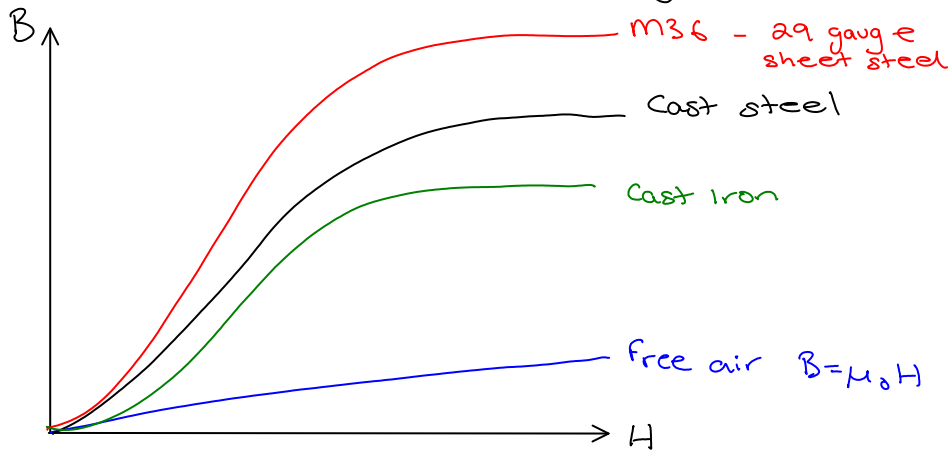


# Lecture 3

Monday, 17 August 2009  
10:33 AM

## Saturation:

Consider the B-H curve for ferromagnetic material

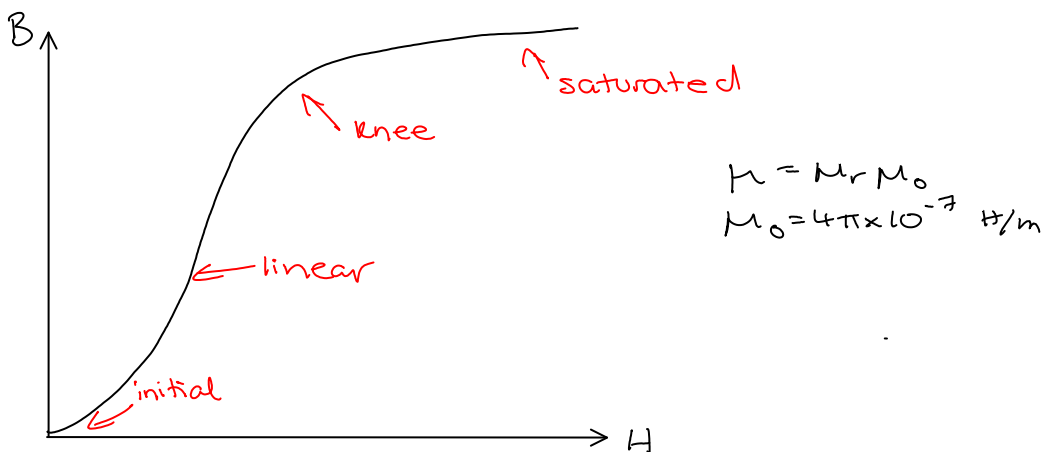


B increases rapidly as H increases from zero.

Hence only a small applied field is required to cause domain boundaries to move and allow more moments to come into alignment.

