INTRODUCTION

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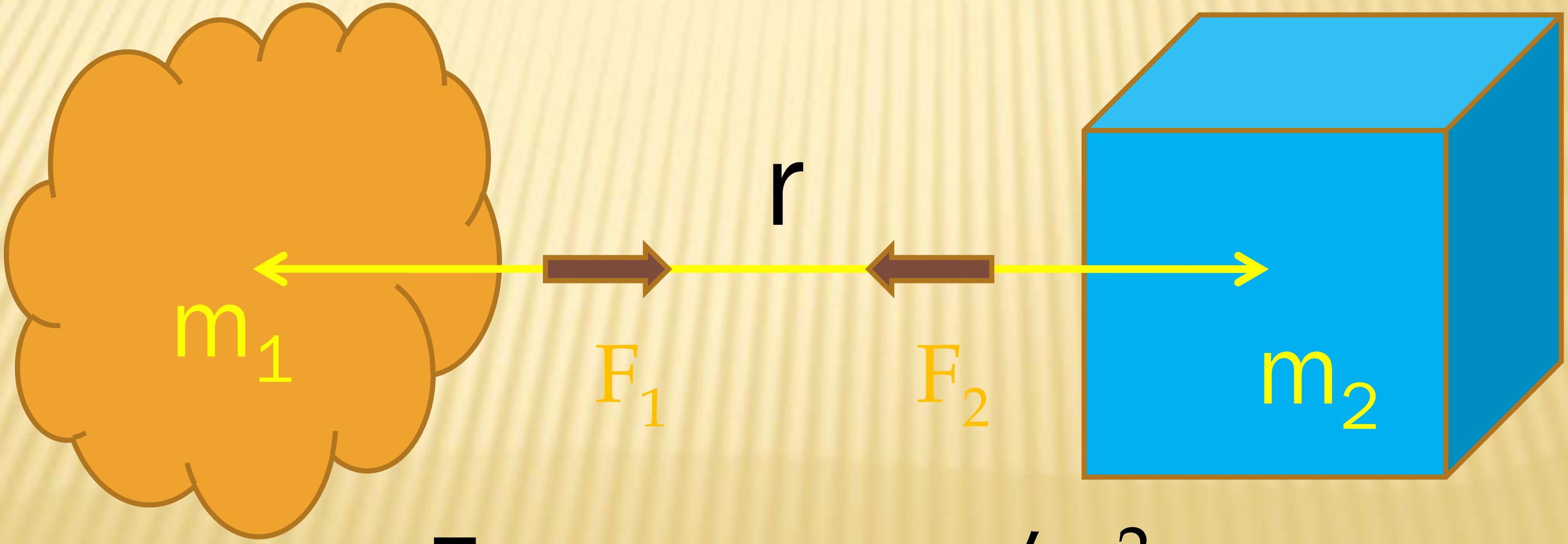
NEWTON'S LAW OF GRAVITATION

Statement : Every particle attracts every other particle in the universe with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers.

The law states that every point mass attracts every other point mass by a force acting along the line intersecting the two points.



