

Magnetism
 magnetic forces
 Motors / generator

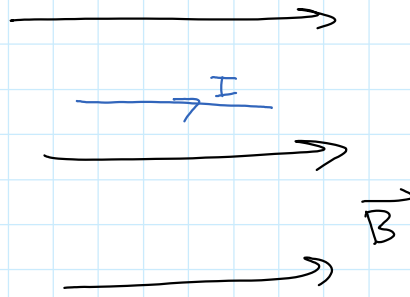
Force on a current carrying wire in a magnetic field

$$\vec{F} = I \vec{L} \times \vec{B}$$

or

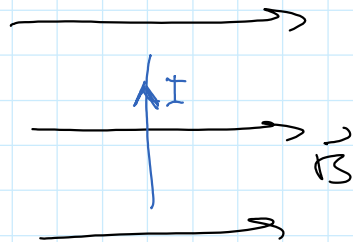
$$|\vec{F}| = ILB \sin \theta$$

a)



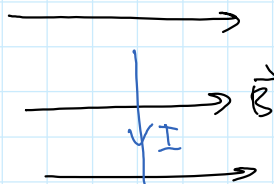
$$F = 0$$

b)



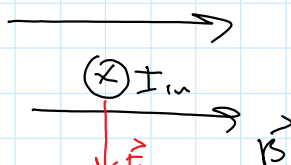
F into page

c)



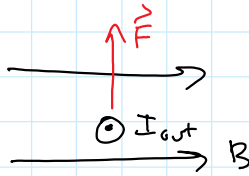
F out of page

d)

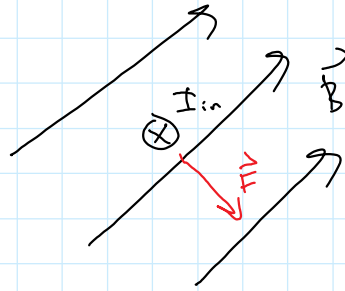




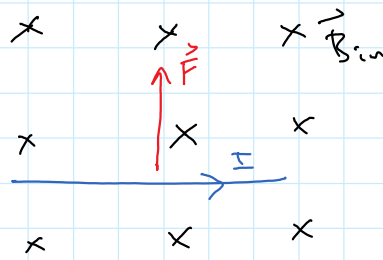
e)



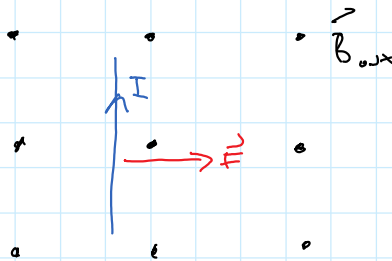
f)



g)

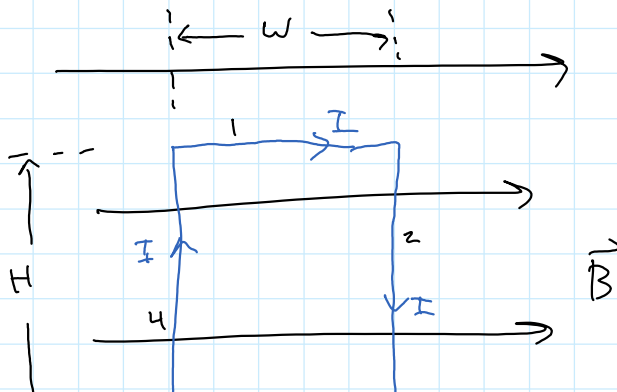


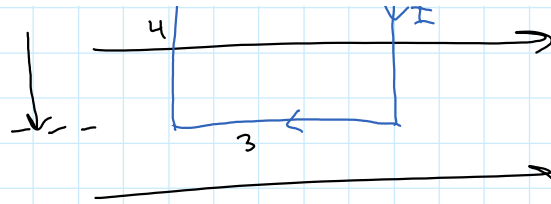
h)



Current Loop

Side view





Find the force on each side and the net force:

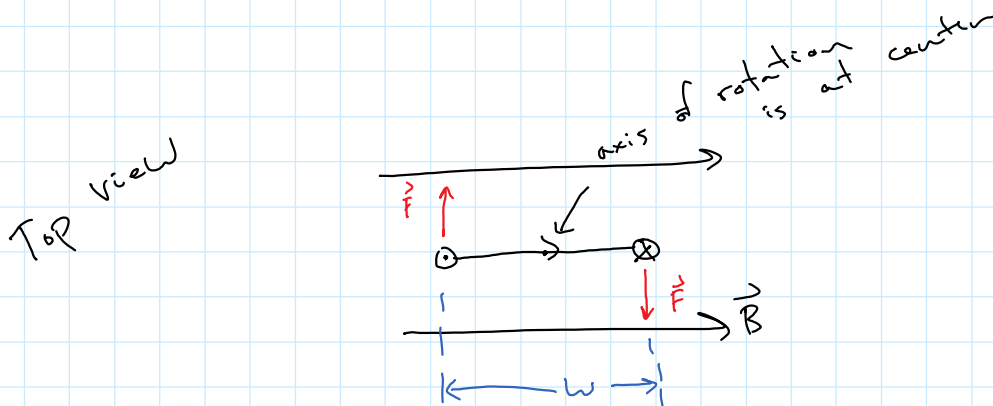
side	Force
1	$F_1 = IWB \sin 0^\circ = 0$
2	$F_2 = IHB \sin 90^\circ = IHB$ out of page
3	$F_3 = IWB \sin 180^\circ = 0$
4	$F_4 = IHB \sin 90^\circ = IHB$ into page

