Electromagnetic Theory I

Problem Set 1

Due: 9 September 2020

This and all future homework will be posted on the course webpage:

http://www.phys.ufl.edu/∼thorn/homepage/eminfo.html

In the homework assignments, I will refer to problems in Jackson by prefixing the problem number with J.

1. a) Solve for the motion of a point particle with charge q and mass m in constant homogeneous electric and magnetic fields that are perpendicular to each other. For definiteness take $\mathbf{B} = B\hat{z}$ parallel to the z-axis and $\mathbf{E} = E\hat{y}$ parallel to the y-axis. Take the initial condition that the particle is at rest at the origin of coordinates. You may assume that the speed of the particle remains much smaller than the speed of light throughout the motion.

b) What condition on the fields must hold if the motion stays nonrelativistic throughout?

2. J, Problem 1.3

3. A total charge Q is distributed inside a sphere of radius R with an isotropic charge density $\rho(r)$.

a) Use Gauss' law to determine the electric field everywhere, both inside and outside the sphere. Your answer will involve an integral over r.

b) Specialize to a charge density of the form $\rho(r) = A(R^2 - r^2)$. Determine A in terms of Q and R, and obtain an explicit expression for the electric field everywhere.

c) Plot the magnitude of the electric field $E(r)$ as a function of r for the result of part b).

4. We will be using SI units thoughout this course. However, in Heaviside-Lorentz (H-L) units (see section 1.3 of the lecture notes) Maxwell's equations gain simplicity and clarity.

a) Show that the Heaviside-Lorentz unit of charge has dimensions of $(\text{Energy})^{1/2} \times (\text{Length})^{1/2}$.

b) Find the numerical value of the electron's charge $\hat{e}$ in Heaviside-Lorentz units.

c) The combination $\hbar c$ also has dimensions of (Energy)×(Length). From part b) determine the numerical value of the (dimensionless) fine structure constant $\alpha = \hat{e}^2/4\pi\hbar c$.