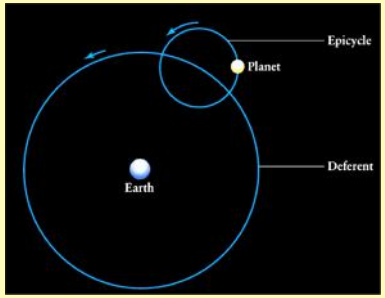
History of Modern Astronomy

Ptolemy
(100 -170 ACE)

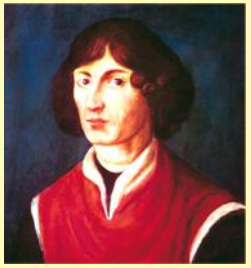
- ***synthesized*** others' work into a ***comprehensive model***
- *included Sun & Moon, Mercury, Venus, Earth, Mars, Jupiter & Saturn*
- ***geocentric*** *(**Earth centered**)* ***model*** *of the solar system*

- used for *1,500 years* ***even though it did not correctly predict planetary motions!***
- planets typically move *eastward* across the sky
- *periodically* they *appear* to *stop*, move *westward* for a while, then *stop* and *move eastward again*
  (eg) *Mars, 2003*
- *westward motion* is called ***retrograde motion***



- ***Ptolemy*** added ***epicycles*** to his model to attempt to account for ***retrograde motion***
- need *different epicycles, periods* for *each planet*
- complex! "Occam's Razor" *(14th century Franciscan friar)*

Nicolaus Copernicus
(1473-1543)

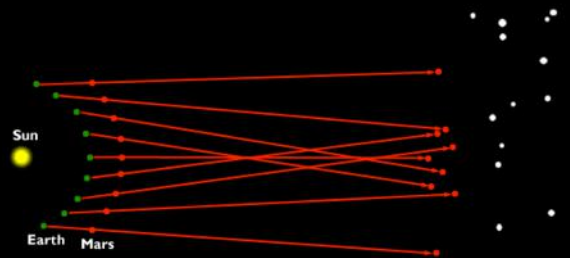


• Ptolemy's ***geocentric model*** was ***complex & inaccurate***

• revived *Greek idea* of ***heliocentric*** *(Sun centered)* ***model*** of the solar system in ***1543***

• offered *simple* explanation for ***retrograde motion*** but ***didn't*** improve planetary motions otherwise

Retrograde explained

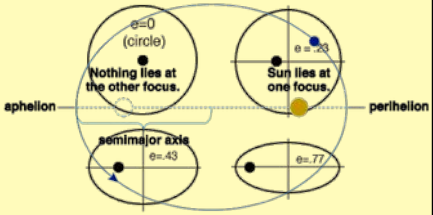


Johannes Kepler
(1571 - 1630)

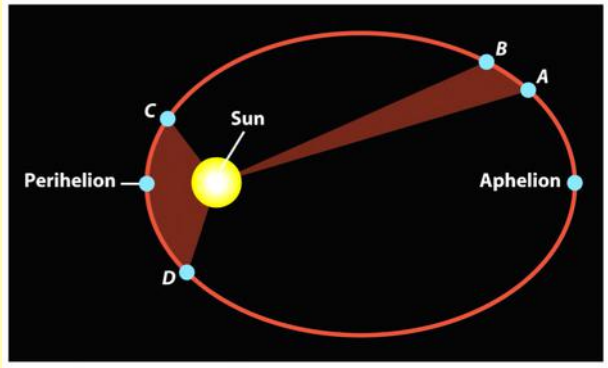
• took ***13 years*** to develop **3 laws of motion** for ***heliocentric model***

