Week 4–6: Physics I – Newton's Law of Universal Gravitation

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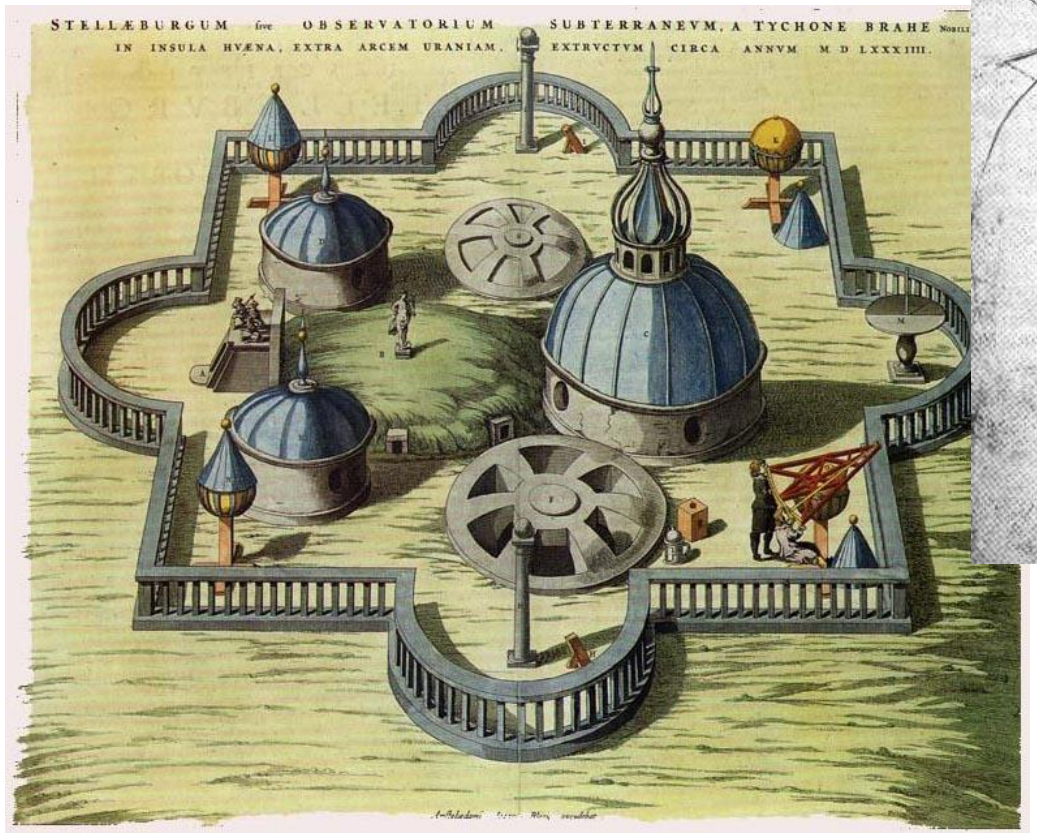
Outline

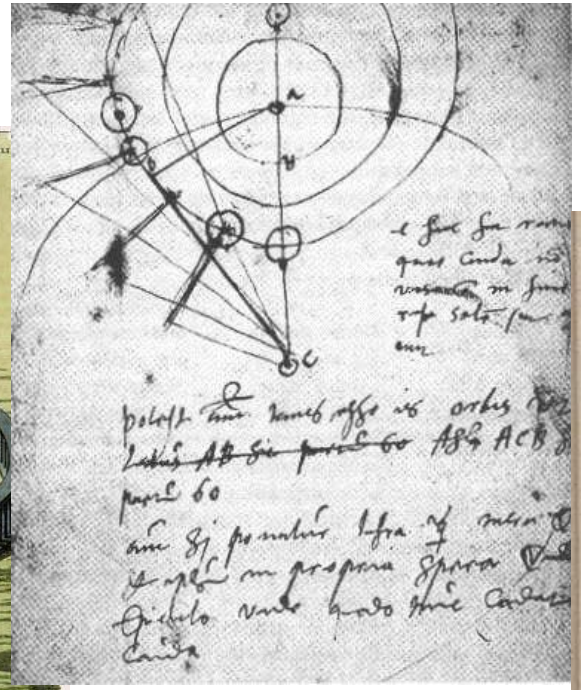
- Kepler’s Laws of Planetary Motion
- Newton’s Law of Universal Gravitation

