

# task\_1.9.3\_with\_calculation

## Student Group

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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  $6 \text{ cm}$  and  $8 \text{ cm}$ .
- distance between the plates:  $2 \text{ mm}$
- 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  $C_{\text{A}}$  and a  $C_{\text{B}}$ . 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  $C_{\text{A}}$  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  $C_{\text{B}}$  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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