Basic Electrical Technology

2. Magnetic Circuits & Electromagnetism

LECTURE 15 – 15 DEC 2021

Parallel Magnetic Circuits

Parallel Magnetic Circuit

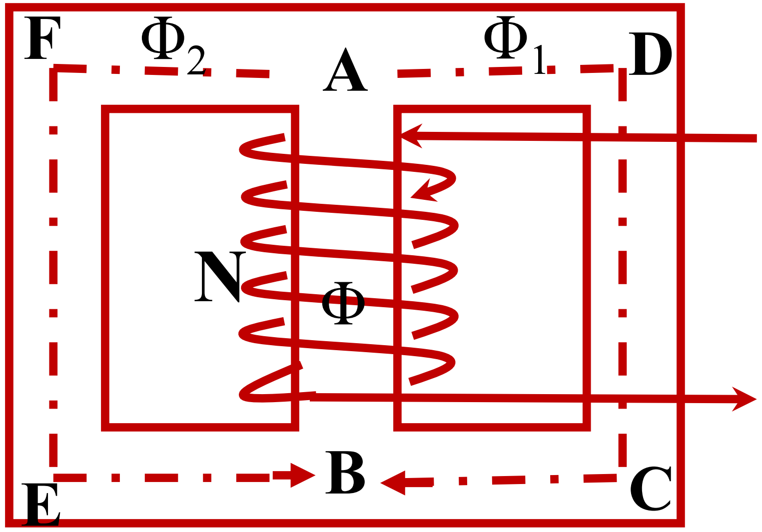
- More than one path for flux
- Can be compared to a parallel electric circuit which has more than one path for electric current

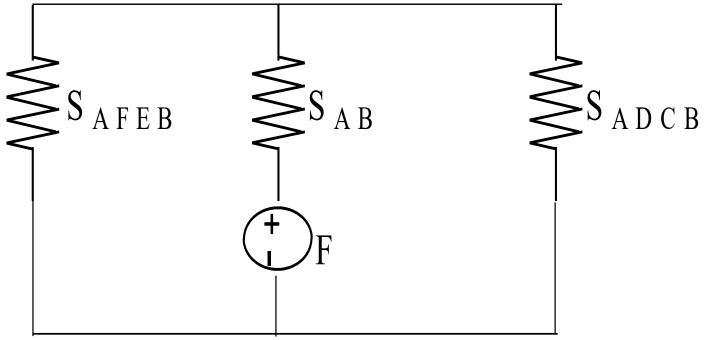
- $\mathbf{\Phi} = \mathbf{\Phi_1} + \mathbf{\Phi_2}$

