

task_ddjurcpk494go2q1_with_calculation

Student Group

First Name	Surname	Matrikel Nr.

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electric field, magnetic field, exam ee2 SS2024

Exercise E6 Fields of an coax Cable
(written test, approx. 12 % of a 120-minute written test, SS2024)

2. On the graph of the magnitude of the electric field $E(r)$ with the radius r of the coax cable (dia. 4.0 mm) shows the cross-section (0.5 mm) of the inner conductor (0.6 mm) in the center diagram. Use appropriate dimensions and labels for the diagram. The calculation appears:

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- Inner conductor: $+3.3\text{ mA}$, $+10\text{ nC}$ (current into the plane of the diagram)
- Outer conductor: -3.3 mA , 0 nC (current out of the plane of diagram)

- for $(0.1\text{ mm} | 0)$: $E_{(r_i)} = 5.28\text{ V/m}$
- for $(0.55\text{ mm} | 0)$: $E_{(r_o)} = 0.985\text{ V/m}$

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

In general, the E -field is proportional to $\frac{1}{r}$ for the situation between both conductors (the enclosing area is the surface of a cylindrical shape (here for simplicity without the round endings)).

Here, the position radius r is the correct radius.

For the E -field as a function of the radius r (as there is no D within the conductor) within a circle with the radius x :

This leads to: $D(x) = \frac{Q_{enc}}{A} = \frac{Q_{enc}}{\pi \cdot x^2}$

This is proportional to the area within this radius. Therefore, the formula $H = \frac{D}{\epsilon_0}$ gets $H(x) = \frac{Q_{enc}}{\epsilon_0 \cdot \pi \cdot x^2} \cdot x = \frac{Q_{enc}}{\epsilon_0 \cdot \pi \cdot x}$

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 different r : $D(r) = \frac{Q_{enc}}{2 \cdot \pi \cdot r} = \frac{10 \cdot 10^{-9} \text{ C}}{2 \cdot \pi \cdot 0.1 \cdot 10^{-3} \text{ m} \cdot 0.5 \cdot 10^{-3} \text{ m}}$
- $D_{(r_o)} = \frac{Q_{enc}}{2 \cdot \pi \cdot r_o} = \frac{10 \cdot 10^{-9} \text{ C}}{2 \cdot \pi \cdot 0.55 \cdot 10^{-3} \text{ m} \cdot 0.5 \cdot 10^{-3} \text{ m}}$

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 $(0.55\text{ mm} | 0)$?

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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 $r_{\text{i}} = 0.1 \text{ mm}$, and H_{o} at $r_{\text{o}} = 0.55 \text{ mm}$:

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

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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