Electrodynamics, spring 2003

Exercise 8 (Thu 27.3., Fri 28.3.)

1. A straight long wire (cross-section circle with radius a carries a steady current I. Show that the energy flow to the wire equals to the Joule heating.
2. In a long conducting cylinder there is a current flowing parallel to the axis so that the total current is $I(t) = I_0 e^{-i\omega t}$. The radius of the cylinder is a and its electromagnetic parameters are constant (σ, μ, ϵ). Assume slow temporal changes: $\omega\epsilon/\sigma << 1$.
   a) Calculate the current density in the cylinder. Derive first the diffusion equation of the current density. You will need Bessel functions in calculations (see some physical textbook on mathematics).
   b) Study the DC limit $\omega \to 0$. (If you could not solve the general current density you can anyhow deduce this limit in another way.)
3. Show by a careful differentiation that

$$\varphi(\mathbf{r}, t) = \frac{1}{4\pi\epsilon_0} \int_V \frac{\rho(\mathbf{r}', t - |\mathbf{r} - \mathbf{r}'|/c)}{|\mathbf{r} - \mathbf{r}'|} \, dV'$$

   satisfies the wave equation of the potential.
4. a) Show that a possible gauge condition of the vector potential is $\mathbf{r} \cdot \mathbf{A} = 0$.
   b) Express $\mathbf{A}$ in this gauge in terms of the magnetic field $\mathbf{B}$. Tip: consider $\mathbf{r} \times \mathbf{B}$.

Return answers until Tuesday 25.3. at 14 o'clock (note the extended time).

The first exam (välikoe) is on Friday, March 21, at 9.00-13.00 (in D101). You will get an English translation.
Material: sections 1-8 of lecture notes and exercises 1-7.

Lecture on Thursday 13.3. is exceptionally in E207. During the exam week, there are no exercises, but lectures are at their normal times. On the lecture of Thursday 20.3., we will go through what we have learned in sections 1-8 of the lectures.