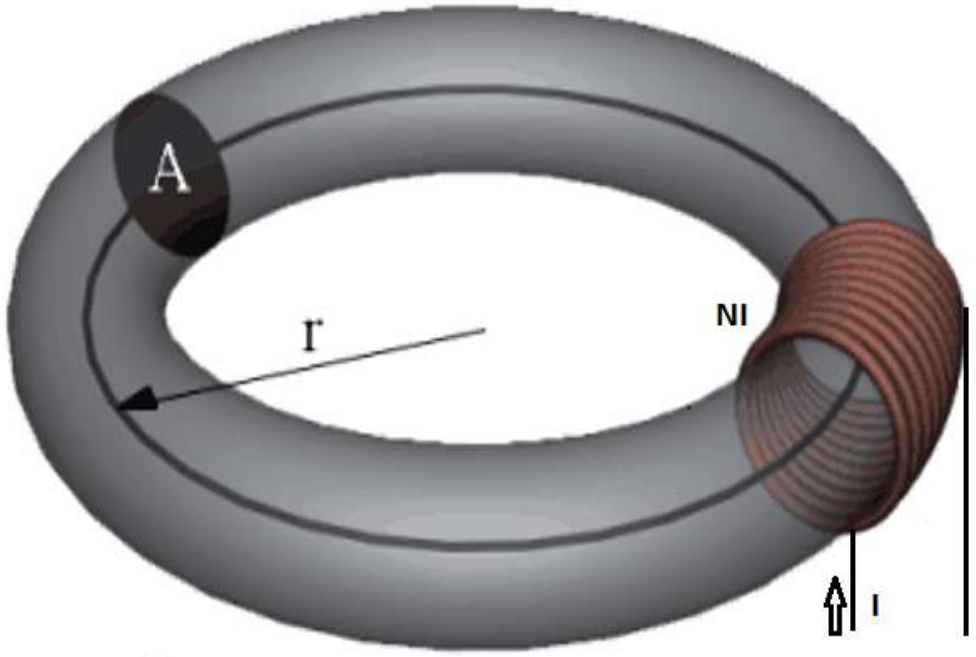
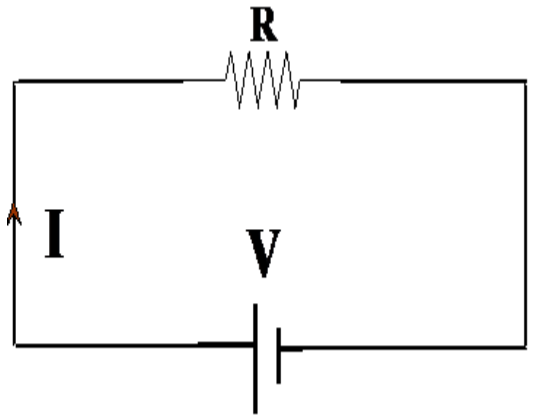
Basic Electrical Technology

Series Magnetic Circuits

Magnetic Circuits

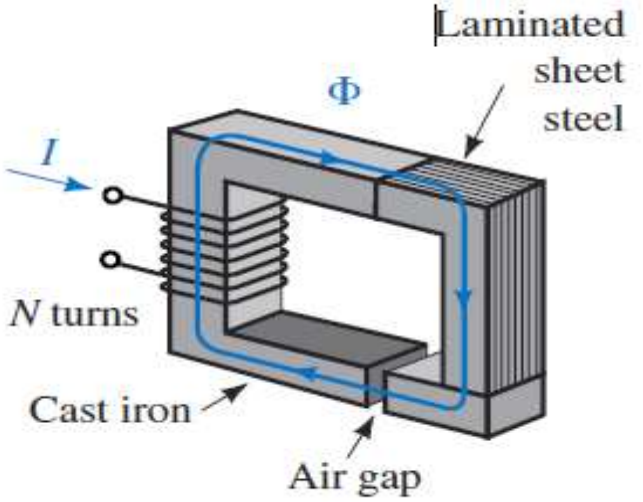
The complete closed path followed by any group of magnetic lines of flux





