and \( r(t) = 0 \) when \( x - x_c = R / \sqrt{2E/m} \).

In this case we see that \( \theta(t) \to \pm \infty \) as \( t \to \infty \),

as it approaches \( t_{\text{collision}} = t_c + R / \sqrt{2E/m} \). So the orbit is a spiral into the origin with the spiral becoming ever tighter as time progresses.

![Diagram of spiral orbit](image)

It is also interesting to study this problem using the variational equation methods of problem 61.

1) The Lagrangian is \( L = \frac{1}{2} m [ \dot{r}^2 + (r \dot{\theta})^2 ] = \frac{2}{r^2} \).

2) The equations of motion are

\[
\frac{dL}{d\dot{r}} = m \ddot{r}, \quad \frac{dL}{d\dot{\theta}} = m r \ddot{\theta} + \frac{2 \lambda}{r^3} \Rightarrow
\]

\[
m \ddot{r} = \frac{2 \lambda}{r^3} + r \dot{\theta}^2\]

\[\Box\]