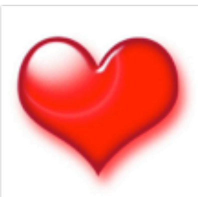
Newton's Law of Universal Gravitation

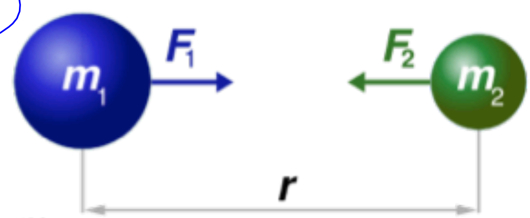


- Newton found a force of attraction between any two things with mass

- Newton's Law of Universal Gravitation:

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

* inverse square law



$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

- m_1 and m_2 = masses measured in kg
- r = distance between the two masses in m
- G = Gravitational Constant

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

Newton's Law of Universal Gravitation

- Smaller Scale:

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

G → 6.67×10^{-11}

r → Center to Center

- Larger Scale: *

Our Force of Gravity

- Based on Newton's Law of Universal Gravitation

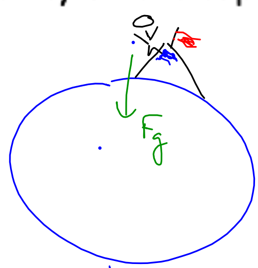
$$F_g = mg \qquad\qquad F_G = G\frac{m_1 \cdot m_2}{r^2}$$

*Difference between g and G?

(G → 6.67×10^{-11}; g → acceleration of gravity $-9.8\ m/s^2$)

Example 7

- What is the value for the acceleration of gravity on the top of Mount Everest? (altitude = 8,848 m)
  - Radius of Earth = 6.371×10^6 m



$F_g = F_G$

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

$-g = \frac{G \cdot M}{r^2} = \frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(6.371 \times 10^6 + 8848)^2} = 9.78\ m/s^2$

Newton's Law of Universal Gravitation

- The larger the two masses, the larger the attraction
  - The larger the distance between the two masses, the force of attraction falls away very quickly.
  - *Inverse-Square Law:

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

*Coulomb's

Our Force of Gravity

- In general....
  - Use $F_g = mg$ when we are here on Earth
  - Use $F_G = G\frac{m_1 \cdot m_2}{r^2}$ if we are leaving Earth

Universal Gravitation and Centripetal Forces

Example 8

Calculate the period of the moon around the earth in days based on Newton's Law of Universal Gravitation. Treat the Earth and Moon as point sources

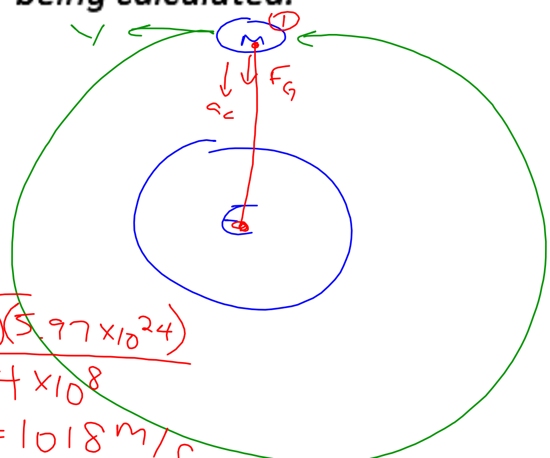
Necessary Constants:

Mass of Earth = 5.97×10^{24} kg

Mass of Moon = 7.35×10^{22} kg

Distance Between Earth & Moon = 3.84×10^{8} m

Objects get treated at point sources when their size is negligible based on the other sizes or distances also being calculated.



$$\Sigma F_y = -F_G$$
$$m(-a_c) = -F_G$$
$$m\frac{v^2}{r} = F_G$$
$$\frac{m_1 v^2}{r} = \frac{G m_1 m_2}{r^2}$$
$$v^2 = \frac{G \cdot m_2}{r}$$
$$v = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{3.84 \times 10^{8}}}$$
$$v = 1018\ m/s$$