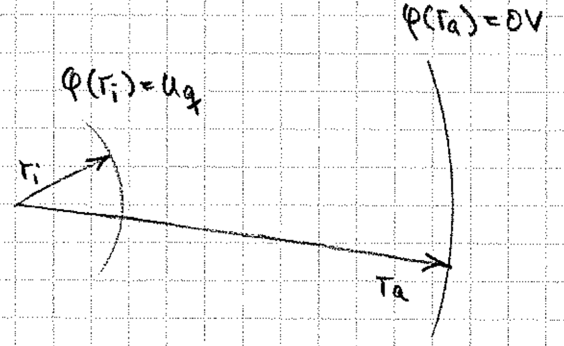
GET (2) Rechenübung (25) Aufgabe (1) Markus Symmank 05.06.2025

Anordnung aus Rü (24) Aufg. (2)



aus Rü 24/2:

$$E(r) = \frac{U_q}{\ln\left(\frac{r_a}{r_i}\right) r}$$

ges: $\varphi(r)$

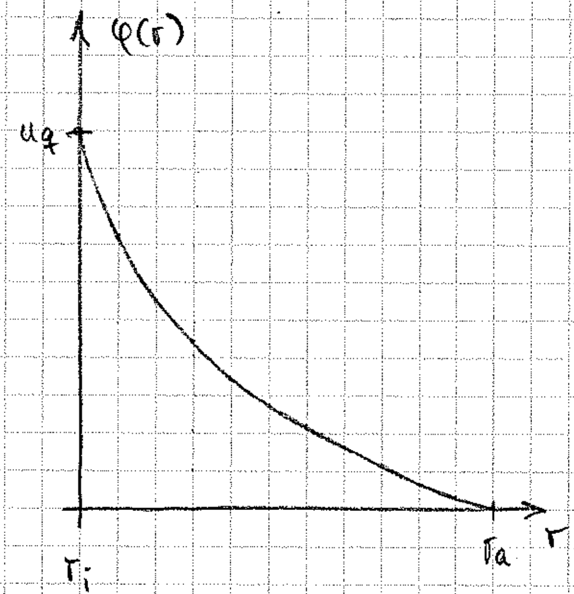
Ansatz: Potenzialdifferenz

$$U = \int_r^{r_a} E(r)\, dr = \varphi(r) - \varphi(r_a) \leftarrow 0V$$

$$\rightsquigarrow \varphi(r) = \int_r^{r_a} E(r)\, dr = \frac{U_q}{\ln\left(\frac{r_a}{r_i}\right)} \int_r^{r_a} \frac{1}{r}\, dr = \frac{U_q}{\ln\left(\frac{r_a}{r_i}\right)} \Big[\ln(r)\Big]_r^{r_a}$$

$$\varphi(r) = \frac{U_q}{\ln\left(\frac{r_a}{r_i}\right)} \left(\ln(r_a) - \ln(r)\right)$$

$$\underline{\underline{\varphi(r) = \frac{U_q}{\ln\left(\frac{r_a}{r_i}\right)} \ln\left(\frac{r_a}{r}\right)}}$$



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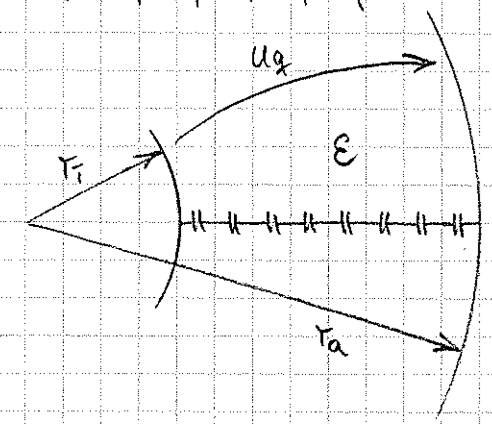
geg: $r_i, r_a, \varepsilon, h, u_q$



a) ges: C $\rightsquigarrow$ Ansatz: Infitisimale Reihenschaltung von Kapazitäten

$$\frac{1}{C} = \sum_{i=1}^{N} \frac{1}{C_i} \longrightarrow \frac{1}{C} = \int \frac{1}{dC}$$

$$dC = \varepsilon \frac{A(r)}{dr} = \frac{2\pi r h \varepsilon}{dr}$$

$$\frac{1}{C} = \int_{r_i}^{r_a} \frac{dr}{2\pi r h \varepsilon} = \frac{1}{2\pi h \varepsilon} \int_{r_i}^{r_a} \frac{1}{r}\, dr$$

