task_ddjurcpk494go2q1_with_calculation

Student Group

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Table of Contents

electric field, magnetic field, exam ee2 SS2024

Exercise E1 Capacitor
(written test, approx. 12 % of a 120-minute written test, SS2024)

[illegible] cable with the origin in the center of the coax cable. Due to the given [illegible] $\varepsilon_{\rm r,c}>\varepsilon_{\rm r,air}$, while the distance between the plates remains the same. Give a generalized formula $C_2=f(A,d,x,\varepsilon_{\rm r,c}, \varepsilon_{\rm r,air})$.

Result

Path

Path

- Inner conductor: $+3.3 ~\rm mA$, $+10 ~\rm nC$ (current into the plane of the diagram)
- Outer conductor: $-3.3 ~\rm mA$, $-10 ~\rm nC$ (current out of the plane of diagram)

$C = \varepsilon_0 A {{\varepsilon_{\rm r, air} \cdot \varepsilon_{\rm r, c} }\over{ (d-x)\cdot\varepsilon_{\rm r, c} + x\cdot\varepsilon_{\rm r, air} }}$

Path

There are two ways now. Either: \begin{align*} Q &= C \cdot U = 1.1 ~\rm pF \cdot 3.3 ~ V = 3.6522... ~pC \\ \end{align*} Or: \begin{align*} Q &= D \cdot A = 146 \cdot 10^{-9} \rm {{C}\over{m^2}} \cdot 25 \cdot 10^{-6} ~m^2 = 3.6522... ~pC \\ \end{align*}

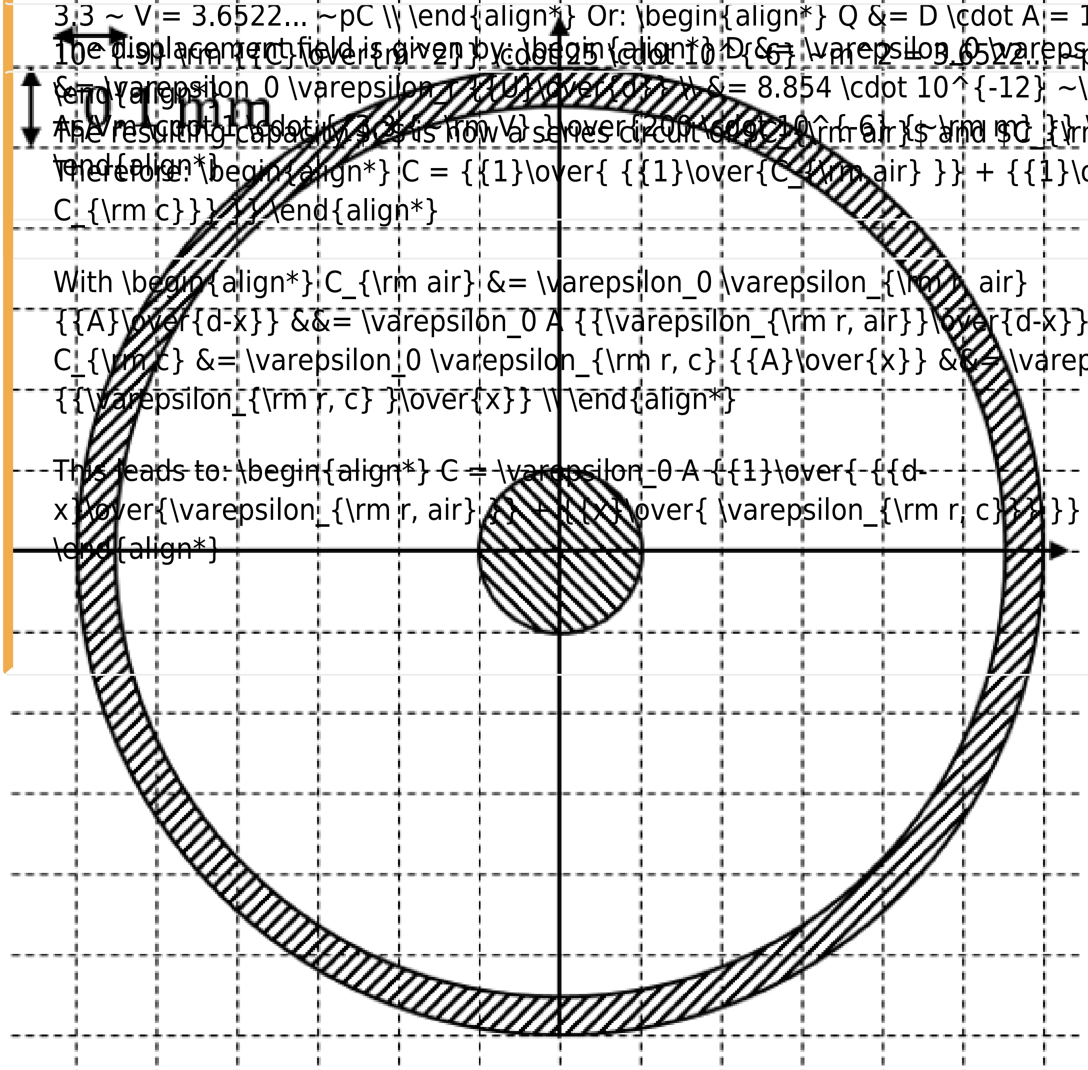
The displacement field is given by: \begin{align*} D &= \varepsilon_0 \varepsilon_r E \\ &= \varepsilon_0 \varepsilon_r {{U}\over{d}} \\ &= 8.854 \cdot 10^{-12} ~\rm As/Vm \cdot 1 \cdot {{3.3 ~\rm V} }\over{200 \cdot 10^{-6} {~\rm m} }} \\ \end{align*}

