BRAIN MAP

CLASS XI

MASTERJEE CLASSES

NEWTON'S LAWS OF MOTION

Problem Solving Strategies

- Identify the unknown forces and accelerations.
- Draw FBD of bodies in the system.
- Resolve forces into their components.
- Apply $\Sigma\vec{F} = M\vec{a}$ in the direction of motion.
- Apply $\Sigma\vec{F} = 0$ in the direction of equilibrium.
- Write constraint relation if exists.
- Solve equations $\Sigma\vec{F} = M\vec{a}$ and $\Sigma\vec{F} = 0$.

Newton's 1st Law

A body continues its state of rest or motion until unless an external force is acted on it.

- Inertia of rest
- Inertia of motion
- Inertia of direction

Newton's 2nd Law

The rate of change of linear momentum of a body is directly proportional to the external force applied on the body in the direction of force.

$$F = \frac{dp}{dt} = ma$$

LAWS OF MOTION AND THEIR CONSEQUENCES

Pseudo Force

$$\vec{F}_{ext} + \vec{F}_{Pseudo} = M\vec{a}$$

$$\vec{F}_{pseudo} = -M\vec{a}_{frame}$$

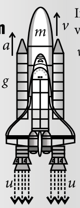
For non-inertial frame of reference

Newton's 3rd Law

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

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

Rocket Propulsion



Instantaneous velocity

$$v = u\log_e\left(\frac{m_0}{m_r}\right) - gt$$

Acceleration

$$a = \frac{u}{m}\frac{dm}{dt} - g$$

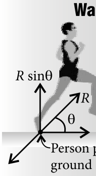
Burn out speed

$$v_{max} = u\log_e\left(\frac{m_0}{m_r}\right)$$

Thrust

$$F = -u\frac{dm}{dt}$$

Walking



Ground pushes the person (reaction)

Person presses the ground (action)

Horse Cart Type System

For horse cart type system

$$a = \frac{F_x - f}{M_H + M_{cart}}$$

F_x = horizontal component of reaction force

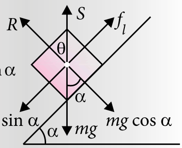
f = frictional force

Angle of Friction (θ) and Angle of Repose (α)

$$S = \sqrt{R^2 + f_l^2}$$

$$\tan\theta = \frac{f_l}{R} = \mu_s = \tan\alpha$$

∴ Numerically, $\theta = \alpha$



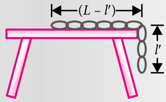
The motion resisted by a bonding between the body and the surface in contact represented by single force called

FRICTION

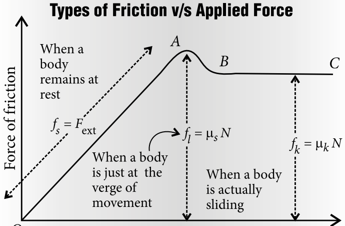
Maximum Length of Hanging Chain

Length of a chain hanging in air

$$l' = \frac{\mu L}{1+\mu}$$

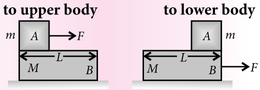


Types of Friction v/s Applied Force



Motion of Two Bodies One Resting on the Other

Force F applied to upper body | Force F applied to lower body



Force F applied to upper body

- **When there is no friction**
  - $a_A = F/m;\ a_B = 0$
  - A will fall from B after time

$$t = \sqrt{\frac{2L}{a}} = \sqrt{\frac{2mL}{F}}$$

- **Friction present between A and B ($F < f_l$)**
  - Combined system will move together with $a = F/(M+m)$

- **Friction present between A and B ($F > f_l$)**
  - Relative acceleration

$$a = a_A - a_B = \frac{MF - \mu_k mg(m+M)}{mM}$$

  - A will fall from B after time

$$t = \sqrt{\frac{2L}{a}} = \sqrt{\frac{2mML}{MF - \mu_k mg(m+M)}}$$

Force F applied to lower body

- **When there is no friction**
  - $a_B = F/M$ and $a_A = 0$
  - A will fall from B (backward) after time t

$$\therefore\ t = \sqrt{\frac{2L}{a}} = \sqrt{\frac{2ML}{F}}$$

- **Friction present between A and B ($F < f_l$)**
  - Both the bodies will move together

$$a = \frac{F}{M+m} \text{ and } f_l = \mu_s mg$$

  - Pseudo force on the body A,

$$F' = ma = \frac{mF}{m+M}$$

- **Friction present between A and B ($F > f_l$)**
  - Relative acceleration

$$a = a_A - a_B = -\left[\frac{F - \mu_k g(m+M)}{M}\right]$$

  - A will fall from B (backward) after time

$$t = \sqrt{\frac{2L}{a}} = \sqrt{\frac{2ML}{F - \mu_k g(m+M)}}$$