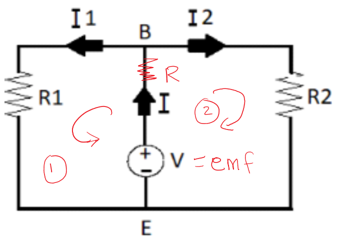


Loop 2

$V - IR - I_2 R_2 = 0$

$\boxed{V = IR + I_2 R_2}$

Loop 1

$V - IR - I_1 R_1 = 0$

$\boxed{V = IR + I_1 R_1}$

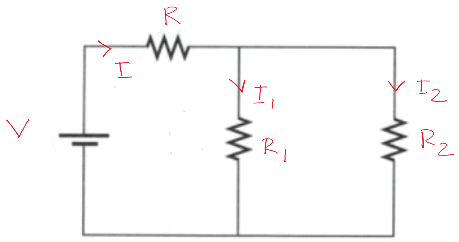
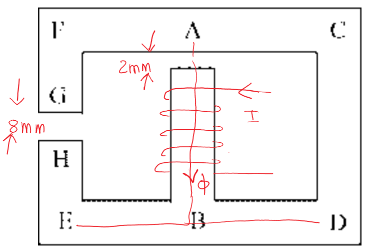
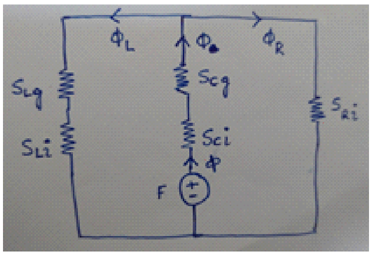


Illustration 6 - Magnetic Circuits

The magnetic circuit shown in Fig. is made of a material having relative permeability of 2000. The central limb is wound with 1000 turns and has an air gap of length of 2 mm. The side limb air gap is 8 mm. Calculate the current required to set up a flux of 2.6 mWb in the central limb. Mean lengths of various sections are as follows: AB = 24 cm, ACDB = AFGHEB = 60 cm. Cross sectional area of the structure is 10 cm^2.





$$\emptyset = \emptyset_L + \emptyset_R$$

$$S_{ci} = \frac{l_{ci}}{A_{ci}\,\mu_0\,\mu_{rci}} = \frac{(24\times10^{-2}) - (2\times10^{-3})}{10\times10^{-4}\times4\pi\times10^{-7}\times2000} = 94697.19114\ AT/Wb$$

$$S_{cg} = \frac{l_{cg}}{A_{cg}\,\mu_0\,\mu_{rcg}} = \frac{(2\times10^{-3})}{10\times10^{-4}\times4\pi\times10^{-7}\times1} = 1591549.431\ AT/Wb$$

$$S_{Li} = \frac{l_{Li}}{A_{Li}\,\mu_0\,\mu_{rLi}} = \frac{(60\times10^{-2}) - (8\times10^{-3})}{10\times10^{-4}\times4\pi\times10^{-7}\times2000} = 235549.3158\ AT/Wb$$

$$S_{Lg} = \frac{l_{Lg}}{A_{Lg}\,\mu_0\,\mu_{rLg}} = \frac{(8\times10^{-3})}{10\times10^{-4}\times4\pi\times10^{-7}\times1} = 6366197.124\ AT/Wb$$

$$S_{Ri} = \frac{l_{Ri}}{A_{Ri}\,\mu_0\,\mu_{rRi}} = \frac{(60\times10^{-2})}{10\times10^{-4}\times4\pi\times10^{-7}\times2000} = 238732.4146\ AT/Wb$$

$$mmf_{Total} = \emptyset\,(S_{ci} + S_{cg}) + [\emptyset_L\,(S_{Li} + S_{Lg})\ or\ \emptyset_R\,S_{Ri}]$$

$$\emptyset_R = \emptyset \times \left[\frac{(S_{Li} + S_{Lg})}{(S_{Li} + S_{Lg}) + S_{Ri}}\right]$$
$$= 2.6\times10^{-3}\times\left[\frac{(235549.3158\ +\ 6366197.124)}{(235549.3158\ +\ 6366197.124) + 238732.4146}\right]$$
$$= 2.50926\ mWb$$