Kepler's Laws of Planetary Motion

1. planets move around the Sun in *elliptical* orbits

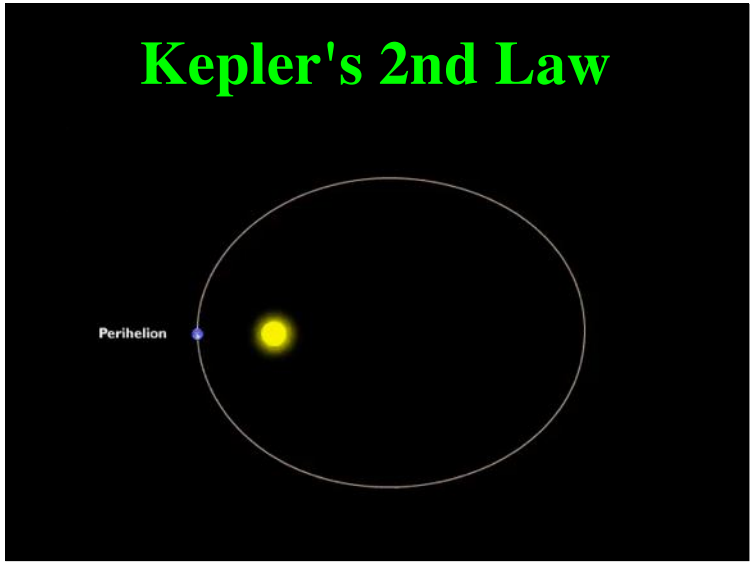


2. A line joining a planet and the Sun will "sweep out" *equal areas in equal amounts of time*



• planets move *faster close to the Sun (**perihelion**)*

Kepler's 2nd Law



3. The *time* for a planet to orbit the Sun (*period, P*) depends on its *average distance from the Sun* (*a*):

$$P^2 = a^3$$

- *period* measured in *years* & *semi-major axis* (*a*) measured in *astronomical units* (*AU*)

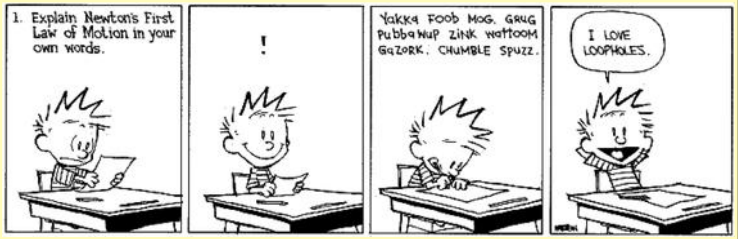
(eg) Jupiter: a = 5, P = $\sqrt{(5)^3} = \sqrt{125} \approx 11$ years

CLICKER: For Saturn, a ≈ 10, so P is ***roughly***
(a) 5 years (b) 10 years (c) 30 years (d) 1000 years

Isaac Newton

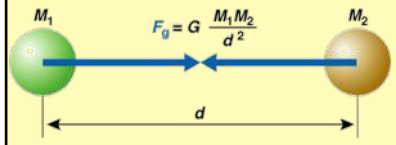
(1642 - 1727)

- *invented reflecting telescope*
- *invented calculus*
- *deduced gravitation & basic laws of motion*

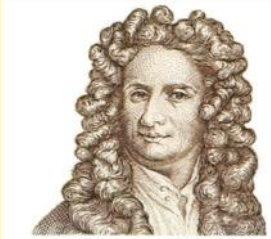


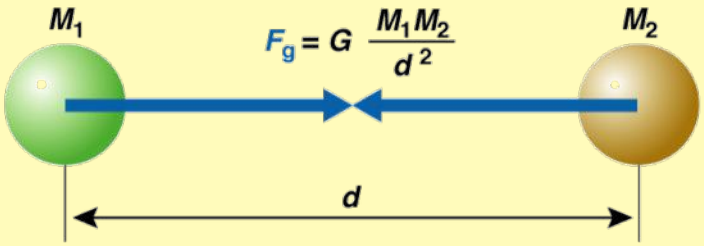
Law of Gravitation

- *any objects* with mass *attract each other*



- attraction occurs *even over astronomical distances*

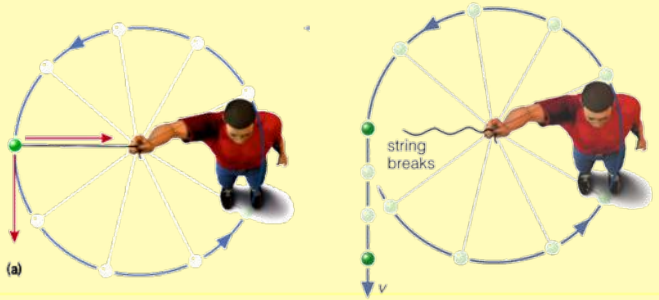




CLICKER: *What is the effect on the force of gravity if two objects are moved twice as far apart?*

(a) the force is one quarter as big
(b) the force is cut in half
(c) the force is doubled
(d) no impact (gravity is a constant)

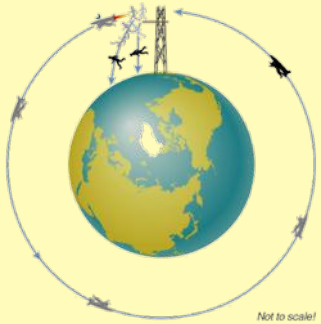
- whirl a ball at the end of a string…
- ball *wants* to move in *straight line*
- keep it moving in a circle by *exerting a force*



- Sun's ***gravity*** *keeps* ***planets*** *in orbit*
- Earth does the same thing to satellites, etc.

Q: *Why don't things in orbit just fall to Earth?*

DEMO: *drop an object vs throw an object*



A: *They do! But they also move "sideways" fast enough to avoid getting closer to the Earth.*

DEMO: *a bucket of water*

- gravity is the force that shapes our universe!