* TIDAL FORCES, ENERGY CONSERVATION

→ Estimation of distances of Astronomical bodies from the Earth.

→ The Radius of the Earth.

→ Estimating the sizes of the Moon, the Sun and the plane.

* Galilean law of falling bodies

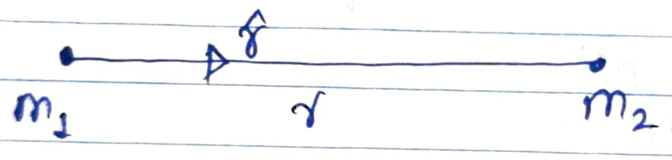
acceleration is independent of the mass of the falling body.

$$\cancel{m}a = \cancel{m}g \qquad [a = g]$$

Intertial mass is indistinguishable from Gravitational mass

$$m_I = m_G$$

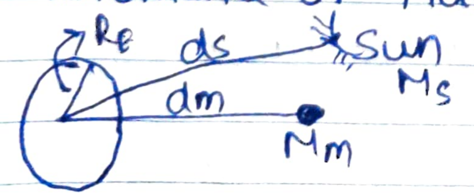
→



$$\vec{F}_{1\to2} = -\frac{G m_1 m_2}{r^2}\hat{r}$$

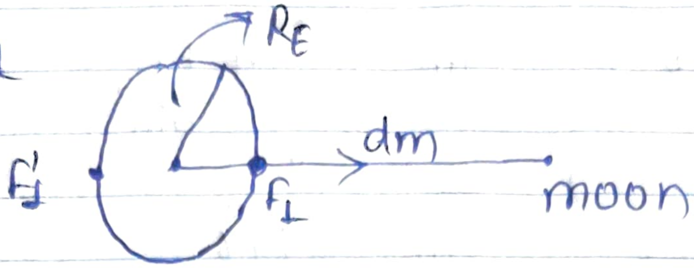
$$\vec{F}_{2\to1} = -\vec{F}_{1\to2}$$

* Phenomena of Tides:-



For any point on the surface of the earth the true distance varies b/w $(d_{s,m} \pm R_E)$

* Moon - Earth Force



$$F_\perp = \frac{G M_e M_M}{(d_m - R_E)^2}$$

$$\Delta F_\perp = F_\perp - F_\perp'$$

$$F_\perp' = \frac{G M_e M_m}{(d_m + R_E^2)}$$

$$\boxed{d >> R_E}$$

$$F_\perp = \frac{K}{(d_m - R_E)^2} \qquad K = G M_E M_m$$

$$= \frac{K}{d_m^2 \left[1 - \frac{R_E}{d_m}\right]^2}$$

$$\boxed{\frac{R_E}{d_m} << 1}$$

$$= F_0 \left[\frac{1}{1 - \left(\frac{2R_E}{d_m} - \frac{R_E^2}{d_m^2}\right)}\right]$$

$$= F_0 \frac{1}{1 - x}$$

$$\frac{1}{1-x} = 1 + x + x^2 + O(x^3)$$

$$x = \left(\frac{2R_E}{d_m} - \frac{R_E^2}{d_m^2}\right) ; \frac{R_E}{d_m} = r$$

$$= (2r - r^2)^x$$

$$= 1 + 2r + 3r^2$$

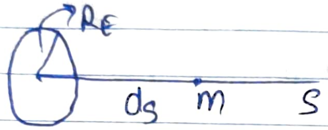
$$F_1 = F_0\left[1 + 2r + 3r^2\right] + \text{higher order terms}$$

$$F_1' = \frac{K}{(d_m + R_E)^2} = \frac{K}{d_m^2}\left(\frac{1}{1 + \frac{R_E^2}{d_m^2}}\right)$$

$$\Rightarrow \frac{K}{d_m^2}\,\frac{1}{(1+r)^2}$$

$$\Delta F_1 = 4F_0\left(\frac{R_E}{d_m}\right)$$ r is a dimensionless quantity

$\Delta F_2 \Rightarrow$ Force on the Earth due to the Sun at diametrically opposite position.



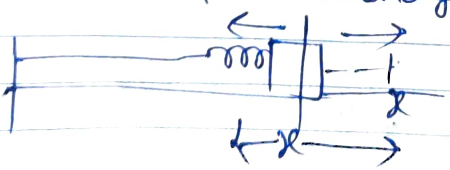
$$\Delta F_2 = 4F_0'\left(\frac{R_E}{d_s}\right) \quad ; \quad \Delta F_1 = \frac{4GM_eM_m}{d_m^2}\cdot\frac{R_E}{d_m}$$

$$\Delta F_2 = \frac{4GM_e}{d_s^3}\cdot\frac{R_E}{d_s}$$

* We calculate ratio

$$\frac{\Delta F_1}{\Delta F_2} = \frac{M_m}{M_s}\left(\frac{d_s}{d_m}\right)^3 \simeq 3.5 \quad \left\{\begin{array}{l} M_m = 7.3\times10^{22}\,kg \\ M_s = 2\times10^{30}\,kg \\ d_s = 150\times10^6\,km \\ d_m = 0.3\times10^6\,km \end{array}\right.$$

* Gravitational Potential Energy



$$F = -kx$$

Stored energy $\boxed{\frac{1}{2}kx^2}$

$$E_T = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 \Rightarrow \text{const.}$$

$$\frac{dE}{dt} = 0 \Rightarrow mv\frac{dv}{dt} + kxv = 0$$