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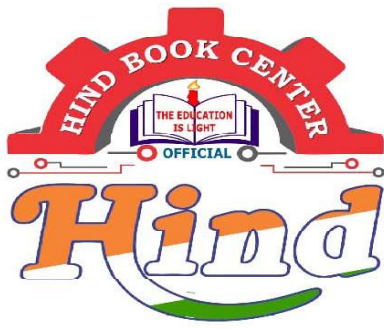
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By- Ravinder Sir

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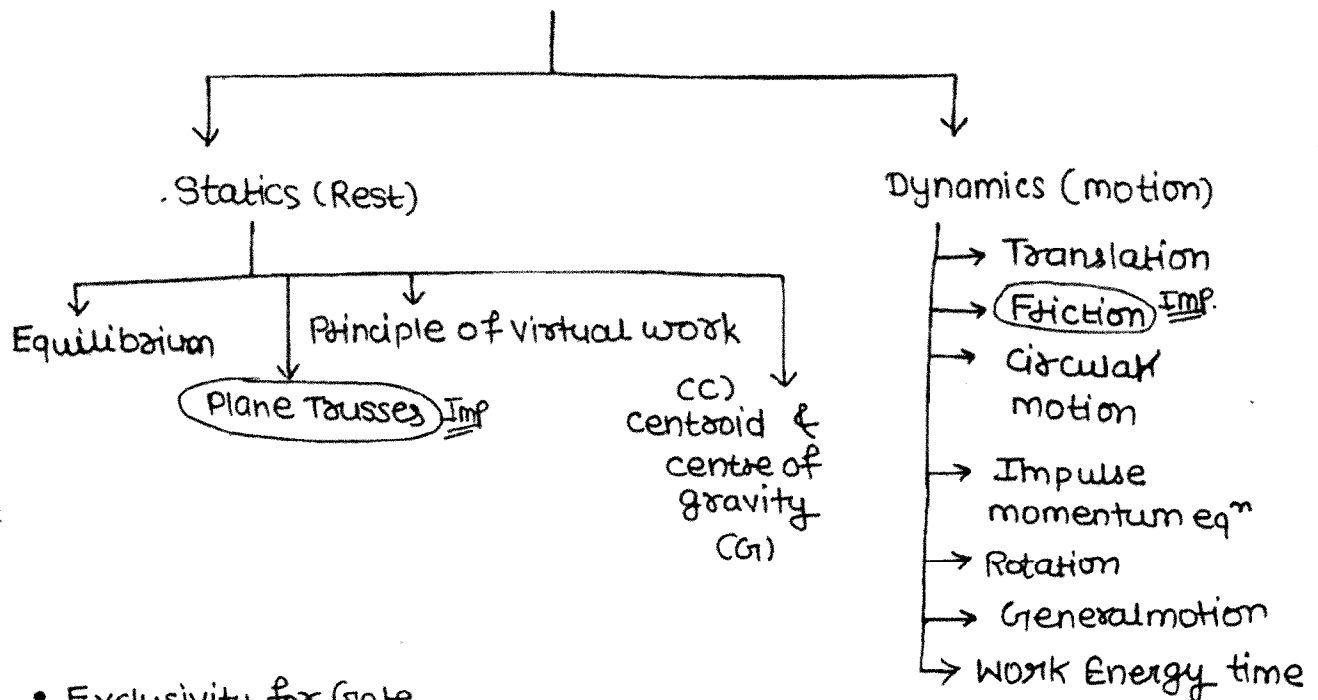
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Engg. Mechanics

"Study of motion of rigid bodies under the action of external forces."



• Exclusivity for Gate

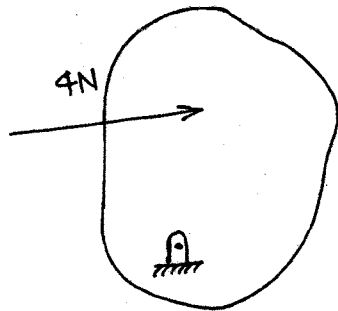
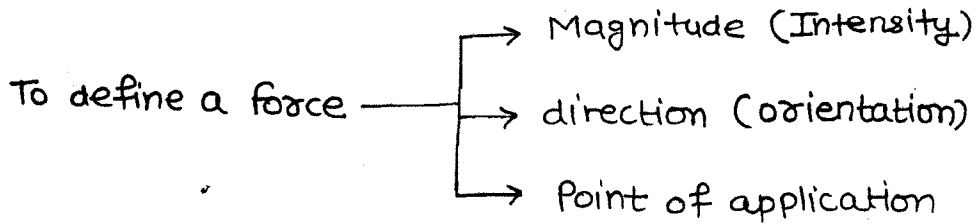
- ◆ friction & its application
 - Rolling friction
 - wedge
 - Screw Jack
 - Application in vehicles
 - Belt friction
- * Lagrange's Equation

