UNIVERSITY OF LEIPZIG
INSTITUTE FOR THEORETICAL PHYSICS
Department: Theory of Elementary Particles

TP2 2017

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List of problems 2

4. Using Dirac delta functions in the appropriate coordinates, express the following charge distributions as three-dimensional charge densities $\rho(\mathbf{x})$.

   (a) In cylindrical coordinates, a charge λ per unit length uniformly distributed over a cylindrical surface of radius b.

   (b) In cylindrical coordinates, a charge Q spread uniformly over a flat circular disc of negligible thickness and radius R.

   (c) The same as part (b), but using spherical coordinates.

5. Suppose that, instead of the Coulomb force law, one found experimentally that the force between any two charges q_1 and q_2 was

$$\mathbf{F}_{12} = \frac{q_1 q_2}{4\pi\varepsilon_0}\,(1-\sqrt{\alpha\, r_{12}})\,\frac{\mathbf{r}_{12}}{r_{12}^3}\,, \quad \mathbf{r}_{12} = \mathbf{r}_1 - \mathbf{r}_2\,,$$

   where α is a constant (with dimension of an inverse length).
   Write down the appropriate electric field $\mathbf{E}$ surrounding a point charge q. Choose a path around this point charge and calculate the line integral $\oint \mathbf{E}\cdot d\mathbf{l}$. Compare with the Coulomb result.
   Find $\oint \mathbf{E}\cdot d\mathbf{S}$ over a spherical surface of radius $\mathbf{r}_1$ with the point charge at this center. Compare with the Coulomb result.