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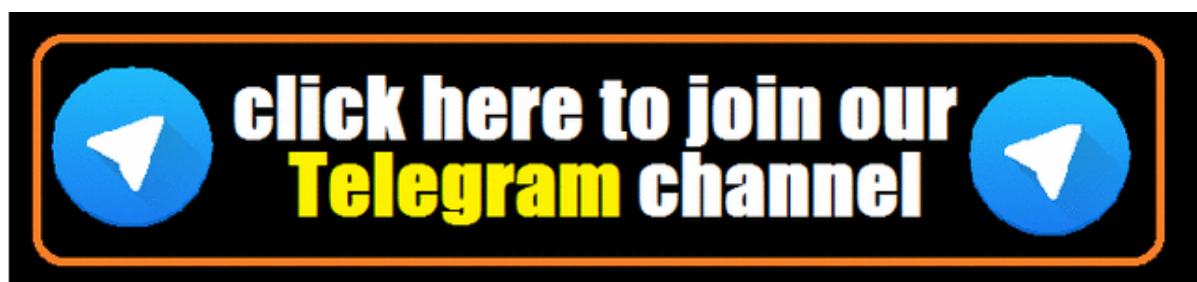
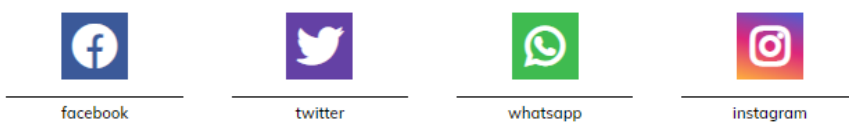


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Date ____/____/____

Page No.: ____

Chapter - 3 - Gravitation# GRAVITY

It is the pulling force by which every object in the universe attract towards each other. Sun, Earth and moon exerts gravitational force on smaller objects.

NEWTON'S LAW OF GRAVITY

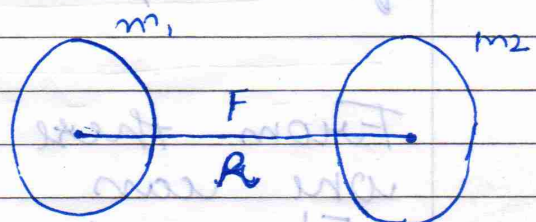
- Every object in the universe attracts every other object by a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.
- Let m_1 and m_2 are masses of two heavenly bodies.
- Distance between them is R

Thus, the force of gravitation (F) will be

$$F \propto m_1 \times m_2$$

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

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



$$F = \frac{G m_1 m_2}{R^2} \quad (\text{where } G = \text{universal constant})$$

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Date: / /

Page No.:

Inverse Square law

1)- The force of gravitation is inversely proportional to the square of the distance between the two objects

$$2)- F \propto \frac{1}{(R)^2}$$

When the distance between two object ~~decreases~~ then the gravitational force increases

3)- If the distance between the two particles is doubled then the gravitational force becomes one-fourth

When the distance is R , then Force, $F \propto \frac{1}{R^2}$

When the distance is $2R$, then of Force, $F' \propto \frac{1}{(2R)^2}$

From these two relationship we can write,

$$\frac{F'}{F} = \frac{1}{(2R)^2} \times \frac{R^2}{1} = \frac{1}{4}$$

$$F' = \frac{F}{4}$$

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Date: / /

Page No.:

Thus we can write, when the distance between the two particles is doubled, the gravitational force becomes one-fourth

If the distance b/w the two particles is halved the gravitational force becomes four times,
When the distance is R , then

$$\text{Force, } F \propto \frac{1}{R^2}$$

$$\text{Force, } F \propto \frac{1}{\left(\frac{R}{2}\right)^2}$$

From these relationships,

$$\frac{F'}{F} = \frac{1/(R/2)^2}{1/R^2} = \frac{(R)^2 \times 4}{(R)^2} = 4$$

$$F' = 4F$$

Or,

Thus, when the distance b/w the two particles is halved the gravitational force became four times.

Date: ___/___/___

Page No.: ___

★ SIGNIFICANCE OF NEWTON'S LAW OF GRAVITATION

- The gravitational force is responsible for :-

- Existence of solar system
- Holding the atmosphere near the surface of water.
- Flow of water in river.
- Motion of planet around sun.
- Motion of moon around earth.

