Newton's laws of motion

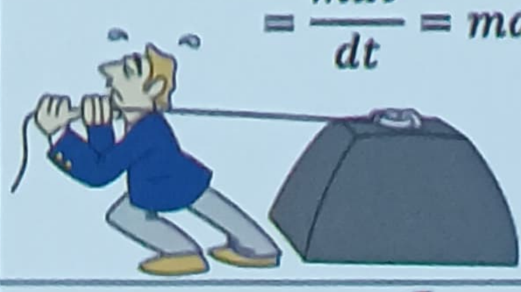
Everybody continues to be in its state of rest or of uniform motion in straight line unless compelled by some external force to act.

FIRST LAW OF MOTION

SECOND LAW OF MOTION

The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts.

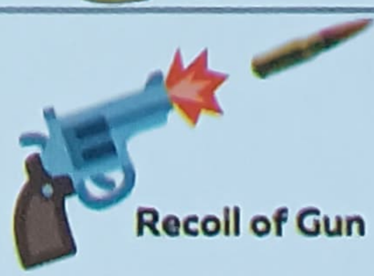
$$F \propto \frac{dp}{dt} \Rightarrow F = k\frac{d}{dt}(mv) \Rightarrow F = \frac{mdv}{dt} = ma$$



THIRD LAW OF MOTION

To every action, there is always an equal and opposite reaction.

$$F_{12} = -F_{21}$$

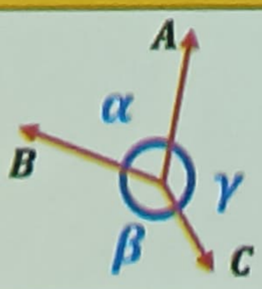


Law of Conservation of Momentum

The total momentum of an isolated system of interacting particles is conserved.

$$p'_A + p'_B = p_A + p_B$$

Lami's Theorem



If three forces acting on a particle are in equilibrium, then

$$\frac{A}{\sin\beta} = \frac{B}{\sin\gamma} = \frac{C}{\sin\alpha}$$

Friction

A force acting on the point of contact of the objects, which opposes the relative motion is called friction.

μ_l = coefficient of limiting friction
R = normal reaction
μ_k = coefficient of kinetic friction

Limiting Friction,

$$f_{s\,(max)} = \mu_l R$$

Angle of friction,

$$\mu_l = \tan\theta$$

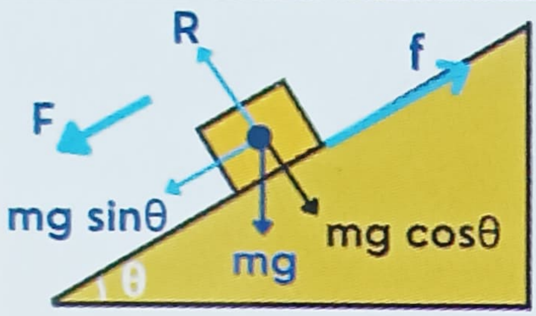
Angle of Response or Angle of Sliding,

$$\mu_l = \tan\alpha$$

Kinetic Friction,

$$f_k = \mu_k R$$

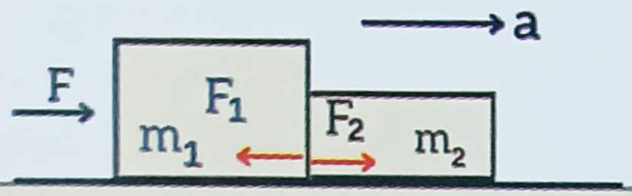
Motion on a Rough Inclined Plain



$$R = mg\cos\theta$$
$$F = mg\sin\theta - f$$
$$a = g(\sin\theta - \mu\cos\theta)$$