$$S_{AB} = \frac{l_{AB}}{\mu_0\, \mu_{rAB}\, A_{AB}}$$

$$S_{ADCB} = \frac{l_{ADCB}}{\mu_0\, \mu_{rADCB}\, A_{ADCB}}$$

$$S_{AFEB} = \frac{l_{AFEB}}{\mu_0\, \mu_{rAFEB}\, A_{AFEB}}$$





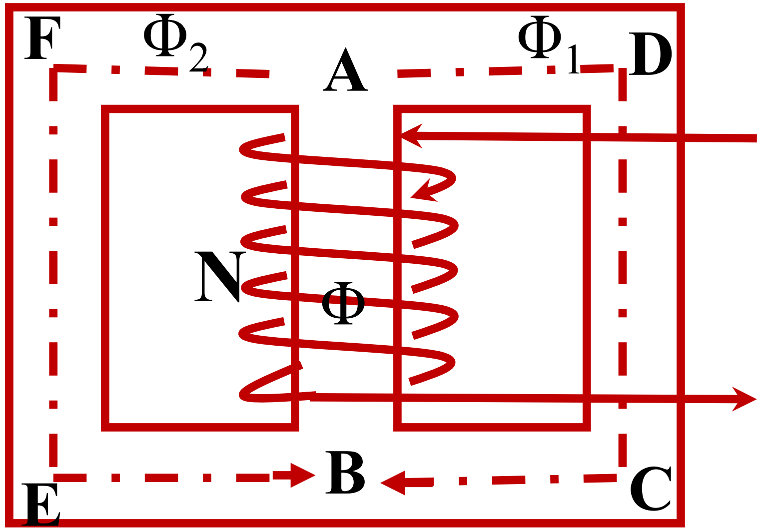
Analogous Electrical Circuit

Parallel Magnetic Circuit

- $(\text{Mmf})_{Total} = (\text{Mmf})_{AB} + (\text{Mmf})_{ADCB}$

  OR

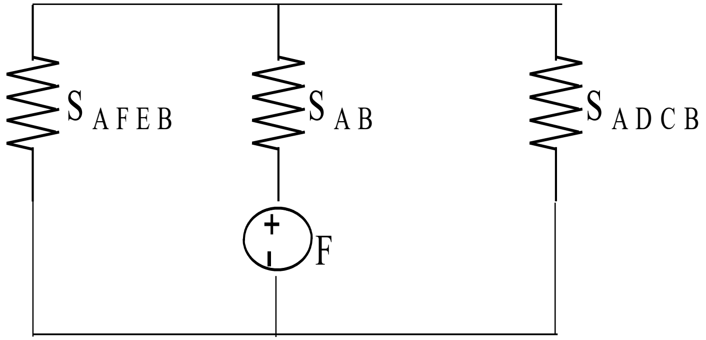
  $(\text{Mmf})_{Total} = (\text{Mmf})_{AB} + (\text{Mmf})_{AFEB}$



- $(\text{Mmf})_{Total} = \Phi\, S_{AB} + \Phi_1\, S_{ADCB}$

  OR

  $(\text{Mmf})_{Total} = \Phi\, S_{AB} + \Phi_2\, S_{AFEB}$



Analogous Electrical Circuit

Parallel Magnetic Circuit

- More than one path for magnetic flux
- Can be compared to a parallel electric circuit which has more than one path for electric current

