Gravity

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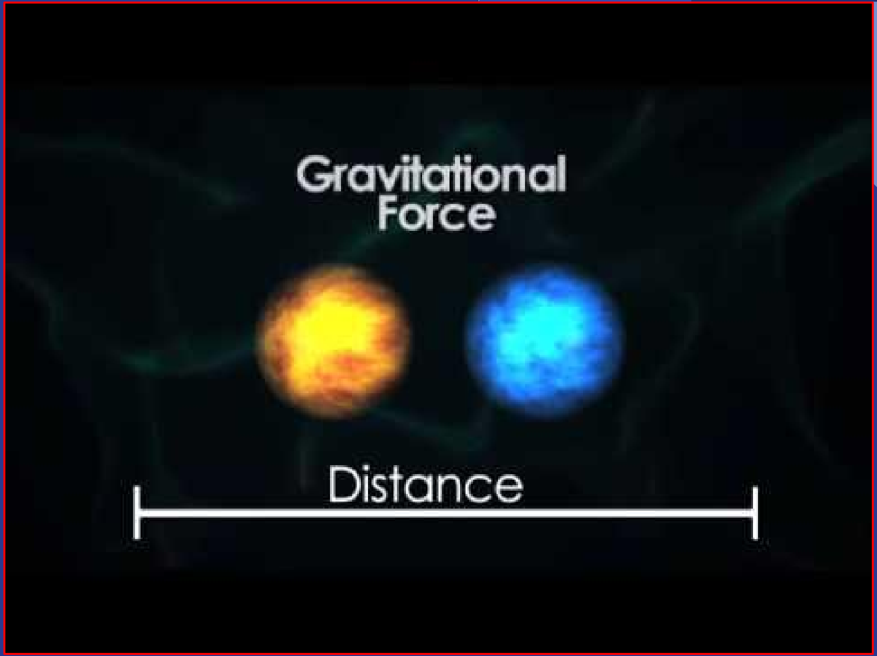
What is Gravity?

- Interaction between masses
- There is an attraction between all masses, no matter what the size.
- Force that attracts one body of mass toward another body of mass
- Keeps celestial objects in orbit
- Four dimensional through space time



Newton's Principles Applied to Gravity

- Who is Sir Isaac Newton?
  - Developed three laws of motion
- Newton's First Law of Motion
  - An object at rest stays at rest and an object in motion stays in motion with the same speed and the same direction unless acted upon by an unbalanced force
- Thus, there needs to be a force other than gravity that throws off the balance and accelerates an object in a certain direction

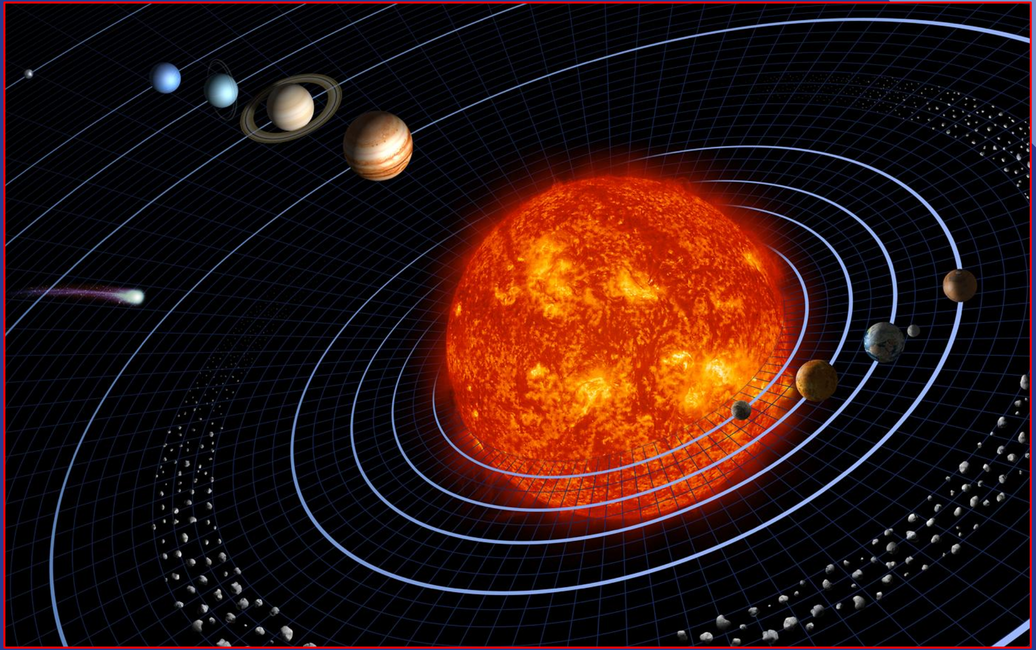
Force of Gravity

- 3 quantities that gravitational force depends on:
  - Mass of first object: M
  - Mass of second object: m
  - Distance between objects: r

