Now there are 3 possibilities:

1) $\dot{H} = 0$

2) $(\ddot{H} + H) = 0$

3) $$\frac{kH\, G''(kH)}{G'(kH)} = \frac{H\, G''(H)}{G'(H)}$$

In case 1, $H = \text{cnst} = 1/r_0$ and we have learned that circular orbits of any radius are possible. This doesn't say much about the potential except that it is attractive everywhere. So we exclude this case.

In case 2, $\ddot{H} + H = 0 \Rightarrow H = a\cos(\phi + b)$ where $a + b$ are constants. Putting this into (A) with $u = H$

$$\Rightarrow a^2\left[\sin^2(\phi+b) + \cos^2(\phi+b)\right] = 2mL^{-2}\left[E - G\{a\cos(\phi+b)\}\right]$$