Series Magnetic Circuit

- Flux ϕ is the same in all sections if leakage flux is neglected.
- Flux density and reluctance in each section may vary, depending on its effective cross-sectional area and material.
- Equivalent reluctance is the sum of reluctance of different parts/elements.
- The resultant MMF is the sum of MMFs in each individual parts/elements



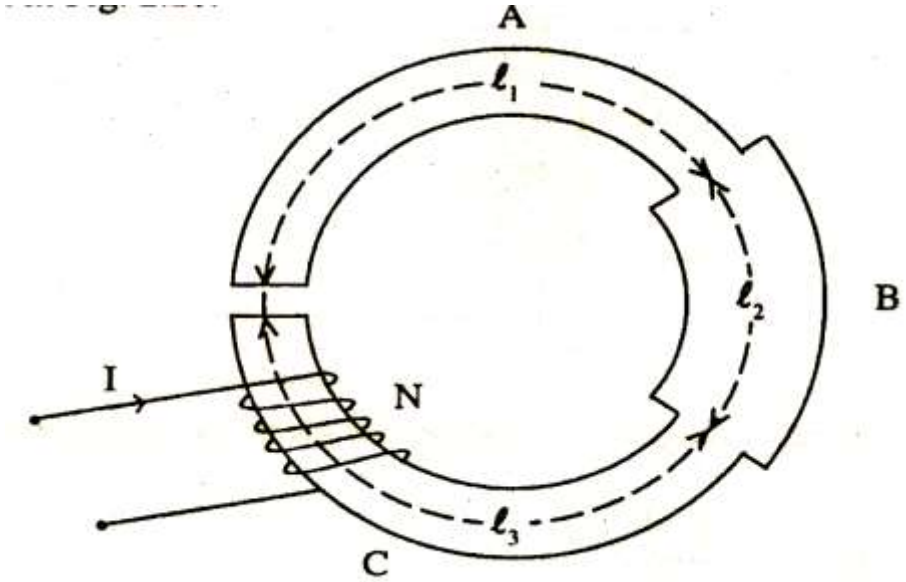
Rectangular shaped series magnetic circuit with air gap.

Series Magnetic Circuit

$$S_1 = \frac{l_1}{\mu_0 \mu_{r1} A_1},\ S_2 = \frac{l_2}{\mu_0 \mu_{r2} A_2}$$

$$S_3 = \frac{l_3}{\mu_0 \mu_{r3} A_1}, S_g = \frac{l_g}{\mu_0 A_1}$$

$$S_T = S_1 + S_2 + S_3 + S_g$$



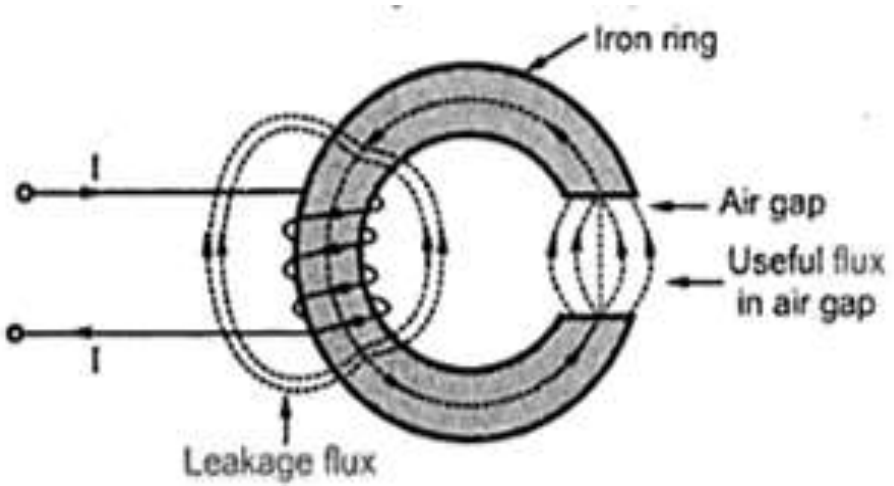
$$Total\ mmf = \phi_1 S_1 + \phi_2 S_2 + \phi_3 S_3 + \phi_g S_g$$

