The solution to the radial equation for the inverse square force law is:

\[ r(\phi) = \frac{c}{1 + \epsilon \cos(\phi)} = \frac{1 + \epsilon}{1 + \epsilon \cos(\phi)} r(0) \]

In this form, \( \epsilon \) is taken as positive with the minimum \( r \) on the positive \( x \) axis. If the minimum \( r \) is on the negative \( x \) axis, \( \epsilon \) is negative.

You should recognize the following values of \( \epsilon \):

- \( \epsilon = 0 \) circle
- \( 0 < \epsilon < 1 \) ellipse
- \( \epsilon = 1 \) parabola
- \( \epsilon > 1 \) hyperbola

The energy is related to the eccentricity, \( \epsilon \), by the following equation:

\[ E = \frac{\alpha^2 \mu}{2 L^2} \left( \epsilon^2 - 1 \right) \]

where the force is \( F = \alpha/r^2 \) and \( L \) is the angular momentum.

1. We begin with essentially the same problem as homework problem 22.1. This time specify the following:

   (a) The particles are attracted by an attractive central force = \(-\alpha/r^2\). \( \alpha = 0.1875 \times 10^7 \).

   (b) The masses of the two objects are \( m_1 = 150 \) kg and \( m_2 = 300 \) kg.

   (c) The total energy is \( E = -156250 \) J.

   (d) The separation distance at \( t = 0 \) s is \( a = 10 \) m.

   (e) At \( t = 0 \) s, the radial velocity of each object is zero.

   Make a plot of \( r(\phi) \) and also a plot of \( r_1 \) and \( r_2 \) separately.

2. For the same data as in homework problem 23.1, solve the radial equation for total energies of \(-180000 \) J, \(-100000 \) J, \(-50000 \) J, \( 0 \) J, and \(+50000 \) J. Plot each orbit and make a graph of the total effective potential (real + centrifugal) for each system.

3. Find the eccentricity for each orbit of homework problem 23.2. Plot each orbit using Eq. 8.59 from the text combined with the initial conditions.