Forces on Bodies
Problem Solving

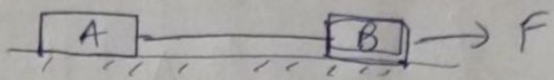
When more than one Bodies involved :-

1) Draw FBD of each body & apply Newton's 2^{nd} Law to each body.
2) Relation b/w forces b/w the 2 bodies / connecting element.

Newton's 3^{rd} Law :

$$F_{AB} = -F_{BA}$$

Eg :-



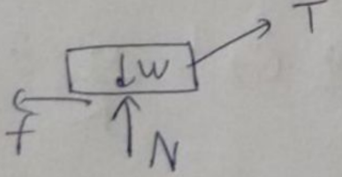
★ Forces on Particle :-

a) Weight (gravity)

b) Contact forces — Normal Reaction, friction

Other contact forces like { String, Spring connected to particle

★ (1)



No. of eqⁿ from Newton's Law = 2
(In x & y direction)

N, f are 2 unknowns

a or T will also ~~be~~ be unknown.

Block could be at rest or moving.

If rest then $a = 0$.

If moving then $f = \mu_k N$; Impending slip ⇒ $f = \mu_s N$

② You do not know if the body is moving or not. Applied forces are given.

<u>Step-1</u> Assume no motion $\Rightarrow a = 0$.

Find value of f at contact surface

<u>Step-2</u> Draw FBD & solve $\Sigma F_x = 0$ & $\Sigma F_y = 0$.

<u>Step-3</u> If $f \le \mu_s N$

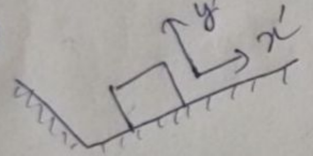
then, assumption correct and we have found out the sol^n.

<u>Step-4</u> If $f > \mu_s N$, then our assumption is incorrect. We revisit the problem

$a \ne 0$, $f = \mu_k N$

a can be solved.

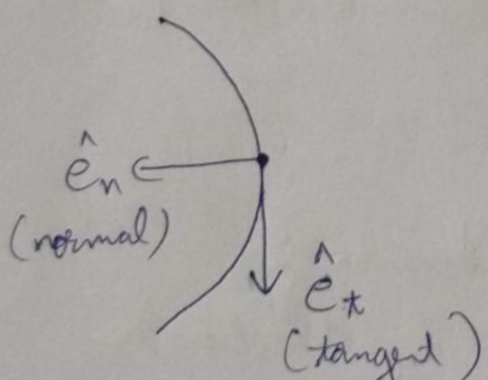
③



In this case take the x-axis along the inclined surface

④ If particle moves on a curved path.

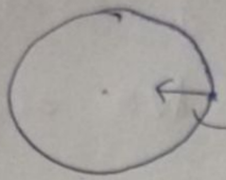
$$\vec{a} = \frac{dv}{dt}\hat{e}_t + \frac{v^2}{R}\hat{e}_n$$



Circular Motion of bodies :-

Circular path $\longrightarrow$ $R \rightarrow$ radius of circle

Uniform circular motion $\rightarrow$ Speed is constant



$\rightarrow a = \dfrac{v^2}{R}$ (pointing towards centre)

Centripetal acceleration :-

$$a = \frac{v^2}{R} \leftarrow \text{(towards the centre)}$$

If circular motion is not uniform then acc. has 2 components :-

a) Centripetal acceleration towards centre $= \dfrac{v^2}{R}$

b) Tangential component $= \dfrac{dv}{dt}$ (tangent to the path at that instant)

$$\cancel{v = \omega} R$$

☆ $v = \omega R$

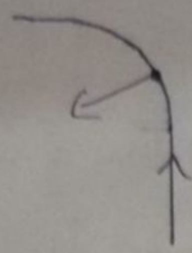
↑ angular velocity

$$a_c = \frac{v^2}{R} = \frac{\omega^2 R^2}{R} = \omega^2 R$$

$$a_t = \frac{dv}{dt} = \frac{d\omega}{dt} \cdot R = \alpha R$$

(α = Angular acc.)

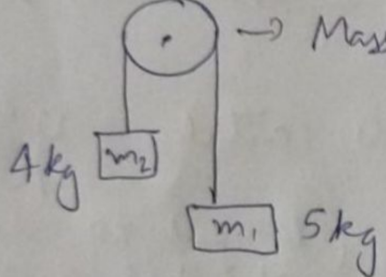
☆ Passanger in the rear seat of car, the ~~car~~ Car is turning left in cirular path then,



If $\frac{mv^2}{R} > \mu_s mg$ | If $\mu_s mg > \frac{mv^2}{R}$

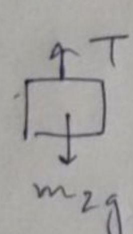
Passanger will start to slip | No slip

Net acc. $= \frac{v^2}{R} - a_p$
(towards centre)

☆ 

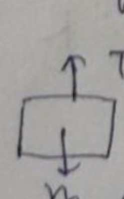
→ Massless & frictionless pulley.
(Tension is const.)
(Acc. of both mass are same in magnitude)

$\Rightarrow$ FBD of 4kg block $\Rightarrow$



$T - m_2 g = m_2 a$ — (1)

FBD of 5kg block $\Rightarrow$



$m_1 g - T = m_1 a$ — (2)

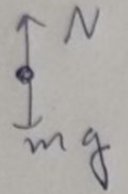
Solve 2 eqⁿ in 2 variables

☆ Passanger of mass m, stands on an elevator on a weighing scale.

w_1 (may or may not be equal to mg)

FBD of ~~part~~ person ⇒

(i) Case I ⇒ $a = 0$ (of elevator)



$$N = mg$$

$$\boxed{W' = mg}$$

(ii) If $a\uparrow$ is +ve (upwards)

$$W' = m(a+g)$$

(iii) $a\downarrow$ (downward)

$$W' = m(g - a_d)$$

(iv) Free fall ⇒ If $ma_d > mg$.

$$\boxed{W' = 0}$$