$$= H_1 l_1 + H_2 l_2 + H_3 l_3 + H_g l_g$$

$$= \left(\frac{B_1 l_1}{\mu_0 \mu_{r1}} + \frac{B_2 l_2}{\mu_0 \mu_{r2}} + \frac{B_3 l_3}{\mu_0 \mu_{r3}} + \frac{B_g l_g}{\mu_0}\right)$$

Useful & Leakage Flux

- **Magnetic leakage:**
  - The passage of magnetic flux outside the path along which it can do useful work.



- Total flux of coil = Useful flux + Leakage flux

- **Leakage Coefficient**:

$$\lambda = \frac{\text{Total Flux of the Coil}}{\text{Useful Flux}}$$

Illustration 1

An iron ring has a circular cross- sectional area of 5 cm^2 and a mean circumference of 100 cm. The ring is uniformly wound with a coil of 1000 turns. Relative permeability of iron is 800.

a) Find the current required to produce a flux of 1 mWb in the ring.
b) If a saw cut of 2 mm wide is made in the ring, find the flux produced, if the current is same as that found in **part a**.
c) Find the current required to produce the same flux as in **part a** for the cut made in the ring in **part b**.

Ans:

a) 1.99 A
b) 0.385 mWb
c) 5.17 A

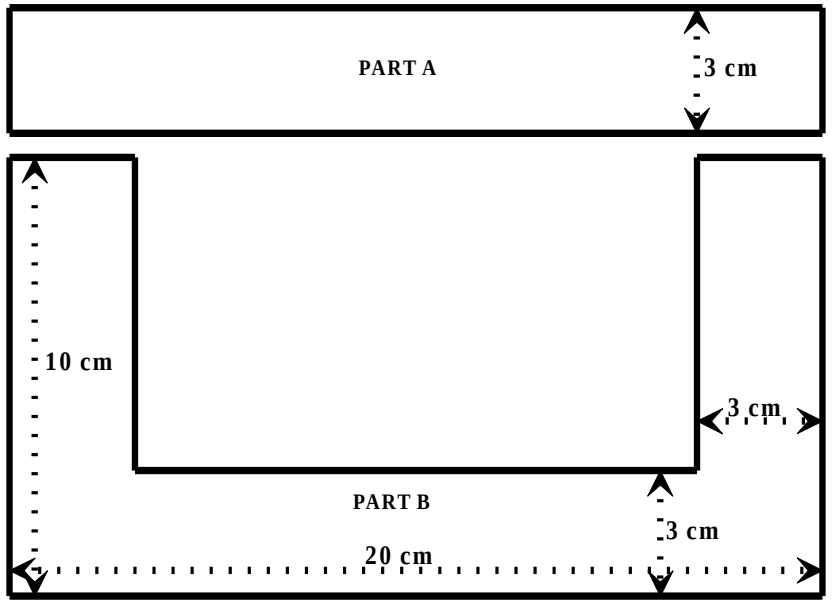
Illustration 2

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 permeabilities 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.

Hint:

Length of Part A = 1.5 + (20-1.5-1.5)+1.5 = 20cm
Length of Part B = (10-1.5)+(20-1.5-1.5)+(10-1.5) = 34 cm



Ans:

S_A = 176838.83AT/Wb,
S_B = 250521.67AT/Wb
S_g = 3536776.51AT/Wb
S_T = 3964137AT/Wb
mmf = 2500 AT
Φ = 0.63 mWb, B = 0.7 T

Illustration 3

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.

Ans: 0.703 Wb/m^2