2^{nd} HOMEWORK
Due March 25, 2009

1. In symmetric fission, a uranium nucleus splits into two equal pieces each of which is a palladium nucleus. The palladium nucleus is spherical with a radius of $5.9 \times 10^{-15} m$ and a charge of $46e$ uniformly distributed over its volume. Suppose that, immediately after fission, the two palladium nuclei are barely touching. What is the value of the total electric field at the center of each? What is the repulsive force between them? What is the acceleration of each? The mass of a palladium nucleus is $1.99 \times 10^{-25}\ kg$. (H. C. Ohanian, "Physics," pg622, Q12)

2. The tube of a Geiger counter consists of a thin conducting wire of radius $1.3 \times 10^{-3}\ cm$ stretched along the axis of a conducting cylindrical shell of radius 1.3 cm. The wire and the cylinder have equal and opposite charges of $7.2 \times 10^{-10}\ C$ distributed along their length of 9.0 cm. Find a formula for the electric field in the space between the wire and the cylinder; pretend that the electric field is that of an infinitely long wire and cylinder. What is the magnitude of the electric field at the surface of the wire? (H. C. Ohanian, "Physics," pg622, Q17)

3. The electric charge of the proton is not concentrated in a point but, rather, distributed over a volume. According o experimental investigations at the Stanford Linear Accelerator, the charge distribution of the proton can be approximately described by a charge density which is an exponential function of the radial distance:

$$\rho = \frac{e}{8\pi b^3} e^{-r/b}$$

where b is a constant, $b = 0.23 \times 10^{-15}\ m$. Find the electric field as a function of the radial distance. What is the magnitude of the electric field at $r = 1.0 \times 10^{-15}\ m$? (*Hint:* The following integral may be useful: $\int x^2 e^{-x} dx = -x^2 e^{-x} - 2e^{-x}(x+1)$) (H. C. Ohanian, "Physics," pg624, Q26)

4. In terms of x, y, and z, the potential of a point charge is

$$V(x,y,z) = \frac{1}{4\pi\epsilon_0} \frac{q'}{\sqrt{x^2+y^2+z^2}}$$

(a) By differentiating this potential function, calculate the components E_x, E_y and E_z of the electric field.

(b) Show that the magnitude $\sqrt{E_x^2 + E_y^2 + E_z^2}$ agrees with the usual expression for the electric field of a point charge

(H. C. Ohanian, “Physics,” Ch25, pg647, Q33)

5. A point charge $-2Q$ is at the origin of coordinates; two point charges $+Q$ are on the z axis, at $z = \pm l$ respectively.

(a) Show that, for $r >> l$, the net potential of these charges is approximately

$$V = \frac{2Ql^2}{4\pi\epsilon_0 r^2}\frac{3\cos^2\theta - 1}{2}$$

(b) Calculate E_x, E_y and E_z expressing them in these in terms of the coordinates x, y, and z.

(*Hint:* $(1+x)^n \simeq 1 + nx + \frac{1}{2}n(n-1)x^2$ (H. C. Ohanian, “Physics,” pg648, Ch25, Q22)