

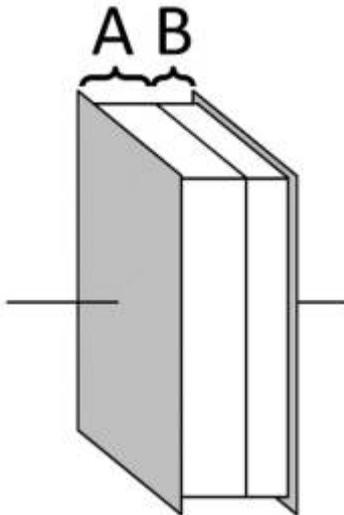
task_1.9.3_with_calculation

Student Group

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Task 1.9.3: 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:
 - $\varepsilon_{r,A} = 1$ (air)
 - thickness $d_A = 1.5 \text{ mm}$
- Dielectric B:
 - $\varepsilon_{r,B} = 100$ (ice)
 - thickness $d_B = 0.5 \text{ mm}$

$$\varepsilon_0 = 8.854 \cdot 10^{-12} \text{ F/m}$$

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.

$$\text{This results in: } C = \frac{C_A \cdot C_B}{C_A + C_B}$$

The partial capacitance C_A can be calculated by
$$C_A = \varepsilon_0 \varepsilon_{r,A} \cdot \frac{A}{d_A} \quad | \quad \text{with } A = 3 \text{ cm} \cdot 5 \text{ cm} = 6 \cdot 10^{-2} \cdot 8 \cdot 10^{-2} \text{ m}^2 = 48 \cdot 10^{-4} \text{ m}^2 \\ C_A = 8.854 \cdot 10^{-12} \text{ F/m} \cdot \frac{48 \cdot 10^{-4} \text{ m}^2}{1.5 \cdot 10^{-3} \text{ m}} \quad C_A = 28.33 \cdot 10^{-12} \text{ F}$$

The partial capacitance C_B can be calculated by
$$C_B = \varepsilon_0 \varepsilon_{r,B} \cdot \frac{A}{d_B} \quad C_B = 100 \cdot 8.854 \cdot 10^{-12} \text{ F/m} \cdot \frac{48 \cdot 10^{-4} \text{ m}^2}{0.5 \cdot 10^{-3} \text{ m}}$$

$$\frac{48 \cdot 10^{-4} \text{ m}^2}{0,5 \cdot 10^{-3} \text{ m}} \parallel C_B \&= 8.500 \cdot 10^{-9} \text{ F}$$

Result

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

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