# BRAIN MAP CLASS XI

# LAWS OF



SIR ISSAC NEWTON (1643-1727)

# Inertia of Direction

The property due to which a body cannot change its direction of motion by itself.

## **Inertia of Rest**

The property of a body due to which it cannot change its state of rest by itself.

# **Inertia of Motion**

The tendency of a body to remain in a state of uniform motion in a straight line.



# Newton's 1st Law

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



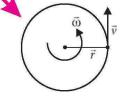
# Circular Motion

Non-uniform circular motion

Acceleration,  $\vec{a} = \vec{a}_T + \vec{a}_C = \vec{\alpha} \times \vec{r} + \vec{\omega} \times \vec{v}$ 

A body moving in a circular path is called circular motion.

Centripetal force 
$$F_e = \frac{mv^2}{r}$$







# Motion of a Car on **Banked Road**

 Maximum velocity on banked road to avoid skidding

$$v_{\text{max}} = \sqrt{\frac{rg(\mu_s + \tan \theta)}{(1 - \mu_s \tan \theta)}}$$

Optimum speed on a smooth banked road

 $N\cos\theta$ 

$$v_0 = \sqrt{rg \tan \theta}$$

Road

Horizontal surface

surface

# 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.



 $Force = mass \times acceleration$ F = ma, SI unit  $\equiv N$ 



LAWS OF MOTION AND

THEIR CONSEQUENCES

# Newton's 3rd Law

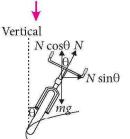
To every action there is always an equal and opposite reaction

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



# Bending of a Cyclist on a circular turn

Angle of bending  $\theta = \tan \theta$ 



# Motion of a Car on Level Road

Maximum velocity on a curved road to avoid skidding

$$v_{\text{max}} = \sqrt{\mu_s rg}$$

# **Impulse**

A large force acts for a very short duration of time producing a finite change in momentum.

 $J = F \times t = \Delta p$ 

## Conservation of Linear Momentum

Total momentum of an isolated system of interacting particles is conserved if there is no external force acting on it.  $P_{\text{initial}} = P_{\text{final}}$ 



# Friction

Resistance offered to the relative motion between the surface of the two bodies in contact.



- Acceleration of a body sliding down a rough inclined plane,  $a = g(\sin \theta - \mu \cos \theta)$
- Angle of friction,  $\theta = \tan^{-1}(\mu_s)$ .
- Angle of repose,  $\alpha = \tan^{-1}(\mu_s)$ .
- Numerically,  $\alpha = \theta$

# **Types of Friction**

- (a) Static friction: acts when a body is at rest on application of a force,  $f_s = F_{\text{ext}}$
- (b) Limiting friction: acts when a body is just at the verge of movement,  $f_l = \mu_s N$
- (c) Kinetic friction: acts when a body is actually sliding,  $f_1 = \mu_s N$

# **Problem Solving Techniques** in Mechanics

- Make free body diagram of each element showing all external forces acting on it.
- Analyse the magnitude and direction of pseudo forces if there is any.
- For equilibrium of concurrent forces use

$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots + \vec{F}_n = 0$$

$$\frac{F_1}{\sin \alpha} = \frac{F_2}{\sin \beta} = \frac{F_3}{\sin \gamma}$$
 (Lami's theorem)  
• For horse cart type system

$$a = \frac{F_x - f}{M_H + M_{\text{cart}}}$$
 F<sub>x</sub>= horizontal component of reaction 
$$f = \text{frictional force}$$

