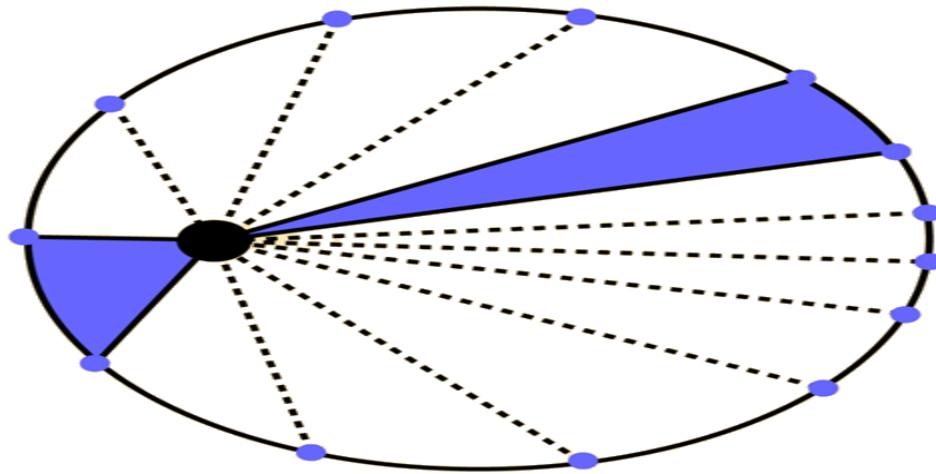


Kepler's Laws

I. The Law of Orbits: All planets move in elliptical orbits, with the sun at one focus.

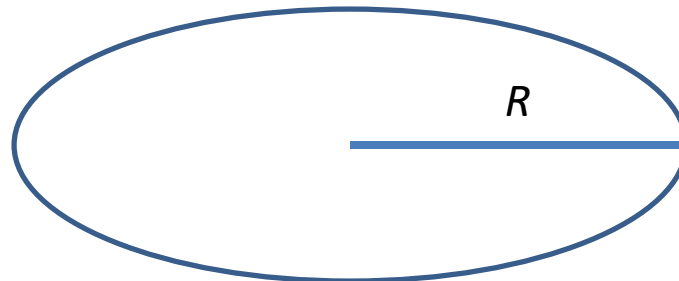
II. The Law of Areas: A line that connects a planet to the sun sweeps out equal areas in equal times.

$$\frac{\Delta A}{\Delta t} = \text{const}$$



III. The Law of Periods: The square of the period of any planet is proportional to the cube of the semimajor axis of its orbit (i.e. the “bigger” radius of the ellipse):

$$T^2 = \text{const} \times R^3$$



Newton's Law of Gravity

Two masses, m_1 and m_2 , experience *gravitational attractive force* to each other, that depends on distance between them, r :

$$F = -\frac{Gm_1m_2}{r^2}; \quad G = 6.7 \times 10^{-11} \frac{m^3}{kg \cdot s^2}$$

G is called Gravitational Constant.

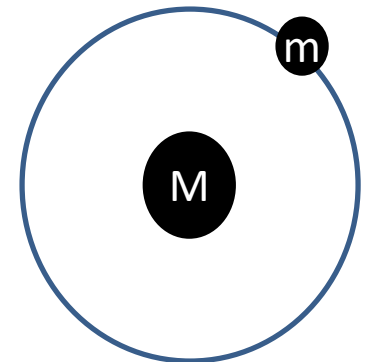
From Newton's Universal Gravity, one can derive Kepler's Laws. The easiest is to derive the Third Kepler's Law for the case of a circular orbit.

Consider a planet of mass m on a circular orbit of radius R around a star of mass M . Since its centripetal acceleration, $a=v^2/R$, is due to gravity, we obtain:

$$\frac{GMm}{R^2} = ma = m \frac{v^2}{R}$$

Here, speed $v = 2\pi R/T$, and therefore, Kepler was right!

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



Homework

Problem 1. By using a powerful telescope, you discovered a new planet and a satellite that orbits it very close to its surface (i.e. radius of the orbit is almost equal to the radius of the planet). The satellite make one rotation in 2 hours. Can you find the average density of the planet?

Problem 2. If we lived in a 2D world, the Newton's Gravity would have a slightly different form:

$$F = -\frac{G'Mm}{R}$$

Can you predict how would Kepler's Third Law change? Assume a circular orbit