$$\emptyset_1 = \emptyset_2 + \emptyset_3$$

$$S_1 = \text{Reluctance of path EFAB}$$

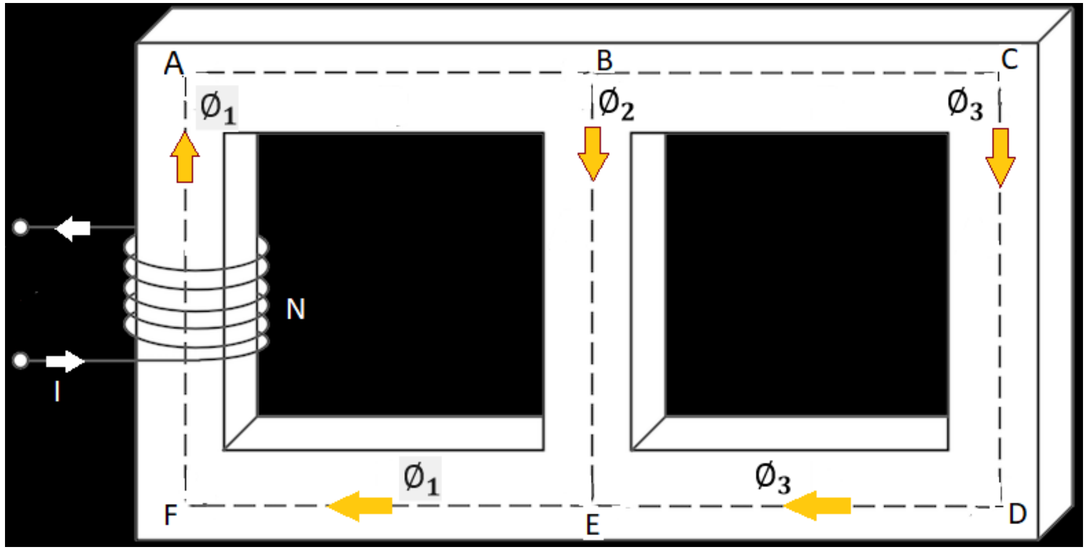
$$S_2 = \text{Reluctance of path BE}$$

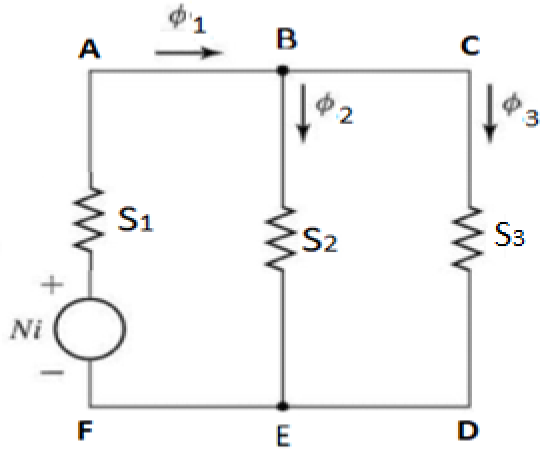
$$S_3 = \text{Reluctance of path BCDE}$$

$$\textbf{Total mmf required}$$
$$= \mathbf{mmf_{EFAB} + mmf_{BE}} \quad \textbf{or} \quad \mathbf{mmf_{BCDE}}$$

$$\mathbf{NI = \emptyset_1 S_1 + \emptyset_2 S_2 = \emptyset_1 S_1 + \emptyset_3 S_3}$$

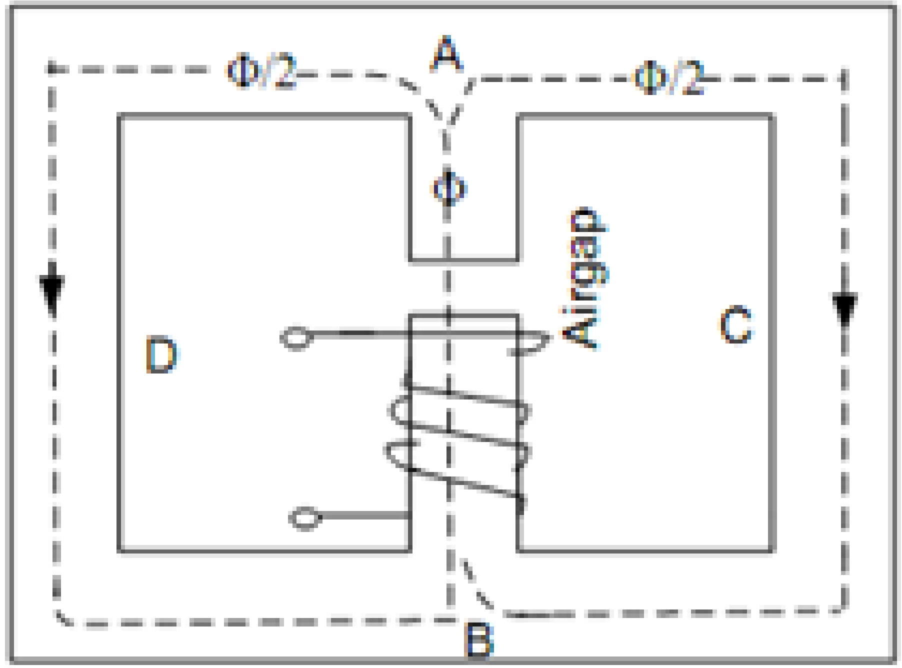
- S_1, S_2 and S_3 must be determined from calculation of $\frac{l}{A\mu_0\mu_r}$ for those paths of the magnetic circuit in which $\emptyset_1$, $\emptyset_2$ and $\emptyset_3$ exist respectively

