

task_1.9.3_with_calculation

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Exercise 1.9.6 layered plate capacitor (exam task, ca 6 % of a 60-minute exam, WS2020)

Determine the capacitance C for the plate capacitor drawn on the right with the following data:

- rectangular electrodes with edge length of 6 cm and 8 cm .
- distance between the plates: 2 mm
- dielectric A :
 - $\epsilon_{r,A} = 1$ (air)
 - thickness $d_A = 1.5 \text{ mm}$
- Dielectric B :
 - $\epsilon_{r,B} = 100$ (ice)
 - thickness $d_B = 0.5 \text{ mm}$

$$\epsilon_0 = 8.854 \cdot 10^{-12} \text{ F/m}$$

Tips for the solution

- Which circuit can be used to replace a layered structure with different dielectrics?

Solution

The total capacitance C can be divided into a partial capacitance C_{A} and a C_{B} . These are connected in series.

This results in: $C = \frac{C_{\text{A}} \cdot C_{\text{B}}}{C_{\text{A}} + C_{\text{B}}}$

The partial capacitance C_{A} can be calculated by
$$C_{\text{A}} = \epsilon_0 \epsilon_{r,A} \cdot \frac{A}{d_{\text{A}}} \quad | \quad \text{with } A = 3 \text{ cm} \cdot 5 \text{ cm} = 6 \cdot 10^{-2} \cdot 8 \cdot 10^{-2} \text{ m}^2 = 48 \cdot 10^{-4} \text{ m}^2 \\ = 8.854 \cdot 10^{-12} \text{ F/m} \cdot \frac{48 \cdot 10^{-4} \text{ m}^2}{1.5 \cdot 10^{-3} \text{ m}} = 28.33 \cdot 10^{-12} \text{ F}$$

The partial capacitance C_{B} can be calculated by
$$C_{\text{B}} = \epsilon_0 \epsilon_{r,B} \cdot \frac{B}{d_{\text{B}}} = 100 \cdot 8.854 \cdot 10^{-12} \text{ F/m} \cdot \frac{48 \cdot 10^{-4} \text{ m}^2}{0.5 \cdot 10^{-3} \text{ m}} = 8.500 \cdot 10^{-9} \text{ F}$$

Result

$$C = 28.24 \cdot 10^{-12} \text{ F} \rightarrow 28 \text{ pF}$$

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