Electric Materials - Conductors & Dielectrics

Reading assignment

Popović and Popović, Chapter 6 and Chapter 7

Connor and Salon, III-1 → III-30 and IV-1 → IV-6

Software

lesson2_4.m

Problem 1 - charge on conductors

Run the Matlab program lesson2_4.m. Figure 1 will show a set of equipotential lines (surfaces?) for a sheet of charge (finite length) with uniform charge density. *Note: There are also several Mathcad worksheets dealing with sheets of charge that are useful, in particular Section 3.9. (Also Problem 3.3.4 and Example 3.15).*

a. In what direction does **E** point? What force do the charges feel?

b. Consider a second case where a rectangular section of conductor is placed at the same voltage as the center of the sheet of charge in part a. The equipotentials for this case will look different than in Figure 1. Sketch some equipotentials on the cross-section view below.

c. Sketch the surface charge density on the conductor as a function of position.

Problem 2 - Gauss' law

A coaxial cable has an inner conductor with radius *a* , an outer conductor with radius *b* , and an insulating material with a relative permittivity of ε_r. Assume the outer conductor is grounded.

a. Assume that the inner conductor has a surface charge density of ρ_{sa} and find **D** and **E** between the conductors.

b. Find the voltage difference, V_{ab}, between the conductors in terms of ρ_{sa}.

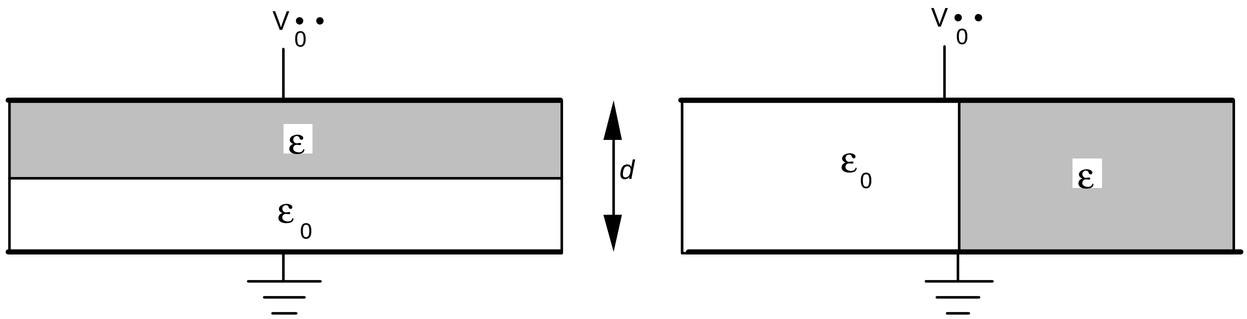
c. In reality, we can control V_{ab}, not ρ_{sa}. Rewrite the expressions for **D** and **E** in terms of V_{ab}.

d. Assume that *a* = 1 cm, *b* = 2 cm, and the dielectric material is polystyrene with ε_r = 2.6 and a dielectric strength of 2×10^7 V/m. At what value of V_{ab} will the cable fail and where (what radii) will the failure occur.

Problem 3 - boundary conditions
Consider the two parallel plate geometries below. Assume that the plate dimensions are large compared to the separation *d* and ignore fringe effects. For the two figures, the electric field in the air region is given by:

$\mathbf{E} = -(V_0 / d) * (2\varepsilon_r / (1+\varepsilon_r))\ \mathbf{a}_z$ figure on left

$\mathbf{E} = -(V_0 / d)\ \mathbf{a}_z$ figure on right



a. For both cases, find **E** in the dielectric region. Find **D** in both regions. Within a given region, **D** and **E** do not vary with position.
b. Find the charge density on the plates at all locations.

Problem 4 - boundary conditions
The **E** field on the air side of a dielectric-dielectric boundary is $\mathbf{E} = 100\ \mathbf{a}_x + 100\ \mathbf{a}_y$.
What is **E** on the dielectric side?