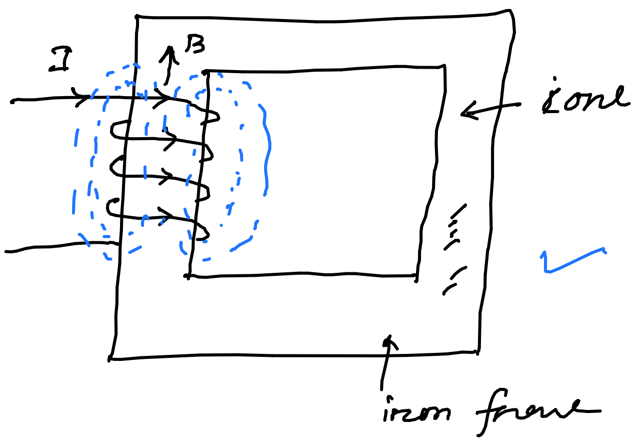
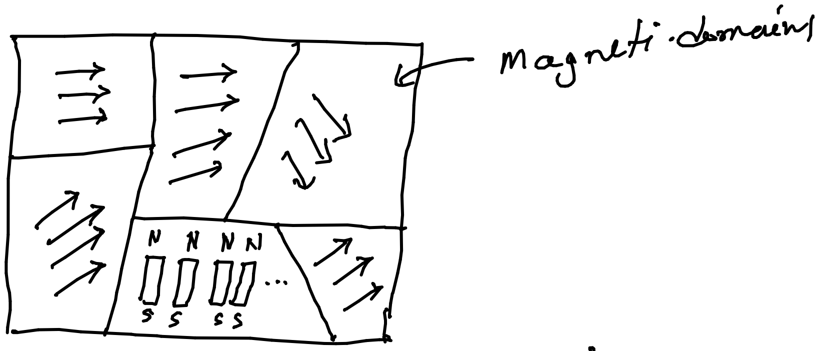
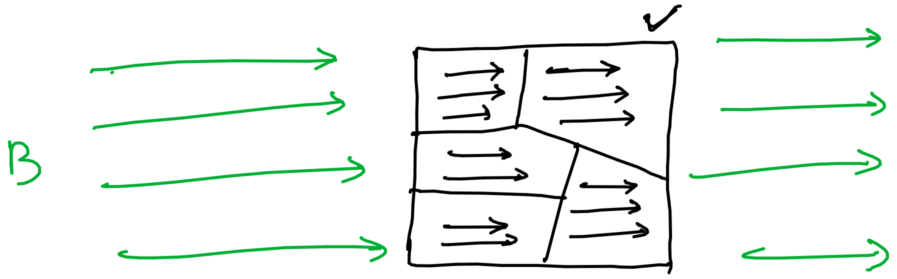


The iron core contains several "magnetic domains"



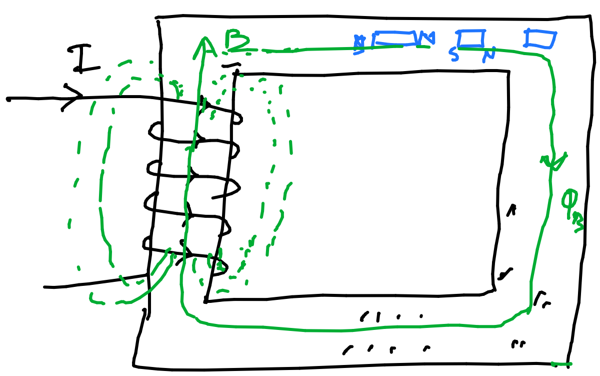
These magnetic domains are aligned (in unmagnetized) in arbitrary direction s.t. the net magnetic field outside is zero.



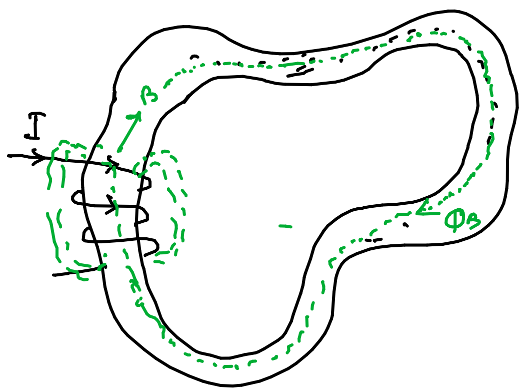
All magnetic domains are aligned in the direction magnetic field B.

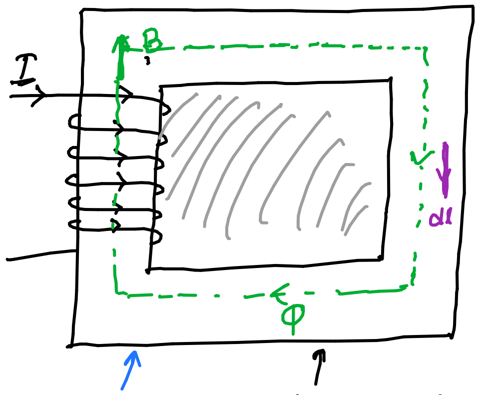
- Since the magnetic domains are aligned in the direct' of external magnetic field B, the flux ϕ_B will increase inside the iron.

