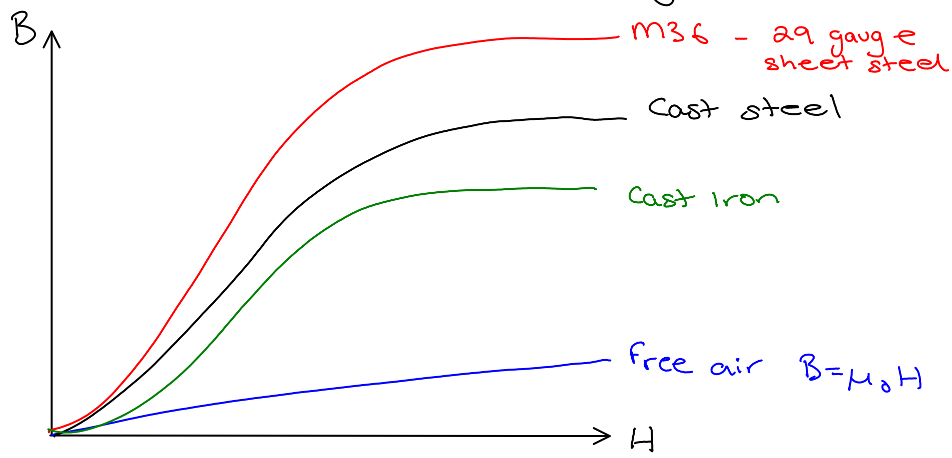
Lecture 3

Monday, 17 August 2009
10:33 AM

Saturation:

Consider the B-H curve for ferromagnetic material

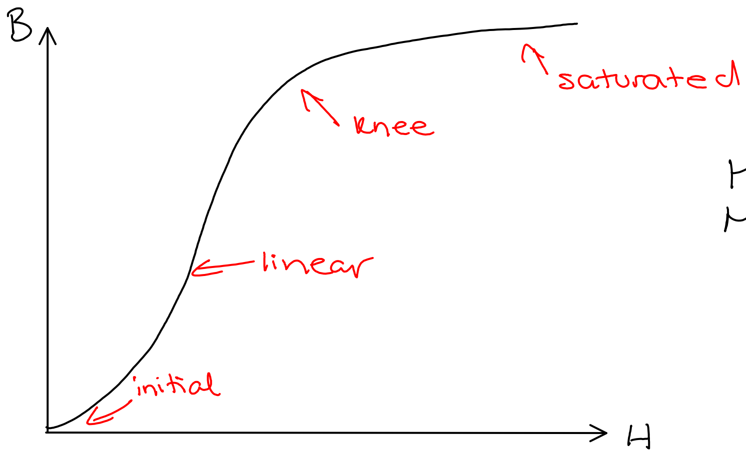


B increases rapidly as H increases from zero.

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

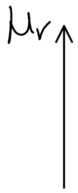
As H is increased further the slope of B-H is reduced indicating walls are moving less rapidly.

