FYI Orbits and Ellipses

The paths that moons take around planets and planets take around stars are called orbits. Tycho Brahe was a wealthy Danish astronomer in the late 1500s who, through careful observation, gathered much of the data that were used to develop today's understandings about orbits. Johannes Kepler used Brahe's data to establish the three basic laws that describe the motion of orbiting bodies. The first of these important laws states that the orbits of planets (or moons) are ellipses, with the sun (or planet) at one focus.

In an elliptical orbit, the body being orbited occupies one of the two foci in an ellipse. Nothing occupies the other **focus**. There are two points of special interest on the ellipse. The point where the orbiting body comes closest to the central body is called **perigee** if the object is orbiting Earth, or **perihelion** if the object is orbiting the sun. The point of greatest distance is called **apogee** if the object is orbiting Earth, or **aphelion** if the object is orbiting the sun. Each ellipse has a **major axis** "a" that is the straight line through the foci connecting the aphelion and perihelion points. The **minor axis** "b" is perpendicular through the center of the ellipse. The distance between the two foci is called "c."

In a circular orbit, a planet or moon travels exactly the same speed at every point in the orbit. In an elliptical orbit, however, this is not the case. An object such as a comet, in a highly elliptical orbit around the sun, travels very fast when it is near perihelion (where the gravitational force is stronger) and very slowly when it is near aphelion (where gravitational force is weaker).

The measure of how elliptical an orbit is is called the eccentricity of the ellipse. Eccentricity is defined as the ratio of the distance between the foci (c) to the distance of the object from the sun (a). A circle has a single focus and an eccentricity of zero. Most planets and moons have eccentricities below 0.1. These would be nearly circular orbits. Objects such as Halley's comet, however, can have very eccentric, cigar-shaped orbits with eccentricities in the 0.9 range.

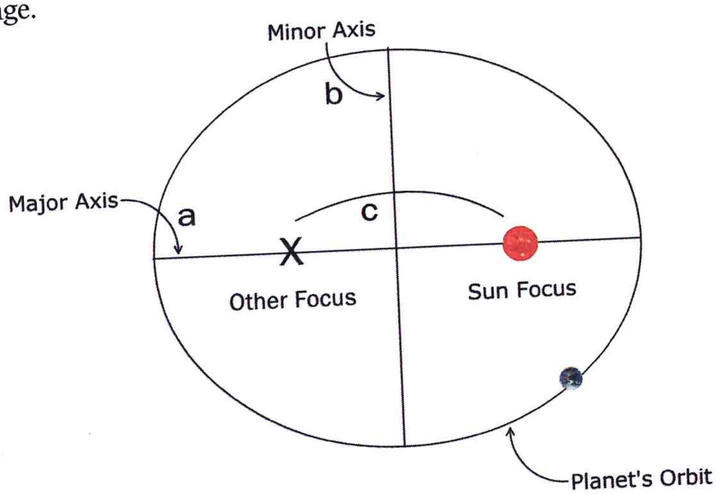

Figure 2-12: Diagram of a planet's elliptical orbit (NOT to scale)

To calculate an eccentricity when you cannot find one of the foci and measure c, you can use an alternate method. Since the apogee distance (R_a) is equal to c plus the perigee distance (R_p), c can be found by subtracting R_p from R_a. Then, dividing by a, the major axis will produce the eccentricity of the ellipse.

$$e = \frac{R_p - R_a}{a}$$

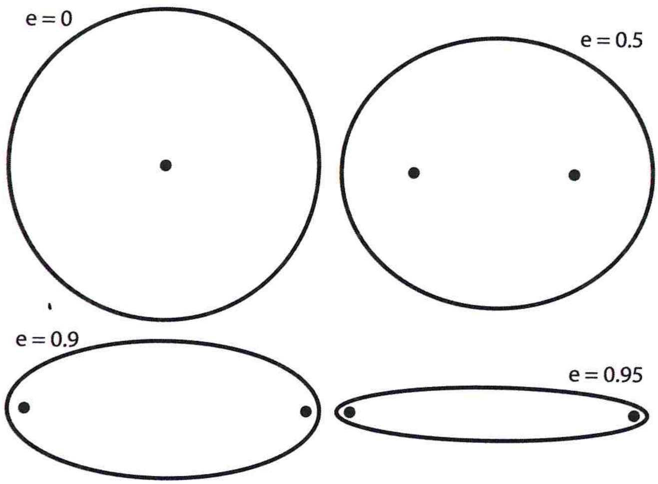

Figure 2-13: Diagram showing a variety of ellipses. All ellipses have an eccentricity somewhere between zero and one.

Checking In

1. In what ways is a circular orbit different from an elliptical orbit?
2. Explain how the eccentricity is a measure of how "stretched out" an ellipse is.