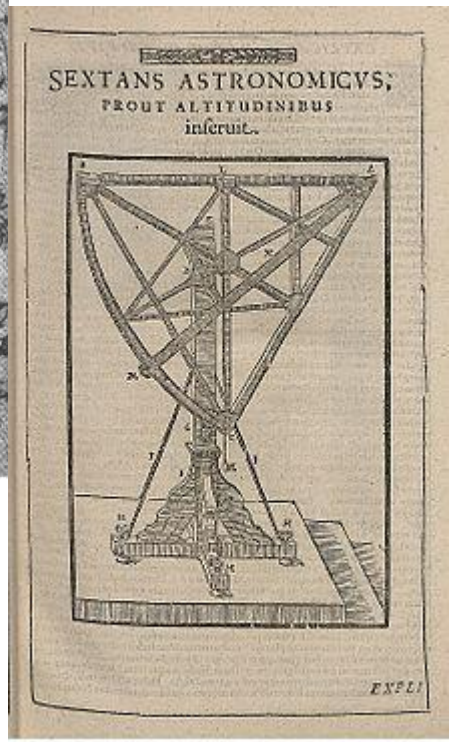
Kepler’s Laws of Planetary Motion

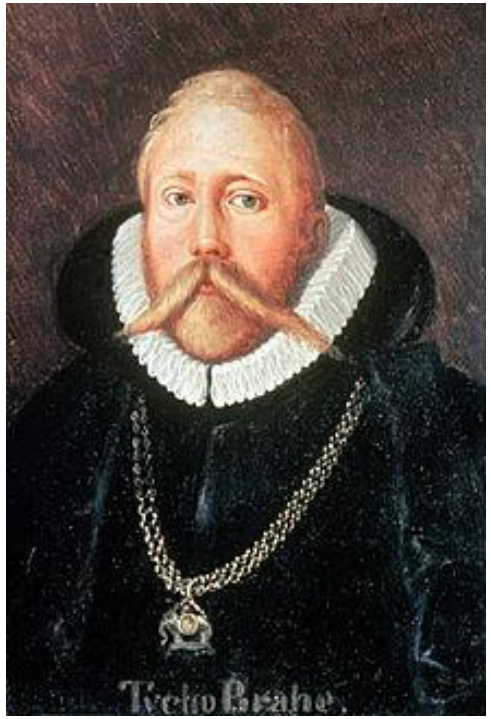
Tycho Brahe (1546-1601)*

- Danish nobleman known for his ***accurate and comprehensive astronomical and planetary observations***.







