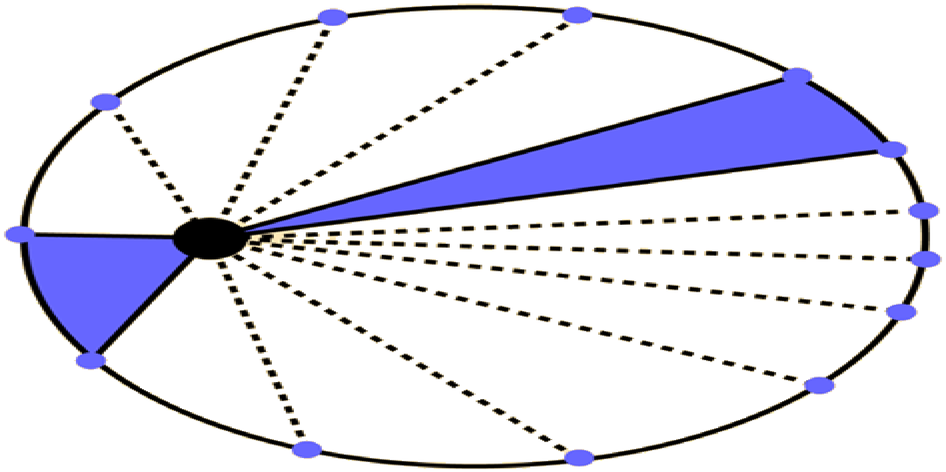
Kepler's Laws

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

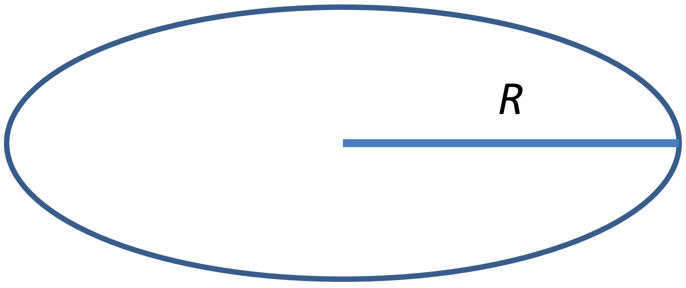
II. The Law of Areas: A line that connects a planet to the sun sweeps out equal areas in equal times.

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



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):

$$T^2 = const \times R^3$$



Newton's Law of Gravity

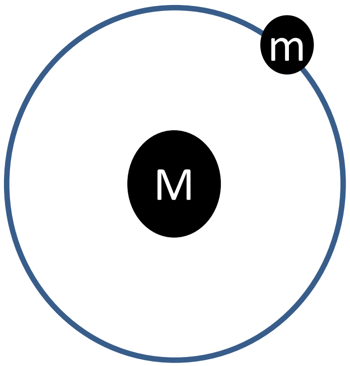
Two masses, m_1 and m_2 , experience *gravitational attractive force* to each other, that depends on distance between them, r:

$$F = -\frac{Gm_1m_2}{r^2}; \qquad G = 6.7\times10^{-11}\frac{m^3}{kg\cdot s^2}$$

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

a) By using Newton's law of gravity, find the gravitational acceleration on the surface of a planet with mass M and radius R. For doing this, consider an apple of mass m. Its weight is mg. But is also must be equal to Newton's gravitational force.

b) Imagine that you discovered a planet with the same density as Earth, but its radius is twice as big. What will be the value of g on that planet?

Problem 2.
If we were living 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