$$\frac{1}{C} = \frac{\ln(r_a) - \ln(r_i)}{2\pi h \varepsilon}$$

$$\searrow$$

$$C = \frac{2\pi h \varepsilon}{\ln\left(\frac{r_a}{r_i}\right)}$$

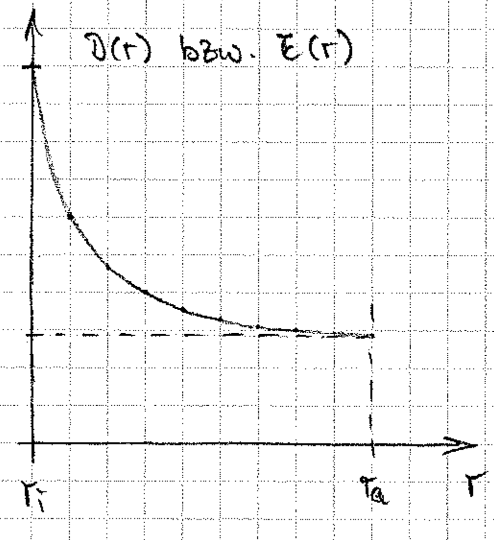
b) ges: $D(r)$ Verschiebungsflussdichte, $E(r)$

$$D(r) = \frac{Q}{A(r)} = \frac{u \cdot C}{A(r)} = \frac{u_q \cdot \cancel{2\pi h} \varepsilon}{\ln\left(\frac{r_a}{r_i}\right) \cancel{2\pi} r \cancel{h}} = \frac{u_q \varepsilon}{\ln\left(\frac{r_a}{r_i}\right)} \cdot \frac{1}{r}$$

$$D = \varepsilon E \rightsquigarrow E = \frac{D}{\varepsilon}$$

$$E(r) = \frac{u_q}{\ln\left(\frac{r_a}{r_i}\right)} \cdot \frac{1}{r}$$

✓ Stimmt mit Ergebnis aus RÜ 24/2 überein



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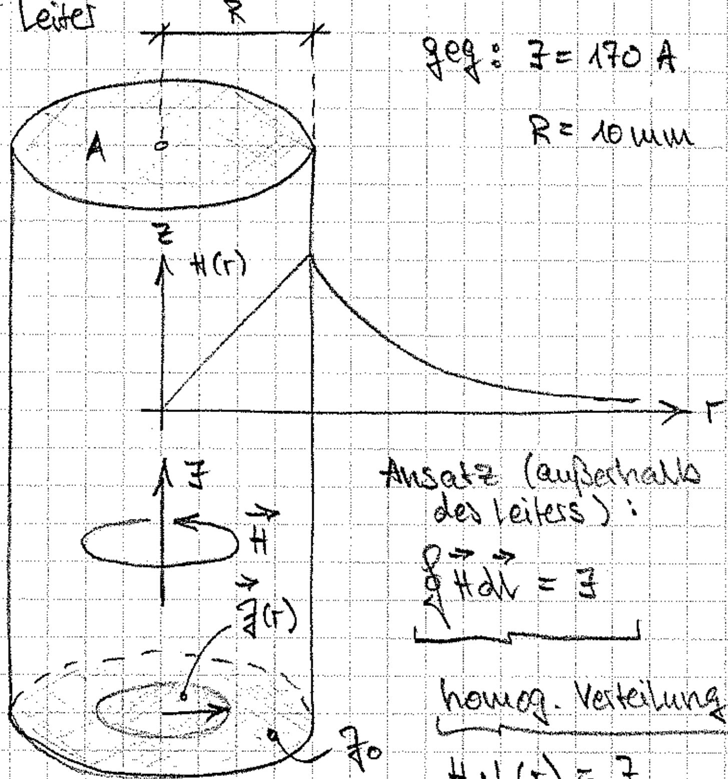
Sehr langer, stromdurchflossener Leiter



geg: $I = 170\,A$

$R = 10\,mm$

Durchflutungsgesetz:

$$\vec{\nabla} \times \vec{H} = \vec{J}$$

↓ Stokes

$$\int_A \vec{\nabla} \times \vec{H}\, dA = \int_A \vec{J}\, dA$$

↓

$$\oint \vec{H}\, d\vec{l} = I$$

Ansatz (außerhalb des Leiters):