$$F \propto m_1 \cdot m_2 / r^2$$

$F \propto m_1 . m_2 / r^2$ $\quad F = G \, m_1 . m_2 / r^2$

$$G = F . r^2 / m_1 . m_2 \ldots\ldots \quad (1)$$

G - Gravitational Constant

Unit of G - $N . m^2 / Kg^2$

$F = m . a, \ a = dv/dt, \ v = dx/dt$

$F = Kg . M / sec^2$

$[F] = [M^1 L^1 T^{-2}]$

$[r^2] = [M^0 L^2 T^0]$

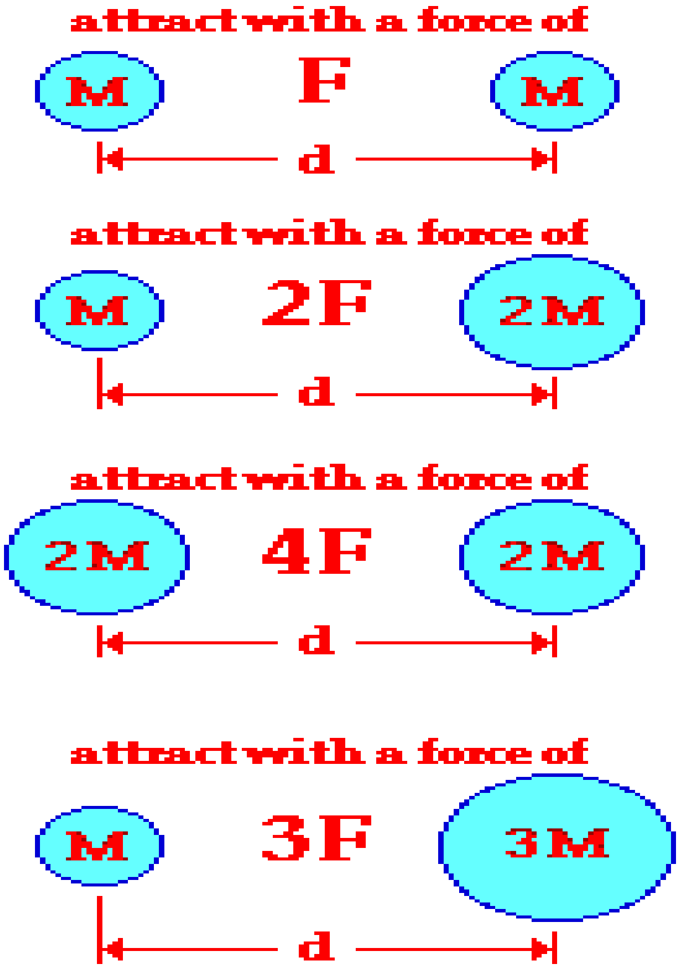
$[m_1.m_2]=[M^2 L^0 T^0]$

$[G] = [M^{1-2} L^{1+2} T^{-2}]$

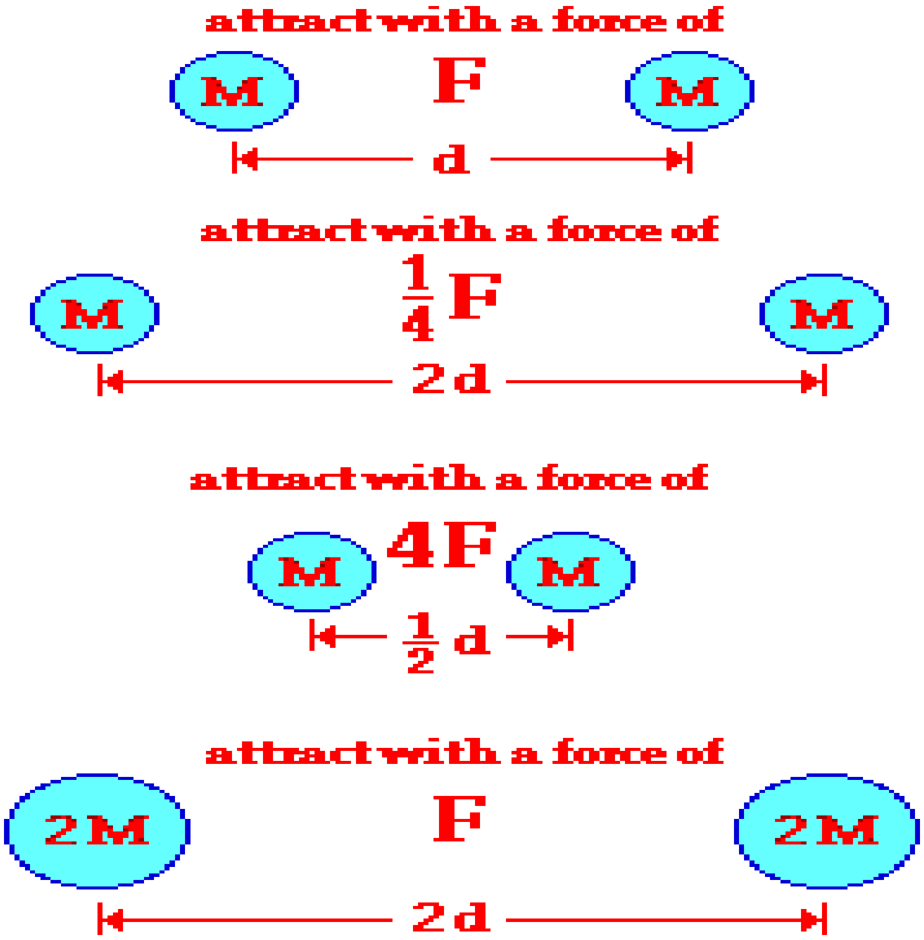
Dimensions of G

$[G] = [M^{-1} L^3 T^{-2}]$

Effect of Mass on F_{grav}



Effect of Distance on F_{grav}



GRAVITATIONAL FIELD

- The area around the body within which the force of attraction is applicable is called Gravitational Field.
- The Intensity or strength of the Gravitational Field at a point is defined as the force experienced by a unit mass at that point.

$$F \propto M . m / r^2$$

$$F = - G M . m / r^2$$

For M = 1

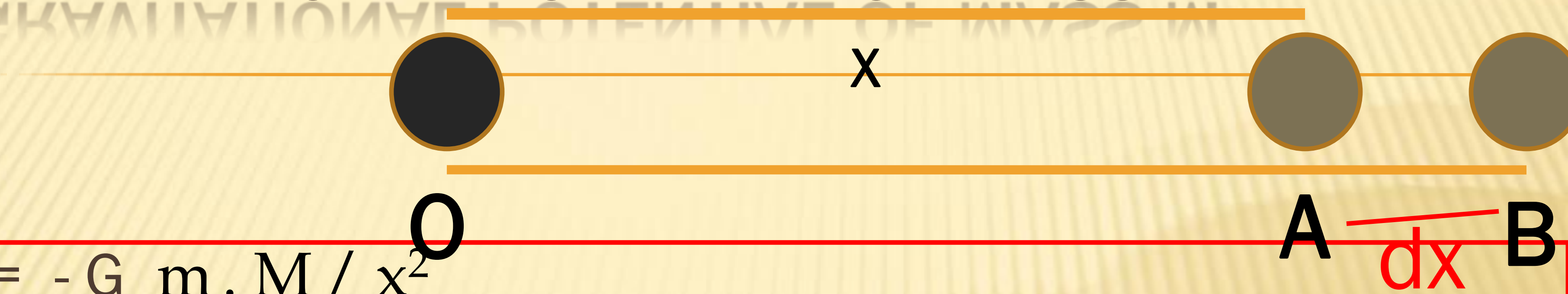
$$F = - G . m / r^2$$

GRAVITATIONAL POTENTIAL

Force of Attraction Decreases
Force of Attraction Increases

The potential energy is equal to the amount of energy required to bring the unit mass from the area of no gravitational force present.

GRAVITATIONAL POTENTIAL OF MASS M



$F = -G\ m.M / x^2$

$F = -G\ m.1 / x^2$

$F = -G\ m / x^2$

Work Done = Force . Displacement [From B to A]

$= -G\ m / x^2 . dx$

$= -\int G\ m / x^2 . = -\int G\ m\, x^{-2}\, dx$

$V = -G\ m / r$ [Is the potential at distance r. The potential difference at infinite difference V=0.]

GRAVITATIONAL POTENTIAL (V)

The work done in bringing a unit mass from the given point to infinity against gravitational force of attraction.

$$V = -G\ m/x$$

m – mass of the ring

x - distance

GRAVITATIONAL FIELD

The area around the body within which the force of attraction is applicable is called Gravitational Field.

GRAVITATIONAL FIELD INTENSITY (E)

The Intensity or strength of the Gravitational Field at a point is defined as the force experienced by a unit mass at that point.

