NEWTON'S LAW OF MOTION

First Law of Motion

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

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

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.	$p'_a + p'_B = p_A + p_B$
Impulse	Change in momentum

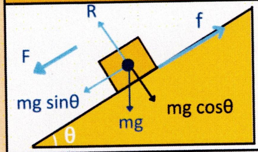
Lami's Theorem

If three forces acting on a particle are in equilibrium, then	$\frac{A}{\sin\beta} = \frac{B}{\sin\gamma} = \frac{A}{\sin\alpha}$
Equilibrium of Particle	where net external force on particle is **zero**

Friction

Limiting Friction $f_{s\,(max)} = \mu_s R$	**Kinetic friction** $f_k = \mu_k R$
Angle of Repose $\mu_s = \tan\alpha$ α is angle of inclination, where block just begin to slide down the plane	**Angle of friction** $\mu_s = \tan\theta$ (θ is angle between resultant and normal)

Motion on a Rough Inclined Plain

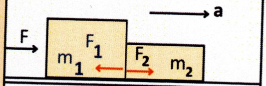


$R = mg\cos\theta$
$F = mg\sin\theta - f$
$a = g(\sin\theta - \mu\cos\theta)$

Pseudo force	$\vec{F}_{pseudo} = ma_{frame\ of\ refrence}$

Motion of Bodies in Contact

Two bodies in contact



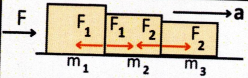
Acceleration on bodies,

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

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

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

Three bodies in contact



Acceleration on bodies,

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

Contact force b/w m_1 and m_2

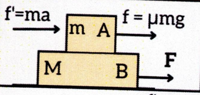
$$F_1 = \frac{(m_2 + m_3)F}{(m_1 + m_2 + m_3)}$$

Contact force b/w m_2 and m_3

$$F_2 = \frac{m_3 F}{(m_1 + m_2 + m_3)}$$

Motion of two bodies, one resting on the other

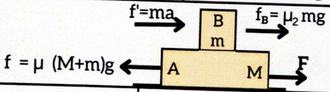
Two bodies on smooth surface



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

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

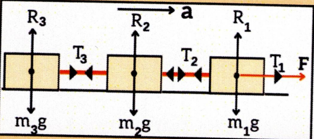
Two bodies on rough surface



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

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

Motion of two bodies, one resting on the other



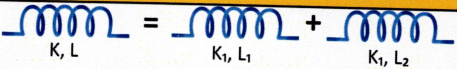
$$a = \frac{F}{(m_1 + m_2 + m_3)}$$

Tension in string

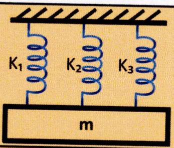
$$T_2 = (m_2 + m_3)a = \frac{(m_2 + m_3)F}{(m_1 + m_2 + m_3)}$$

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

Spring constant & length of spring



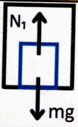
$$KL = K_1L_1 = K_2L_2$$

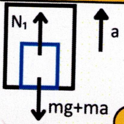


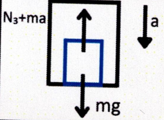
$$K_{eq} = K_1 + K_2 + K_3$$

$$T = 2\pi\sqrt{\frac{m}{K_{eq}}}$$

Elevator question



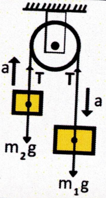




Thrust force	Variable mass system
$F_{thurst} = \frac{dm}{dt} = v_{relative}$	$\vec{F} = m\frac{d\vec{v}}{dt} + v\frac{d\vec{m}}{dt}$

Pulley Mass System

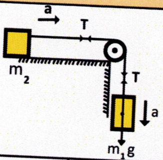
When unequal masses m_1 and m_2 suspended from a pulley ($m_1 > m_2$)



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

$$T = \frac{2m_1m_2}{(m_1 + m_2)}g$$

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



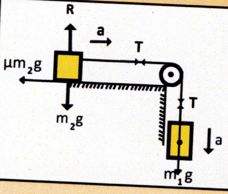
$$a = \frac{m_1g}{(m_1 + m_2)}$$

$$T = \frac{m_1m_2g}{(m_1 + m_2)}$$

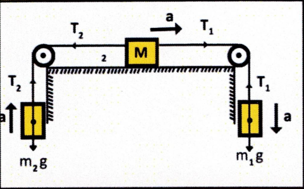
When a body of mass m_2 is placed on a rough horizontal surface

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

$$T = \frac{m_1m_2(1 + \mu)g}{(m_1 + m_2)}$$



When two masses m_1 and m_2 ($m_1 > m_2$) are conn. to M



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

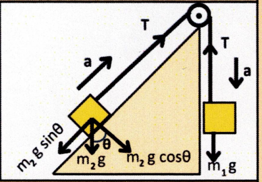
$$T_1 = \left(\frac{2m_2 + M}{m_1 + m_2 + M}\right) m_1 g$$

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

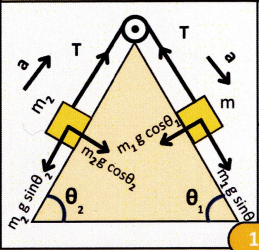
Motion on smooth inclined surface

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

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



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



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

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