1. Magnetfeld eines Koaxialkabels

For $r \leq R_1$:

$$I_{in} = I\,\frac{r^2}{R_1^2}$$
$$I_{in}\mu_0 = \oint \vec{B}(\vec{r})\,\mathrm{d}\vec{s} = B(r)\oint \mathrm{d}s = B(r)2r\pi$$
$$B(r) = \frac{I\mu_0}{2\pi R_1^2}r$$

For $R_1 \leq r \leq R_2$:

$$I_{in} = I$$
$$I_{in}\mu_0 = \oint \vec{B}(\vec{r})\,\mathrm{d}\vec{s} = B(r)\oint \mathrm{d}s = B(r)2r\pi$$
$$B(r) = \frac{I\mu_0}{2\pi}\frac{1}{r}$$

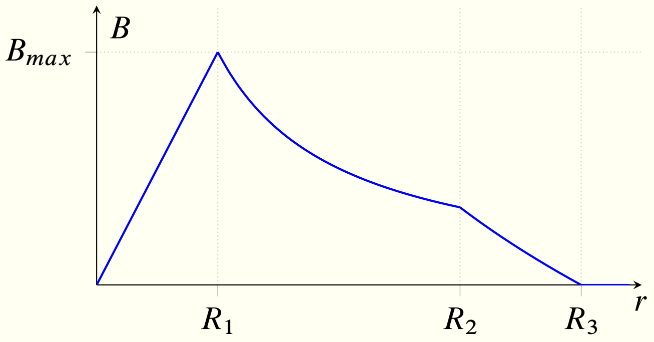
For $R_2 \leq r \leq R_3$:

$$I_{in} = I\left(1 - \frac{r^2-R_2^2}{R_3^2-R_2^2}\right)$$
$$I_{in}\mu_0 = \oint \vec{B}(\vec{r})\,\mathrm{d}\vec{s} = B(r)\oint \mathrm{d}s = B(r)2r\pi$$
$$B(r) = \frac{I\mu_0}{2\pi}\left(\frac{1}{r} - \frac{r^2-R_2^2}{r(R_3^2-R_2^2)}\right)$$

For $R_3 \leq r$:

$$I_{in} = 0$$
$$B(r) = 0$$

$$\boxed{B(r) = \begin{cases} \frac{I\mu_0}{2\pi R_1^2}r & \text{for } 0 < r \leq R_1, \\ \frac{I\mu_0}{2\pi}\frac{1}{r} & \text{for } R_1 \leq r \leq R_2, \\ \frac{I\mu_0}{2\pi}\left(\frac{1}{r} - \frac{r^2-R_2^2}{r(R_3^2-R_2^2)}\right) & \text{for } R_2 \leq r \leq R_3, \\ 0 & \text{for } R_3 \leq r. \end{cases}}$$



2. Anwendung des Gesetzes von Biot-Savart – „Haarnadel“

$$r = \sqrt{x^2 + y^2 + z^2}$$

$$\begin{aligned}
\mathrm{d}B_1 &= \tfrac{\mu_0 I}{4\pi} \tfrac{|\mathrm{d}\vec{l}\times\vec{r}|}{r^3} = \tfrac{\mu_0 I}{4\pi} \tfrac{\mathrm{d}l}{r^2} = \tfrac{\mu_0 I}{4\pi} \tfrac{\mathrm{d}\varphi R}{r^2} \\
B_1 &= \tfrac{\mu_0 I}{4\pi} \tfrac{R}{r^2} \int\limits_0^\pi 1 \,\mathrm{d}\varphi = \tfrac{\mu_0 I}{4} \tfrac{R}{r^2} \\
B_{x,1} &= B_1 \sin(\theta) = \tfrac{\mu_0 I}{4} \tfrac{R}{r^2} \sin(\theta) = \tfrac{\mu_0 I}{4} \tfrac{R^2}{r^3} \\
B_{z,1} &= B_1 \cos(\theta) = \tfrac{\mu_0 I}{4} \tfrac{R}{r^2} \cos(\theta) = \tfrac{\mu_0 I}{4} \tfrac{Rz}{r^3}
\end{aligned}$$

$$\begin{aligned}
\mathrm{d}B_2 &= \tfrac{\mu_0 I}{4\pi} \tfrac{|\mathrm{d}\vec{l}\times\vec{r}|}{r^3} = \tfrac{\mu_0 I}{4\pi} \tfrac{\mathrm{d}l\sin(\theta)}{r^2} = \tfrac{\mu_0 I}{4\pi} \tfrac{\mathrm{d}l\sqrt{y^2+z^2}}{r^3} \\
B_2 &= \tfrac{\mu_0 I}{2\pi} \int\limits_{-\infty}^0 \tfrac{\sqrt{y^2+z^2}}{r^3} \,\mathrm{d}x = \tfrac{\mu_0 I}{2\pi} \tfrac{1}{\sqrt{y^2+z^2}} \\
B_{z,2} &= B_2 \cos(\theta) = \tfrac{\mu_0 I}{2\pi} \tfrac{1}{\sqrt{y^2+z^2}} \cos(\theta) = \tfrac{\mu_0 I}{2\pi} \tfrac{z}{\sqrt{y^2+z^2}\sqrt{x^2+y^2+z^2}} \\
\vec{B}(z) &= \tfrac{\mu_0 I}{4} \begin{pmatrix} R^2/\left(x^2+y^2+z^2\right)^{3/2} \\ 0 \\ \tfrac{Rz}{\left(x^2+y^2+z^2\right)^{3/2}} + \tfrac{2z}{\pi\sqrt{y^2+z^2}\sqrt{x^2+y^2+z^2}} \end{pmatrix}
\end{aligned}$$

3. Drehmoment auf rechteckige Leiterschleife

a)

b)