

Exercise Sheet 9

Discussion 13.11.2024

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.

- The space between the cylinders is filled with a dielectric material with relative permittivity ϵ_{r1} (see Fig. 1a).
- The two halves of the cable are filled with dielectric materials with relative permittivity ϵ_{r1} and ϵ_{r2} (see Fig. 1b).
- The first half of the space between the cylinder is filled with a dielectric material with relative permittivity ϵ_{r1} , and the second half is with ϵ_{r2} (see Fig. 1c).

Consider now the situation described in point (c).

- 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 $\epsilon_{r1} = 1$ (vacuum) and $\epsilon_{r2} = 2$.

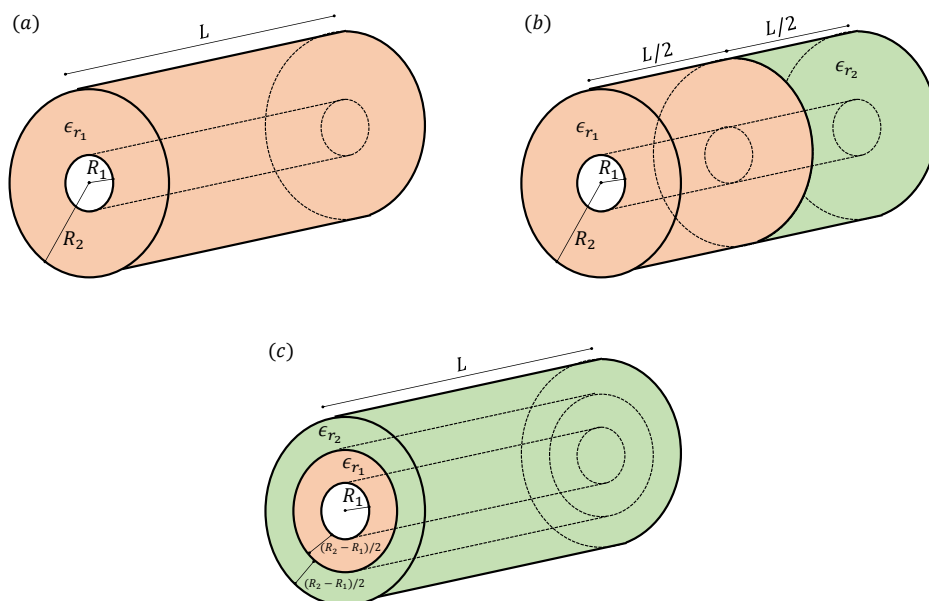


Figure 1: Coaxial capacitors

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.