THIRD YEAR EXAMPLE CLASS SHEET ONE
PHYS30121 Introduction to Nuclear and Particle Physics
Problems 1: Background and revision

1: Nuclear Physics Units

In order to avoid unwieldy powers of ten, nuclear physicists tend to use units of MeV and fm since these are the appropriate energy and length scales for nuclei. If you practice using them, you can do numerical calculations much quicker. Symbols in this section have their conventional meanings.

(i) Find the product $\hbar c$ in units of MeV.fm from the standard SI values.

(ii) Find the value of $e^2/4\pi\epsilon_0$ in units of MeV.fm from the standard SI values.

(iii) Show that the values above are consistent with the fine structure constant, $\frac{e^2}{4\pi\epsilon_0\hbar c} = \frac{1}{137.0}$

(iv) Just using the answers in (i) and (ii) in MeV and fm, without using SI units at all, what is the electrostatic potential energy between two protons if they are separated by a distance of 5 fm?

A gentle warning, other fields of physics adopt different unit conventions!

2: Energy of a Charged Sphere

Use first-year electromagnetism to derive an expression for the energy you need to assemble a sphere carrying a total charge Ze of radius R with constant charge density.

[Hint, think of building up the sphere by adding rings, each of thickness dr. Calculate the small amount of energy you need to add a ring at the point in the assembly where the radius has reached a value r, then integrate the result from $r = 0$ to R.]

Use this to estimate, in MeV, the electrostatic energy stored in a Pb nucleus with $Z = 82$ and a radius of 17.3 fm. *Do it without SI units!*