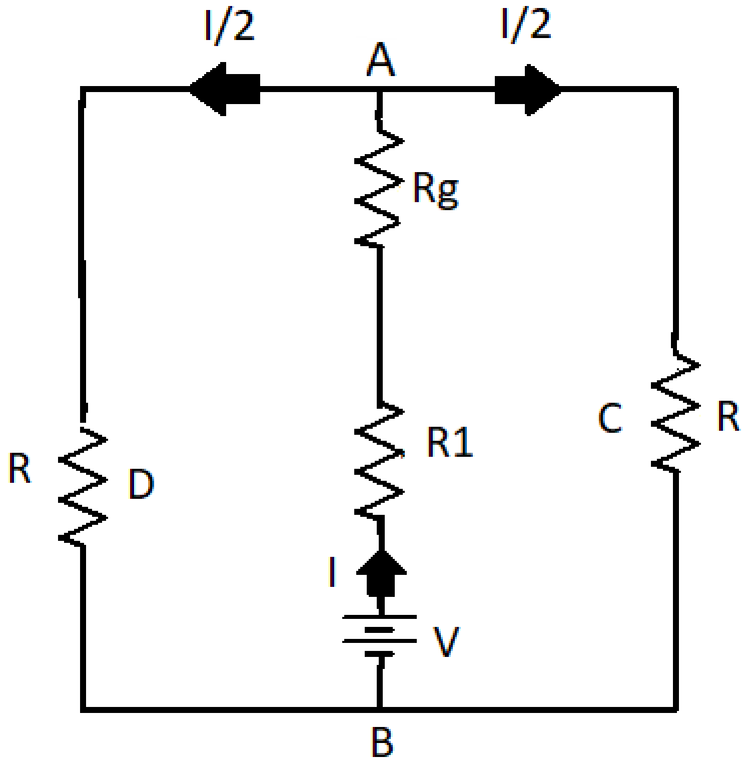




Analogous Electric circuit

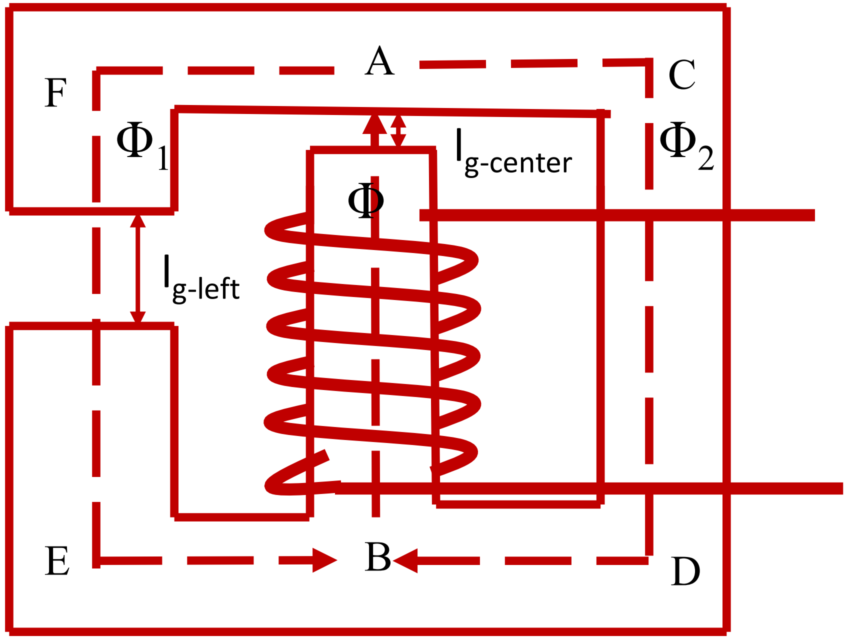
Parallel Magnetic Circuit with Air Gap

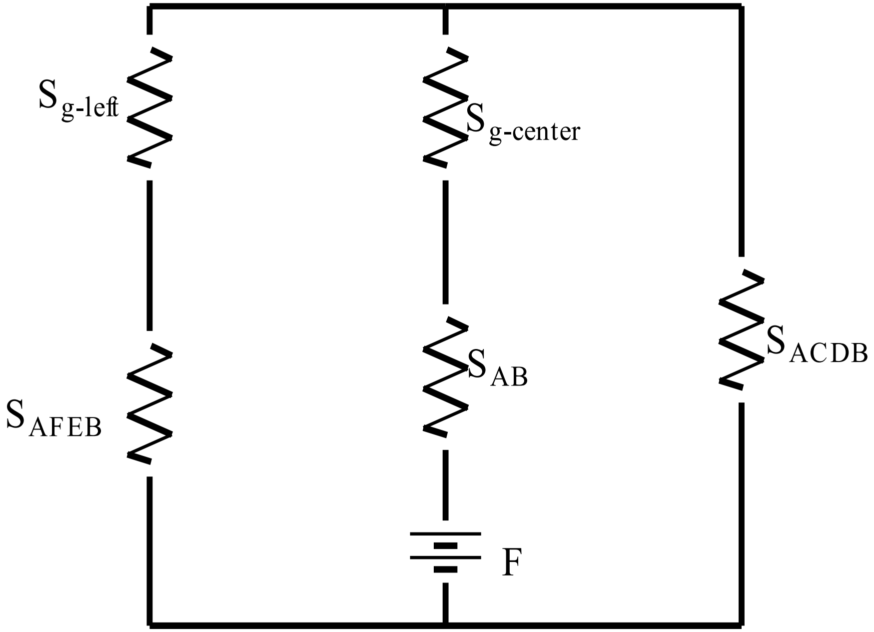




mmf required for this circuit would be the sum of: (i) that required for central limb (air-gap + core material) and, (ii) that required for either of two parts (not both)

Parallel Magnetic Circuit with Air Gap



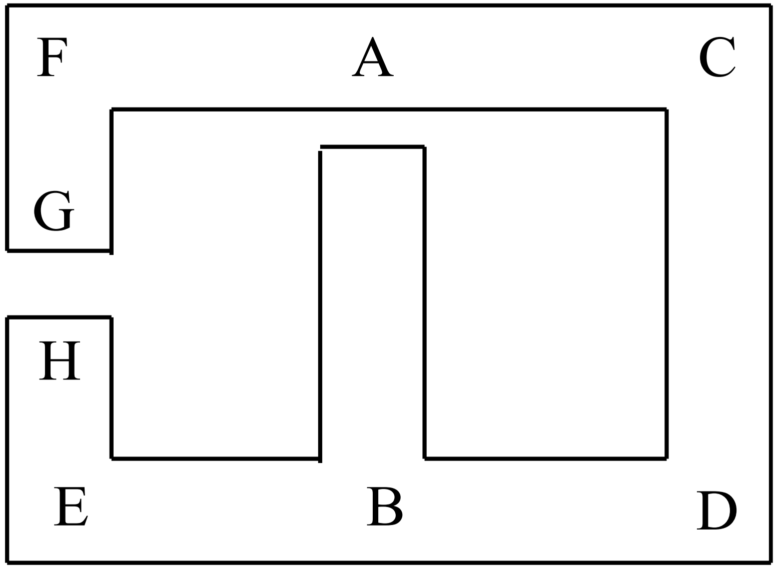


$$\mathbf{S_{AFEB}} = \frac{(\mathbf{L_{AFEB}} - \mathbf{L_{gleft}})}{\boldsymbol{\mu_0\ \mu_{rAFEB}\ A_{AFEB}}} \qquad \mathbf{S_{AB}} = \frac{(\mathbf{L_{AB}} - \mathbf{L_{gcenter}})}{\boldsymbol{\mu_0\ \mu_{rAB}\ A_{AB}}} \qquad \mathbf{S_{ACDB}} = \frac{\mathbf{L_{ACDB}}}{\boldsymbol{\mu_0\ \mu_{rACDB}\ A_{ACDB}}}$$

$$\mathbf{S_{g-center}} = \frac{\mathbf{L_{gcenter}}}{\boldsymbol{\mu_0\ A_{g-center}}} \qquad \mathbf{S_{g-left}} = \frac{\mathbf{L_{gleft}}}{\boldsymbol{\mu_0\ A_{g-left}}}$$

