UNIVERSITY OF LEIPZIG
INSTITUTE FOR THEORETICAL PHYSICS
Department: Theory of Elementary Particles

TP2 2015

Lecturer: PD Dr. A. Schiller

List of problems 10

(28. and 29. required, use 30. to collect an additional point)

28. A steady current I flows in a wire along the z-axis. Consider three half-planes originating from that axis in a fan-shape manner. Denote the angles between those half-planes by α_1, α_2 and α_3 with $\alpha_1 + \alpha_2 + \alpha_3 = 2\pi$. The regions between the half-planes are filled with homogeneous magnetic materials of permeabilities μ_1, μ_2 and μ_3, respectively. Denote the magnetic induction vector of the current I in vacuum by $\mathbf{B}_0$.
Calculate the resulting magnetic fields $\mathbf{H}_i$ and $\mathbf{B}_i$ in the three regions as function of $\mathbf{B}_0$, the angles α_i and permeabilities μ_i.

29. An infinitely long, solid dielectric cylinder of radius a is permanently polarized so that the polarization is everywhere radially outward, with a magnitude proportional to the distance from the axis of the cylinder

$$\mathbf{P}(\rho) = \frac{1}{2} P_0 \, \rho \, \mathbf{e}_\rho \, .$$

(a) Find the charge density in the cylinder.
(b) If the cylinder is rotated with a constant angular velocity ω about its axis without change in $\mathbf{P}$, what is the magnetic field on the axis of the cylinder?

Hints:
Rotating bounded charge densities lead to effective currents.
From those densities determine the effective volume and surface current densities in the rotating cylinder.
Using the current densities, calculate the vector of the magnetic induction on the axis.

30. Find the interaction energy between two small currents described by their magnetic moments $\mathbf{m}_1$ and $\mathbf{m}_2$.
What is the interaction force between those currents and the torque vectors acting on the currents?
Discuss the special case of parallel magnetic moments.