Kepler's laws

Satellites orbiting the earth follow the same laws that govern the motion of the planets around the sun. Kepler's laws apply quite generally to any two bodies in space which interact through gravitation. The massive of the two bodies is referred to as the *primary* and the other, the *secondary* or *satellite*.

Kepler's First Law

Kepler's first law states that the path followed by a satellite around the primary will be an ellipse. An ellipse has two focal points $F1$ and $F2$ as shown in Figure 1.1. The center of mass of the two-body system, termed the *bary center,* is always center of the foci.

The semi major axis of the ellipse is denoted by '*a'* and the semi minor axis, by '*b'*. The eccentricity '*e'* is given by

$$e = \frac{\sqrt{a^2 - b^2}}{a}$$

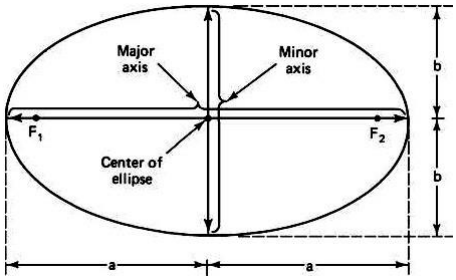

Fig 1.1 Foci $F1$ and $F2$, the semi major axis *a*, and the semi minor axis *b* of an ellipse

Kepler's Second Law

Kepler's second law states that for equal time intervals, a satellite will sweep out equal areas in its orbital plane focused at the bary center. Referring to Figure 1.2, assuming the satellite travels distances S_1 and S_2 meters in 1 second, then the areas A_1 and A_2 will be equal. The average velocity in each case is S_1 and S_2 m/s, and because of the equal area law, it follows that the velocity at S_2 is less than that at S_1.

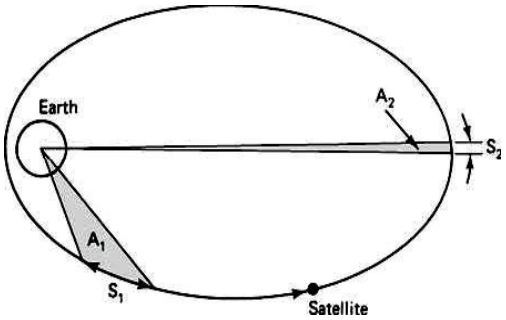

Fig 1.2 The areas $A1$and $A2$ swept out in unit time are equal

Kepler's Third Law

Kepler's third law states that the square of the periodic time of orbit is proportional to the cube of the mean distance between the two bodies. The mean distance is equal to the semi major axis *a*.

For the artificial satellites orbiting the earth, Kepler's third law can be written in the form

$$a^3 = \mu/n^2$$

Where 'n' is the mean motion of the satellite in radians per second and the earth's geocentric gravitational constant is given by

$$\mu = 3.986005 \times 10^{14} m^3/s^2$$

Newton's laws

Newton's First law

An object at rest will remain at rest unless acted on by an unbalanced force. An object in motion continues in motion with the same speed and in the same direction unless acted upon by an unbalanced force. This law is also called "the law of inertia".

Newton's Second law

Acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object).

Newton's Third law

For every action there is an equal and opposite re-action. This means that for every force there is a reaction force that is equal in size, but opposite in direction. Whenever an object pushes another object it gets pushed back in the opposite direction equally hard.