• Actual Force :->

If a force has been acted on the body then it must have been applied by some other body

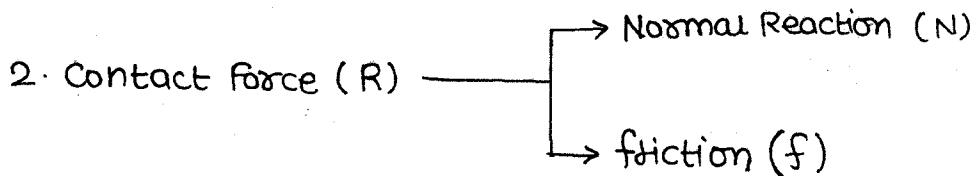
• Pseudo force :->

If a force is acted upon a body ~~is~~ but has not been applied by any other body.



• Types of forces

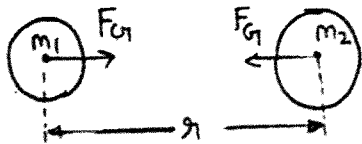
1. Gravity (W)



3. Tension (T)

4. Spring force (F_s)

• Gravity →



$$F_{G1} = \frac{G m_1 m_2}{r^2}$$

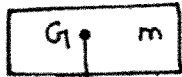
$$G = 6.67 \times 10^{-11}$$

$$g = \frac{G M_e}{R_e^2}$$

M_e = Mass of Earth
 R_e = Radius of Earth

$$W = mg$$

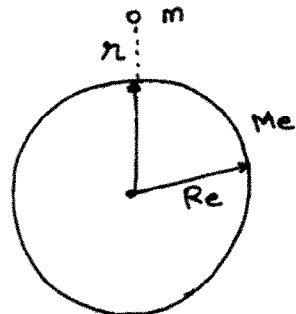
(Pulling)



$\downarrow mg \Rightarrow$ on mass m by Earth

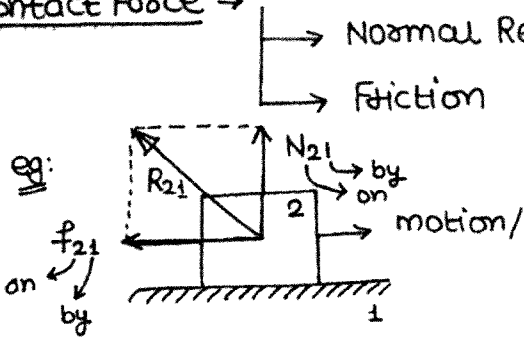
$$F_G = \frac{G M_e m}{R_e^2}$$

$$F_G = mg$$



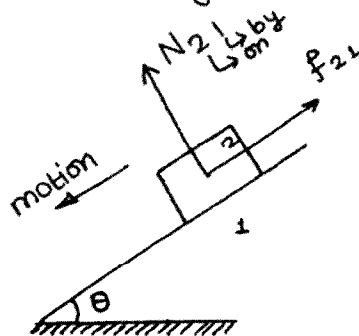
$(R_e + r \approx R_e)$

• Contact Force →



Normal Reaction (Pushing)

Friction

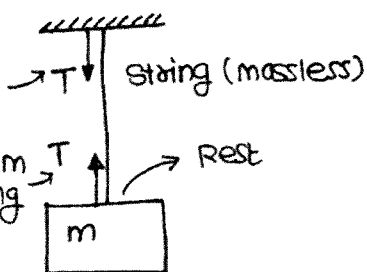


• Tension →

ex-1. (Pulling)

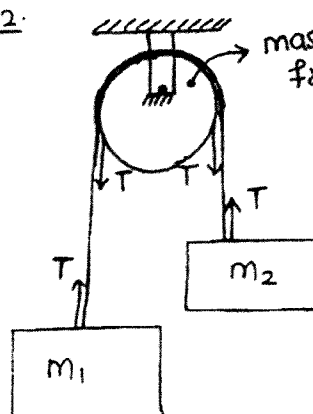
on support by string

on mass m by string



ex-2.

