Manhattan Project — Assignment 5 — Droplet Model of Fission, Critical Mass

1. The Radius of the Uranium Nucleus

Use the empirical formula (2.25) on p. 50 to get the radius of the Uranium nucleus. Write your answer using the length unit of the Fermi, abbreviated Fm, which is the same as a femtometer, abbreviated fm. (How convenient that Fm and fm are the same.) Round your answer to two significant figures (one decimal place).

2. The Surface Area of the Uranium Nucleus

Use your answer for Problem 1 to calculate the (a) the surface area, $A = 4\,\pi R^2$, and (b) the volume, $V = \frac{4}{3}\,\pi R^3$, of a Uranium nucleus. Your answers should be in Fm^2 ("square Fermis") for A and Fm^3 ("cubic Fermis") for V.

3. Reed Problem 3.3 — Coulomb Energy of a Nucleus

and

4. Reed Problem 3.4 — Coulomb Energy of Two Nuclei

I tried really hard to make my own liquid-drop-model fission problem, but I couldn't make it work. So instead Problems 3 and 4 are just two of Reed's problems.

5. Critical Mass and Bomb Energy

(a) On p. 111, Reed says the critical mass of Uranium is about 100 lb (although this can be improved with a tamper). Find the necessary conversion factors to get the critical radius from this. You will need to look up the density of Uranium, call that ρ. You will need to solve two formulas for R_{crit},

$$V_{\mathrm{crit}} = \frac{4}{3}\,\pi\,R_{\mathrm{crit}}^3 \quad \text{and} \quad W_{\mathrm{crit}} = \rho V_{\mathrm{crit}},$$

where $W_{\mathrm{crit}} = 100$ lb is the weight of the critical mass.

(b) Assume that a bomb has $R_{\mathrm{core}} = 1.2\,R_{\mathrm{crit}}$. What does equation Reed's Equation 3.18 give you for E? The easiest way to answer will be in Joules, but that presumes that you have converted everything else to SI units (meters, kilograms, and seconds). Reed gives you t=10ns on p. 111.

(c) Use the conversion factor $1\ \mathrm{kt} = 4.2 \times 10^{12}\,\mathrm{J}$ to convert your answer to kilotons.