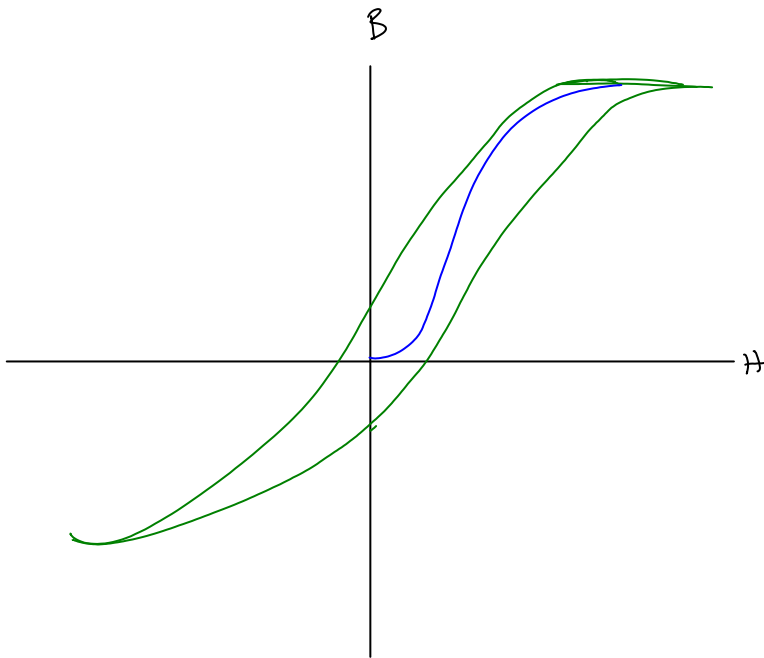
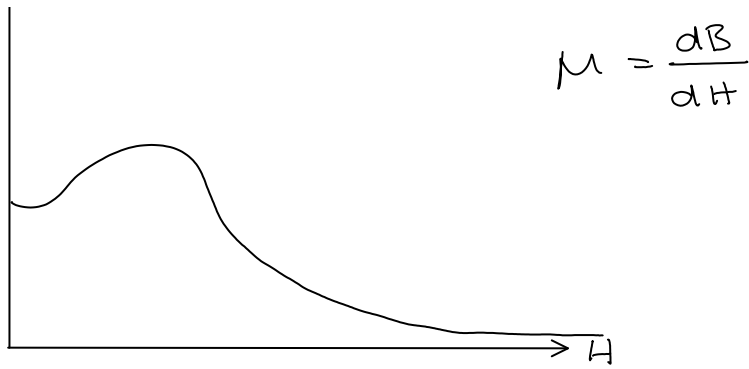
As H is increased further the slope of B-H is reduced indicating walls are moving less rapidly.

As H ↑ further all moments are aligned and increase in B with H →  $M_0$ .



