

Mechanics-3



SAFALTA CLASS<sup>TM</sup>

An Initiative by अमरउजाला

# Uniform Circular Motion (एकसमान वृत्तीय गति):

- The movement of a body following a circular path is called a circular motion.  
वृत्ताकार पथ का अनुसरण करने वाले पिंड की गति को वृत्तीय गति कहा जाता है।

constant speed

- Now, the motion of a body moving with constant speed along a circular path is called Uniform Circular Motion.

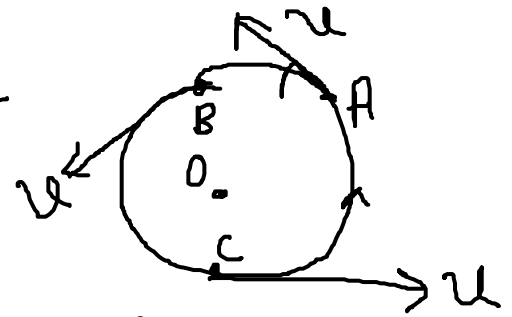
वृत्ताकार पथ के साथ निरंतर गति के साथ गतिमान पिंड की गति को एकसमान वृत्तीय गति कहा जाता है।

- Here, the speed is constant but the velocity changes.

गति स्थिर है लेकिन वेग बदल जाता है।

• if a particle is moving in a uniform circular motion:

• 1) Its speed is constant



$$\vec{v} \rightarrow |\vec{v}| \cdot \hat{v}$$

• 2) Velocity is changing at every instant

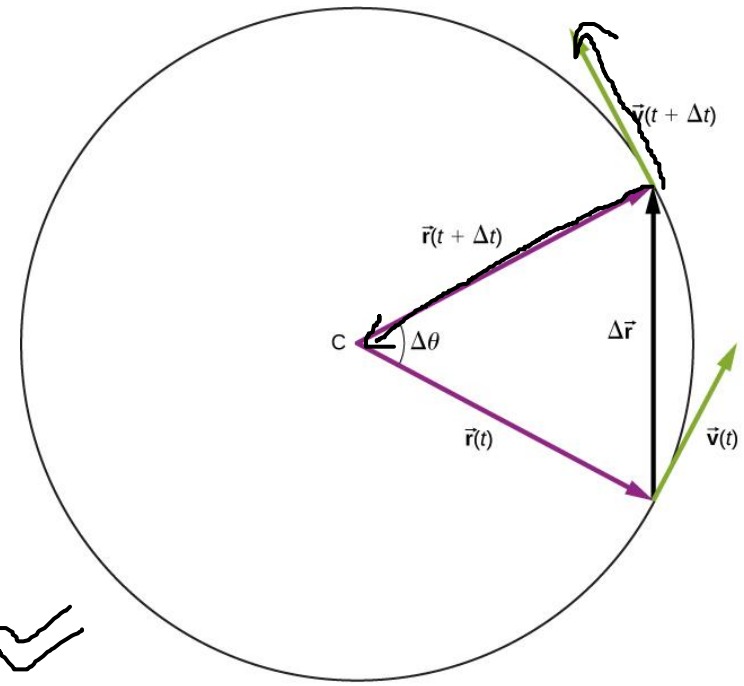
• 3) There is no tangential acceleration

• 4) Radial (centripetal) acceleration =  $\omega^2 r$

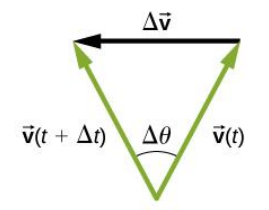
$$= \omega^2 r$$

• 5)  $v = \omega r$

$v = \omega r$   $\rightarrow$  Angular velocity



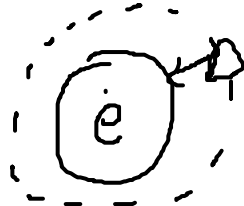
(a)



(b)

# Uniform Circular Motion Examples

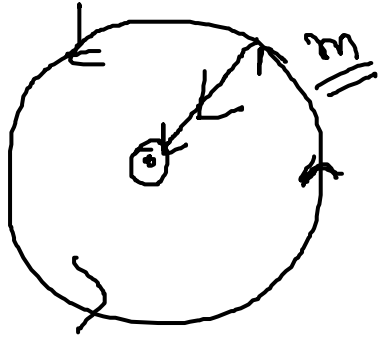
- Motion of artificial satellites around the earth is an example of uniform circular motion. The gravitational force from the earth makes the satellites stay in the circular orbit around the earth.