Ferro magnetic materials.



- The flux density B or ϕ_B is significantly large inside the iron in comparison to air.





iron core can be thought of as Ampere loop

Ampere's law

$$\oint_{loop} \vec{H} \cdot \vec{dl} = I_{enclosed}.$$

$\vec{dl}$ & $\vec{H}$ are in same direction

- Assume that H is constant over the entire core

$$\oint_{loop} H dl = I_{enclosed}$$

$$\Rightarrow H \oint_{loop} dl = I_{enclosed}.$$

$$= I_{penetrated}$$

th. the surface attached to the loop

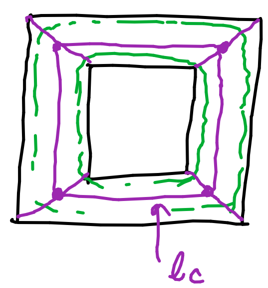
$$\Rightarrow H \oint_{loop} dl = NI$$

N : No. of turns in the coil.

$$\Rightarrow H l_c = NI$$

l_c : mean core length

$$\boxed{\Rightarrow H = \frac{NI}{l_c}}$$



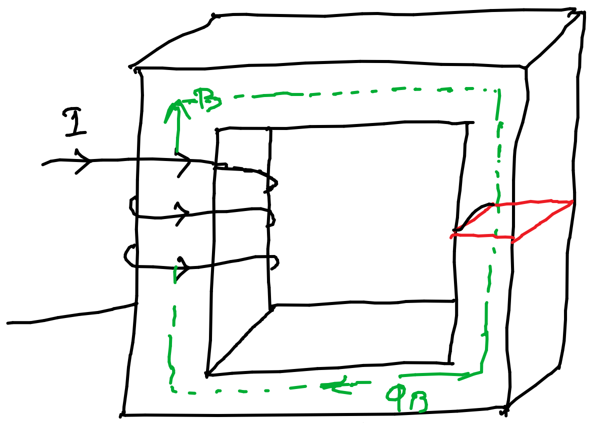
Magnetomotive Force.

$$\boxed{\mathcal{F} := NI}$$

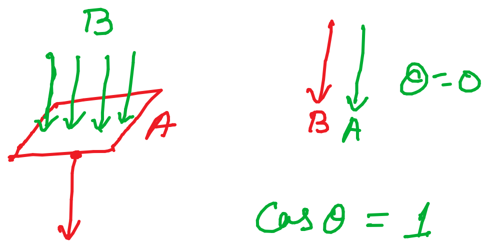
- The flux $\varphi_B = \iint_{\text{surface}} \vec{B} \cdot d\vec{A}$

For a constant / uniform magnetic field. over the entire surface

$$\varphi_B := \vec{B} \cdot \vec{A} \qquad A : \text{Surface Area.}$$



iron core



$$\cos\theta = 1$$

$$\varphi_B = BA$$

The core magnetic flux density → B_c

Cross-sectional area of core is → A_c

$$\varphi_B^c = B_c A_c \Rightarrow B_c = \frac{\varphi_B^c}{A_c}$$

Under the assumption that $B_c = \mu_c H_c$

$$H = \frac{NI}{l_c} = \frac{\mathcal{F}}{l_c}$$

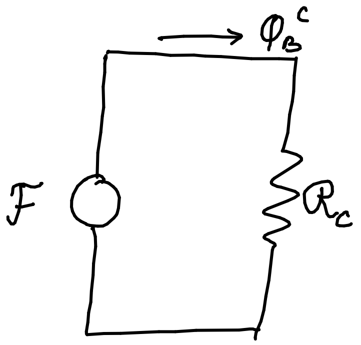
$$\Rightarrow \mathcal{F} = H l_c = \frac{B_c}{\mu_c} l_c = \frac{\varphi_B^c \, l_c}{A_c \, \mu_c}$$

$$\mathcal{F} = \left(\frac{l_c}{\mu_c A_c}\right)\phi_B^c$$

↳ Reluctance of iron core

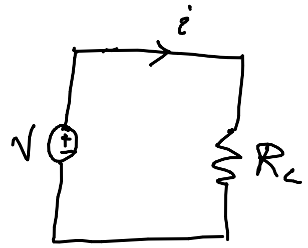
$$\boxed{\mathcal{F} = \mathcal{R}_c \phi_B^c}$$