Motion of Bodies in Contact

Two bodies in contact



Acceleration on bodies,

$$a = \frac{F}{(m_1 + m_2)}$$

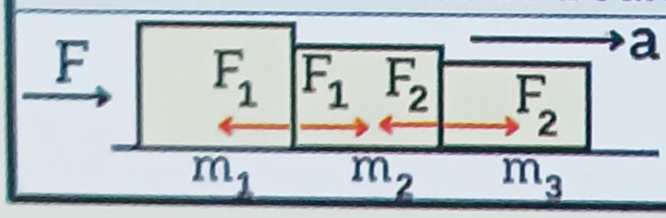
F_1 = Contact force on m_1

$$F_1 = m_1 a = \frac{m_1 F}{(m_1 + m_2)}$$

F_2 = Contact force on m_2

$$F_2 = m_2 a = \frac{m_2 F}{(m_1 + m_2)}$$

Three bodies in contact



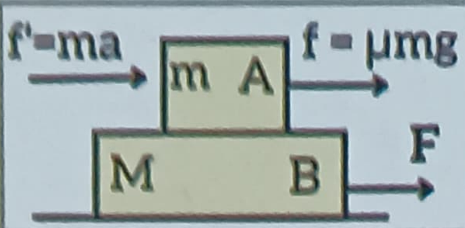
Acceleration on bodies,

$$a = \frac{F}{m_1 + m_2 + m_3}$$

Contact force between m_1 and m_2	Contact force between m_2 and m_3
$F_1 = \frac{(m_2 + m_3)F}{(m_1 + m_2 + m_3)}$	$F_2 = \frac{m_3 F}{(m_1 + m_2 + m_3)}$

Motion of Two Bodies, One Resting on the Other

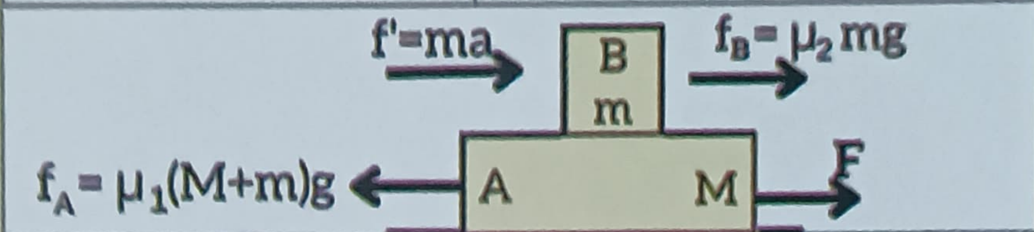
Two bodies on smooth surface



$$a = \frac{F}{(M + m)}$$

$$f = \mu N = \mu mg$$

Two bodies on rough surface



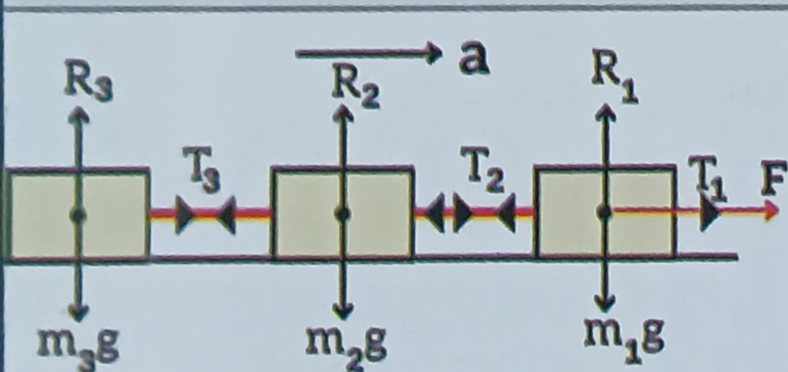
Net acceleration,

$$a = \frac{F}{(M + m)} \mu_1 g$$

Net accelerating force,

$$F - f_a = F - \mu_1 (M + m) g$$

Motion of Bodies Connected by Strings



$$a = \frac{F}{(m_1 + m_2 + m_3)}$$

Tension in string

$$T_2 = (m_2 + m_3)a = \frac{(m_2 + m_3)F}{(m_1 + m_2 + m_3)}$$

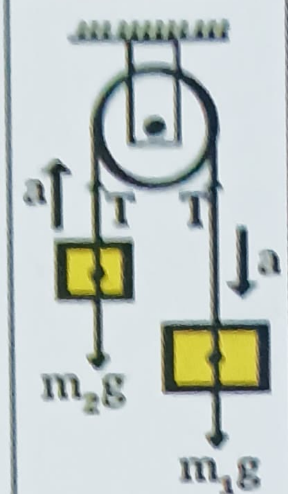
$$T_3 = m_3 a = \frac{m_3 F}{(m_1 + m_2 + m_3)}$$

