Planetary Motion

Kepler's Laws of Planetary Motion

&

Newton's Law of Universal Gravitation

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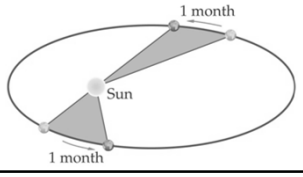
Kepler's Three Laws of Planetary Motion

- 1st Law
  - All planets move in elliptical orbits with the sun at one focus
- 2nd Law
  - A line joining the planet to the sun sweeps out equal area in equal time.
    - Planets move faster when closer to the sun



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Kepler's Three Laws of Planetary Motion

- 3rd Law
  - For any objects orbiting the same planet or star:

$$\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$$

Use Earth #s for T_2 & r_2

Earth's Period around the sun = 365.25 days or 1 YEAR

Average distance from the sun to the Earth = 1.5×10^{11} m or 1 AU

List of distances can be found in Table 8 – 1 on page 178

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Example Problem

- A small unnamed planet was discovered 1.2×10^{12} m from the sun. How long would it take this unnamed planet to orbit the sun?

$$\left(\frac{T_P}{T_{EARTH}}\right)^2 = \left(\frac{r_P}{r_{EARTH}}\right)^3$$

$$\frac{T_P^2}{(1\text{ YEAR})^2} = \left(\frac{1.2\times10^{12}}{1.5\times10^{11}}\right)^3$$

$$T_P^2 = (8)^3$$

$$T_P^2 = 512$$

$$T_P = 22.6 \text{ YEARS}$$

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Example Problem #2

- If it takes 686.95 days for Mars to revolve around the sun, what is distance in astronomical units of Mars from the sun?

$$\left(\frac{T_m}{T_E}\right)^2 = \left(\frac{r_m}{r_e}\right)^3$$

$$\left(\frac{686.95}{365.25}\right)^2 = \frac{(r_m)^3}{(1\,AU)^3}$$

$$3.54 = r_m^3$$

$$r_m = (3.54)^{\wedge}(1/3)$$

$$r_m = 1.52\,AU$$

Newton's Law of Gravity

- States that there is an attractive force between all masses.

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

For Earth, = 9.8 m/s^2 (g)

G = 6.67 x 10^{-11}

m_1 and m_2 = mass in kg

d = distance between objects

Example Problem #1

- A 15 kg person and a 32 kg person are 75 centimeters apart. What is the gravitational force between the two people?

$$F = \frac{6.67 \times 10^{-11}(15)(32)}{(.75)^2} = 5.69 \times 10^{-8}\ N$$

Answer: F = 5.69 x 10^{-8} N

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Example Problem #2

- There is an attractive force of 8.15 x 10^{-7} N between to people who are seated 0.60 m apart. If one person weighs 80.0 kg, what is the mass of the other person?

$$8.15 \times 10^{-7} = \frac{6.67 \times 10^{-11}(80)(m)}{(.6)^2}$$

$$8.15 \times 10^{-7} = (1.48 \times 10^{-8})m$$

$$\frac{8.15 \times 10^{-7}}{1.48 \times 10^{-8}} = m$$

$$m = 55.0\ kg$$

m_2 = 55.0 kg

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