As H↑ further all moments are aligned and increase in B with $H \to \mu_0$

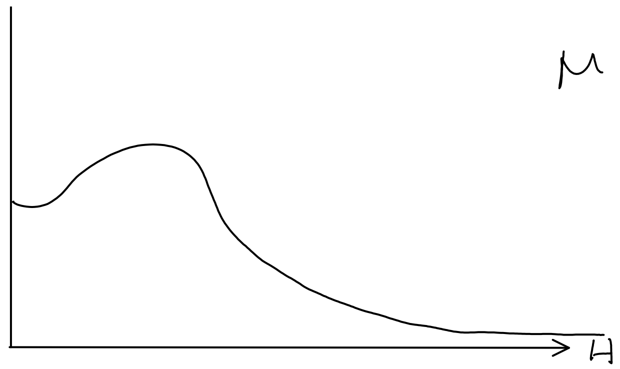


$\mu = \mu_r \mu_0$

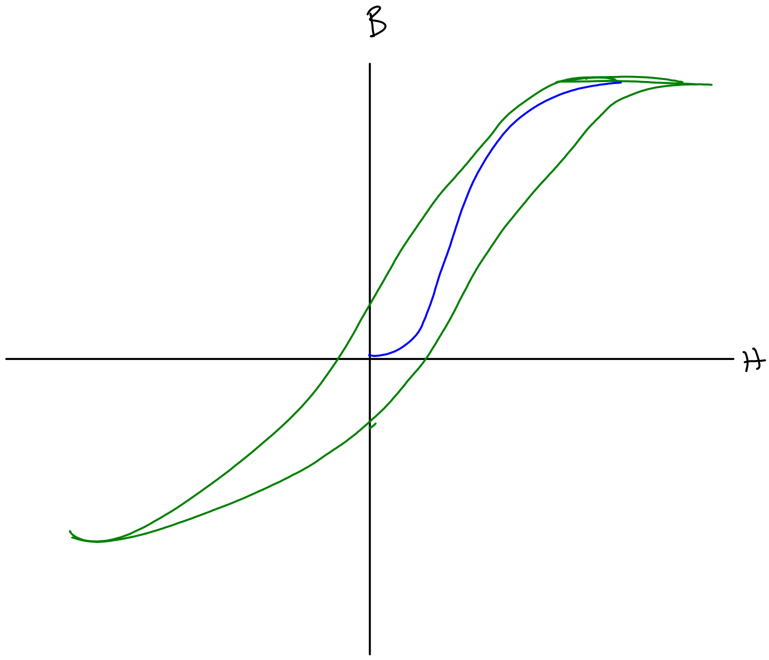
$\mu_0 = 4\pi \times 10^{-7}$ H/m



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



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



B-H with AC current applied

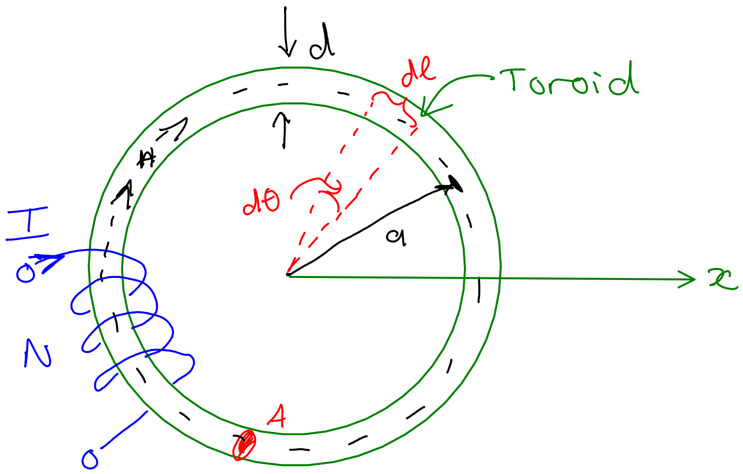
Magnetically soft material
- has small enclosed area and low hysterisis
- good for transformers

Magnetically hard material
- has large enclosed area or large hysterisis loss
- good for perminant magnents

Ampere's Law

$$\oint \underline{H} \cdot d\underline{l} = \sum \text{current enclosed}$$

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

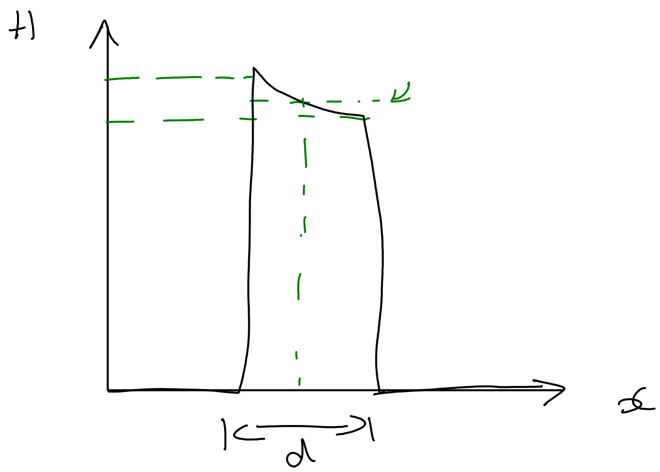


$$\oint \underline{H} . d\underline{l} = NI$$

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

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

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



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

If $a >> d$ 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,

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

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

$$B = \mu H$$

$$\phi = \int \underline{B} \cdot d\underline{A}$$

$= B.A$ $\qquad$ A = cross-section of toroid

$$\phi = \mu H A$$

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

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

$$= \frac{\mathcal{F}}{\mathcal{R}}$$ ⟸ reluctance

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

c/w $I = \dfrac{V}{(l/\sigma A)} - \dfrac{V}{R} = VG$

where $\mathcal{F}$ = magnetomotive force $= NI$

$\mathcal{R}$ = reluctance $= \dfrac{l}{\mu A}$

$\mathcal{P}$ = permeance $= \dfrac{\mu A}{l}$

between

The comparison [illegible]

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

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

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

gives some insight into the nature of R and P.

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

Units of R and P

weber

R : AT / wb

P = wb / A

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

two R in ||

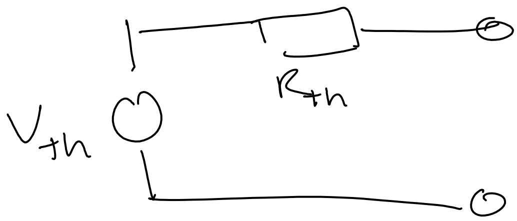
product

$$R_{ap} = \frac{\prod}{\sum}$$

sum

KCL
KVL

Thevenan Equivalent.



loop mesh

Table of Magnetic Quantities

Mag Quantity	Symbol	Unit	Vector / Scalar

Flux Density	B	Tesla	V
Field intensity	H	Amps/meter	V
flux	ϕ	weber	S
Magnetic moment	m	amps.m^2	V
permiability	μ	H/m	S
relative permiability	μ_r	—	S
permiability air	μ_o	H/m	S
flux leakage	λ	Weber	S
mmF	$\mathcal{F}$	amper-turns	S
reluctance	$\mathcal{R}$	amper-turns/Weber	S
Permeance	$\mathcal{P}$	Weber/Amp	S