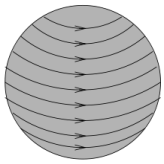
Physics 503
Final Exam 2011

Problem 1 A point electric dipole with dipole moment $\vec{p}$ is located at the center of a spherical hole of radius R inside a dielectric medium of infinite extent and dielectric constant ε.

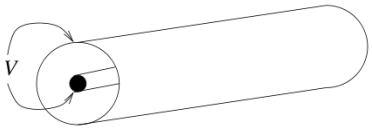
a) Find the electric field everywhere.

b) What is the induced charge density on the surface of the dielectric (jump of the polarization)?

Problem 2 A wire coil is wound around the surface of a solid sphere of radius R and permeability μ. The coil is designed in such a way that it carries a surface current density $\vec{K} = 9\frac{I}{R}\sin\theta\,\cos\theta\,\vec{e}_\phi$. Find the magnetic induction $\vec{B}$ everywhere.



Problem 3 A semi-infinite coaxial cable consist of an inner conductor of radius a surrounded by an outer conductor of radius b. A dielectric with permittivity ε and permeability μ fills the volume between the conductors.



a) If a constant (static) potential difference V_0 is applied between the conductors, what is the electric field inside the cable (between the conductors)?

b) Show that, if a sinusoidal potential difference $V(t) = V_0 e^{-i\omega t}$ is applied at the end of the cable, the Maxwell's equations admit a traveling wave solution of the form

$$\vec{B} = b(r)e^{i(kz-\omega t)}\vec{e}_\phi \tag{1}$$

$$\vec{E} = e(r)e^{i(kz-\omega t)}\vec{e}_r. \tag{2}$$

Here z is the direction along the axis of the cable and r is the radial distance from the axis of the cable (not $|\vec{r}|$). Find $b(r)$ and $e(r)$ in terms of V_0. (Hint: Check that above ansatz satisfies all four Maxwell equations).