

task_ddjurcpk494go2q1_with_calculation

Student Group

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electric field, magnetic field, exam ee2 SS2024

Exercise E1 Capacitor

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

2. With the graph of the magnitude of the electric field strength E of the diagram, the cross-section of the capacitor is shown with the inner and outer conductors. The diagram shows the results for the magnitude of the electric field strength E in the region between the conductors and the label for the diagram appears:

Path

- Inner conductor: $+3.3 \text{ mA}$, $+10 \text{ nC}$ (current into the plane of the diagram)
- for $(0.1 \text{ mm} | 0)$: $E_{\text{in}} = 528 \text{ V/m}$
- Outer conductor: -3.3 mA , 0 nC (current out of the plane of diagram)
- for $(0.55 \text{ mm} | 0)$: $E_{\text{out}} = 6.985 \text{ V/m}$

The magnitude of the electric displacement field D can be calculated by: $\int D \cdot dA = Q_{\text{enc}}$.

Here, for any position r from the center, the surrounding area is the surface of a cylindrical shape (here for simplicity without the round endings).

In general, the E -field is proportional to $\frac{1}{r}$ for the situation between both conductors.

So, the E -field is zero on the surface of the inner conductor and zero in the region outside the conductor.

This leads to: $D(x) = \frac{Q}{A} = \frac{Q}{2\pi r \cdot l}$

This is proportional to the area within this radius. Therefore, the formula $H = \frac{1}{2\pi r} \cdot I$ gets $H(x) = \frac{I}{2\pi r}$ at $r = 0.1 \text{ mm}$ and $H(x) = \frac{I}{2\pi r}$ at $r = 0.55 \text{ mm}$.

So, we get for D at $r = 0.1 \text{ mm}$ and D at $r = 0.55 \text{ mm}$.

For x within the outer conductor one also gets a linear proportionality with a $D_{\text{out}} = \frac{Q}{2\pi r \cdot l}$ and $D_{\text{in}} = \frac{Q}{2\pi r \cdot l}$.

Hint: For the direction, one has to consider the sign of the enclosed charge. By this, we see that the D -field is positive.

But here, again only the magnitude was questioned!

.. What is the magnitude of the magnetic field strength H at $(0.1 \text{ mm} | 0)$ and $(0.55 \text{ mm} | 0)$?

Path

The magnitude of the magnetic field strength H can be calculated by: $H = \frac{I}{2 \pi \cdot r}$

So, we get for H_{i} at $(0.1 \text{ mm} | 0)$, and H_{o} at $(0.55 \text{ mm} | 0)$:

$$\begin{aligned} H_{\text{i}} &= \frac{I}{2 \pi \cdot r_{\text{i}}} \quad \&= \frac{+3.3 \text{ A}}{2 \pi \cdot \{0.1 \cdot 10^{-3} \text{ m}\}} \quad \& H_{\text{o}} &= \frac{I}{2 \pi \cdot r_{\text{o}}} \\ & &= \frac{+3.3 \text{ A}}{2 \pi \cdot \{0.55 \cdot 10^{-3} \text{ m}\}} \quad \end{aligned}$$

Hint: For the direction, one has to consider the right-hand rule. By this, we see that the H -field on the right side points downwards.

Therefore, the sign of the H -field is negative.

But here, only the magnitude was questioned!

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