- The motion of electrons around its nucleus.
- The motion of blades of the windmills.
- The tip of second's hand of a watch with circular dial shows uniform circular motion.

• **Centripetal Force** : Centripetal force is the component of force acting on an object in curvilinear motion which is directed toward the axis of rotation or center of curvature.

अभिप्रेत =  $\frac{v^2}{r}$  :-



$a_c = \frac{v^2}{r}$

$m = \text{mass}$

$$F = \frac{m v^2}{r}$$

- ✓ • **Spinning a ball on a string or twirling a lasso:** Here the centripetal force is provided by the force of tension on the rope pulls the object in toward the centre.
- ✓ • **Turning a car:** Here the centripetal force is provided by the [frictional force](#) between the ground and the wheels.
- ✓ • **Going through a loop on a roller coaster:** The force is provided by the Normal Force as the seat or wall pushes you toward the centre.
- ✓ • **Planets orbiting around the Sun:** Centripetal Force is provided by Gravity.

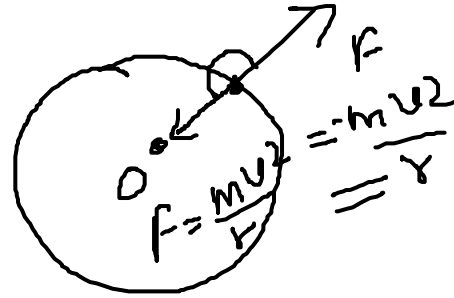
- **Centrifugal Force** : Centrifugal force is a force that arises from the body's inertia and appears to act on a body that is moving in a circular path which is directed away from the centre around which the body is moving.

अधो-दिशि दिशि

Pseudo force

- Weight of an object at the poles and on the equator

- A bike making a turn.



- Vehicle driving around a curve

$$\vec{F} = -\frac{mv^2}{r}$$

- Equatorial railway

$$\vec{F}_{cp} = -\vec{F}_{cf}$$

# Gravitational Force (गुरुत्वाकर्षण बल):

mass द्रव्यमान

- Each body in this universe attracts other bodies towards itself with a force known as **Gravitational Force**.

इस ब्रह्मांड का प्रत्येक निकाय गुरुत्वाकर्षण बल के रूप में ज्ञात एक बल के साथ अन्य निकायों को अपनी ओर आकर्षित करता है।

- Gravitation is a study of the interaction between two masses.  
गुरुत्वाकर्षण, दो द्रव्यमानों के बीच पारस्परिक क्रिया का एक अध्ययन है।



• Gravitational force is a central force.  $m_1 m_2^0$ .

गुरुत्वाकर्षण बल एक केंद्रीय बल है।

• Out of the two masses, the heavier one is called **source mass** and the lighter one is called **test mass**. दो द्रव्यमानों में से, भारी को स्रोत द्रव्यमान कहा जाता है और हल्का को परीक्षण द्रव्यमान कहा जाता है।

# Newton's Law of Gravitation :

$$F \propto m_1 m_2$$

$$F \propto \frac{1}{r^2}$$

$$F \propto \frac{m_1 m_2}{r^2}$$

$$\rightarrow F = G \times [M_1 M_2] / r^2$$

↓ Universal Grav. Constant



- The dimension formula of  $G$  is  $[M^{-1}L^3T^{-2}]$ . Also, the value of the gravitational constant,



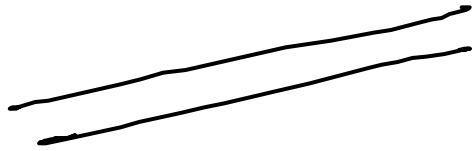
$$G = \frac{F \cdot r^2}{m_1 m_2} = \frac{N \cdot m^2}{kg^2}$$

- In SI units:  $6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$ ,

- In CGS units:  $6.67 \times 10^{-8} \text{ dyne cm}^2 \text{ g}^{-2}$

## Examples :

- ① earth revolve around sun. ✓
- ② Tides (उदर - अरि) ✓
- ③ Eclipse ✓
- ④ motion of satellites.



# Relation b/w G & g :

$$\vec{F} = G \frac{m_1 m_2}{r^2}$$

$$m_1 = M_e$$

$$m_2 = m_o$$

$$\Rightarrow \vec{F} = G \frac{M_e m_o}{r^2}$$

$$\Rightarrow \vec{F} = m_o g$$

~~गुरुत्वाकर्षण~~  
G grav.  $\leftarrow$   $g = G \frac{M_e}{r^2}$   
Acceleration  $\rightarrow$  ✓✓

# • Weight and Mass (वजन और द्रव्यमान):

$W = mg = \text{Newton}$  force  $\rightarrow W$  mass  $\rightarrow m = \text{kg}$

- Mass of an object is the measure of its inertia and is constant throughout the universe.

