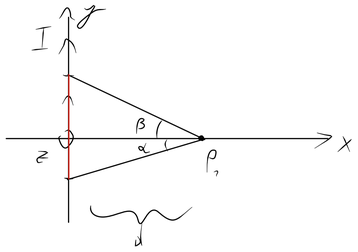
$$P = I^2 R = \frac{\mathcal{E}^2 R}{\left(R + \frac{1+\sqrt{5}}{2} r\right)^2} \Omega^2$$

$$\frac{dP}{dR} = \frac{\left(R + \frac{1+\sqrt{5}}{2} r\right) - \mathcal{E}^2 R \cdot 2 \left(R + \frac{1+\sqrt{5}}{2} r\right)}{\left(R + \frac{1+\sqrt{5}}{2} r\right)^4}$$

$$R + \frac{1+\sqrt{5}}{2} r - 2R = 0$$

$$R = \frac{1+\sqrt{5}}{2} r$$

$6 + 2\sqrt{5}$



$$d\bar{B} = \frac{\mu_0 I}{4\pi} \frac{d\bar{l} \times \bar{r}}{r^3} \qquad d\bar{l} = d \sec^2\varphi \, \hat{e}_y \, d\varphi = \begin{bmatrix} 0 \\ d\sec^2\varphi \\ 0 \end{bmatrix} d\varphi \qquad \bar{r} = \begin{bmatrix} d \\ -d\tan\varphi \\ 0 \end{bmatrix}$$

$$\bar{l} = d \tan\varphi \, \hat{e}_y$$

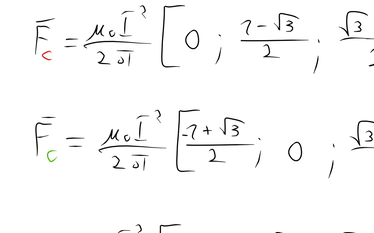
$$d\bar{l} \times \bar{r} = \begin{bmatrix} 0 \\ d\sec^2\varphi \, d\varphi \\ 0 \end{bmatrix} \times \begin{bmatrix} d \\ -d\tan\varphi \\ 0 \end{bmatrix} = d^2 d\varphi \begin{bmatrix} 0 \\ 0 \\ \sec^2\varphi \end{bmatrix} = d^2 d\varphi \sec^2\varphi \, \hat{e}_z$$

$$\bar{B} = \frac{\mu_0 \bar{I}}{4\pi} \int_{-\alpha}^{\beta} \frac{d^2 \sec^2\varphi \, d\varphi}{\sqrt{d^2 + d^2 \tan^2\varphi}^3} = \frac{\mu_0 \bar{I}}{4\pi d} \int_{-\alpha}^{\beta} \cos\varphi \, d\varphi = \frac{\mu_0 \bar{I}}{4\pi d} \left(\sin\beta + \sin\alpha\right) \hat{e}_z =$$

$d \sec\varphi$

$$= \frac{\mu_0 I}{4\pi d} \left(\frac{y_\beta}{\sqrt{d^2 + y_\beta^2}} - \frac{y_\alpha}{\sqrt{d^2 + y_\alpha^2}} \right) = \left\{ \begin{array}{l} y_\beta - y_\alpha = a \\ y_\alpha + a = y_\beta \end{array} \right\} = \frac{\mu_0 I}{4\pi d} \left(\frac{y + a}{\sqrt{d^2 + (y+a)^2}} - \frac{y}{\sqrt{d^2 + y^2}} \right) \hat{e}_z = B(y) \hat{e}_z$$

y to współrzędna dolna



Ruszam prętem, nie punktem.

$$d\bar{F} = \bar{I} \cdot d\bar{y} \times \bar{B} \qquad d\bar{F} = I \, dy \, B(y) \, \hat{e}_y \times e_z = I \, dy \, B(y) \, \hat{e}_x$$

