$$L = \frac{1}{2}\mu r^2 - V_{\text{eff}}(r)$$

where

$$V_{\text{eff}} = \frac{\ell}{2\mu r^2} + U(r)\ell = mr^2\dot{\phi}$$

$$\mu = \frac{m_1 m_2}{m_1 + m_2}$$