Physics 321, Autumn Quarter 2015
Electrodynamics: Homework Assignment 3

(a) Turn in all problems and clearly note all constants and assumptions you use. (1-point penalty each otherwise)

(b) Use 8½ x 11 paper & staple (1-point penalty each otherwise)

Due 9:30 am Thursday October 22

1. Challenge problem. Equation 2.29 in Griffiths is the electrostatic potential at a field point in terms of a volume integral over all the charge in the system. What if, in addition, there's a boundary somewhere with a specified electrostatic potential? Make use of "Green's 2^{nd} Identity" (Griffiths problem 1.61d) to find the contribution to the electrostatic potential at the field point from this surface potential. Hints: V is a scalar function, as is 1/r. $\nabla^2(1/r) = -4\pi\delta(\mathbf{r})$. The contribution from the surface will undoubtedly involve an integration over that surface. Ignore the contribution from the gradient of the potential at the surface.

2. Consider an ideal parallel-plate capacitor of area A. As usual, there's charge +Q on one plate, and –Q on the other. (Ignore fringing fields).

a. What's the electric field everywhere between the plates?
b. What's the electrostatic field energy density at each point between the plates?
c. How much work does an outside agent do in letting the plates slowly move closer together over a distance ΔX?
d. How much work is removed thereby from the electrostatic field?
e. From your answer in (d), find the force the outside agent applied to the plate.

3. In 1959 Lyttleton and Bondi suggested that Hubble's expansion of the universe could be due to "neutral" matter carrying a net electric charge. Imagine a spherical volume τ of the universe containing un-ionized atomic hydrogen of uniform density N atoms per cubic meter. Further assume hydrogen has a slight charge imbalance: the proton charge is $(1+y)e$. with e the magnitude of the electric charge.
(a) Find the electric field **E** at radius r from the center.
(b) Find the numerical value of y where the electrostatic repulsion just balances the gravitational attraction and the gas begins to expand.

At that time, some thought matter was being continuously created in space, so during the expansion, the gas density remained constant. In this case, the repulsive force is proportional to the distance from the center, as is the velocity. Unfortunately for Lyttleton and Bondi, a Millikan oil drop experiment at about that time put a more stringent limit on y.

4. An alpha-particle has kinetic energy K far from a gold nucleus, and it travels head on towards the gold nucleus. The α-particle just barely touches the surface of the nucleus, then reverses direction. Find K assuming the gold nuclear radius is around 5 fermi. Rutherford used isotopes with α-particle K's up to 5 MeV and he observed the phenomenon of backward α-particle scattering. What did Rutherford conclude? Recall: an α-particle is a helium nucleus. Assume the gold nucleus is uniformly-charged and spherical, and the α-particle is small.

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