**ADVANCED DYNAMICS — PHY 4241/5227**

**HOME AND CLASS WORK – SET 9**

(30) SI units (due February 24 in class).

1. How is one second [s] defined (1 point)?
2. How is one meter [m] defined (1 point)?
3. How is one kilogram [kg] defined (1 point)?
4. How is one Newton [N] defined (1 point)?
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 $\mu_0$ is the *permeability of vacuum*. What is the (exact) value of $\mu_0$ (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 $\kappa_0$ is called *Coulomb constant* and $\epsilon_0$ *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 $\epsilon_0$ (1 point)?

(31) EM waves in vacuum

1. Use $\epsilon_{ijk}$ notation and Einstein's summation convention to show (due March 3 before class).
$$\nabla \times (\nabla \times \vec{A}) = \nabla\,(\nabla \cdot \vec{A}) - \nabla^2 \vec{A}\quad \text{(3 points)}\ .$$
2. Use SI units and write down Maxwell's equations in vacuum (2 points, March 3 in class).
3. Calculate $\nabla \times (\nabla \times \vec{E})$ to derive
$$\nabla^2 \vec{E} = \left(\frac{1}{v}\frac{\partial}{\partial t}\right)^2 \vec{E}\ \ \text{with}\ \ v = \frac{1}{\sqrt{\mu_0 \epsilon_0}}\quad \text{(3 points, March 3 in class)}\ .$$
4. Calculate $v = 1/\sqrt{\epsilon_0\,\mu_0}$ and make an observation (2 points, March 3 in class).

(32) Homework, due March 5 before class (4 points). Repeat the previous considerations for $\nabla \times (\nabla \times \vec{B})$.

Read the relativity notes up to Eq. (1.42), p.10 (due Monday March 15).