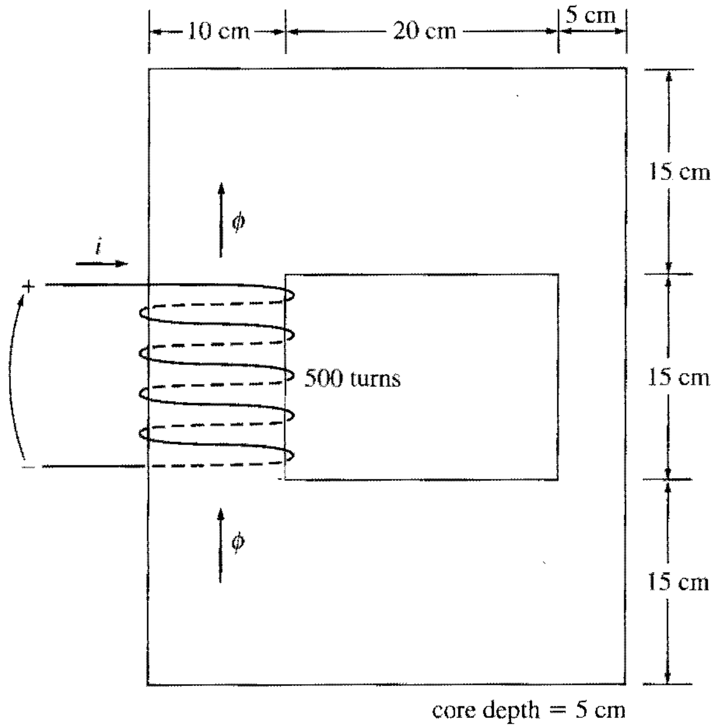
1–5 A ferromagnetic core is shown in Figure P1–2. The depth of the core is 5 cm. The other dimensions of the core are as shown in the figure. Find the value of the current that will produce a flux of 0.003 Wb. With this current, what is the flux density at the top of the core? What is the flux density at the right side of the core? Assume that the relative permeability of the core is 1000.

Figure P1–2 | The core of Problems 1–5 and 1–16.



- First, draw the equivalent magnetic circuit.

First, find cross-sectional areas: $A_L = (10\text{ cm})(5\text{ cm}) = 50\text{ cm}^2 = 0.005\text{ m}^2$,

$A_T = A_B = (15\text{ cm})(5\text{ cm}) = 75\text{ cm}^2 = 0.0075\text{ m}^2$, and

$A_R = (5\text{ cm})(5\text{ cm}) = 25\text{ cm}^2 = 0.0025\text{ m}^2$.

Next, find mean path lengths: $\ell_L = \ell_R = 15/2 + 15 + 15/2 = 30\text{ cm} = 0.3\text{ m}$ and

$\ell_T = \ell_B = 10/2 + 20 + 5/2 = 27.5\text{ cm} = 0.275\text{ m}$.

Calculate reluctances, using (1-32) $\mathcal{R} = \dfrac{\ell}{\mu A}$, on the:

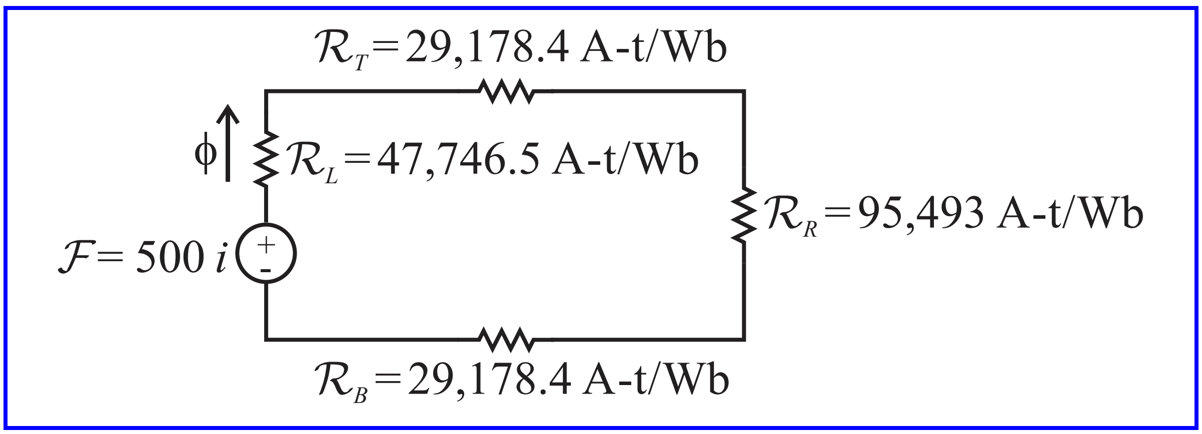
left $\mathcal{R}_L = \dfrac{\ell_L}{\mu A_L} = \dfrac{0.3}{1000(4\pi\bullet 10^{-7})0.005}$ $\Rightarrow$ $\underline{\mathcal{R}_L = 47{,}746.5\text{ A-t/Wb}}$, top $\mathcal{R}_T = \dfrac{\ell_T}{\mu A_T} = \dfrac{0.275}{1000(4\pi \bullet 10^{-7})0.0075}$ $\Rightarrow$ $\mathcal{R}_T = 29{,}178.4$ A-t/Wb,

right $\mathcal{R}_R = \dfrac{\ell_R}{\mu A_R} = \dfrac{0.3}{1000(4\pi \bullet 10^{-7})0.0025}$ $\Rightarrow$ $\mathcal{R}_R = 95{,}493.0$ A-t/Wb, and

bottom $\mathcal{R}_B = \dfrac{\ell_B}{\mu A_B} = \dfrac{0.275}{1000(4\pi \bullet 10^{-7})0.0075}$ $\Rightarrow$ $\mathcal{R}_B = 29{,}178.4$ A-t/Wb.

Calculate coil mmf, using (1-27) $\mathcal{F} = Ni$ $\Rightarrow$ $\mathcal{F} = 500i$. Use RHR with current, to find the polarity of coil mmf.

Magnetic circuit



Use (1-33) to calculate the equivalent reluctance ‘seen’ by the coil as

$\mathcal{R} = \mathcal{R}_L + \mathcal{R}_T + \mathcal{R}_R + \mathcal{R}_B = 47{,}746.5 + 29{,}178.4 + 95{,}493 + 29{,}178.4$

$\Rightarrow$ $\mathcal{R} = 201{,}596.3$ A-t/Wb.

Per (1-28) $\mathcal{F} = \phi\mathcal{R} \Rightarrow 500i = 0.003\ (201{,}596.3)$ $\Rightarrow$ **$i = 1.2096$ A**.

The coil mmf is $\mathcal{F} = 0.003\ (201{,}596.3)$ $\Rightarrow$ $\mathcal{F} = 604.7888$ A-t (bonus).

Per (1-26), $\phi = BA$. On the top, the magnetic flux density is

$B_T = \phi / A_T = 0.003 / 0.0075$ $\Rightarrow$ **$B_T = 0.4$ Wb/m^2**.

On the right side, the magnetic flux density is

$B_R = \phi / A_R = 0.003 / 0.0025$ $\Rightarrow$ **$B_R = 1.2$ Wb/m^2**.