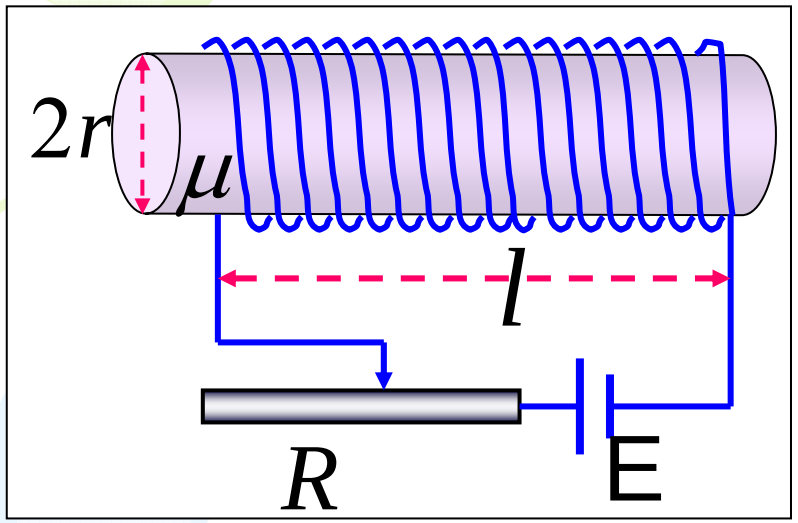



$$\mathcal{E} - L\frac{\mathrm{d}I}{\mathrm{d}t} = RI$$

$$\mathcal{E}I\mathrm{d}t - LI\mathrm{d}I = RI^2\mathrm{d}t$$

$$\int_0^t \mathcal{E}\, I\mathrm{d}t = \frac{1}{2}LI^2 + \int_0^t RI^2\mathrm{d}t$$

电源作功

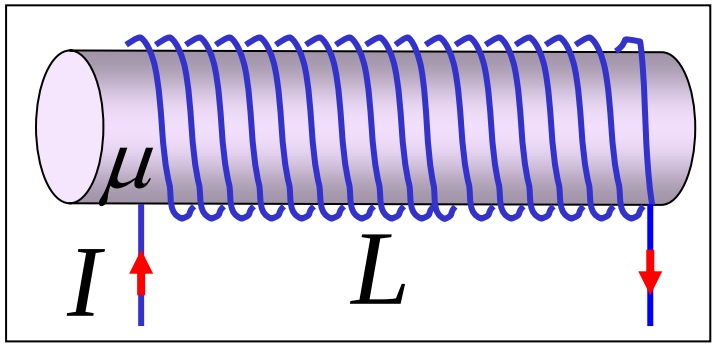
电源反抗自感电动势作的功

回路电阻所放出的焦耳热

自感线圈磁能

$$W_{\mathrm{m}} = \frac{1}{2}LI^2$$

- 自感线圈磁能 $W_{\mathrm{m}} = \frac{1}{2} LI^2$




$$L = \mu n^2 V, \quad B = \mu n I$$

$$W_{\mathrm{m}} = \frac{1}{2} LI^2 = \frac{1}{2} \mu n^2 V \left(\frac{B}{\mu n}\right)^2 = \frac{1}{2} \frac{B^2}{\mu} V = w_{\mathrm{m}} V$$

