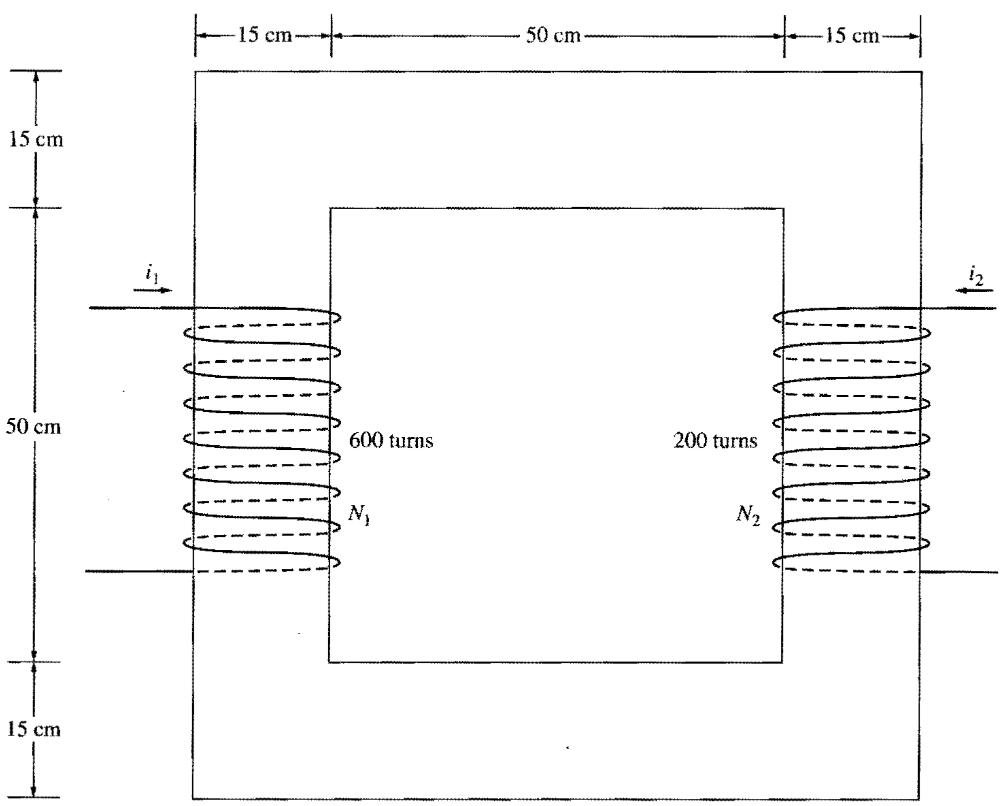
1–12 The core shown in Figure P1–4 is made of a steel whose magnetization curve is shown in Figure P1–9. Repeat Problem 1–7, but this time do *not* assume a constant value of μ_r. How much flux is produced in the core by the currents specified? What is the relative permeability of this core under these conditions? Was the assumption in Problem 1–7 that the relative permeability was equal to 1000 a good assumption for these conditions? Is it a good assumption in general?

1–7 A two-legged core is shown in Figure P1–4. The winding on the left leg of the core (N_1) has 600 turns, and the winding on the right (N_2) has 200 turns. The coils are wound in the directions shown in the figure. If the dimensions are as shown, then what flux would be produced by currents $i_1 = 0.5$ A and $i_2 = 1.00$ A? Assume $\mu_r = 1000$ and constant.

Figure P1–4 | The core of Problems 1–7 and 1–12.



Calculate coil mmfs, using (1-27) $\mathcal{F} = Ni$, as:

$\mathcal{F}_1 = 600(0.5) \;\Rightarrow\; \underline{\mathcal{F}_1 = \mathbf{300\ A\text{-}t}}$ and $\mathcal{F}_2 = 200(1) \;\Rightarrow\; \underline{\mathcal{F}_2 = \mathbf{200\ A\text{-}t}}$.