$E = -dV/dr$, V – Gravitational Potential

r - distance

FORMULIES SOLID SPHERE

$V = -G\, m/x$ & $E = -dV/dx$

Density = Mass/Volume (Total Surface Area)

$\rho = M/V$

$M = \rho V$

Volume V = Area x Thickness

Area $= 4 \pi x^2$, Thickness = dx

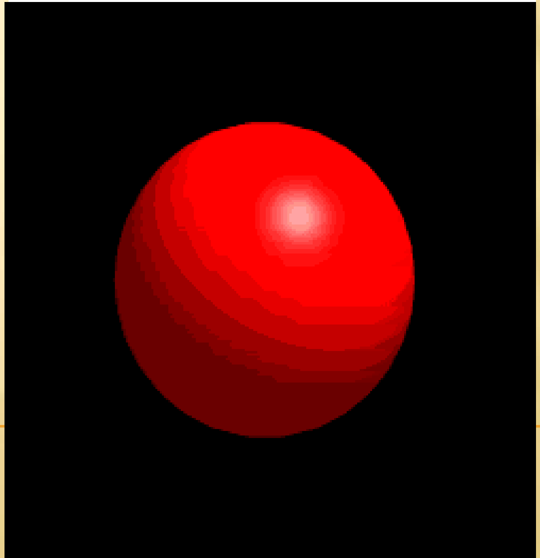
$V = 4 \pi x^2 .\ dx$

$M = \rho\, 4 \pi x^2 .\ Dx$, $\int x\, dx = x^2 / 2$, $dx^2/dx = x^1$

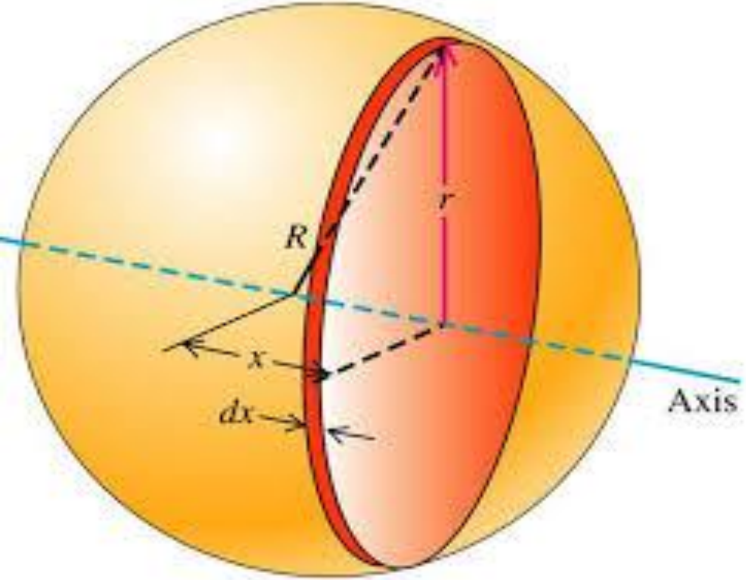
SOLID SPHERE

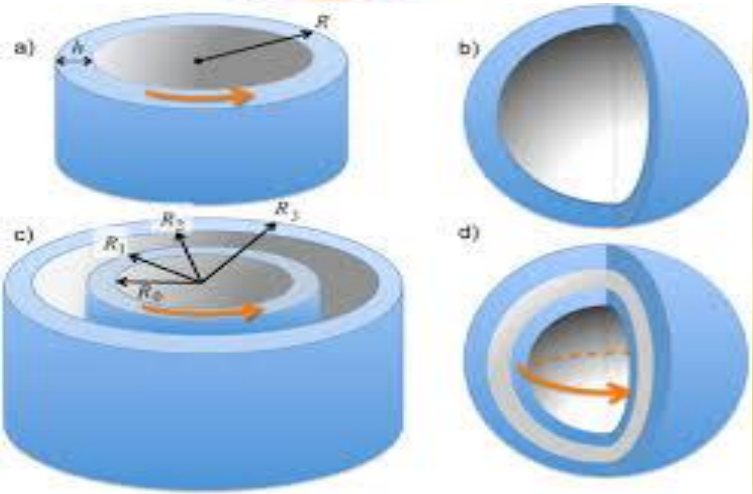
At a point out side the Solid Sphere.

At a point InSide the Solid Sphere.



At a point on the Solid Sphere.