Pulley Mass System

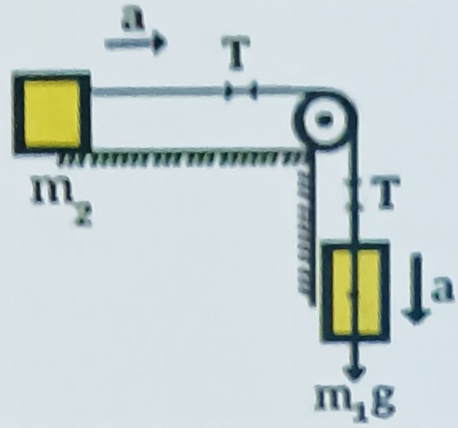
When unequal masses m_1 and m_2 suspended from a pulley ($m_1 > m_2$)

$$a = \frac{(m_1 - m_2)}{(m_1 + m_2)} g$$

$$T = \frac{2m_1 m_2}{(m_1 + m_2)} g$$



When a body of mass m_2 is placed on a frictionless horizontal surface

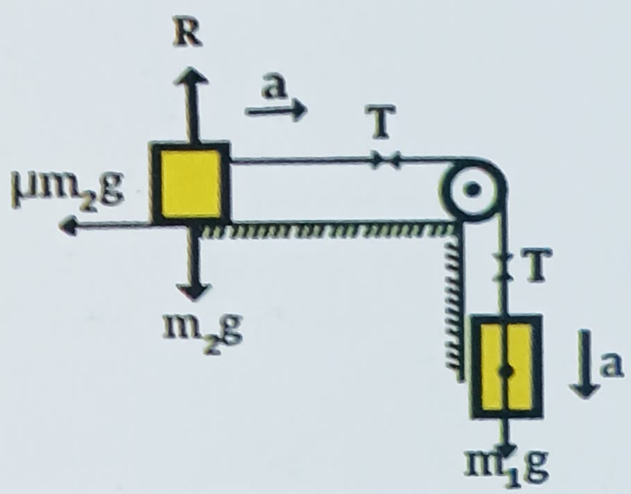


$$a = \frac{m_1 g}{(m_1 + m_2)}; T = \frac{m_1 m_2 g}{(m_1 + m_2)}$$

When a body of mass m_2 is placed on a rough horizontal surface

$$a = \frac{(m_1 - \mu m_2)g}{(m_1 + m_2)}$$

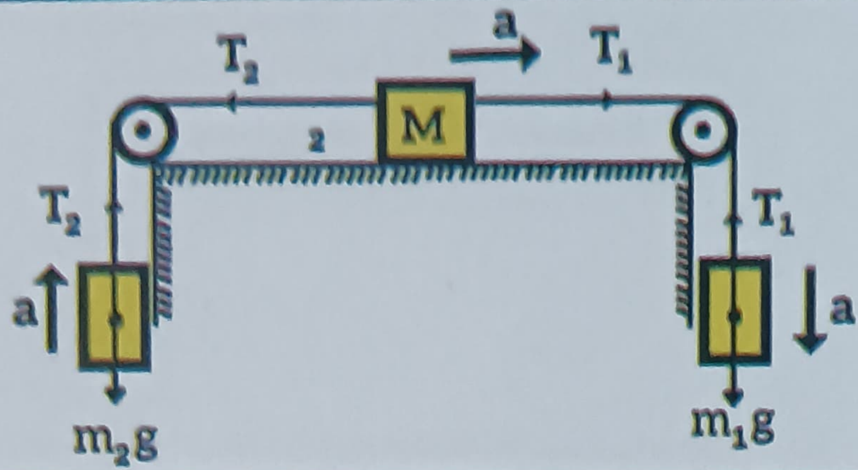
$$T = \frac{m_1 m_2 (1 + \mu)g}{(m_1 + m_2)}$$



