55. This problem involves the following formulas which we quote from the Notes on central force motion:

A) $\left(\frac{du}{d\phi}\right)^2 + u^2 = 2m^2L^{-2}\left[E - G(u)\right]$ where $G(u) = V(1/u)$

B) For nearly circular orbits, $u = u_0 + \Delta\cos[g(\phi - \phi_0)]$ where $\Delta/u_0 \ll 1$ and $g(u_0) = \left[1 - u_0 G''(u_0)/G'(u_0)\right]^{1/2}$

C) $\Theta_p = 2\pi g$

a) We know that if $r = h(\phi)$ is an orbit, so is $r = k\,h(\phi)$ for every positive k. Equivalently, writing $H(\phi) = 1/h(\phi)$, we know that if $u = H(\phi)$ is an orbit, so is $u = k\,H(\phi)$ where $u = 1/r$. Use the notation $\dot{u} = du/d\phi$, and differentiate (A) to get

$$\ddot{u} + u = -m^2L^{-2}G'(u).$$ Now solve for m^2L^{-2} to get

$$\boxed{(\ddot{u} + u)/G'(u) = -m^2L^{-2}}.$$ This is OK if $G'(u) \neq 0$.