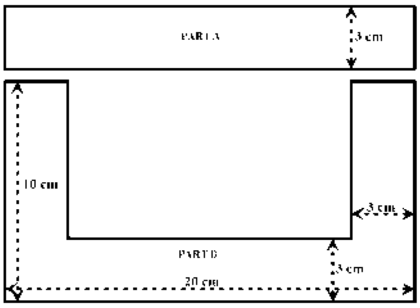
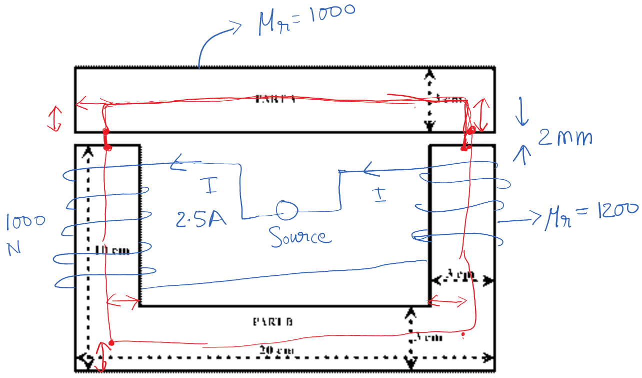
Illustration 3 - Magnetic Circuits

The magnetic circuit shown in the figure is made of iron having a square cross-section of 3 cm side. It has two parts A and B, with relative permeability of 1000 and 1200 respectively, separated by two air gaps, each 2 mm wide. The part B is wound with a total of 1000 turns of wire on the two side limbs carrying a current of 2.5 A. Calculate

a) The reluctances of Part-A, Part-B & air gaps
b) the total reluctance
c) the mmf
d) the flux and the flux density





$$\text{Length of Part A} = 1.5 + (20 - 1.5 - 1.5) + 1.5 = 20 \text{ cm} = 20 \times 10^{-2} \text{ m}$$

$$\text{Length of Part B} = (10 - 1.5) + (20 - 1.5 - 1.5) + (10 - 1.5) = 34 \text{ cm} = 34 \times 10^{-2} \text{ m}$$

$$\text{Length of air gap} = 0.002 + 0.002 = 4 \times 10^{-3} \text{ m}$$

$$S_A = \frac{l_A}{A_A\, \mu_0\, \mu_{rA}} = \frac{(20 \times 10^{-2})}{9 \times 10^{-4} \times 4\pi \times 10^{-7} \times 1000} = 176838.8257\ AT/Wb$$

$$S_B = \frac{l_B}{A_B\, \mu_0\, \mu_{rB}} = \frac{(34 \times 10^{-2})}{9 \times 10^{-4} \times 4\pi \times 10^{-7} \times 1200} = 250521.6697\ AT/Wb$$

$$S_g = \frac{l_g}{A_g\, \mu_0\, \mu_{rg}} = \frac{(4 \times 10^{-3})}{9 \times 10^{-4} \times 4\pi \times 10^{-7} \times 1} = 3536776.513\ AT/Wb$$

$$\mathrm{S_T = S_A + S_B + S_g = 3964137.009\ AT/Wb}$$

$$mmf = NI = 1000 \times 2.5 = 2500\ AT$$

$$\emptyset = \frac{\text{mmf}}{\text{Reluctance}} = \frac{2500}{3964137.009} = 0.63065 \text{ mW}$$

$$\mathrm{B} = \frac{\emptyset}{\mathrm{A}} = \frac{6.30654287 \times 10^{-3}}{9 \times 10^{-4}} = 0.70073 \text{ T or Wb/m}^2$$

Illustration 4 - Magnetic Circuits

A ring of cross sectional area 12 cm^2 has 3 parts made of following materials:

Part	Material	Length	Relative Permeability
A	Iron	25 cm	800
B	Steel	18 cm	1100
C	Air	2 mm	---

A coil of 660 turns carrying a current of 2.1 A is wound uniformly on the ring. Determine the flux density in the air gap. Assume no leakage and fringing effect.