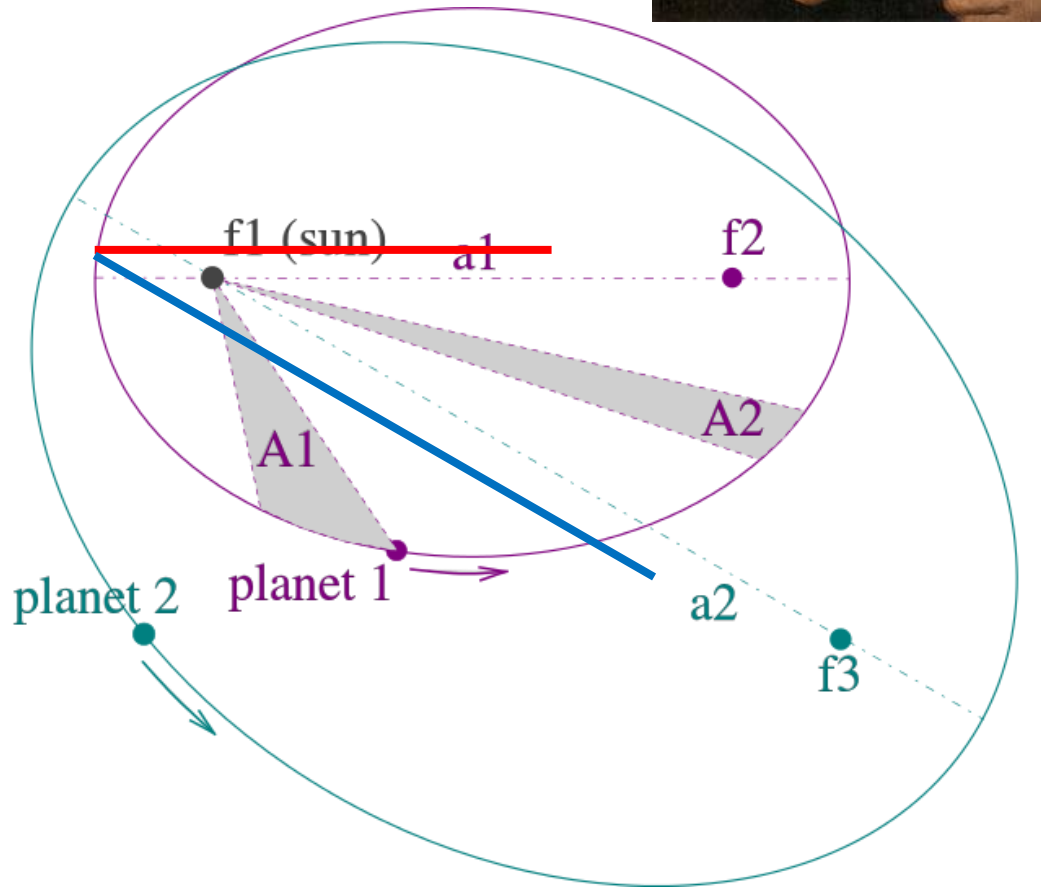


** Based on Wikipedia.*

Johannes Kepler (1571-1630)*

- German mathematician, astronomer, and astrologer known for his ***laws of planetary motion***.
  1. The orbits are *ellipses*, and the Sun is placed in focal point f1.
  2. A1 and A2 have the same surface area, and the times for planet 1 to cover A1 and A2 are the same.
  3. The square of the *orbital period (P)*of a planet is proportional to the cube of the *semi-major axis of its orbit (a)*, i.e.,

$$\frac{P1^2}{a1^3} = \frac{P2^2}{a2^3} = constant$$

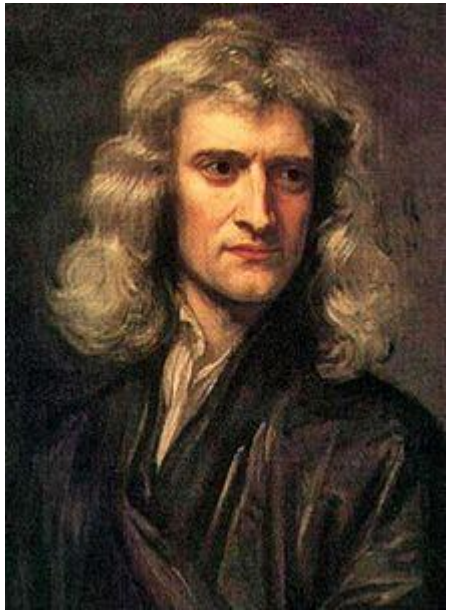


**** Based on Wikipedia.***

Kepler’s Laws of Planetary Motion

Newton’s Law of Universal Gravitation

Isaac Newton (1642-1727)*



- English mathematician, astronomer, and physicist who is widely recognised as one of the most influential scientists of all time for his contributions to scientific revolution, including the following ***laws of motions (below)*** and ***law of universal gravitation***:

1. **관성의 법칙**: In an inertial reference frame, an object either remains at rest or continues to move at a constant velocity, unless acted upon by a force.