$$\underbrace{\oint \vec{H}\, d\vec{l}}_{\text{homog. Verteilung}} = I$$

$$H \cdot L(r) = I$$

$$H(r) = \frac{I}{L(r)} = \frac{I}{2\pi} \cdot \frac{1}{r}$$

$$B(r) = \mu_0 H(r) = \frac{\mu_0 \cdot I}{2\pi} \cdot \frac{1}{r}$$

Ansatz (innerhalb des Leiters):

$$\oint \vec{H}\, d\vec{l} = \underbrace{\int \vec{J}\, d\vec{A}}_{I}$$

homog. Verteilung

$$H\, L(r) = J_0 A(r)$$

$$H \cdot 2\pi \cancel{r} = \frac{I}{\cancel{\pi} R^2} \cancel{\pi} r^{\cancel{2}}$$

$$H \cdot 2\pi = \frac{I}{R^2} r$$

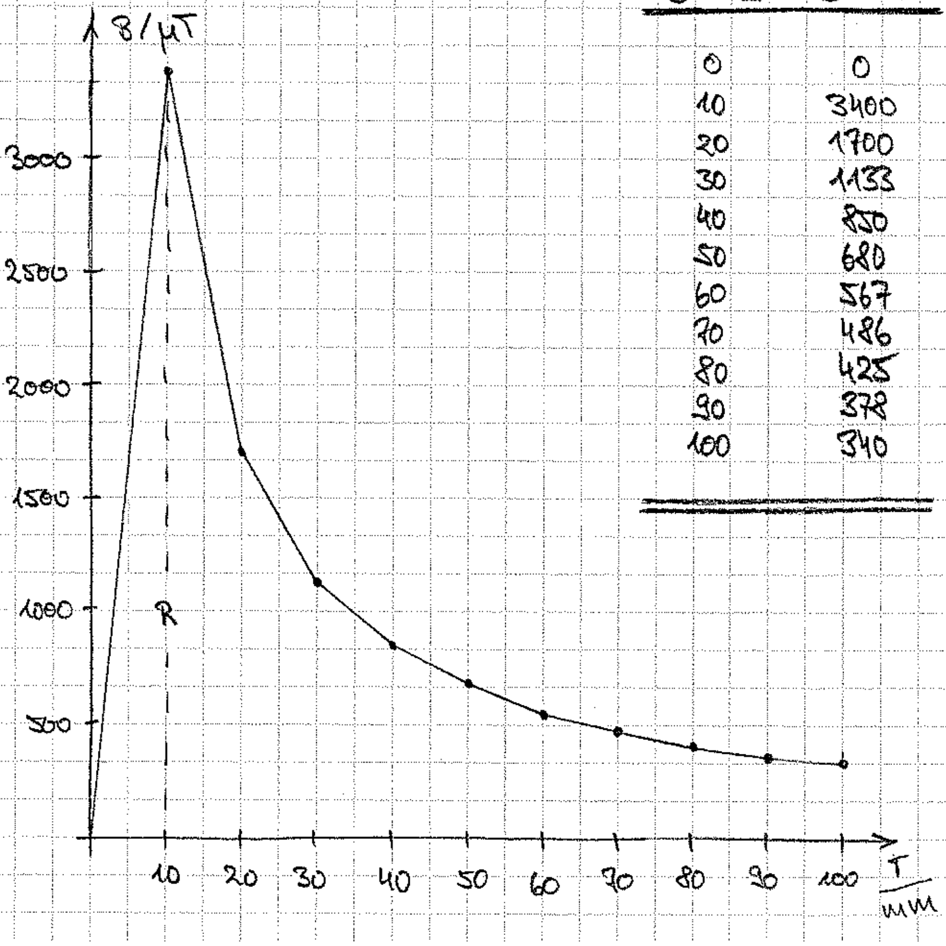
$$\rightsquigarrow H(r) = \frac{I}{2\pi R^2} r$$

$$B(r) = \mu_0 \mu_r H(r)$$

$$\rightsquigarrow B(r) = \frac{\mu_0 \mu_r I}{2\pi R^2} r$$

$\mu_{r,Cu} \approx 1$

$$\hookrightarrow B(r) = \frac{\mu_0 I}{2\pi R^2} r$$



r [mm]	B [μT]
0	0
10	3400
20	1700
30	1133
40	850
50	680
60	567
70	486
80	425
90	378
100	340