As these coils are in series, the total mmf on the core is

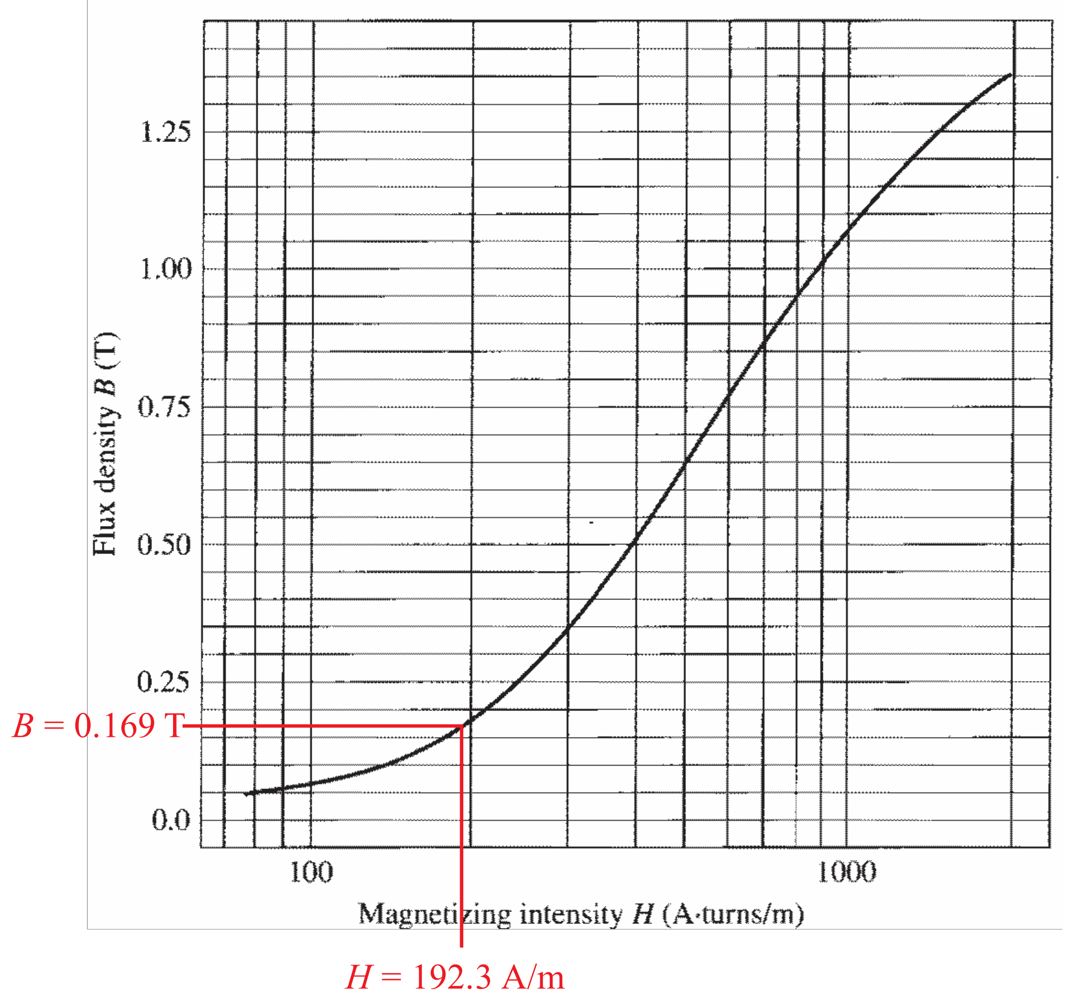
$$\mathcal{F} = \mathcal{F}_1 + \mathcal{F}_2 = 300 + 200 \;\Rightarrow\; \underline{\mathcal{F} = 500\ \text{A-t}}.$$

The core mean path lengths are $\ell_L = \ell_R = \ell_T = \ell_B = \ell = 15/2 + 50 + 15/2 = 65$ cm $=$ 0.65 m. The total mean path around the core is $\ell_c = 4\,(0.65\text{ m}) \Rightarrow \underline{\ell_c = 2.6\text{ m}}$.

The magnetic field intensity in the core is (1-20) $H = \dfrac{\mathcal{F}}{\ell_c} = \dfrac{500}{2.6} = \underline{192.3\text{ A/m}}$.

Using the magnetization curve, the magnetic flux density is $\underline{B = 0.169\text{ T}}$ when this magnetic field is applied to the core.

Figure P1–9 | The magnetization curve for the core material of Problems 1–12 and 1–14.



The core cross-sectional area is $A = 15\text{ cm}\,(15\text{ cm}) = 225\text{ cm}^2 = 0.0225\text{ m}^2$.

Using (1-25b), we find the flux as $\phi = BA = 0.169\ (0.0225) \Rightarrow$ $\underline{\boldsymbol{\phi = 3.80\text{ mWb}}}$.

[This is significantly smaller than $\underline{\phi = 5.437\text{ mWb}}$ found in problem 1-7.]

From the constitutive relationship, the magnetic permeability is

$$\mu = \mu_r\,\mu_0 = B/H = 0.169/192.3 = 8.788\times10^{-4}\text{ H/m}.$$

Then, $\mu_r = \mu/\mu_0 = 8.788\times10^{-4}/4\pi\times10^{-7} \quad \Rightarrow$ $\underline{\boldsymbol{\mu_r = 699}}$**.**

$\Rightarrow$ **$\mu_r = 1000$ is NOT a good assumption for this problem or in general.**