$\mu_r \uparrow$

$$\mu = \frac{dB}{dH}$$



B-H with AC current applied

Magnetically soft material

- has small enclosed area and low hysteresis
- good for transformers

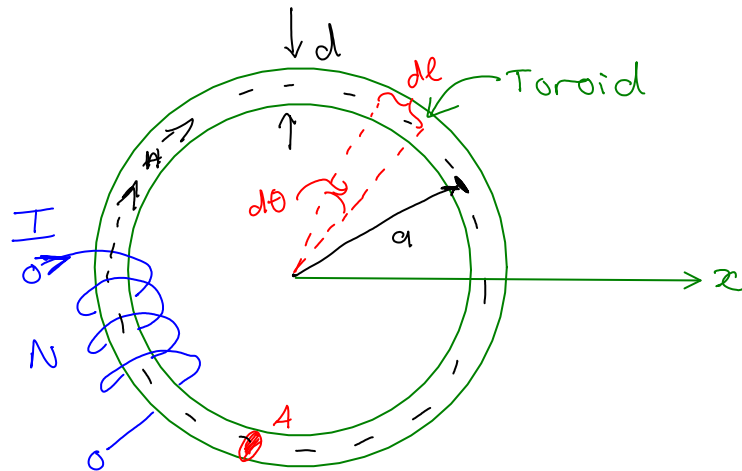
Magnetically hard material

- has large enclosed area or large hysteresis loss
- good for permanent magnets

Ampere's Law

$$\oint \underline{H} \cdot d\underline{e} = \sum \text{Current enclosed}$$

$$= NI = N \int \underline{I} \cdot d\underline{A}$$

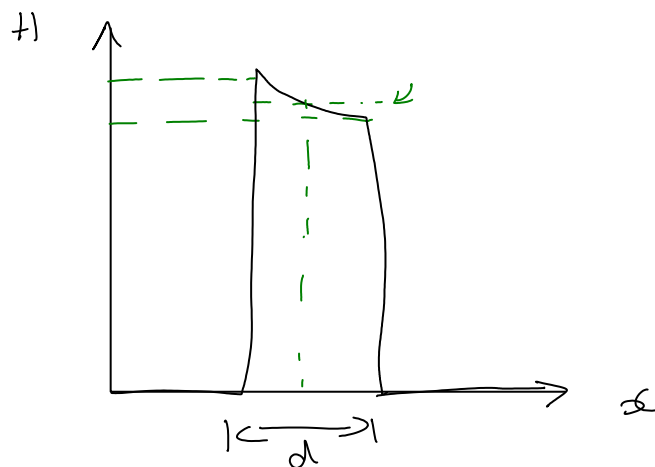


$$\oint \underline{H} \cdot d\underline{\ell} = NI$$

$$\int_0^{2\pi} H_a \cdot a \, d\theta = NI$$

$$\therefore H_a a \, d\theta = NI$$

$$H_a = \frac{NI}{2\pi a}$$



Applying Ampere's law outside or inside the toroid shows that  $H$  is zero  $\because \sum I = 0$

If  $a \gg d$  then the value of  $H$  inside the toroid will be close to a constant and so the concept of a "mean path" at

radius  $r_{in} + \frac{d}{2}$  may be introduced,

$$l = 2\pi \left( r_{in} + \frac{d}{2} \right)$$

$$H_l = \frac{NI}{l} \approx H \text{ anywhere in the toroid}$$

$$B = \mu H$$

$$\phi = \int \underline{B} \cdot \underline{dA}$$

$$= B \cdot A \quad A = \text{cross-section of toroid}$$

$$\phi = \mu H A$$

$$\phi = \frac{\mu (NI) A}{l}$$

$$= \frac{NI}{\left( \frac{l}{\mu A} \right)}$$

$$= \frac{F}{R} \quad \leftarrow \text{reluctance}$$

$$\therefore \phi = \frac{NI}{l/\mu A} = \frac{F}{R} = F P$$

$$\text{d/w } I = \frac{V}{(l/\mu A)} = \frac{V}{R} = V G$$

where  $F$  = magnetomotive force  $= NI$

$$R = \text{reluctance} = \frac{l}{\mu A}$$

$$P = \text{permeance} = \frac{\mu A}{l}$$

$\mu$  - - - - - between

the comparison with

may be written  $\mathcal{F}$  (script F)

$$\phi = \frac{\mathcal{F}}{\mathcal{R}} \quad \text{and} \quad \mathcal{I} = \frac{V}{\mathcal{R}}$$

$$\phi = \mathcal{F} \mathcal{P} \quad \text{and} \quad \mathcal{I} = V \mathcal{G}$$

gives some insight into the nature of  $\mathcal{R}$  and  $\mathcal{P}$ .

The reluctance is a measure of the difficulty of establishing a given flux flow in the toroid.

Units of  $\mathcal{R}$  and  $\mathcal{P}$

$$\mathcal{R} : \text{AT} / \text{wb} \leftarrow \text{weber}$$

$$\mathcal{P} = \text{wb} / \text{A}$$

Ohms Law  $\mathcal{I} = \frac{V}{\mathcal{R}}$

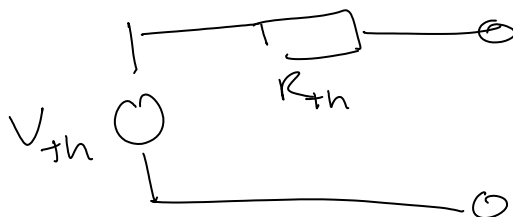
$$\mathcal{R}_{\text{eq}} = \frac{\prod \leftarrow \text{product}}{\sum \leftarrow \text{sum}}$$

two R in ||

KCL

KVL

Thevenin Equivalent.



loop mesh

Table of Magnetic Quantities

<u>Magnetic Quantity</u>	<u>Symbol</u>	<u>Unit</u>	<u>Vector / Scalar</u>
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Flux Density	$B$	Tesla	V
Field intensity	$H$	Amps/meter	V
Flux	$\phi$	Weber	S
Magnetic moment	$m$	amps. $\cdot$ m <sup>2</sup>	V
permiability	$\mu$	H/m	S
relative permiability	$\mu_r$	—	S
permiability air	$\mu_0$	H/m	S
Flux leakage	$\lambda$	Weber	S
mmf	$\mathcal{F}$	amper-turns	S
reluctance	$R$	amper-turns/Weber	S
Permeance	$P$	Weber/Amp	S