किसी वस्तु का द्रव्यमान उसकी जड़ता का माप है और पूरे ब्रह्मांड में स्थिर है।

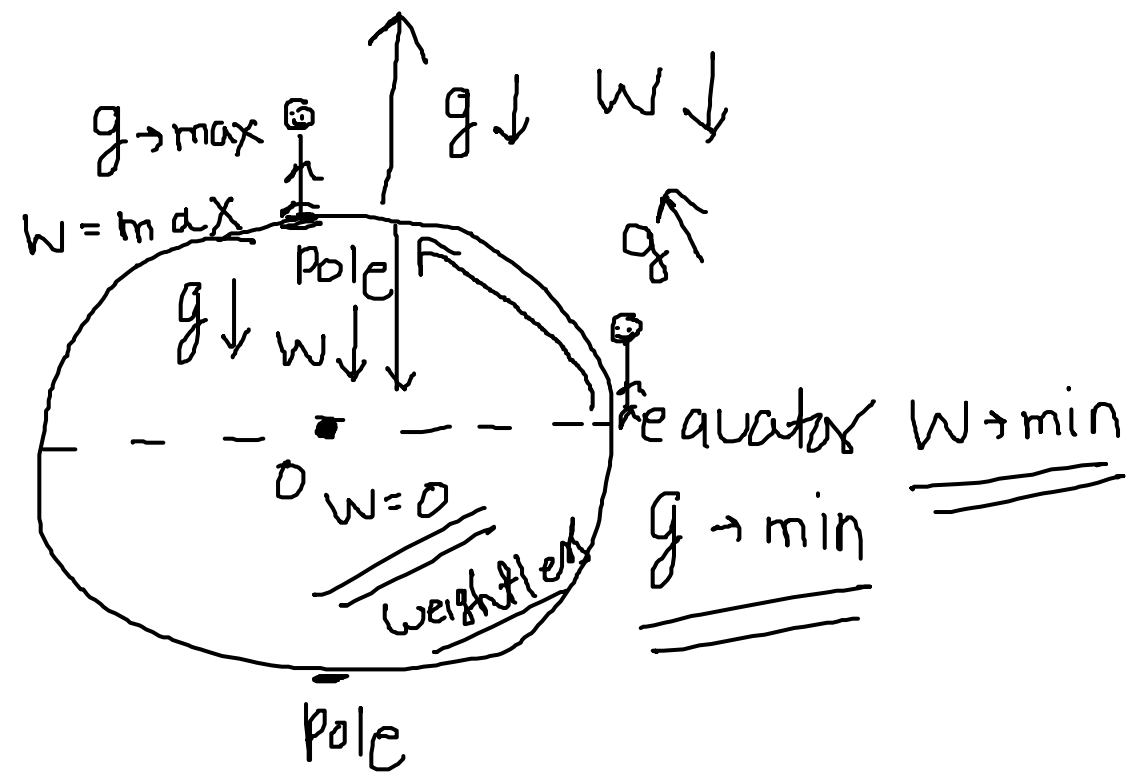
- Weight of an object keeps changing as the value of  $g$  changes.

किसी वस्तु का वजन  $g$  परिवर्तनों के मूल्य के रूप में बदलता रहता है

- Weight is nothing but a force of attraction of the Earth on an object =  $mg$ .

वजन और कुछ नहीं बल्कि एक वस्तु =  $mg$  पर पृथ्वी के आकर्षण का एक बल है।

# Variation of 'g' :



At equator  $\rightarrow W \rightarrow \text{min}$   
 At poles  $\rightarrow W \rightarrow \text{max}$

Above surface  $\rightarrow W \uparrow \downarrow$   
 Below "  $\rightarrow W \downarrow$