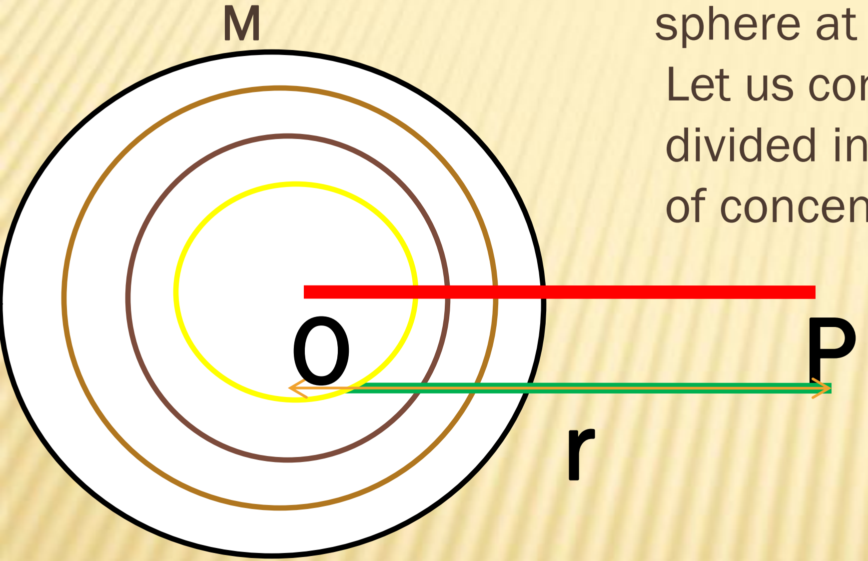




Spherical Shell

- At a point out side the Spherical Shell.
- At a point In side the Spherical Shell.
- At a point on the Spherical Shell.

SOLID SPHERE – POINT OUTSIDE



Consider point P is outside to solid sphere at a distance r form centre O. Let us consider the solid sphere is divided into large number of concentric spheres of masses $m_{1,}$ $m_{2,}$ m_3 ……

$$V = -G\ m / r$$

$$V = -G\ m_1 / r + -G\ m_2 / r + -G\ m_3 / r + \ldots\ldots.$$

$$V = -G\ M / r \quad [m_1 + m_2 + m_3 + \ldots\ldots = M]$$

G (6.673×10^{-11} N m^2/kg^2), m_1 (5.98×10^{24} kg), m_2 (70 kg) and d (6.38×10^6 m) into the universal gravitation equation and solving for F_{grav}. The solu

$$F_{grav} = \frac{(6.673 \times 10^{-11}\ \text{N m}^2/\text{kg}^2)\cdot(5.98 \times 10^{24}\ \text{kg})\cdot(70\ \text{kg})}{(6.38 \times 10^6\ \text{m})^2}$$

$$F_{grav} = 686\ \text{N}$$

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$$F_{grav} = \frac{(6.673 \times 10^{-11}\ \text{N m}^2/\text{kg}^2)\cdot(5.98 \times 10^{24}\ \text{kg})\cdot(70\ \text{kg})}{(6.39 \times 10^6\ \text{m})^2}$$

$$F_{grav} = 684\ \text{N}$$

The Universality of Gravity

Gravitational interactions do not simply exist between the earth and other objects; and not simply between the sun and other planets. Gr

	Mass of Object 1(kg)	Mass of Object 2 (kg)	Separation Distance (m)	Force of Gravity (N)
a.	Football Player100 kg	Earth 5.98×10^{24} kg	6.38×10^{6} m (on surface)	
b.	Ballerina40 kg	Earth 5.98×10^{24} kg	6.38×10^{6} m (on surface)	
c.	Physics Student 70 kg	Earth 5.98×10^{24} kg	6.60×10^{6} m (low-height orbit)	
d.	Physics Student70 kg	Physics Student 70 kg	1 m	
e.	Physics Student70 kg	Physics Student 70 kg	0.2 m	
f.	Physics Student70 kg	Physics Book 1 kg	1 m	

1 ... 2. 392 ... 4 ... the power -7 5.8.17 x 10 -6 6