8-7 Orbits and Energy

Plots of the kinetic and potential energy as a function of time for five orbits are shown in Figure 8-7A, and graphs of the total energy are shown in Figure 8-7B. The total energy determines whether the orbit is closed or open (in the open case the object never comes back). If the total energy is negative the orbit is closed, and if it is positive the orbit is open. The special case of zero total energy represents the situation in which the initial speed is the escape speed.

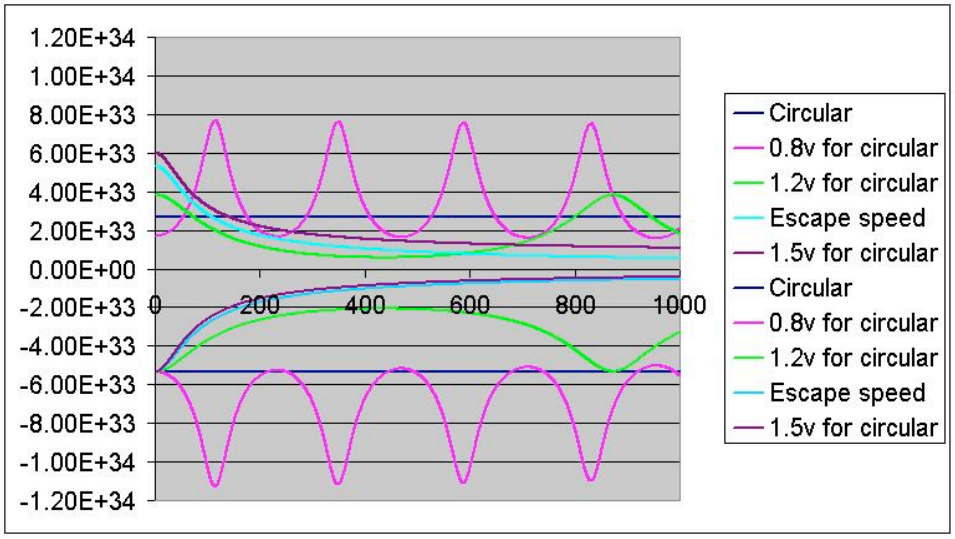

Figure 8-7A: Kinetic energies (positive values) and gravitational potential energies (negative values) for five different orbits, one being circular and corresponding closely to the Earth's orbit around the Sun; two being elliptical (and periodic); one corresponding to the escape speed; and the fifth being an open orbit in which the Earth would never come back. The *y*-axis has units of joules while the *x*-axis is time in units of days.

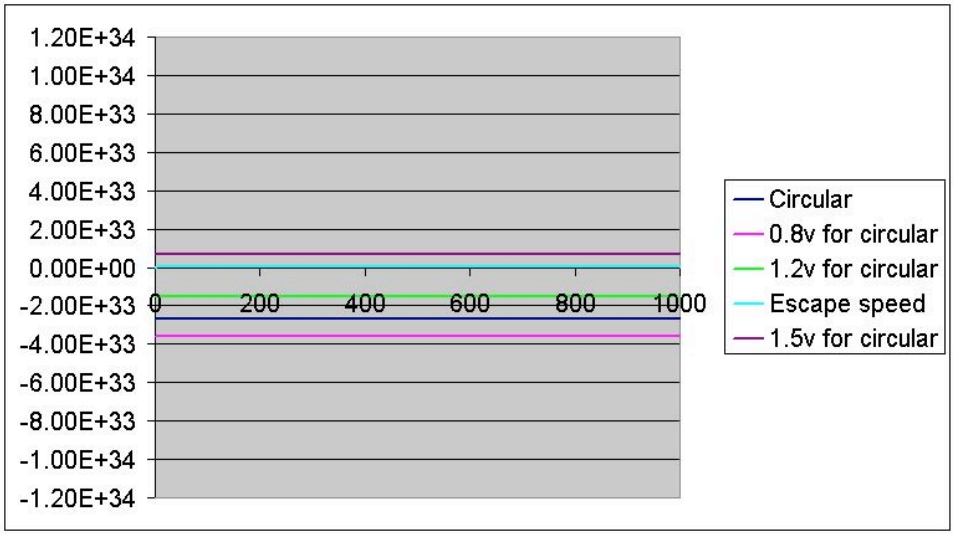

Figure 8-7B: Plots of the total mechanical energy (the sum of the kinetic plus the gravitational potential energy) for the five orbits discussed above. The *y*-axis has units of joules while the *x*-axis is time in units of days.

Related End-of-Chapter Exercises: 11 and 61.

Essential Question 8.7: For which of the orbits discussed above is the total mechanical energy conserved? What does the value of the total mechanical energy have to do with the orbit?

Answer to Essential Question 8.7: There is no energy-loss mechanism, so the total mechanical energy is conserved in each case. A total energy of 0 corresponds to the escape speed, while if the total energy is positive the orbit is open and the orbiting object escapes from the system. Negative total energies correspond to bound systems in which the orbiting object remains in orbit. The circular orbit is a special case in which $E = -K$ and $U = -2K$.