The resulting capacity C_2 is now a series circuit of $C_{\rm air}$ and $C_{\rm c}$.

Therefore: \begin{align*} C = {{1}\over{ {{1}\over{C_{\rm air} }} + {{1}\over{ C_{\rm c}}} }} \end{align*}

With \begin{align*} C_{\rm air} &= \varepsilon_0 \varepsilon_{\rm r, air} {{A}\over{d-x}} &&= \varepsilon_0 A {{\varepsilon_{\rm r, air}}\over{d-x}} \\ C_{\rm c} &= \varepsilon_0 \varepsilon_{\rm r, c} {{A}\over{x}} &&= \varepsilon_0 A {{\varepsilon_{\rm r, c} }\over{x}} \\ \end{align*}

This leads to: \begin{align*} C = \varepsilon_0 A {{1}\over{ {{d-x}\over{\varepsilon_{\rm r, air}}} + {{x}\over{ \varepsilon_{\rm r, c}}} }} \end{align*}



1. What is the magnitude of the magnetic field strength H at $\rm (-0.1 ~mm | 0)$ and $\rm (0.55 ~mm | 0)$?

2. Plot the graph of the magnitude of $H(x)$ from $\rm (-0.6 ~mm | 0)$ to $\rm (0.6 ~mm | 0)$ in one diagram. Use proper dimensions and labels for the diagram!

3. What is the magnitude of the electric displacement field D at $\rm (-0.1 ~mm | 0)$ and $\rm (0.55 ~mm | 0)$?

4. Plot the graph of the magnitude of $D(x)$ from $\rm (-0.6 ~mm | 0)$ to $\rm (0.6 ~mm | 0)$ in one diagram. Use proper dimensions and labels for the diagram!

Path

> \begin{align*} C &= \varepsilon_0 \varepsilon_r {{A}\over{d}} \\ &= 8.854 \cdot 10^{-12} ~\rm As/Vm \cdot 1 \cdot {{25 \cdot 10^{-6} {~\rm m} }\over{200 \cdot 10^{-6} {~\rm m} }} \end{align*}