Lecture 8

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EE114 - Power Engineering 1

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Magnetic field intensity (H)

Flux density (B)

Flux (ϕ)

$$\oint H.dl = \Sigma i$$

$$B = \mu H$$

$\odot$ i

permeability

$$\mu = \mu_0 \mu_r$$

$H \rightarrow$ unit A/m

$B \rightarrow$ Wb/m^2 or T (tesla)

line integral

$$\oint \overline{B} \cdot dl = \Sigma \mu i$$

$\mu_0 \rightarrow$ permeability of free space ($4\pi \times 10^{-7}$)

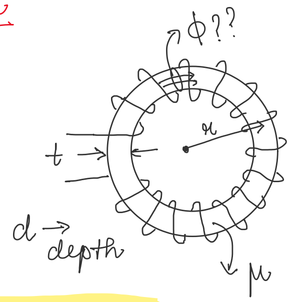
$\mu_r \rightarrow$ relative permeability

$$\phi = \int B \, dA$$

flux

unit Wb (weber)

eg. toroidal



$t << r$

N — turns.

$r \rightarrow$ mean radius

$$\phi \rightarrow B \rightarrow H \rightarrow i$$

Flux in this cross section?

If $t << r$, the H in the cross section is nearly the same

$$\phi = B A_c$$

$$\oint H dl = \Sigma i$$

$$H \times 2\pi r = Ni$$

$$H = \frac{Ni}{2\pi r}$$

$$B = \mu H$$

$$B = \frac{\mu N i}{2\pi r}$$

$$\phi = B A_c \quad \& \quad A_c = d \times t$$

$$\phi = \frac{\mu N i}{2\pi r} \times td \quad \text{—(i)}$$

$Ni \longrightarrow MMF$

We know

$$e = N\frac{d\phi}{dt} \quad \text{—(ii)}$$

$$\& \quad e = L\frac{di}{dt} \quad \text{—(iii)}$$

Using (i) & (ii)

$$e = \frac{N^2 \mu td}{2\pi r}\frac{di}{dt} \quad \text{—(iv)}$$

Using (iv) & (v)

$$\boxed{L = \frac{\mu N^2 A_c}{2\pi r}} = \frac{\mu N^2 A_c}{l}$$

$$\boxed{L = \frac{N^2}{R}} \qquad R = \frac{l}{\mu A_c}$$

* Prove $MMF = R\phi$??

$$B = \mu H \quad \& \quad H = \frac{Ni}{2\pi r} \qquad \phi = BA_c$$

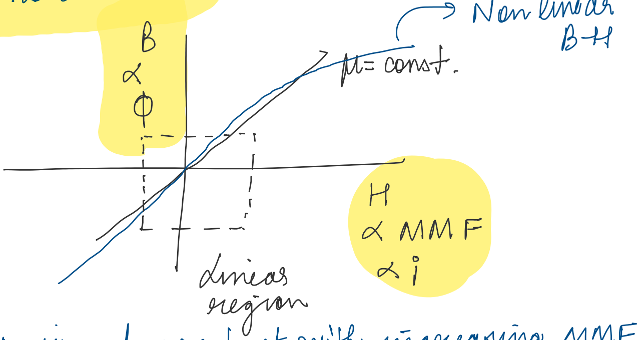
$$\phi = \mu H A_c$$
$$= \frac{\mu N i}{2\pi r} A_c$$

$$\phi = \frac{\mu N i A_c}{l} \longrightarrow \frac{\phi l}{\mu A_c} = MMF$$

$$\boxed{MMF = \phi R}$$

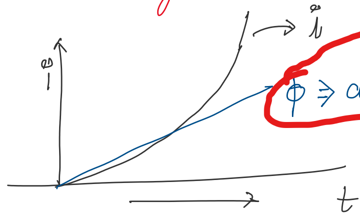
$MMF \to$ voltage $\quad R \to$ resistance $\quad \phi \to$ current

We use the electrical equivalent of magnetic circuit only if μ is constant.



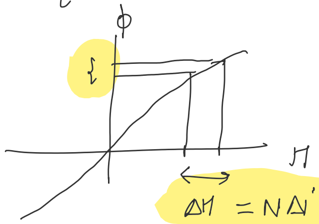
In reality μ is not constant with increasing MMF as the core saturates.

Ques :- For the non linear BH curve plot current vs time for a dc voltage source applied across coil.



$\phi \Rightarrow$ continuously increasing

$$e = N\frac{d\phi}{dt}$$



$\Delta H = N\Delta i$

For small increase in ϕ, a large increase in current is required outside linear region

$$\frac{\Delta B}{\Delta H} = \mu$$

* Core that is saturated is as good as air.