

29:52 Exploration of the Solar System
Class Notes for February 15, 2008
Application of Kepler's Laws and Introduction to Eclipses

Kepler's Laws can be used to explain a number of important characteristics of the solar system, and also help in the planning of space flights.

1. Kepler's 3rd Law can be used to calculate the time for a flight from the Earth to Mars (or any other planet). The spaceship has to travel from the orbit of the Earth (1.00 au) to the orbit of Mars (1.52 au). It does this by traveling on an ellipse with a major axis = $1.00 + 1.52 = 2.52$ au. The semimajor axis is then 1.26 au. We can calculate the period of this orbit by using Kepler's 3rd Law, and find that the period is 1.41 years. This is the time to go completely around in the orbit (a round trip). We want the time to go from perihelion to aphelion (one way trip), which is half of this, or 0.70 years = 258 days.
2. Kepler's Laws explain one of the factors responsible for the fact that the length of the solar day changes throughout the year. Because the Earth moves in an elliptical orbit (albeit one with a very small eccentricity), the angular change in the position of the Earth in its orbit changes during the year. This means that the angular shift of the Sun against the background stars (the same angle) similarly changes. The apparent solar day equals the sidereal day (a constant) plus the time for the Earth to rotate through an angle equal to the angular shift of the Sun against the stars. Since this angle changes from day to day, so does the length of the apparent solar day.
3. Kepler's 1st Law explains why Mars is at different distances from Earth at times of opposition. The distance between the Earth and Mars at opposition is the difference in the distance of the Earth from the Sun and the distance of Mars from the Sun. The orbit of Mars is rather elliptical (eccentricity of 0.093), so there is a substantial difference between the perihelion and aphelion distances. When opposition occurs near the time of Martian perihelion (as happened in 2003), the Earth-Mars distance is very small. When opposition occurs near Martian aphelion, this distance can be nearly twice as large. In 2003, the Earth-Mars distance at opposition was 0.373 au. At the next opposition, in January 2010, it will be at 0.664 au.

Eclipses

We begin with discussion of the observational properties of eclipses.

1. A *lunar eclipse* consists of a dark shadow moving over the surface of the Moon during a period of several hours. Lunar eclipses only occur at times of full moon.
2. A *solar eclipse* occurs when the light from the disk of the Sun is blocked, so that stars become visible in the daytime sky. A picture of a solar eclipse is shown in Figures 9.5 and 9.7 of the textbook. Solar eclipses occur only at times of new moon.

In the next lecture, we will discuss what is happening to cause these eclipses.