ADVANCED DYNAMICS — PHY 4241/5227

HOME AND CLASS WORK – SET 8

(February 21, 2009)

Read chapter 7.3 of Griffith (due Monday February 23).

Also, **bring a calculator** on Monday.

(34) SI units (due February 23 in class).

1. How is one second [s] defined (1 point – done)?
2. How is one meter [m] defined (1 point – done)?
3. How is one kilogram [kg] defined (1 point – done)?
4. How is one Newton [N] defined (1 point – done)?
5. How is one Ampere [A] defined (1 point)?
6. How is one Coulomb [C] defined (1 point)?
7. From the Biot-Savart law it follows that the force exerted by one (infinitely long) wrire on a section of length l of a parallel wire is given by

$$F = \frac{\mu_0}{2\pi} \frac{I_1 \, I_2}{d} \, l \ ,$$

where μ_0 is the *permeability of vacuum*. What is the (exact) value of μ_0 (1 point)?

8. Using the above units, Coulomb's law read

$$F(r) = \frac{\kappa_0 \, Q_1 \, Q_2}{r^2} \, , \quad \kappa_0 = \frac{1}{4\pi \, \epsilon_0}$$

where κ_0 is called *Coulomb constant* and ϵ_0 *permittivity of vacuum*. They can, for instance, be estimated by force measurements. In SI units $\epsilon_0 = 8.85418782 \times 10^{-12}$. What are the physical dimensions of ϵ_0 (1 point)?

(35) EM waves in vacuum (due February 23 in class).

1. Use ϵ_{ijk} notation and Einstein's summation convention to show

$$\nabla \times (\nabla \times \vec{A}) = \nabla \, (\nabla \cdot \vec{A}) - \nabla^2 \vec{A} \quad \text{(3 points)} \ .$$

2. Use SI units and write down Maxwell's equations in vacuum (2 points).
3. Calculate $\nabla \times (\nabla \times \vec{E})$ to derive

$$\nabla^2 \vec{E} = \left(\frac{1}{v} \frac{\partial}{\partial t} \right)^2 \vec{E} \ \text{ with } \ v = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \quad \text{(3 points)} \ .$$

4. Calculate $v = 1/\sqrt{\epsilon_0 \, \mu_0}$ and make an observation (2 points).

(36) Homework, due February 27 before class (4 points). Repeat the previous considerations for $\nabla \times (\nabla \times \vec{B})$.