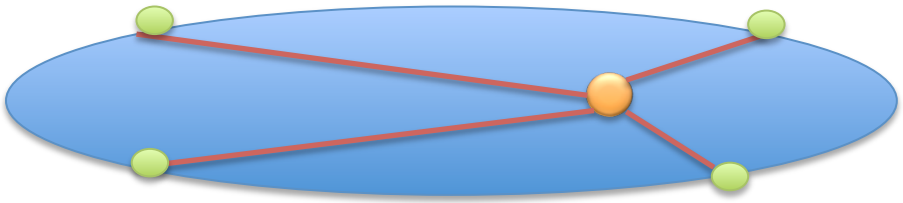
Kepler’s Laws

Johannes Kepler

- Worked as an assistant to the Danish astronomer Tycho Brahe
- Acquired Brahe's data when his mentor passed away
- Spent 16 years trying to come up with a mathematic model for planetary motion.

Kepler's Laws

1. All planets move in elliptical orbits with the sun at one focal point.
2. The Law of Areas: A line drawn from the sun to any planet sweeps out equal areas in equal time intervals.
    - Planet moves faster when it is closer to the sun to sweep out the same area in a given time period.

1 month  1 month

Can you figure out how orbital period is related to orbital radius?

Planet	Period (days)	Average Radius (A.U.)*
Mercury	88	0.39
Venus	224	0.72
Earth	365	1.00
Mars	686	1.52
Jupiter	4,307	5.20
Saturn	10,768	9.54
Uranus	30,660	19.18
Neptune	60,225	30.06

*An astronomical unit (A.U.) is the distance between the Sun and Earth (~93 million miles)

Kepler's 3rd Law

- Using a graphing calculator, the data correlates perfectly ($R^2=1$) when it is a power relationship.
  - y = radius, x = period

$$y = kx^{\frac{2}{3}}$$

$$\therefore period^2 \propto radius^3$$

- Kepler's 3rd Law: The square of the orbital period of any planet is proportional to the orbital radius raised to the third power.
- 50 years later, Newton shows why: $T^2 = \dfrac{4\pi^2 r^3}{Gm}$