1 Yukawa

In a solid, a free electron doesn't see" a bare nuclear charge since the nucleus is surrounded by a cloud of other electrons. The nucleus will look like the Coulomb potential close-up, but be screened" from far away. A common model for such problems is described by the Yukawa or screened potential:

$$U(r) = -\frac{k}{r}e^{-\frac{r}{\alpha}} \tag{1}$$

(a) Graph the potential, with and without the exponential term. Describe how the Yukawa potential approximates the "real" situation. In particular, describe the role of the parameter α.

(b) Draw the effective potential for the two choices $\alpha = 10$ and $\alpha = 0.1$ with $k = 1$ and $\ell = 1$. For which value(s) of α is there the possibility of stable circular orbits?