A spacecraft of mass \( m \) is in a circular orbit about the Earth at radius \( r_1 \) and would like to move into a circular orbit of larger radius \( r_2 \) with the least possible expenditure of fuel. Derive the following quantities, showing all work (memorizing the equations from the textbook is not sufficient). Your results should be expressed in terms of \( r_1, r_2, k = GM_e m, \) and \( m \).

a) What is the velocity of the spacecraft in the original circular orbit?

b) What is the semimajor axis \( a \) of the elliptical transfer orbit?

c) By how much must the velocity of the spacecraft increase to enter into the transfer orbit?

d) How much time will pass before it reaches the radius \( r_2 \) of the final circular orbit?

Some formulas for bound Keplerian orbits:

\[
  r = \frac{a(1 - \epsilon^2)}{1 + \epsilon \cos \theta} \quad \tau^2 = \frac{4\pi^2 m}{k} a^3 \quad a = \frac{-k}{2E} \quad \epsilon = \sqrt{1 + \frac{2E \ell^2}{mk^2}}
\]