57.9: Bound and Unbound Orbits

The planetary orbits we've considered so far are elliptical orbits: the planets (according to Kepler's first law) move in ellipses, with the Sun at one focus. Similarly, satellites of the planets move in ellipses around the parent body. In general, the motion of a body under the inverse-square gravitational force is a conic section, i.e. a circle, ellipse, parabola, or hyperbola. Circular and elliptical orbits are bound orbits: if only two bodies are present, then the orbit retraces itself indefinitely. Parabolic and hyperbolic orbits are unbound: the body will orbit its parent body once, then move off toward infinity, leaving the vicinity of the parent body forever.

- A circular orbit is a special case of an elliptical orbit, for which the eccentricity $e = 0$.
- An elliptical orbit is one in which the body orbits its parent body, with the parent at one of the foci of the ellipse. Elliptical orbits have eccentricity $0 < e < 1$.
- A parabolic orbit is barely unbound, and lies at the boundary between a highly eccentric elliptical orbit and a hyperbolic orbit. Parabolic orbits have eccentricity $e = 1$.
- A hyperbolic orbit is unbound, and has eccentricity $e > 1$. In a hyperbolic orbit, the body orbits its parent once along one of the branches of the hyperbola, with the parent body at the focus of that branch of the hyperbola.

One could argue that in the real world there are no truly circular or parabolic orbits, since the eccentricity e will never be exactly 0 or 1. But some orbits have their eccentricities close enough to 0 or 1 for them to at least be approximated as circular or parabolic.

While the planets all orbit the Sun in elliptical orbits, comets may orbit the Sun in any kind of orbit. Some comets like Halley's comet are in highly eccentric elliptical orbits that return to the Sun at regular intervals. Other comets are in unbound orbits, and visit the Sun only once; they have sufficient energy to leave the solar system forever along hyperbolic orbits.