PHY 3107, Spring 2017, Homework #9

1.) The α-decay of the element ^{238}U releases E=4.268 MeV of kinetic energy (also known as the "Q" value of the reaction). Equation 7.13, $T(E) = e^{-4\pi Z\sqrt{\frac{E_0}{E}}+8\sqrt{\frac{ZR}{r_0}}}$ describes the transmission of the α-particle through the potential energy barrier, while the potential barrier is given by the Coulomb potential, $U(r) = 2kZ\frac{e^2}{r}$. A) Find the height of the barrier (e.g., set $r = R = 1.2A^{1/3}$ and solve for the potential). B) Use example 7.6 to find the transmission and C) half-life of ^{238}U (you can take f=10^{21}Hz, as in the example in the book).

2.) An electron current travels on aluminum wires, separated by a layer of aluminum oxide (Al_2O_3). Use example 7.1 and model the aluminum oxide as a square barrier of height 9.00 eV. Take the kinetic energy of the electrons to be 7.50 eV. Find the thickness of the Al_2O_3 layer if the transmission, T(E), is: a) 0.01% and b) 95%.

3.) Consider an electron with initial energy 0.5 eV approaching a barrier of height 1.0 eV and width 5.0 Å. A) What is the numerical probability for the particle to make it to the other side of the barrier? B) Download and run the "Quantum Tunneling and Wave Packets" simulation from the webpage at https://phet.colorado.edu/en/simulations/category/physics . [This will require Java.] Make sure you are using plane waves, not wave packets, and program the sim to calculate the probability for you. Do they agree? C)Switch the PhET sim to wave packets and watch the wave packet with the same parameters evolve. Does the sim give you the same result for the probability of transmission? What if you change the initial width of the wave packet? Play with the parameters to get a feel for how things are working.