Exercise Sheet 9

Discussion 12.11.2025

Exercise 1 - Coaxial capacitor

Consider a coaxial cable of length L and radii $R_1 < R_2$, where the two cylinders are charged with $+\lambda$ and $-\lambda$. Evaluate the capacitance of the cable in the following cases.

a) The space between the cylinders is filled with a dielectric material with relative permittivity ϵ_{r_1} (see Fig. 1a).

b) The two halves of the cable are filled with dielectric materials with relative permittivity ϵ_{r_1} and ϵ_{r_2} (see Fig. 1b).

c) The first half of the space between the cylinder is filled with a dielectric material with relative permittivity ϵ_{r_1}, and the second half is with ϵ_{r_2} (see Fig. 1c).

Consider now the situation described in point (c).

d) Evaluate $\vec{E}$ and $\vec{D}$ as a function of radial distance from the axis of the cable, and plot $E(r)$ and $D(r)/\epsilon_0$ for the case $\epsilon_{r_1} = 1$ (vacuum) and $\epsilon_{r_2} = 2$.

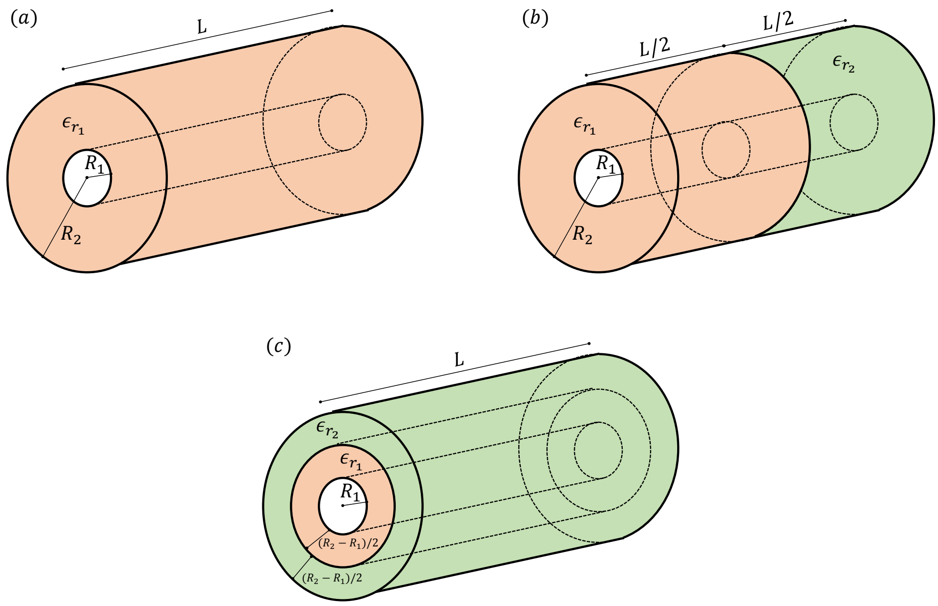

Figure 1: Coaxial capacitors

Exercise 2 - Perturbing capacitors

Consider a charged parallel-plate capacitor in vacuum, with area S and initial separation d.

a) What is the work needed to double the separation of the plates if the potential difference is maintained constant?

Consider now a charged coaxial capacitor of length L and radii $R_1 < R_2$. The inner cylindrical conductor is pulled out along the axis until half of it is outside the outer cylinder.

b) Evaluate the force exerted by the system on the inner conductor.

Exercise 3 - Coalescing charges

Consider 27 identical spherical metallic droplets of radius R that are made to coalesce into a single spherical droplet. Only two of the droplets were charged, one at 5 V and the other at 4 V with respect to ground.

a) Evaluate the electric potential of the big droplet after the merging.

b) Evaluate the change of electrical energy of the system.

Discussion 1 - Conductivity

Similar to viscosity (η) and the relative permittivity (ε_r) also the conductivity (σ) is actually a tensor. Why do you think this is the case? Which variables in the Drude model can be made responsible for this anisotropic behaviour?

Exercise 4 - Spherical resistor

Consider two concentric spheres of radii $R_1 < R_2$ separated by a material with constant resistivity ρ. Evaluate the resistance between the two spheres.