Electrodynamics, spring 2008
Exercise 3 (7.2., 8.2.; Friday group in English)

1. An insulating sphere (radius R) has a radial polarisation: $\mathbf{P} = P_0 \mathbf{r}$ (P_0 = constant). There are no other sources of the electric field.
   a) Calculate the polarisation charge density inside the sphere and at its surface. Show that the total charge of the sphere is zero.
   b) Calculate the electric field and electric displacement everywhere.

2. An infinitely wide insulating plate (thickness d, permittivity ϵ) is placed in a uniform electric field $\mathbf{E}$, so that the angle between $\mathbf{E}$ and the normal of the disk is θ. Determine the polarisation charge density induced at the surface of the plate.

3. There is a constant background electric field $\mathbf{E}_0$ in a uniform material (permittivity ϵ_1). There is also a long cylinder (permittivity ϵ_2, radius R) whose axis is perpendicular to the background field. Calculate the electric field everywhere.

4. The inner radius of a coaxial cable is a. It is surrounded by an insulator (relative permittivity ϵ_r) up to radius b. Then there is air until the outer surface of the cable at radius c. The voltage between the inner and outer surfaces is V. Determine the largest electric field inside this system.

5. Thunderstorms maintain continuously such a negative charge at the Earth's surface that the vertical electric field at the surface is about 100 V/m.
   a) How large is the surface charge density and the total charge? Assume a uniform distribution.
   b) How long could the energy associated with the surface charge provide electricity at the power of 15 GW? (This is the largest electric power consumption measured in Finland.)
   c) Why do we not get electric shocks, although the field is quite large?

6. Extra problem (one point): A car creates a good shield against lightning strokes. However, why is it wise to wait for a few minutes after a stroke before leaving the car?

Return the answers until Tuesday 5.2. 12 o'clock.
A study group ("opintopiiri") has been established for this course. It is held on Mondays at 12-14 in the lecture room D110, starting on January 28. The other dates are given on the homepage (changes are possible).