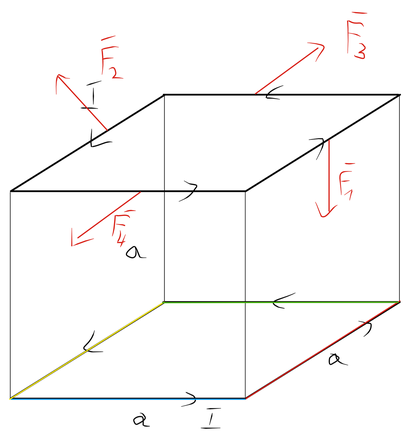
$$\bar{F} = \frac{\mu_0 \bar{I}^2 \hat{e}_x}{4\pi d} \int_{-a}^{0} \frac{y + a}{\sqrt{d^2 + (y+a)^2}} - \frac{y}{\sqrt{d^2 + y^2}} \, dy = \left\{ \begin{array}{lll} u = d^2 + (y+a)^2 & t = d^2 + y^2 & \\ \frac{du}{2} = (y+a)\,dy & \frac{dt}{2} = y\,dy & \\ -a \to d^2 \quad 0 \to d^2 + a^2 & -a \to d^2 + a^2 & 0 \to d^2 \end{array} \right\} =$$

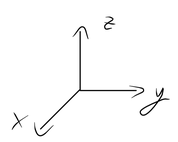
$$= \frac{\mu_0 \bar{I}^2 \hat{e}_x}{8\pi d} \left[\int_{d^2}^{d^2+a^2} \frac{1}{\sqrt{u}} \, du + \int_{d^2}^{d^2+a^2} \frac{1}{\sqrt{t}} \, dt \right] = \frac{\mu_0 \bar{I}^2 \hat{e}_x}{4\pi d} \left[2\sqrt{u} \right]_{d^2}^{d^2+a^2} = \frac{\mu_0 \bar{I}^2 \hat{e}_x}{2\pi d} \left[\sqrt{d^2+a^2} - d \right]$$

$$= \frac{\mu_0 \bar{I}^2 \hat{e}_x}{2\pi d} \cdot \frac{a^2}{\sqrt{d^2+a^2} + d} \xrightarrow{a \to d} \frac{\mu_0 \bar{I}^2 a}{2\pi d}$$

czyli jak dla dwóch nieskończonych prętów, więc się zgadza

$$\bar{F}(d) = \frac{\mu_0 \bar{I}^2 \hat{e}_x}{2\pi d} \frac{a^2}{\sqrt{d^2+a^2} + d}$$





Siły działające na prostopadłe boki będą się równoważyć z racji symetrii i przeciwnych zwrotów prądów.

$$\bar{F}_4 + \bar{F}_3 = 0$$

$$\bar{F}_1(a) = \frac{-\mu_0 \bar{I}^2}{2\pi a} \frac{a^2}{\sqrt{a^2+a^2} + a} \hat{e}_z = \frac{\mu_0 \bar{I}^2}{2\pi} (-\sqrt{2} + 1) \hat{e}_z$$

$$\bar{F}_2(a\sqrt{2}) = \frac{\mu_0 \bar{I}^2}{2\pi \, a\sqrt{2}} \left(\sqrt{2a^2 + a^2} - \sqrt{2}\, a \right) \left[0; -\frac{\sqrt{2}}{2}; \frac{\sqrt{2}}{2} \right] =$$

$$= \frac{\mu_0 \bar{I}^2}{2\pi} \frac{\sqrt{3} - \sqrt{2}}{2} \left[0; -1; 1 \right]$$

$$\bar{F} = \frac{\mu_0 \bar{I}^2}{\pi} \left(\sqrt{3} - 3\sqrt{2} + 2 \right) e_z$$

$$\bar{F}_C = \frac{\mu_0 \bar{I}^2}{2\pi} \left[0; \frac{1-\sqrt{3}}{2}; \frac{\sqrt{3} - 3\sqrt{2}}{2} + 1 \right]$$

$$\bar{F}_C = \frac{\mu_0 \bar{I}^2}{2\pi} \left[\frac{-1+\sqrt{3}}{2}; 0; \frac{\sqrt{3} - 3\sqrt{2}}{2} + 1 \right]$$

$$\bar{F}_C = \frac{\mu_0 \bar{I}^2}{2\pi} \left[0; \frac{-1+\sqrt{3}}{2}; \frac{\sqrt{3} - 3\sqrt{2}}{2} + 1 \right]$$

$$\bar{F}_C = \frac{\mu_0 \bar{I}^2}{2\pi} \left[\frac{1-\sqrt{3}}{2}; 0; \frac{\sqrt{3} - 3\sqrt{2}}{2} + 1 \right]$$