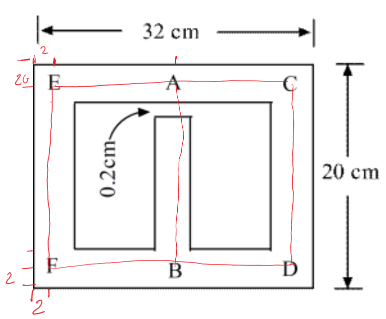
$$mmf_{Total} = 2.6\times10^{-3}\,(94697.19114 + 1591549.431) + [2.50926\times10^{-3}\times 238732.4146]$$
$$= 4983.2829\ AT$$

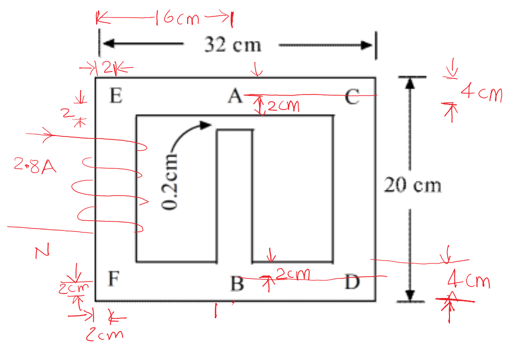
$$I = \frac{mmf_{Total}}{N} = \frac{4983.2829}{1000} = 4.983\ \text{A}$$

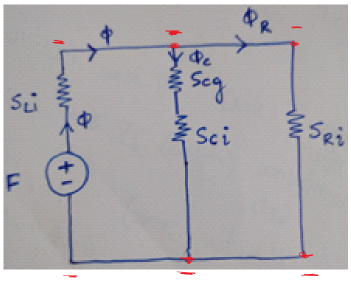
Illustration 6 - Magnetic Circuits

A coil carrying a current of 2.8 A is wound on the left limb of the cast steel symmetrical frame of uniform square cross sect ion 16 cm^2 as shown in Fig. Calculate the number of turns in the coil to produce a flux of 1.8 mWb in the air gap of 0.2 cm length. The relative per meability of cast steel is 1200.

N







$$\emptyset = \emptyset_C + \emptyset_R$$

$$Square\ cross-section => side = 4 \times 10^{-2}\ m$$

$$mmf_{Total} = \emptyset\,(S_{Li}) + [\emptyset_C\,(S_{Ci} + S_{Cg})\ or\ \emptyset_R\,S_{Ri}]$$

$$S_{ci} = \frac{l_{ci}}{A_{ci}\,\mu_0\,\mu_{rci}} = \frac{(20\times10^{-2}) - (0.2\times10^{-2}) - (2\times10^{-2}) - (2\times10^{-2})}{16\times10^{-4}\times4\pi\times10^{-7}\times1200}$$
$$= 65485.62763\ AT/Wb$$

$$S_{cg} = \frac{l_{cg}}{A_{cg}\,\mu_0\,\mu_{rcg}} = \frac{(0.2\times10^{-2})}{16\times10^{-4}\times4\pi\times10^{-7}\times1} = 994718.3943\ AT/Wb$$

$$S_{Ri} = \frac{l_{Ri}}{A_{Ri}\,\mu_0\,\mu_{rRi}} = \frac{\left(20+\frac{32}{2}+\frac{32}{2}-2-2-2-2\right)\times10^{-2}}{16\times10^{-4}\times4\pi\times10^{-7}\times1200} = 182365.039\ \frac{AT}{Wb} = S_{Li}$$

$$mmf_C = mmf_R$$

$$\emptyset_C\,(S_{Ci} + S_{Cg}) = \emptyset_R\,S_{Ri}$$

$$1.8\times10^{-3}\ (65485.62763 + 994718.3943) = \emptyset_R\ 182365.039$$

$$\emptyset_R = 10.464545\ mWb$$

$$\emptyset = \emptyset_C + \emptyset_R = (1.8\times10^{-3}) + (10.464545\times10^{-3}) = 12.264545\ mWb$$

