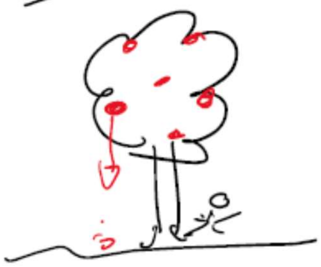
Ch 3.2 Universal Gravitation

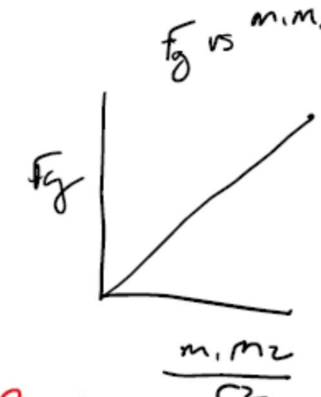
Newton + the apple



all massive object exert an attractive force on each other.

$$F_{12} = -F_{21}$$

magnitude = F_g



$$\boxed{F_g \propto \frac{m_1 m_2}{r^2}}$$

$\propto$ is directly proportional to....

$y = mx + b$

Newton's Law of Universal Gravitation

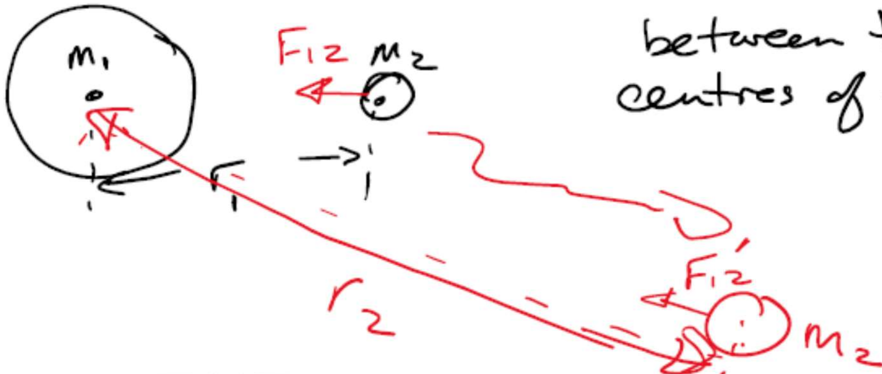
$$\boxed{F_g = \frac{G m_1 m_2}{r^2}}$$

G = universal gravitation constant

$$G = 6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}$$

$$F_g = \frac{G m_1 m_2}{r^2}$$

r = distance between the centres of mass



$$F_{12} = \frac{G m_1 m_2}{r_1^2}$$

$$F_{12}' = \frac{G m_1 m_2}{r_2^2}$$

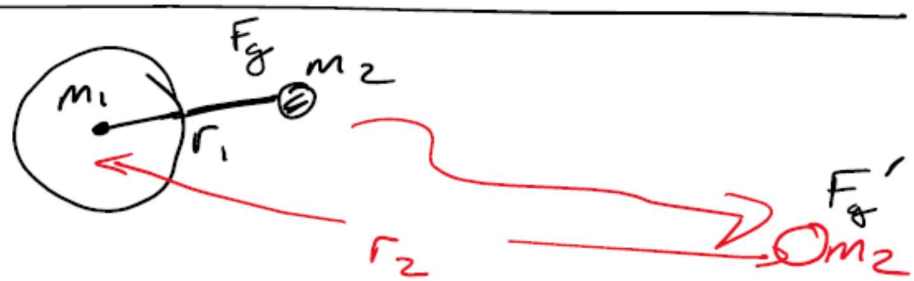
if $r_2 = 3 \times r_1$

then $\boxed{F_{12} = \frac{G m_1 m_2}{r_1^2}}$ $F_{12}' = \frac{G m_1 m_2}{(3r_1)^2}$

$$F_{12}' = \frac{G m_1 m_2}{9 r_1^2}$$

F_{12} vs F_{12}'

$$F_{12}' = \frac{1}{9}\left(\frac{G m_1 m_2}{r_1^2}\right) = \frac{1}{9} F_{12}$$



$$\frac{F_g}{F_g'} = \frac{\frac{G m_1 m_2}{r_1^2}}{\frac{G m_1 m_2}{r_2^2}}$$

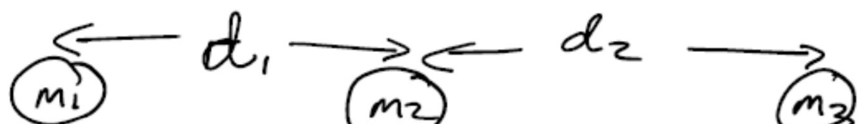
$$\frac{F_g}{F_g'} = \left(\frac{G m_1 m_2}{r_1^2}\right) \times \left(\frac{r_2^2}{G m_1 m_2}\right) = \frac{r_2^2}{r_1^2}$$

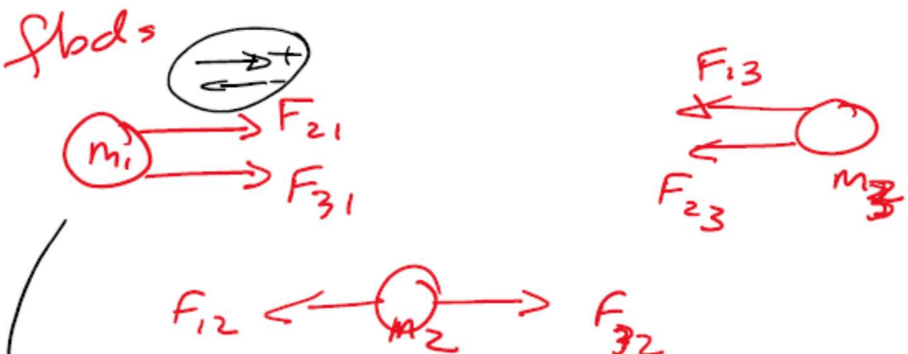
$$\frac{F_g}{F_g'} = \left(\frac{r_2}{r_1}\right)^2$$

$$F_g = F_g'\left(\frac{r_2}{r_1}\right)^2$$

$$F_g' = F_g\left(\frac{r_1}{r_2}\right)^2$$

F_g is a vector and adds as a vector if there are multiple masses





$$\sum F_1 = m_1\vec{a} = \frac{Gm_1m_2}{d_1^2} + \frac{Gm m_3}{(d_1+d_2)^2} = ?$$

$$\sum F_2 = m_2 a = \frac{G m_2 m_3}{d_2^2} - \frac{G m_1 m_2}{d_1^2}$$

Gravitational Field Strength

$= g$

$$F_g = \frac{G m M_E}{R_E^2}$$

$$F_g = mg$$

$$\cancel{m} g = \frac{G \cancel{m} M_E}{R_E^2}$$

$$\boxed{g = \frac{G M_E}{R_E^2}}$$