massless & frictionless



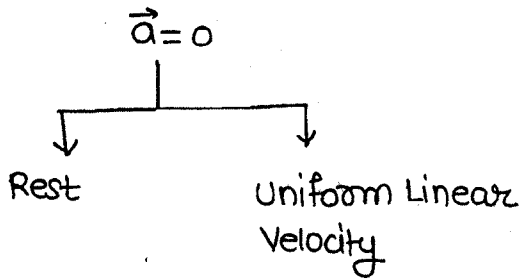
• Spring Force (F_s) →
 (Can be Pulling or Pushing)

$$F_s = K(\Delta x)$$

Spring Constant elongation or Compression from Natural Length

• Newton's First Law (NFL): →

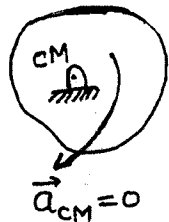
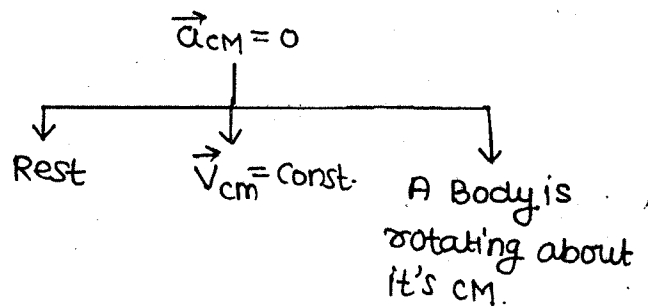
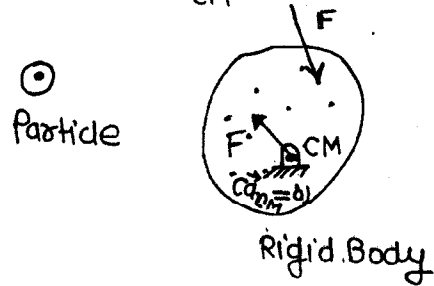
For a particle if $\sum \vec{F} = 0$ then $\vec{a} = 0$ at the same Instant



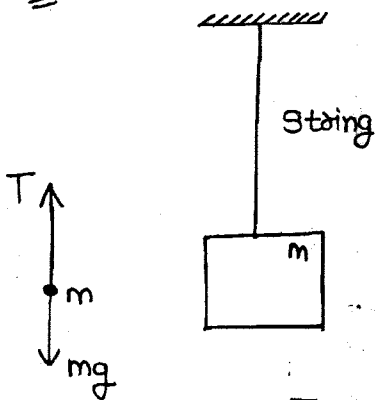
For a Rigid body

If $\sum \vec{F}_{ext} = 0$

then $\vec{a}_{cm} = 0$



Eg: -1



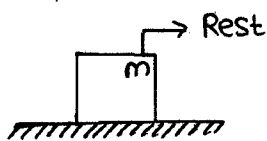
(m) → Rest ⇒ $\vec{a}_{cm} = 0$

$\sum \vec{F}_{ext} = 0$
↳ Newton's 1st Law

$T - mg = 0$ [Newton's First Law]

$T = mg$ [NFL]

Eg: 2



(m) → Rest

$\vec{a}_{cm} = 0$

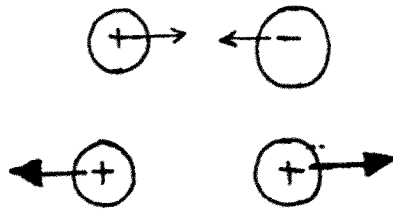
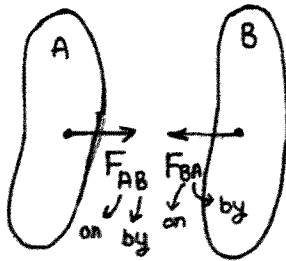
$\sum \vec{F}_{ext} = 0$
↳ (NFL)



$N - mg = 0$

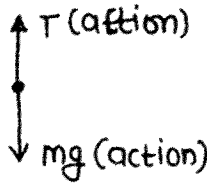
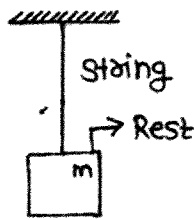
$N = mg$ [NFL]