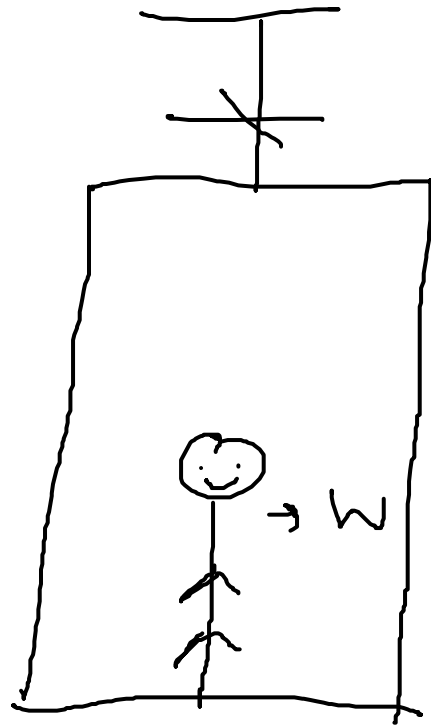
At center  $\downarrow$   
 $W = 0$   
 ✓

# Effect of Earth's Rotation :

⇒ Poles → weight max

⇒ Equator → min. weight

# LIFT:



Lift Stop  $\rightarrow W$

Lift moves  
with constant  $\Rightarrow W$   
velocity

\* Acceleration:- UP  $\rightarrow \uparrow W \uparrow$

Down  $\rightarrow \downarrow W \downarrow$

free fall  $\rightarrow W = 0$



# Escape Velocity :

$$v_e = \underline{\underline{11.2 \text{ km/sec}}} \checkmark$$

पलायन वेग

$$v_e = \sqrt{2g \{R_e\}}$$

↓  
Radius of  
earth



# Kepler's laws (केप्लर के नियम):

- The orbit of a planet is an ellipse with the sun as its foci.

केप्लर के प्रथम नियम के अनुसार प्रत्येक ग्रह सूर्य के चारों ओर दीर्घवृत्ताकार कक्षा में गति करता है। तथा सूर्य ग्रह के एक फोकस या नाभि बिन्दु पर स्थित होता है।

- The line joining the planets and the sun sweeps equal areas in equal intervals of time.

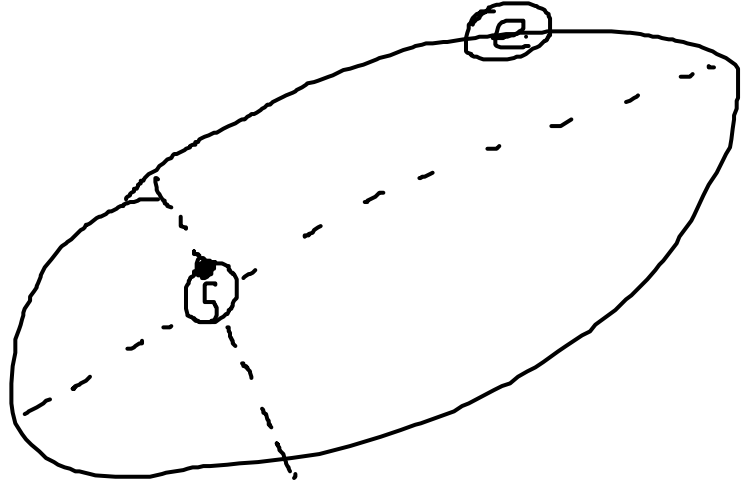
केप्लर के दूसरे नियम के अनुसार सूर्य तथा ग्रहों को जोड़ने वाली रेखा समान समयांतराल में समान क्षेत्रफल तय करती है।

- Cube of a mean distance of a planet from the sun  $\propto$  Square of orbital time period  $T$ .

- परिक्रमण काल का वर्ग ( $T^2$ ) ग्रह की सूर्य से औसत दूरी के घन ( $a^3$ ) के अनुक्रमानुपाती होता है।