Illustration 6

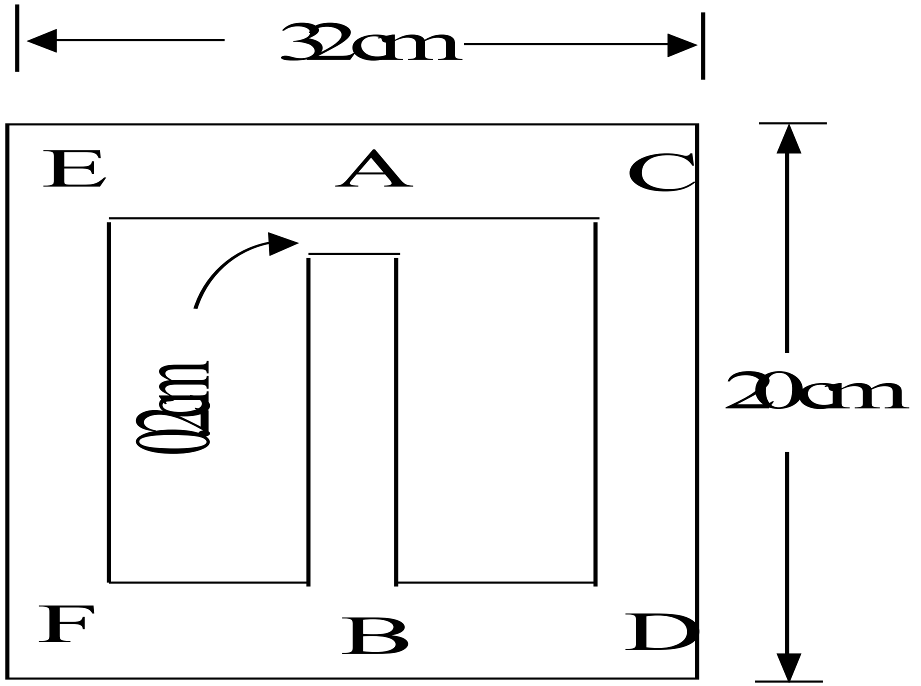
The magnetic circuit shown in Fig. is made of a material having relative permeability of 2000. The central limb is wound with 1000 turns and has an air gap of length of 2 mm. The side limb air gap is 8 mm. Calculate the current required to set up a flux of 2.6 mWb in the central limb. Mean lengths of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



Ans: 4. 98 A

Illustration 7

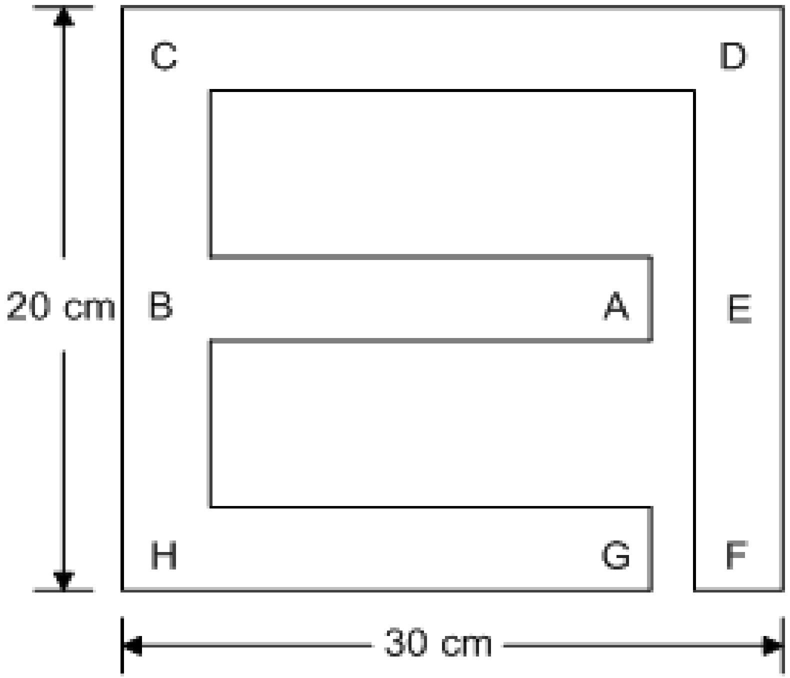
A coil carrying a current of 2.8 A is wound on the left limb of the cast steel symmetrical frame of uniform square cross section 16 cm^2 as shown in Fig. Calculate the number of turns in the coil to produce a flux of 1.8 mWb in the air gap of 0.2 cm length. The relative permeability of cast steel is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



Ans: 1480

Illustration 8

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.



Ans: 8.255387 A