★ UNIT OF GRAVITATIONAL CONSTANT (G)

- According to Newton's law of gravitation,

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

$$G = \frac{F \times R^2}{m_1 m_2}$$

$$G = \frac{N \times m^2}{(kg)^2}$$

$$G = Nm^2 / kg^2$$

★ CENTRE OF MASS

- The point in a body where its mass is assumed to be concentrated is called its centre of mass.
e.g. scale (ruler)

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Date ____/____/____

Page No.: ____

- Centre of mass lie on the mid-way ~~between~~ its ends.
- Rigid extended body: The centre of the mass continuously distributed over the whole surface.

* CENTRE OF GRAVITY

- The point in a body at which the force of gravity is assumed to be is called its centre of gravity.
- Example: Bodies which are of regular shape and have uniform density centre of gravity lies at the geometrical centre of the body.

* NEWTON'S THIRD LAW OF GRAVITATION

If we consider two bodies A & B, the gravitational force exerted by body A on body B is equal and opposite to that exerted by the body B on the body A.

* ACCELERATION DUE TO GRAVITY

- The gravitational force of attraction produces acceleration in both the interacting bodies.

Date: ____/____/____

Page No.: ____

- Since, we know,
 $F = ma$
 $a = \frac{F}{m}$

We can see that acceleration is inversely proportional to the mass of the object.

Therefore the gravitational force acting b/w a small and big body will produce more acceleration in the smaller body.

* FREE FALL ACCELERATION DUE TO GRAVITY

- During free fall condition an object is falling freely under the effects of gravity towards the Earth.
- Due to gravity the lighter object will accelerate faster as compared to the heavier object.

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

$$mg = \frac{G m_1 m_2}{R^2} \quad (F = ma, \quad ma = mg)$$

$$g = \frac{G m_1 m_2}{R^2 m}$$

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Date ____/____/____

Page No.: ____

$$g = \frac{Gm}{R^2}$$

Here, g = acceleration = due to gravity

$$g = 9.8 \text{ N}$$

★ ACCELERATION DUE TO GRAVITY ON MOON

- The acceleration produced in a body due to gravitational pull on the moon is called acceleration due to gravity on moon.
- Mathematically,

$$F = \frac{Gm \times M_{\text{moon}}}{(R_{\text{moon}})^2}$$

$$m g_{\text{moon}} = \frac{Gm \times M_{\text{moon}}}{(R_{\text{moon}})^2}$$

$$g_{\text{moon}} = \frac{Gm \times M_{\text{moon}}}{(R_{\text{moon}})^2 \times m}$$

$$g_{\text{moon}} = \frac{GM_{\text{moon}}}{(R_{\text{moon}})^2}$$

Date: / /

Page No.:

★ VALUE OF g

- Mass of the moon = 7.4×10^{22} Kg
- Radius of the moon = 1.74×10^6 m
- $G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{Kg}^2$

$$g_{\text{moon}} = \frac{GM_{\text{moon}}}{(R_{\text{moon}})^2}$$

$$g_{\text{moon}} = \frac{6.67 \times 10^{-11} \times 7.4 \times 10^{22}}{(1.74 \times 10^6)^2}$$

$$g_{\text{moon}} = \frac{6.67 \times 10^{-11} \times 7.4 \times 10^{22} \times 10}{1.74 \times 10^6 \times 1.74 \times 10^6}$$

$$= \frac{6.67 \times 10^{-11} \times 74 \times 10^{23}}{174 \times 174 \times 10^{12}}$$

$$= \frac{6.67 \times 74 \times 10^{-12} \times 10^{-11} \times 10^{23}}{174 \times 174}$$

$$= \frac{6.67 \times 74}{174 \times 174}$$

Date ____/____/____

Page No.: ____

★ EQUATION OF MOTION UNDER GRAVITY

For free falling body

Acceleration (a) = Acceleration due to gravity (g)

distance (s) = height above the earth (h)

Three equation of motion:-

1) - $v = u + at$

2) - $s = ut + \frac{1}{2}at^2$

3) - $2as = v^2 - u^2$

As per gravity:-

1) - $v = u + gt$

2) - $h = ut + \frac{1}{2}gt^2$

3) - $2gh = v^2 - u^2$

MASS AND WEIGHT★ Mass: It is the amount of matter contained in a body.

- It is a scalar quantity
- Measured by physical balance.
- It remains constant at all the places
- It is measured in Kg, g etc.
- Denoted by (m).

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Date ____/____/____

Page No.: ____

* Weight *

- It is the force with which the body is attracted towards the earth.
- Force of gravity = Mass $\times$ acceleration due to gravity

$$F = mg$$

- Weight = Force of gravity

$$W = mg$$

- The SI unit of weight is Newton (N).
- It is a vector quantity.
- Measured by weighing machine or spring balance.
- Weight of the body (big or small) becomes 0 (zero) at the centre of the earth.

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