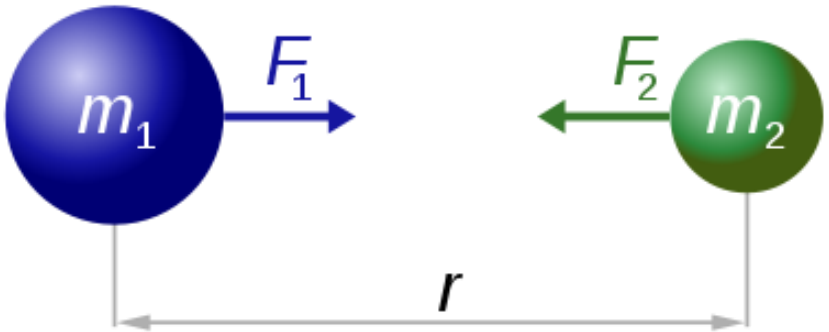
2. **가속도의 법칙**: In an inertial reference frame, the vector sum of the forces F on an object is equal to the mass m of that object multiplied by the acceleration a of the object: $\boldsymbol{F = ma}$.

3. **작용/반작용의 법칙**: When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body.

**** Based on Wikipedia.***

Newton's Law of Universal Gravitation*

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



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

where:

- F is the force between the masses;
- G is the gravitational constant (6.674×10^{-11} N · (m/kg)^2);
- m_1 is the first mass;
- m_2 is the second mass;
- r is the distance between the centers of the masses.

*** Based on Wikipedia.***

Kepler's Laws of Planetary Motion and Newton's Law of Universal Gravitation*

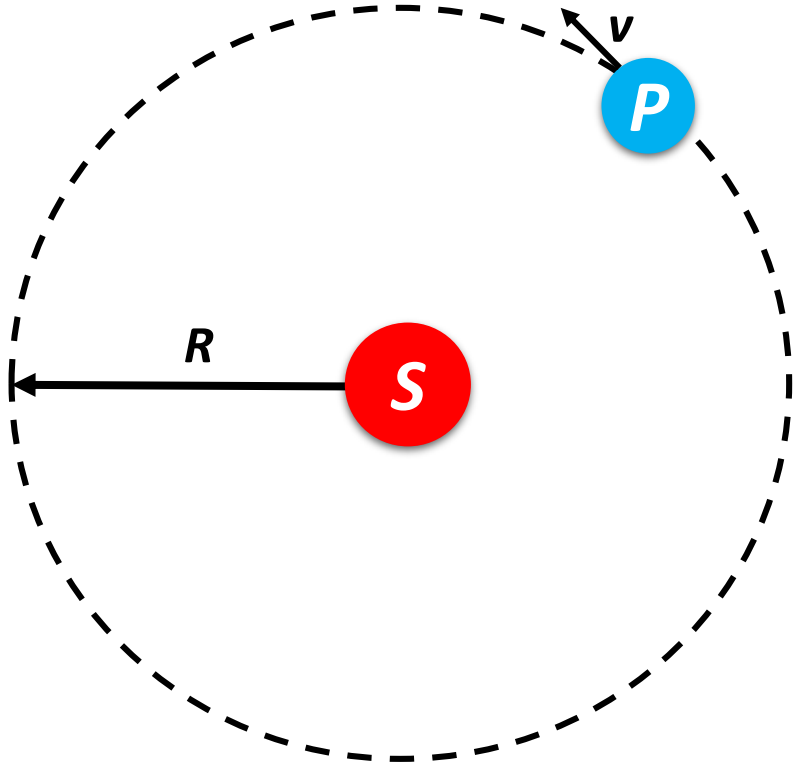
We consider a planet with mass M_{Planet} to orbit in *nearly circular motion* about the sun of mass M_{Sun}.

- Centripetal force (구심력):

$$\frac{M_{Planet} \times v^2}{R}$$

- Gravitational force (중력):

$$\frac{G \times M_{Planet} \times M_{Sun}}{R}$$



** Based on the Physics Classrom.*