• Newton's Third Law (NTL) →

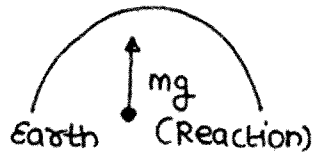
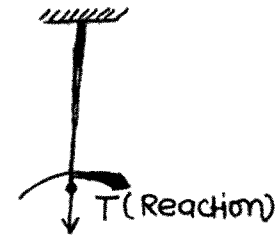


$$\vec{F}_{AB} = -\vec{F}_{BA}$$

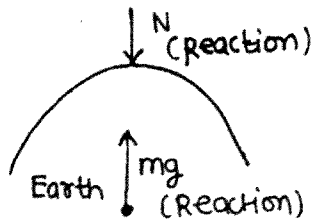
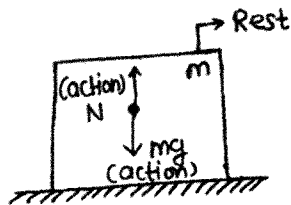
Ex: 1



$$g = \frac{G M_e}{R_e^2}$$



Ex: 2



Reading of weighting

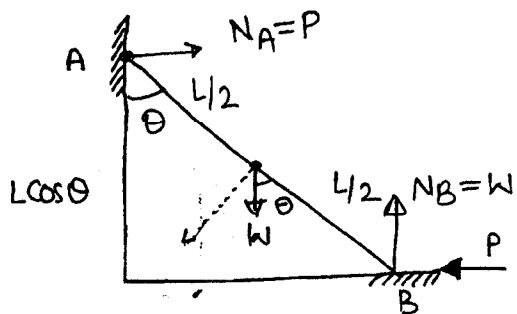
"If a Body A exerts ~~an~~ Force on Body B, then ~~it~~ certainly Body B will exert force on Body A, they will equal in magnitude and opposite in direction, colinear in action and same in Nature."

Imp
• F.B.D. ⇒ It is Representation of all the forces acting on the system by the surrounding

NOTE: → In FBD surrounding should not be shown.

- Equilibrium
 - Rest
 - uniform Linear Velocity
- (i) $\sum \vec{F} = 0$ [$\sum F_x = \sum F_y = \sum F_z = 0$]
- (ii) $\sum \vec{T} = 0$
(about any Point
'or' Line)

Que →



A uniform Ladder AB of Length L and weight W is held in equilibrium ~~at B~~ by Horizontal force P at B as shown in figure: Assume all the surfaces to be smooth
find P

~~$W \times L = P \tan \theta$~~

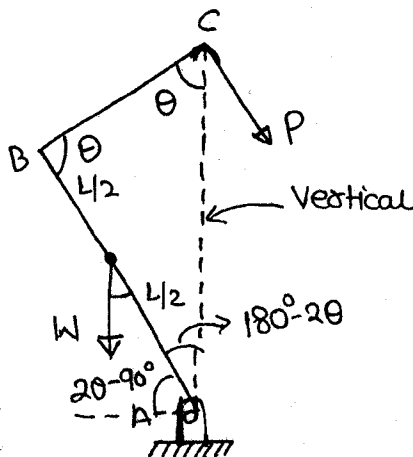
$$\sum M_B = 0$$

$$W \sin \theta \times \frac{L}{2} = P L \cos \theta$$

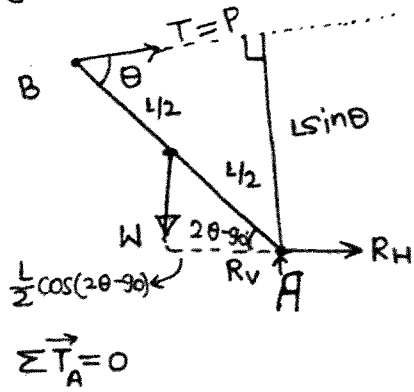
$$P = \frac{W}{2} \tan \theta$$

Que A uniform Rod of weight W and Length L is movable in vertical Plane about hinge at A but it is held in equilibrium by a ~~string~~ force P which is attached to a string BC passing over a smooth Peg C. if $AB = AC$ then the force P is

- (a) $W \cos \theta$
- (b) $\frac{W}{\cos \theta}$
- (c) $W \tan \theta$
- (d) $W \sin \theta$