When two masses m_1 and m_2 ($m_1 > m_2$) are connected to mass M

$$a = \frac{(m_1 - m_2)g}{(m_1 + m_2 + M)}$$

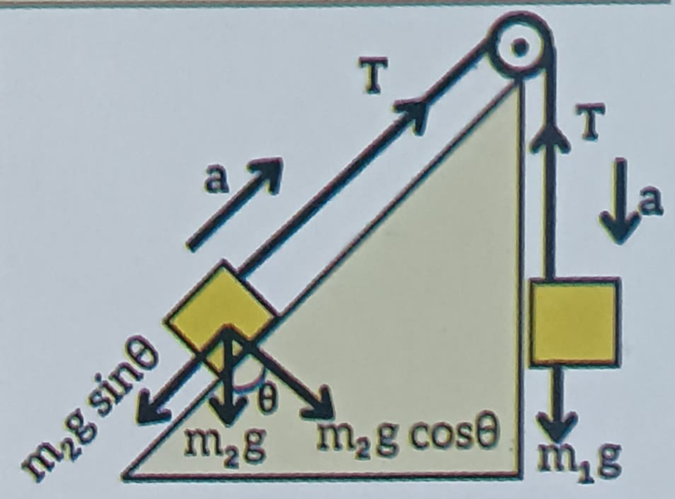
$$T_1 = \left(\frac{2m_2 + M}{m_1 + m_2 + M}\right) m_1 g \;\; ; \;\; T_2 = \left(\frac{2m_1 + M}{m_1 + m_2 + M}\right) m_2 g$$



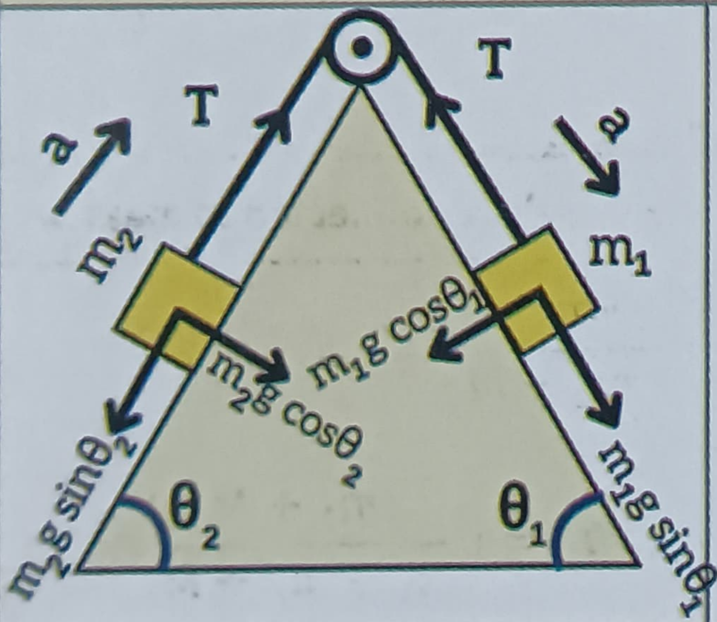
Motion on smooth inclined surface

$$a = \left(\frac{m_1 - m_2 \sin\theta}{m_1 + m_2}\right) g$$

$$T = \frac{m_1 m_2 (1 + \sin\theta) g}{(m_1 + m_2)}$$



Motion of two bodies placed on two inclined planes having different angle of inclination



$$a = \frac{(m_1 \sin\theta - m_2 \sin\theta) g}{m_1 + m_2}$$

$$T = \frac{m_1 m_2}{m_1 + m_2} (\sin\theta_1 + \sin\theta_2) g$$