

task_ddjurcpk494go2q1_with_calculation

Student Group

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Exercise E1 Fields of an coax Cable**(written test, approx. 12 % of a 120-minute written test, SS2024)**

2. With the graph of the magnitude of $E(r)$ with r in mm (see Fig. 4.0.6) shows the cross-section of a coaxial cable with 0.6 mm inner radius and 0.55 mm outer radius. Use proper dimensions and labels for the diagram.

- Path diagram
- 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 the diagram)
 - for $(0.1 \text{ mm} | 0)$: $E_{\text{r}} = 528 \text{ V/m}$
 - for $(0.55 \text{ mm} | 0)$: $E_{\text{r}} = 0.985 \text{ V/m}$

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

In general, the E -field is proportional to $\frac{1}{r}$ for the situation between two conductors (here for simplicity without the round endings).

For the E -field, the surface of the cylinder is the surface of a cylindrical shape (here for simplicity without the round endings). This leads to: $D(r) = \frac{Q_{\text{enc}}}{A} = \frac{Q_{\text{enc}}}{2\pi r \cdot l}$.

This is proportional to the area within this radius. Therefore, the formula $H = \frac{D}{\mu_0}$ gets $H(r) = \frac{Q_{\text{enc}}}{2\pi \cdot \mu_0 \cdot r \cdot l}$. So, we get for D at $r = 0.1 \text{ mm}$ and $r = 0.55 \text{ mm}$. This leads to a formula proportional to $\frac{1}{r}$.

For r within the outer conductor one also gets a linear proportionality with a $\frac{1}{r}$ and $D(r) = \frac{Q_{\text{enc}}}{2\pi \cdot r \cdot l}$. $D(r) = \frac{10 \cdot 10^{-9} \text{ C}}{2\pi \cdot 0.1 \cdot 10^{-3} \text{ m} \cdot 0.5 \cdot 10^{-3} \text{ m}}$. $D(r) = \frac{10 \cdot 10^{-9} \text{ C}}{2\pi \cdot 0.55 \cdot 10^{-3} \text{ m} \cdot 0.5 \cdot 10^{-3} \text{ m}}$.

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

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 $r_{\text{o}} = 0.55 \text{ mm}$:

$$H_{\text{i}} = \frac{I}{2 \pi \cdot r_{\text{i}}} \quad \text{and} \quad H_{\text{o}} = \frac{I}{2 \pi \cdot r_{\text{o}}}$$

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

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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