Considering equilibrium of Rod 'AB'



$$W \times \frac{L}{2} \cos(2\theta - 90) = P \times L \sin\theta$$

$$W = \frac{2P \sin\theta \cos\theta}{\sin\theta} = P \sin\theta$$

$$P = W \cos\theta$$

• Moment of a force 'or' Torque :->

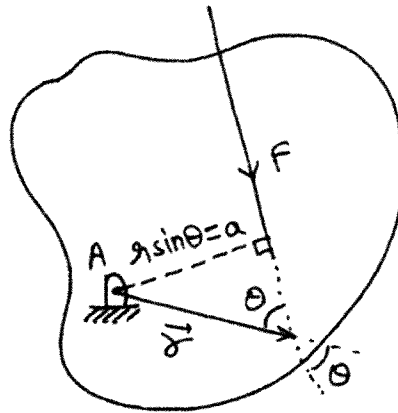
$$(\vec{M} \text{ 'or' } \vec{T})$$

$$\vec{T}_A = \vec{r}_1 \times \vec{F}$$

$$|\vec{T}_A| = r_1 F \sin\theta$$

$$|\vec{T}_A| = F a$$

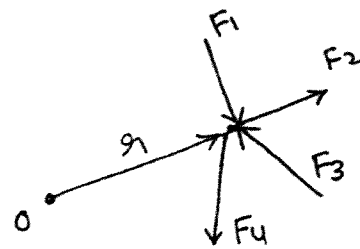
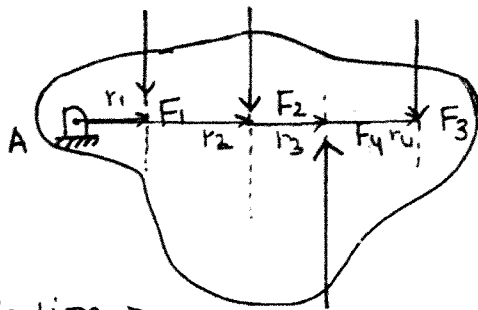
direction $\rightarrow \perp$ inward through A



*** Imp: Property of Numericals (Vector algebra)

• Variignon's Theorem

For a concurrent force system Net Torque about a point will be Torque of resultant force about that point



Application ->

For a concurrent force system

$$\text{if } \Sigma \vec{F} = 0$$

$$\Sigma \vec{T} = 0$$

\rightarrow at any point

Ex. Joints in Truss

$$\Sigma \vec{T}_O = \vec{r}_1 \times \vec{F}_1 + \vec{r}_2 \times \vec{F}_2 + \vec{r}_3 \times \vec{F}_3 + \dots$$

$$= \vec{r}_1 \times \vec{F}_1 + \vec{r}_1 \times \vec{F}_2 + \vec{r}_1 \times \vec{F}_3 + \dots$$

$$= \vec{r}_1 \times (\vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots)$$

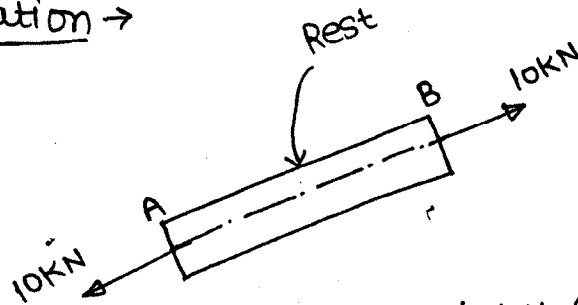
$$\Sigma \vec{T}_O = \vec{r}_1 \times \vec{F}_R$$

• Systems of Equilibrium →

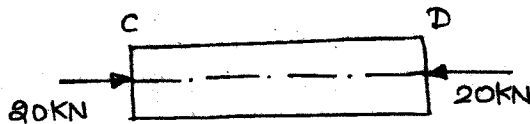
1. Two Force System →

To keep a body in equilibrium under the action of two-force, they must be equal in magnitude and opposite in direction and collinear in action.

Application →



$F_{AB} = 10\text{kN}$ (Tensile)
Intensity of Internal resisting force



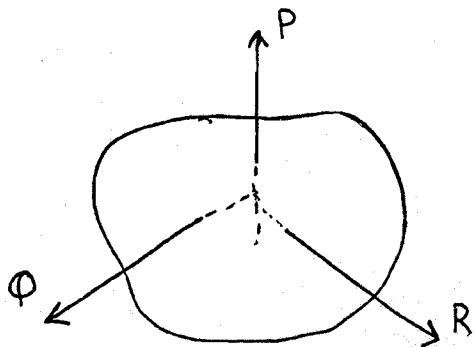
$F_{CD} = 20\text{kN}$ (Compressive)
Intensity of internal resisting force in member CD

2. Three force system →

To keep a body in equilibrium under the action of 3 forces they must be coplanar and concurrent.

$\vec{P}, \vec{Q} \in \vec{R}$

(a) $\vec{P} + \vec{Q} + \vec{R} = 0 \Rightarrow$ coplanar



(b) $\sum \vec{T} = 0$

