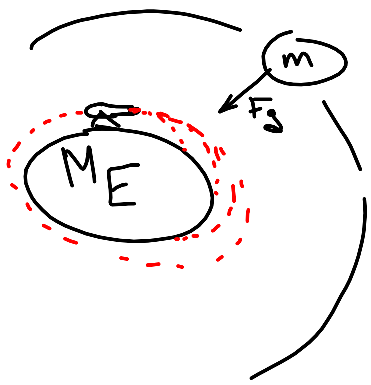
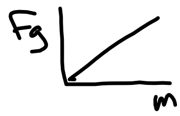
Newton's Law of Universal Gravitation



Since $\Sigma F = ma = F_g = F_c$

$F_g \propto m$



But if F_g is Earth pulls moon then moon pulls Earth means

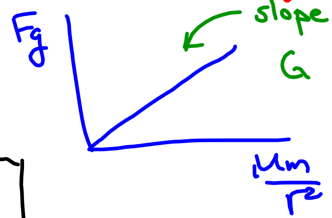
$F_g \propto M_E$

From Kepler's 3rd Law he reasoned

$F_g \propto \frac{1}{r^2}$ (r = separation of objects)

or gravity is an inverse square with distance.

All together $F_g \propto \frac{Mm}{r^2}$



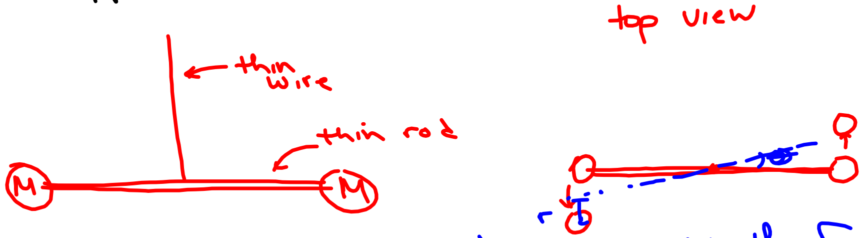
slope he called "G"

G = universal gravitation constant.

$$\boxed{F_g = \frac{GMm}{r^2}}$$

What about G?

It was about 150 years before G was determined using a Cavendish apparatus.



Calculate $G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2}$

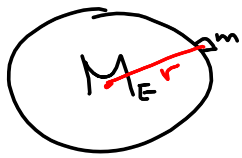
We can measure the F to twist the wire, we can measure the masses, we can measure r.

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

Massing the Earth

On surface of Earth

$$F_g = mg = \frac{GMm}{r^2}$$



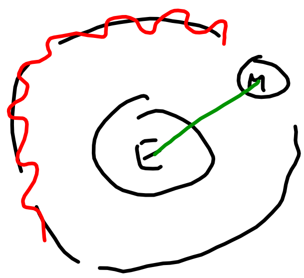
$r = r_E$
$= 6.38\times10^6$ m

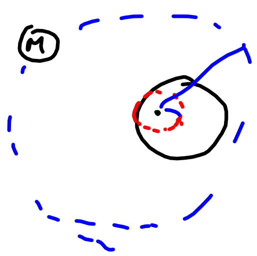
$$g = \frac{GM_E}{r_E^2}$$

$$M_E = \frac{g r_E^2}{G} = \frac{(9.8)(6.4\times10^6)^2}{6.67\times10^{-11}}$$

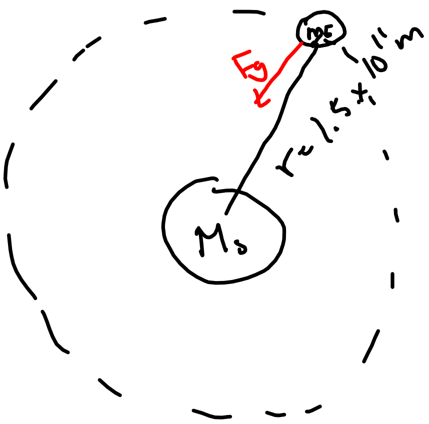
$$= \underline{6.0\times10^{24}\ \text{kg}}$$

$T = 27.3$ d
$r = 3.84\times10^8$ m





Massing the Sun?



$T = 365.24$ d
$= \underline{\underline{3.16\times10^{7}}}$ s

$$\Sigma F = F_g = F_c$$

$$\frac{G M_s \cancel{m_E}}{r^2} = \frac{\cancel{m_E}\, 4\pi^2 r}{T^2}$$

$$M_s = \frac{4\pi^2}{G}\cdot\frac{r^3}{T^2}$$

$$= \frac{4\pi^2\cdot(1.5\times10^{11})^3}{(6.67\times10^{-11})(3.16\times10^{7})^2}$$

$$= \underline{\underline{2.0\times10^{30}}}\ \text{kg}$$

$$K_s = \frac{r^3}{T^2} = \frac{G}{4\pi^2}M_s$$

$$K_E = \frac{G}{4\pi^2}M_E$$

Homework UG sheet #1-4