

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.

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

Diagram showing masses m_1, m_2, m_3, m_4 in a line. $\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots$ (at m_1)

$$= \frac{G m_1 m_2}{(1)^2} + \frac{G m_1 m_3}{(2)^2} + \frac{G m_1 m_4}{(3)^2} + \dots$$

GP Series

$$\frac{\frac{G m_1^2}{1^2}}{1 - \frac{1}{4}} = \frac{G m_1^2}{1 - \frac{1}{4}} = \frac{4}{3} G m_1^2$$

* M, R Hollow sphere

Diagram of a hollow sphere of radius R and mass M . A point mass m is at distance r from the center.

$$F = \frac{G M m m_1}{(R + r)^2}$$

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

* Solid sphere

Diagram of a solid sphere of radius R and mass M . A point mass m is at distance r from the center.

$$F = \frac{G M m m_1}{(R + r)^2}$$

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

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

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

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

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

Diagram showing a hollow sphere of radius R and mass M . A point mass m is at distance d from the center. The force F is shown as F_L and F_R .

$$F_{net} = 0$$

$$\alpha = \frac{d}{4R} - 1$$

Diagram showing a solid sphere of radius R and mass M . A point mass m is at distance d from the center. The force F is shown as F_L and F_R .

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

* 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

Diagram showing a point mass M and a test mass m_0 at distance r . The force F is shown.

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

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

(ii) due to hollow sphere

Diagram of a hollow sphere of radius R and mass M . A point mass m_0 is at distance r from the center.

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

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

$$I_{inside} = 0$$



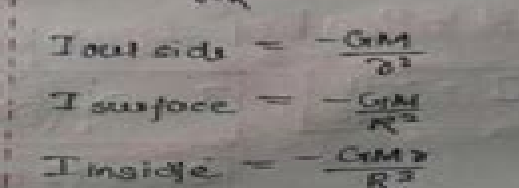
(iii) Solid sphere

Diagram of a solid sphere of radius R and mass M . A point mass m_0 is at distance r from the center.

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

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

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



(iv) Axis of ring



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

$$\alpha \ll R$$

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

$$\alpha \gg R$$

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

Gravitation Study Guide

Emilie Sanchez



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