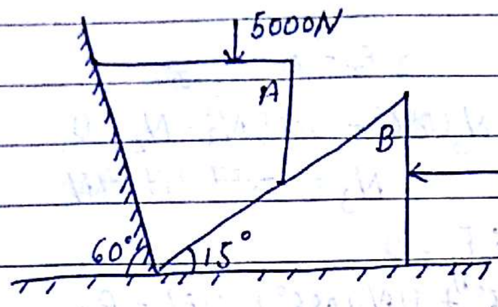
$= \cancel{\dfrac{\left.\frac{x^4}{4}\right]_0^b}{\left.\frac{x^3}{3}\right]_0^b}}$ $= \dfrac{\int_0^b (hx - ax^3) dx}{\int_0^b (h - ax^2) dx}$

$= \cancel{\dfrac{3b}{4}}$ $= \dfrac{\left[\frac{hx^2}{2} - \frac{ax^4}{4}\right]_0^b}{\left[hx - \frac{ax^3}{3}\right]_0^b}$

$= \dfrac{\frac{hb^2}{2} - \frac{ab^4}{4}}{\left[bh - \frac{ab^3}{3}\right]}$

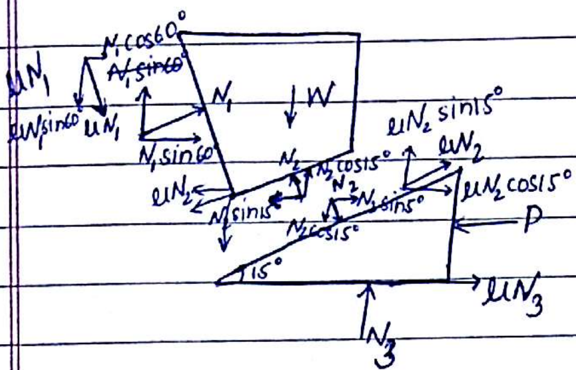
$= \dfrac{3b}{4}\left[\dfrac{2h - ab^2}{3h - ab^2}\right]$

#



$\mu = 0.255$

Wt. of A = 5000 N



Block A

$\Sigma F_x = 0$

$\mu N_1\cos60° + N_1\sin60° - \mu N_2\cos15° - N_2\sin15° = 0$

$$N_1 = \frac{\mu N_2\cos15° + N_2\sin15°}{(\sin60° + \mu\cos60°)}$$

$\Sigma F_y = 0$

$\mu N_1\sin60° + N_1\cos60° + N_2\cos15° - W - N_2\sin15° = 0$

$\cancel{N_2(0.9987) = 5000}$ $N_2(1.07359) = 5000$

$\cancel{N_2 = 5006.3N}$ $N_2 = 4657.27N$ (X)

$\Rightarrow$ $\cancel{N_1 = 2920 N}$ $N_1 = 2367.859N$ (X)

Block B

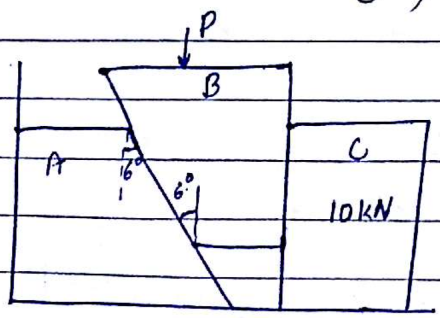
$\Sigma F_x = 0$

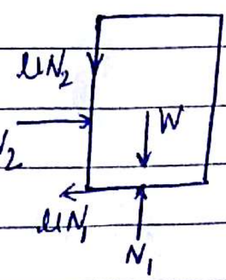
$N_2(\sin15° + \mu\cos15°) + \mu N_3 = P$

$N_3 = N_2(\cos15° \mp \mu\sin15°)$

$= 4191.2$ (X)

Q.





$N_2 = \mu N_1$

$\mu N_2 + W = N_1$

$\cancel{\mu^2 N_1}$

$W = \cancel{N_1(\mu^2 - 1)}$

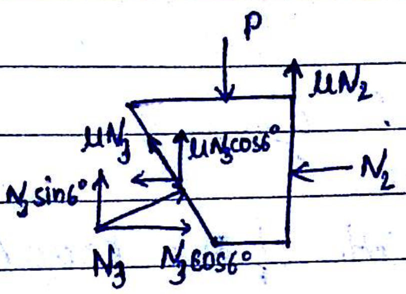
$(1-\mu^2)N_1$

$N_2 = 2.67\,kN$ $N_1 = 10.67\,kN$

Neelgagan

Date:

Page No. 2



$$\Sigma F_x = 0$$

$$N_3 \cos 6° - 0.25 N_3 \overset{\sin 60°}{\wedge} - N_2 = 0$$

$$N_3 = \cancel{2.57}\ 2.757\,kN$$

$$\Sigma F_y = 0$$

$$N_3 \sin 6° + \mu N_3 \cos 6° + \mu N_2 = P$$

$$P = 1.64\ KN$$