

GRAVITATION

* Gravitational force :

- Every matter attract every other matter.
- Central force
- Conservative force
- Long range force
- Quant depend on medium.

$$\vec{F}_{12} = \vec{F}_{21} = \frac{G M_1 M_2}{r^2}$$

* Newton's law of Gravitation


- only valid for point mass and spherical mass system.

$G \rightarrow$ Gravitational constant
 $G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

* Superposition theorem

- Force bet^o 2 object doesn't depend on presence of other object.

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots$$



$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots$$


at $x=0$

$$= \frac{Gmm^2}{(1)^2} + \frac{Gmm^2}{(2)^2} + \frac{Gmm^2}{(3)^2} + \dots$$

G.P. series

$$\frac{a}{1-r} = \frac{Gm^2}{1-\frac{1}{4}} = \frac{4}{3} Gm^2$$

* M, R Hollow sphere



$$F = \frac{G M m}{(R+r)^2}$$

$F_{\text{inside}} = 0$

* Solid sphere



$$F = \frac{G M m}{r^2}$$

$$\rho = \frac{M}{\frac{4}{3}\pi R^3}$$

$$M' = \rho V$$

$$M' = \frac{M r^3}{R^3}$$

$$F = \frac{G M' m}{r^2} = \frac{G M m r^3}{R^3 r^2}$$

$$F_{\text{at } r} = \frac{G M m r}{R^3} \quad F_{\text{surface } R^2} = \frac{G M m}{R^2}$$



$$F_{\text{net}} = 0$$

$$\alpha = \frac{d}{\sqrt{R^2 - 1}}$$



$$F = \frac{G M m}{d(d+L)}$$

* Gravitational field intensity (Grav. force on unit mass)

$$\vec{I} = \lim_{m \rightarrow 0} \frac{\vec{F}}{m}$$

$m_0 \rightarrow \text{test mass}$


(i) due to point mass



$$I = \frac{F}{m_0} \Rightarrow I = -\frac{GM}{r^2}$$

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

(ii) due to hollow sphere

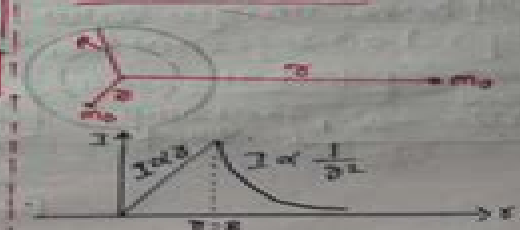


$$I_{\text{outside}} = -\frac{GM}{r^2}$$

$$I_{\text{surface}} = -\frac{GM}{R^2}$$

$$I_{\text{inside}} = 0$$

(iii) Solid sphere

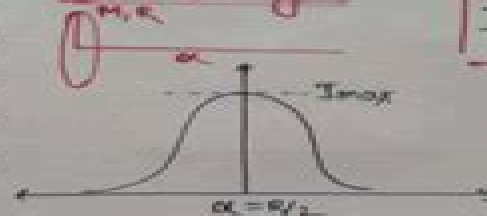


$$I_{\text{outside}} = -\frac{GM}{r^2}$$

$$I_{\text{surface}} = -\frac{GM}{R^2}$$

$$I_{\text{inside}} = -\frac{GM r}{R^3}$$

(iv) Axis of ring



$$I_{\text{max}}$$

$$\alpha = R/2$$

$$I = \frac{G M m}{(R^2 + x^2)^{3/2}}$$

$$\alpha \ll R$$

$$I = \frac{G M \alpha}{R^3}$$

$$\alpha \gg R$$

$$I = \frac{G M}{\alpha^2}$$

$$I_{\text{outside}} = -\frac{GM}{r^2}$$

$$I_{\text{surface}} = -\frac{GM}{R^2}$$

$$I_{\text{inside}} = -\frac{GM r}{R^3}$$

Gravitation Study Guide

KJ Lindholm-Leary



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