phys522: HW #4

1. Electrons in a metal are bound by a potential that may be approximated by a finite square well. Electrons fill up the energy levels up to an energy called the Fermi energy. The difference between the Fermi energy and the top of the well is the work function W of the metal. Photons with energies exceeding the work function can eject electrons from the metal– the photo-electric effect.

   Another way to pull out electrons is through application of an external uniform electric field E, which alters the potential energy as

   $V(x) = -e|E|x$ for $x > 0$

   where x is the coordinate perpendicular to the surface at $x = 0$. Find the transmission coefficient for electrons at the Fermi energy. How does the transmission depend on the applied voltage?

2. The potential for alpha decay is sketched below. Consider the decay of U-238. Take the value of $V_1 = 35\text{MeV}$, and the alpha decay energy is $E_\alpha = 4.2\text{MeV}$. In the WKB approximation calculate the transmission coefficient as $T = e^{-2I}$. Show that I is proportional to x where

   $$\mathrm{x} \approx \frac{\mathrm{Z_d}}{\sqrt{(\mathrm{E}_\alpha[\mathrm{MeV}]}} - \mathrm{Z_d^{2/3}}$$

   where Z_d is the charge/e of the daughter nucleus.

   Using a classical argument to get the frequency with which the alpha particle strikes the barrier, calculate the nuclear decay lifetimes for U-238, U-232,

   Th-215, Po-212 Rn-215 and compare to the experimental values. Make a plot of theory versus experiment and fit to a line.

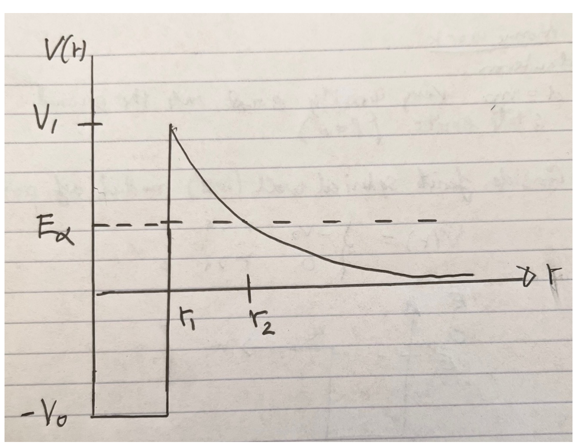

Figure 1: Sketch of alpha decay potential

3. Use the variational principle to estimate the mean height that a particle will "float" above an (impenetrable) table in a gravitational field. Calculate a number for an electron and for a particle of mass 1 g.