$$r^3 \propto T^2$$

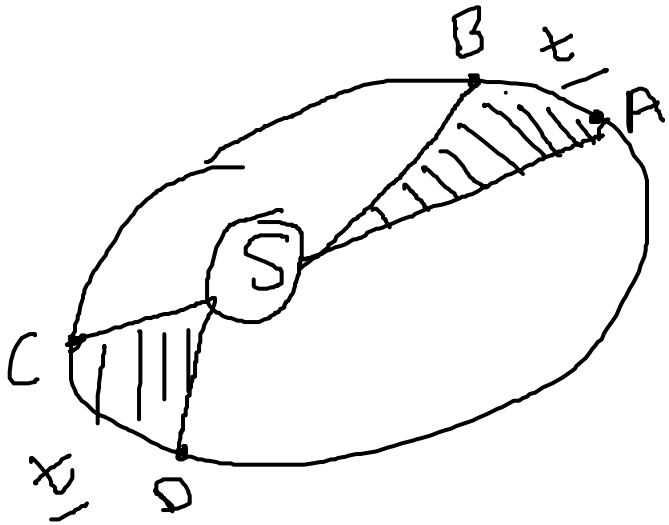
① elliptical (दीर्घवृत्त) : ✓✓



③  $T^2 \propto r^3$

$\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$

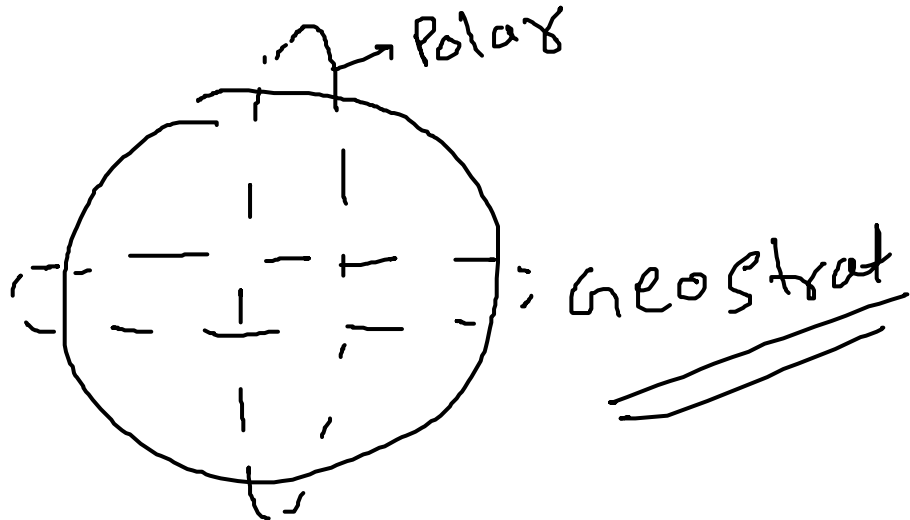
②



$ASB = CSD$

# Geostationary Satellite : ✓

- A geostationary satellite is an earth-orbiting [satellite](#), placed at an altitude of approximately 35,800 kilometers (22,300 miles) directly over the equator, that revolves in the same direction the earth rotates (west to east).
- At this altitude, one orbit takes 24 hours, the same length of time as the earth requires to rotate once on its axis. ✓



Polar Satellite :  $\Rightarrow$  मौसम, वाणिज्य, Defence,

- Polar satellites revolve around the earth in a north-south direction around the earth as opposed to east-west like the geostationary satellites.
- They are very useful in applications where the field vision of the entire earth is required in a single day.

\* Radio, TV, mobile + Geost.  
\* Atmosp. Upper layers  $\rightarrow$  Geost.

# Work , Energy & Power

- **Work** : Work is said to be done when a force applied to an object moves that object.  $\Rightarrow$  Scalar

- $\Rightarrow$  W = F \times d

- The SI unit of work is the joule (J)

$$\underline{\underline{W = F d \cos \theta}}$$

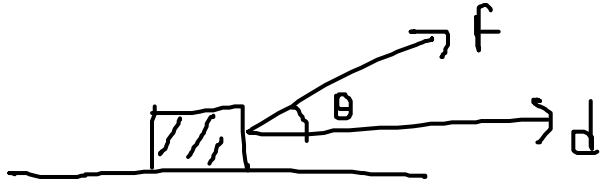
SI unit  $\rightarrow$  J

cgs "  $\rightarrow$  erg

$$\checkmark \left| \underline{1 \text{ J} = 10^7 \text{ erg}} \right|$$

$$\underline{W = F d \cos \theta}$$

$\theta \rightarrow$  Angle of force





# Energy

## Definition

In physics, we can define energy as the capacity to do work.

## Formula

$$\underline{\underline{E = W}}$$

For the potential energy the formula is  
P.E. =  $mgh$

## Unit



The SI unit of energy is joules (J), which is named in honour of James Prescott Joule.

## Types of energy

Mechanical energy

Mechanical wave energy

Chemical energy

Electric energy

Magnetic energy

Radiant energy

Nuclear energy

Ionization energy

Elastic energy

Gravitational energy

Thermal energy

Heat Energy

**Power** : Power can be defined as the rate at which work is done i.e. energy converted.

$$\frac{W}{t} = P$$

Formula :  $P = W/t$

Unit : The unit of power is watt (W).

- An object is horizontally dragged across the surface by a 100 N force acting parallel to the surface. Find out the amount of work done by the force in moving the object through a distance of 8 m ?

- A garage hoist lifts a truck up 2 meters above the ground in 15 seconds. Find the power delivered to the truck. [Given: 1000 kg as the mass of the truck]

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