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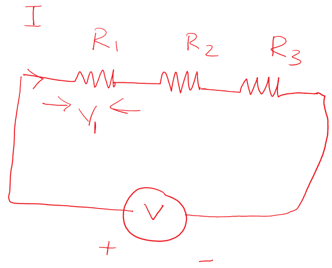

$$S_A = \frac{l_A}{A_A\,\mu_0\,\mu_{rA}} = \frac{(25\times10^{-2})}{12\times10^{-4}\times4\pi\times10^{-7}\times800} = 207232.9988\ AT/Wb$$

$$S_B = \frac{l_B}{A_B\,\mu_0\,\mu_{rB}} = \frac{(18\times10^{-2})}{12\times10^{-4}\times4\pi\times10^{-7}\times1100} = 108514.7339\ AT/Wb$$

$$S_g = \frac{l_g}{A_g\,\mu_0\,\mu_{rg}} = \frac{(2\times10^{-3})}{12\times10^{-4}\times4\pi\times10^{-7}\times1} = 1326291.192\ AT/Wb$$

$$I = \frac{V}{R_1+R_2+R_3} = \frac{V_1}{R_1}$$

$$S_T = S_A + S_B + S_g = 1642038.925\ AT/Wb$$

$$\emptyset = \frac{\text{mmf}}{\text{Reluctance}} = \frac{\text{NI}}{\text{S}_\text{T}} = \frac{660\times2.1}{1642038.925} = 0.84407256\ \text{mWb}$$

$$V_1 = \frac{V * R_1}{R_1+R_2+R_3}$$

$$B = \frac{\emptyset}{A} = \frac{0.84407256\times10^{-3}}{12\times10^{-4}} = 0.70339\ T\ or\ Wb/m^2$$

$$mmf_{Sg} = \frac{mmf_{total} * S_g}{S_T}$$

Illustration 5 - Magnetic Circuits

An iron ring has mean circumferential length 50 cm and area of cross-section 4 cm^2. It is wound with 100 turns of wire. An air gap of 2 mm width is cut in the ring. Determine the current required in the coil to produce a flux of 0.48 mWb in the air gap. Assume leakage factor of 1.05. Assume the following data for magnetization of iron.

B (Wb/m2)	0.9	1.0	1.1	1.2	1.3
H (AT/m)	450	500	550	600	650

$$\emptyset_g = 0.48\times10^{-3}\ Wb$$

$$\text{Leakage Coefficient, K} = 1.05 = \frac{\emptyset_i}{\emptyset_g} = \frac{\emptyset_i}{0.48\times10^{-3}}\quad or\quad \emptyset_i = 0.504\ \times10^{-3}\ Wb$$

$$S_g = \frac{l_g}{A_g\,\mu_0\,\mu_{rg}} = \frac{(2\times10^{-3})}{4\times10^{-4}\times4\pi\times10^{-7}\times1} = 3978873.577\ AT/Wb$$

$$\text{AT}_\text{g} = \emptyset_\text{g}\text{S}_\text{g} = 0.48\times10^{-3}\times3978873.577 = 1909.85932\ \text{AT}$$

$$B_i = \frac{\emptyset_i}{A_i} = \frac{0.504\ \times10^{-3}}{4\times10^{-4}} = 1.26\ Wb/m^2$$

$$Corresponding\ to\ B_i = 1.26,$$
$$H_i = 630\ \frac{AT}{m}\ - by\ simple\ exptrapolation\ from\ table$$

$$\text{AT of iron, AT}_\text{i} = \text{H}_\text{i}\text{L}_\text{i} = 630\times(50\ \times10^{-2} - 2\times10^{-3}) = 313.74$$

$$\text{AT}_\text{Total} = \text{AT}_\text{g} + \text{AT}_\text{i} = 1909.85932 + 313.74 = 2223.599\ \text{AT}$$

$$\text{I} = \frac{\text{AT}_\text{Total}}{\text{N}} = \frac{2223.599}{100} = \mathbf{22.236\ A}$$