↓



Magnetic circuit

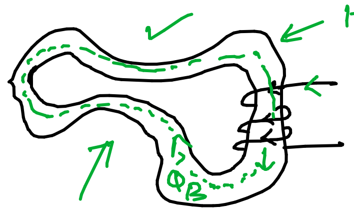
⟷

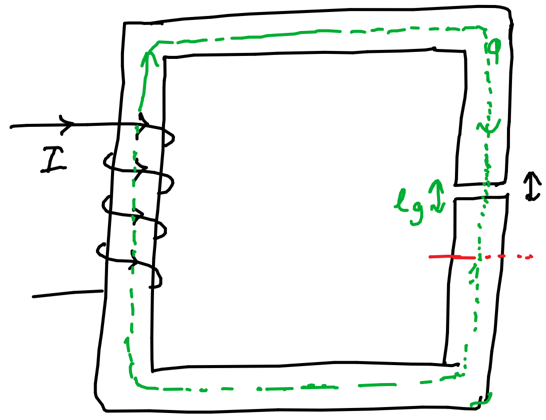


Electric circuit

Magnetic circuit		Electric Circuit
Flux (ϕ)	⟷	Current
M.M.F ($\mathcal{F}$)	⟷	Applied voltage source
Reluctance	⟷	Resistor

- A <u>magnetic circuit</u> is a <u>path</u>, primarily defined by a structure, consisting of high permeability magnetic material.





Length of air gap $\rightarrow l_g$

Length of core $\rightarrow l_c$

Area of air gap $= A_g$.

Area of core $\rightarrow A_c$

mmf $\mathcal{F} = NI$,

$$B_c = \frac{\Phi_B^c}{A_c}$$

$$B_g = \frac{\Phi_B^g}{A_g}$$

$$\Phi_B^c = \Phi_B^g$$

$$\oint \vec{H} \cdot d\vec{l} = \oint H\,dl = H_c l_c + H_g l_g = NI$$

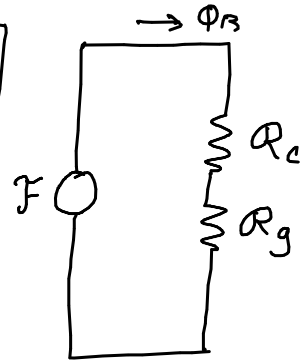
$$\mathcal{F} = \frac{B_c}{\mu_c} l_c + \frac{B_g}{\mu_0} l_g$$

$$= \Phi_B \left[\underbrace{\frac{l_c}{\mu_c A_c}}_{\mathcal{R}_c} + \underbrace{\frac{l_g}{\mu_0 A_g}}_{\mathcal{R}_g} \right]$$

Reluctance for core $\mathcal{R}_c$

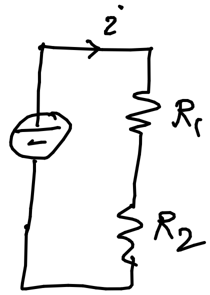
Reluctance for air gap $\mathcal{R}_g$

$$\boxed{\mathcal{F} = \Phi_B [\mathcal{R}_c + \mathcal{R}_g] \quad \Rightarrow \quad \Phi_B = \frac{\mathcal{F}}{\mathcal{R}_c + \mathcal{R}_g}}$$



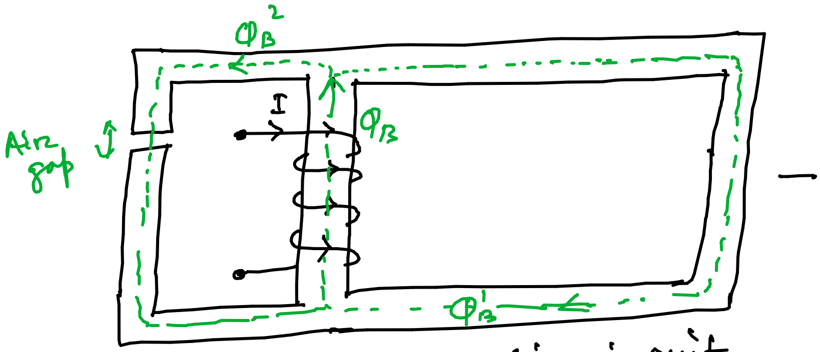
magnetic circuit.

Series



Electric circuit

$$\mathcal{F} = \oint H\,dl = \sum_k \mathcal{F}_k = \sum_k H_k l_k$$

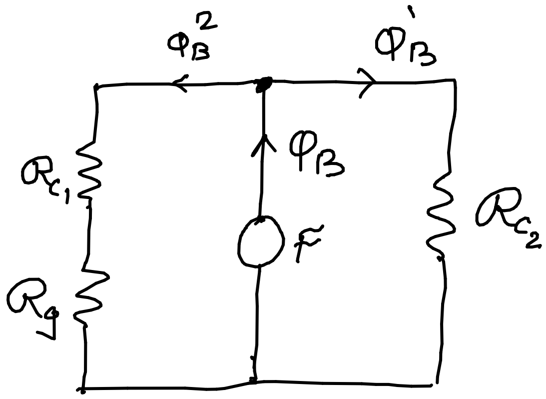


(Parallel) Magnetic circuit

For electric ckt

$$\varphi_B = \varphi_B^1 + \varphi_B^2$$

$\sum_n i_n = 0$ at any node



$$\boxed{\sum_n \varphi_B^n = 0}$$