- $F_g = \frac{GmM}{r^2}$
  - G is the universal gravitational constant
    $G = 6.67 \times 10^{-11}\ Nm^2/kg^2$

Gravitational Potential Energy

- $PE_g = \frac{-Gm_1m_2}{R}$
- Why negative?
  - Negative amount of work is done to bring an object closer to Earth
  - Thus, PE_g is always negative
  - The closer you are to Earth, the less potential energy you have



Escape Speed and Orbital Velocity

- Escape Speed: speed an object must obtain to escape gravity
  - $E = KE + PE$

    $= \frac{1}{2} mv^2 - GMm/R = 0$

    $v_{esc} = \sqrt{2GM/R}$

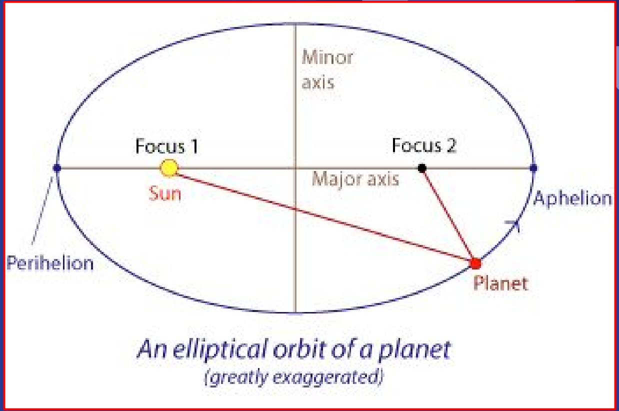
- Orbital Velocity:
  - $F_g = F_c$

    $GMm/R^2 = mv^2/R$

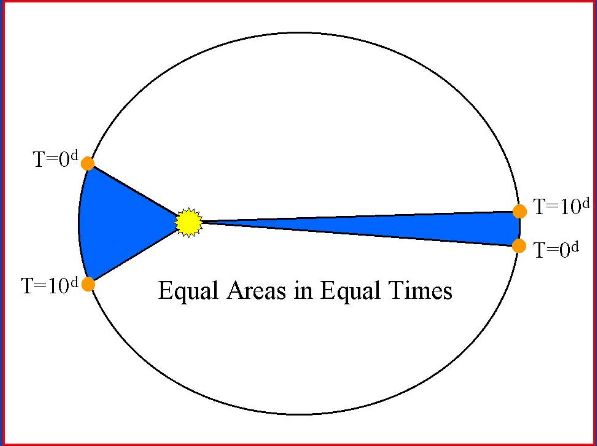
    $V_{orb} = \sqrt{GM/R}$

Kepler's Laws of Planetary Motion

- Who is Johannes Kepler?
  - German Mathematician, astronomer, and astrologer
- 1st Law
  - Orbit of planet is an ellipse with the Sun at one of the two focus points
- 2nd Law
  - Line segment joining a planet and the sun sweeps out equal areas during equal intervals of time
- 3rd Law
  - Square of orbital period of a planet is proportional to the cube of its average distance from the Sun



An elliptical orbit of a planet
(greatly exaggerated)



$$T = \sqrt{\frac{4\pi^2 r^3}{GM}}$$

$$\frac{T_1^2}{T_2^2} = \frac{R_1^3}{R_2^3}$$

First Common Misconception of Gravity

- Sci-fi movie: Gravity
  - The guy flys away from the ship because he was not tied down
  - This could be possible if he had some initial velocity but after he is held back by the girl he if he were to let go then he would have stayed in one spot because they are all falling around the same speed

Second Common Misconception

The moon has no gravity

Third Misconception

When you are in space orbiting the earth you aren’t floating you are just perpetually falling

Fourth Misconception

If the Sun were to become a black hole then the Earth would “fall” into the black hole

Q1: Audience Volunteers Needed

- Data Needed:
  - Mass of Volunteer 1
  - Mass of Volunteer 2
  - Distance between the volunteers
- Given the data, calculate the gravitational force between Volunteer 1 and 2

Q2: Calculating Mass of Earth

- Find the mass of Earth given the following
  - $r = 6.37 \times 10^6$ m
  - $a = g = 9.81$ m/s^2
  - $G = 6.67 \times 10^{-11}$ Nm^2/kg^2

Q3: Gravity Problem Set

- An asteroid has a radius of 2.00 cm.
  a. What mass does this asteroid need to have in order to have Earthlike gravity at its surface?
  b. Calculate the escape speed of this asteroid given that the asteroid is on the surface of Earth.
  c. Calculate the orbital velocity of this asteroid given that the asteroid is on the surface of Earth.
  d. If the radius was increased to 5.00 cm, does the mass of the asteroid need to be higher or lower to achieve Part A's purpose? What about escape speed? What about Orbital velocity?

THANKS FOR WATCHING!