

# task\_ddjurcpk494go2q1\_with\_calculation

## Student Group

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electric field, magnetic field, exam ee2 SS2024

Exercise E10 Fields of an coax Cable (written test, approx. 12 % of a 120-minute written test, SS2024)

2. Plot the graph of the magnitude of the electric field  $E(r)$  with  $r$  in  $\text{mm}$ . The dia  $d = 0.6 \text{ mm}$  shows the cross-section of the inner conductor with  $(0.6 \text{ mm} | 0)$  in center. The diagram also depicts dimensions and labels for the diagram.

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

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

- for  $(0.1 \text{ mm} | 0)$ :  $E_{\text{in}} = 3.28 \dots \text{ V/m}$
- for  $(0.55 \text{ mm} | 0)$ :  $E_{\text{out}} = 0.985 \dots \text{ V/m}$

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 both conductors (the enclosing area is the surface of a cylindrical shape (here for simplicity without the round endings)).

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

For  $x$  within the outer conductor one also gets a linear proportionality with a different  $r$  and  $I$ :  $H = \frac{I}{2\pi r}$  and  $H = \frac{10 \cdot 10^{-9} \text{ C}}{2\pi \cdot 0.1 \cdot 10^{-3} \text{ m} \cdot 0.5 \text{ mm}}$

$D_{\text{in}} = \frac{Q}{2\pi \cdot 0.1 \text{ mm}}$  and  $D_{\text{out}} = \frac{10 \cdot 10^{-9} \text{ C}}{2\pi \cdot 0.55 \cdot 10^{-3} \text{ m} \cdot 0.5 \text{ mm}}$

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