AP Physics - Universal Gravitation

Note Title 11/2/2007

So far, we have learned about one of the properties of mass - inertia, or resistance to acceleration. Mass has another interesting property, gravity, which we will explore in this unit.

Law of Universal Gravitation

Any two masses, m_1 and m_2, are attracted to each other by a gravitational force F_g according to the equation

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

F_g = Force of gravitational attraction [N]

G = Universal constant of gravitation

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

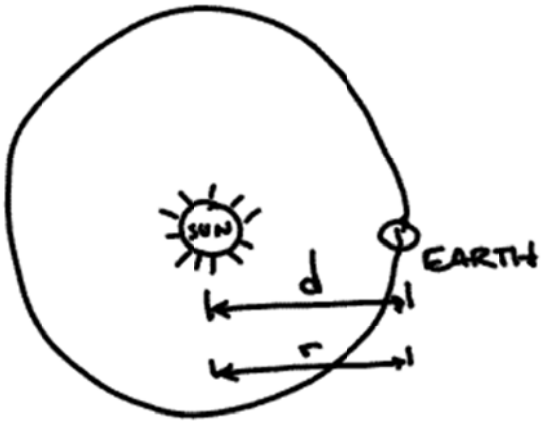
m_1 = mass #1 [kg]

m_2 = mass #2 [kg]

d = distance between center of mass #1 and center of mass #2

Example: Earth orbiting Sun

Using Universal Gravitation, verify that Earth should orbit the sun with a period of 365 days.



$d = r$

(assuming Sun is stationary)

In order to go in a circular orbit, there must be a force to provide the centripetal acceleration. This force is gravity.

$$\Sigma F = ma_c$$

$$F_g = ma_c$$

$$F_g = \frac{4\pi^2 r}{T^2}$$

$$\frac{GM_s m_e}{d^2} = \frac{4\pi^2 r}{T^2} m_e$$

$$\frac{GM_s}{d^2} = \frac{4\pi^2 d}{T^2}$$

$$T = \sqrt{\frac{4\pi^2 d^3}{GM_s}}$$

$d = 1.5 \cdot 10^{11}$ m

$m_s = 2.0 \cdot 10^{30}$ kg

$m_c = 6.0 \cdot 10^{23}$ kg

$$T = \sqrt{\frac{4\pi^2 (1.5 \cdot 10^{11}\ m)}{(6.67 \cdot 10^{-11})(2.0 \cdot 10^{30})}}$$