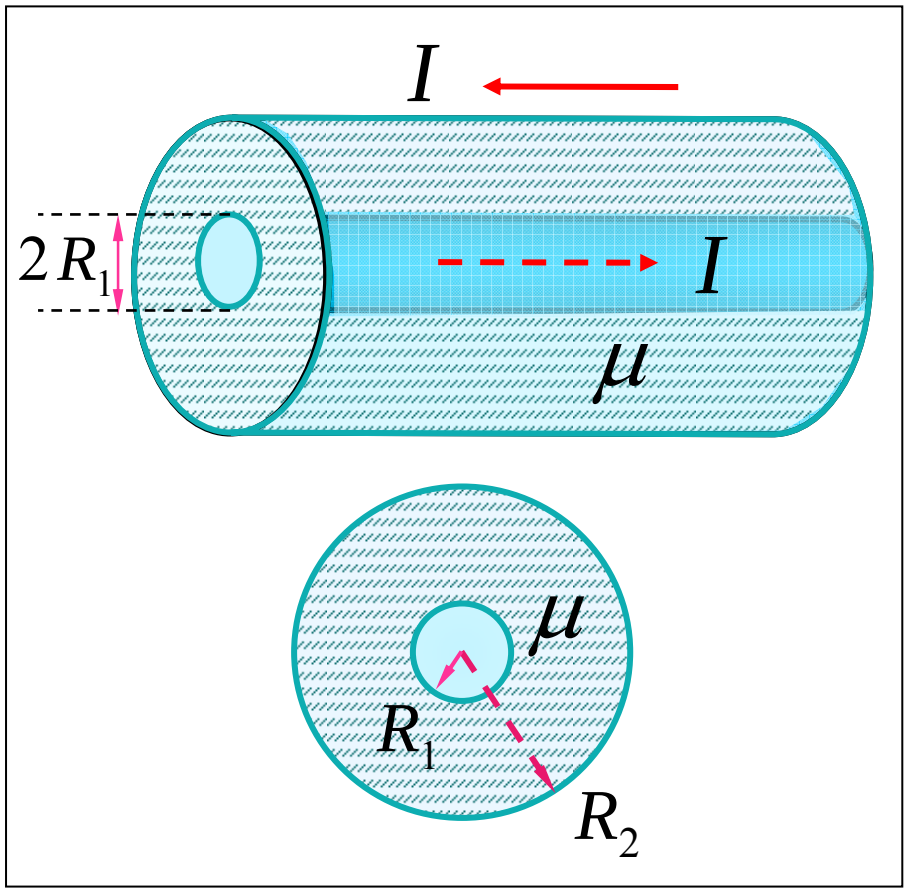
- 磁场能量密度 $w_{\mathrm{m}} = \frac{B^2}{2\mu} = \frac{1}{2} \mu H^2 = \frac{1}{2} BH$

- 磁场能量 $W_{\mathrm{m}} = \int_V w_{\mathrm{m}} \mathrm{d}V = \int_V \frac{B^2}{2\mu} \mathrm{d}V$

例　如图同轴电缆,中间充以磁介质,芯线与圆筒上的电流大小相等、方向相反. 已知 $R_1$, $R_2$, $I$, $\mu$, 求单位长度同轴电缆的磁能和自感. 设金属芯线内的磁场可略.

解　由安培环路定律可求 $H$

$$\begin{cases} r < R_1, & H = 0 \\ R_1 < r < R_2, & H = \dfrac{I}{2\pi r} \\ r > R_2, & H = 0 \end{cases}$$




则　$R_1 < r < R_2$

$$w_m = \frac{1}{2}\mu H^2 = \frac{1}{2}\mu\left(\frac{I}{2\pi r}\right)^2$$

$$R_1 < r < R_2 \quad w_m = \frac{1}{2}\mu\left(\frac{I}{2\pi r}\right)^2 = \frac{\mu I^2}{8\pi^2 r^2}$$

$$W_m = \int_V w_m \mathrm{d}V = \int_V \frac{\mu I^2}{8\pi^2 r^2}\mathrm{d}V$$

单位长度壳层体积

$$\mathrm{d}V = 2\pi r \mathrm{d}r \cdot 1$$

$$W_m = \int_{R_1}^{R_2} \frac{\mu I^2}{4\pi r}\mathrm{d}r = \frac{\mu I^2}{4\pi}\ln\frac{R_2}{R_1}$$

$$W_m = \frac{1}{2}LI^2 \qquad L = \frac{\mu}{2\pi}\ln\frac{R_2}{R_1}$$