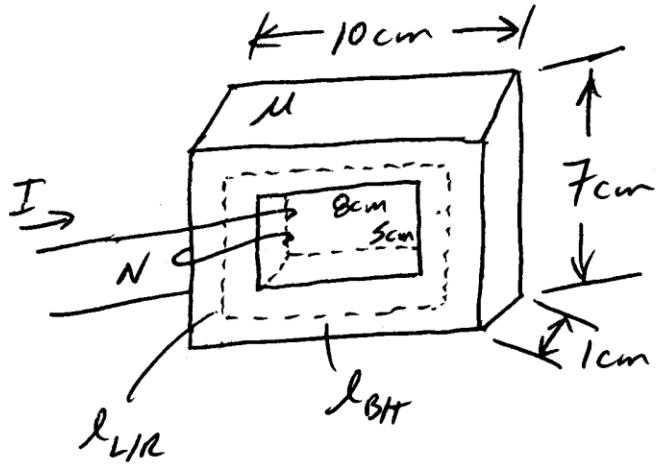
Magnetic Circuit Example

For the problem shown, find/estimate Ψ, L, W_m, $|\bar{B}|$, and $|\bar{H}|$ using the magnetic circuit approach.



$N = 50$ turns

$I = 4$ A

$\mu = 4000\,\mu_0$

$$\ell_{L/R} = 7\text{cm} - \left(\frac{7-5}{2}\right) = 7 - 1 = 6\text{ cm} = \underline{0.06\text{m}}$$

$$\ell_{B/T} = 10\text{cm} - \left(\frac{10-8}{2}\right) = 10 - 1 = 9\text{ cm} = \underline{0.09\text{m}}$$

$$A = 1\text{cm}(1\text{cm}) = \underline{10^{-4}\,\text{m}^2}$$

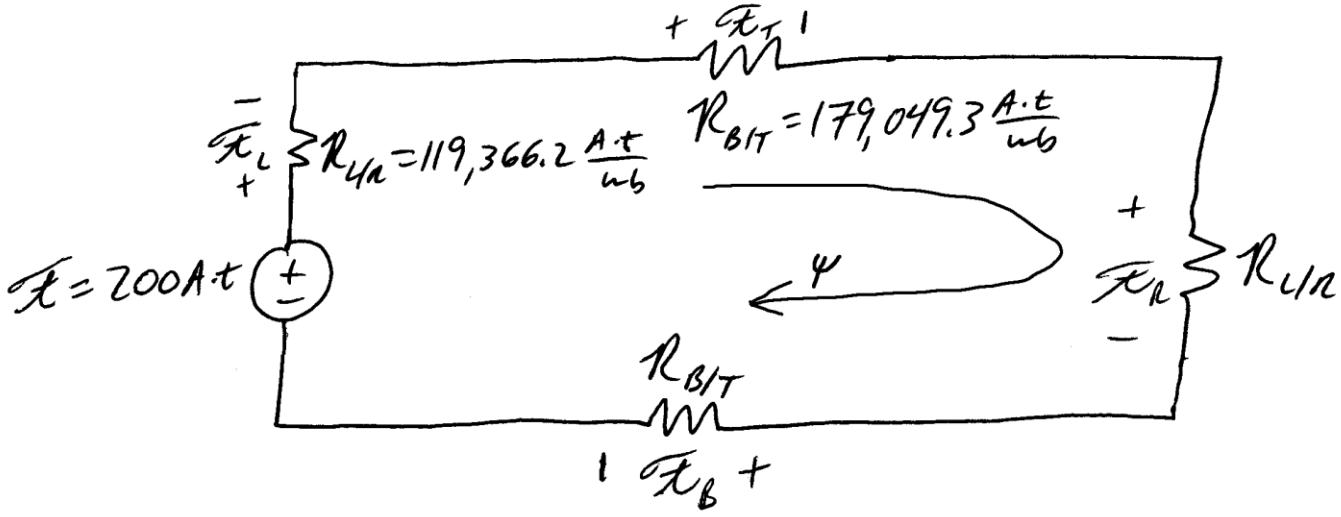
$$\mathcal{R}_{L/R} = \frac{\ell_{L/R}}{\mu A} = \frac{0.06}{4000(4\pi\times10^{-7})(10^{-4})} = \underline{119{,}366.2\ \frac{\text{A.t}}{\text{wb}}}$$

$$\mathcal{R}_{B/T} = \frac{\ell_{B/T}}{\mu A} = \frac{0.09}{4000(4\pi\times10^{-7})(10^{-4})} = \underline{179{,}049.3\ \frac{\text{A.t}}{\text{wb}}}$$

mmf Source $\mathcal{F} = NI = 50(4) = \underline{200\ \text{A.t}}$

ex. cont.

Equivalent Magnetic Circuit



$$\mathcal{R}_{eq} = \mathcal{R}_{LIR} + \mathcal{R}_{BIT} + \mathcal{R}_{LIR} + \mathcal{R}_{BIT}$$

$$= 2(119{,}366.2) + 2(179{,}049.3)$$

$$\mathcal{R}_{eq} = 596{,}831 \ A\cdot t/wb$$

$$L = N^2/\mathcal{R}_{eq} = \frac{50^2}{596{,}831} = 4.189 \ mH$$

$$\Psi = \frac{\mathcal{F}}{\mathcal{R}_{eq}} = \frac{200}{596{,}831} = 0.3351 \ mWb$$

$$W_m = \tfrac{1}{2} L I^2 = \tfrac{1}{2}(4.189 \times 10^{-3})(4^2) = 33.51 \ mJ$$

ex. cont.

$$BA = \Psi \Rightarrow \quad B = |\bar{B}| = \frac{\Psi}{A} = \frac{3.351 \times 10^{-4}}{10^{-4}}$$

$$= 3.351 \text{ Wb/m}^2 = \text{T}$$

$$|\bar{H}| = H = B/\mu = \frac{3.351}{4000(4\pi \times 10^{-7})} = 666.66 \text{ A/m}$$

mmf drops on each side of core?

$$mmf_{B/T} = \mathcal{F}_{B/T} = \Psi \mathcal{R}_{B/T} = (3.351 \times 10^{-4})(179{,}049.3)$$

$$\mathcal{F}_{B/T} = 60 \text{ A·t}$$

"KVL"

$$\mathcal{F} = \mathcal{F}_B + \mathcal{F}_T + \mathcal{F}_L + \mathcal{F}_R$$

$$\hookrightarrow \mathcal{F}_L + \mathcal{F}_R = 200 - 60 - 60 = 80$$

$$\mathcal{F}_{L/R} = 80/2 = 40 \text{ A·t}$$