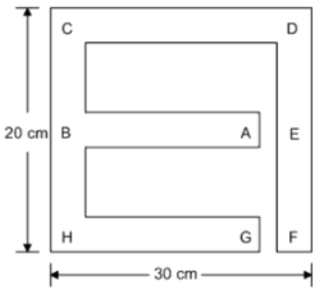
$$mmf_{Total} = \emptyset\,(S_{Li}) + [\emptyset_C\,(S_{Ci} + S_{Cg})\ or\ \emptyset_R\,S_{Ri}]$$

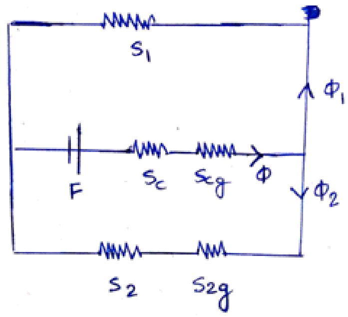
$$mmf_{Total} = (12.264545\times10^{-3}\times182365.039) + (10.464545\times10^{-3}\times 182365.039)$$
$$= 4144.991384\ AT$$

$$N = \frac{mmf_{Total}}{I} = \frac{4144.991384}{2.8} = 1480.3541\ Turns \approx 1480\ Turns$$

Illustration 8 - Magnetic Circuits

The magnetic circuit shown in Figure is made of a material having relative permeability of 2000. The limb AB is wound with 1000 turns. Find the current through the coil to produce a flux of 4 mWb in the limb AB. The length of each air gap is 2 mm and the square cross-sectional area of the frame is 9 cm^2.





Side = 3 cm

$$S_1 = \frac{l_1}{A_1\, \mu_0\, \mu_{r1}} = \frac{\left[\left(\frac{20}{2} + \frac{20}{2} + 30\right) - 1.5 - 1.5 - 1.5 - 1.5\right] \times 10^{-2}}{9 \times 10^{-4} \times 4\pi \times 10^{-7} \times 2000} = 194522.7082\ \frac{AT}{Wb}$$

$$S_2 = \frac{l_2}{A_2\, \mu_0\, \mu_{r2}} = \frac{\left\{\left[\left(\frac{20}{2} + \frac{20}{2} + 30\right) - 1.5 - 1.5 - 1.5 - 1.5\right] \times 10^{-2}\right\} - 2 \times 10^{-3}}{9 \times 10^{-4} \times 4\pi \times 10^{-7} \times 2000} = 193638.5141\ \frac{AT}{Wb}$$

$$S_c = \frac{l_c}{A_c\, \mu_0\, \mu_{rc}} = \frac{\{[(30) - 1.5 - 1.5] \times 10^{-2}\} - (2 \times 10^{-3})}{9 \times 10^{-4} \times 4\pi \times 10^{-7} \times 2000} = 118482.0132\ \frac{AT}{Wb}$$

$$S_{cg} = S_{2g} = \frac{l_{cg}}{A_{cg}\, \mu_0\, \mu_{rcg}} = \frac{(2 \times 10^{-3})}{9 \times 10^{-4} \times 4\pi \times 10^{-7} \times 1} = 1768388.257\ AT/Wb$$

$$\emptyset_1 = \emptyset \times \left[\frac{(S_2 + S_{2g})}{(S_2 + S_{2g}) + S_1}\right] == 4 \times 10^{-3} \times \left[\frac{(193638.5141\ +\ 1768388.257)}{(193638.5141\ +\ 1768388.257) + 194522.7082}\right] = 3.639196\ mWb$$

$$mmf_{Total} = \emptyset\,(S_c + S_{cg}) + [\emptyset_2\,(S_2 + S_{2g})\ or\ \emptyset_1\, S_1]$$

$$NI = 4 \times 10^{-3}(118482.0132 + 1768388.257) + 3.639196 \times 10^{-3}(194522.7082) = 8255.387\ AT$$

$$I = \frac{8255.387}{1000} = \mathbf{8.255387\ A}$$