$$\vec{F}_{\text{net}} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4$$

$$= 0$$

No net force \rightarrow But we have torque \rightarrow it rotates

Find the torque at this instant:



$$\tau_{\text{net}} = F \frac{w}{2} + F \frac{w}{2} = Fw = (IHB)w$$

$$= IB(Hw)$$

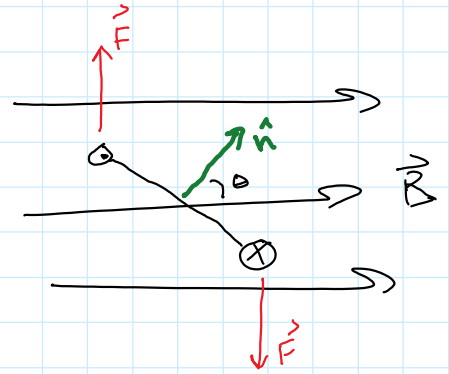
$$= I B A$$

↑
area of loop

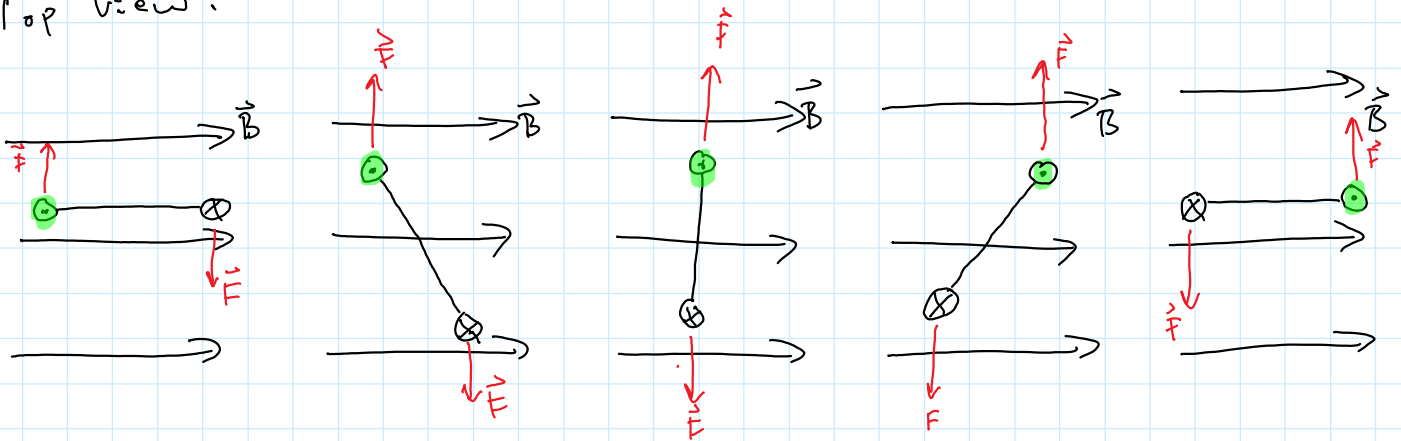
for any angle :

$$\tau = I A B \sin\theta$$

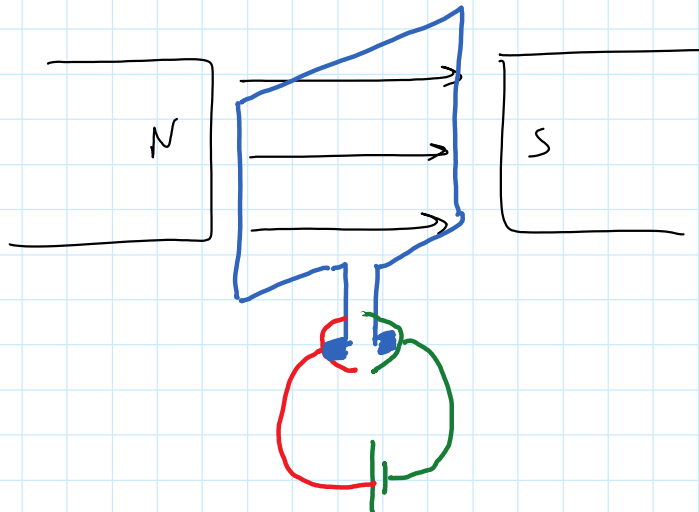
⏟
 $I \vec{A} \times \vec{B}$



Top view :



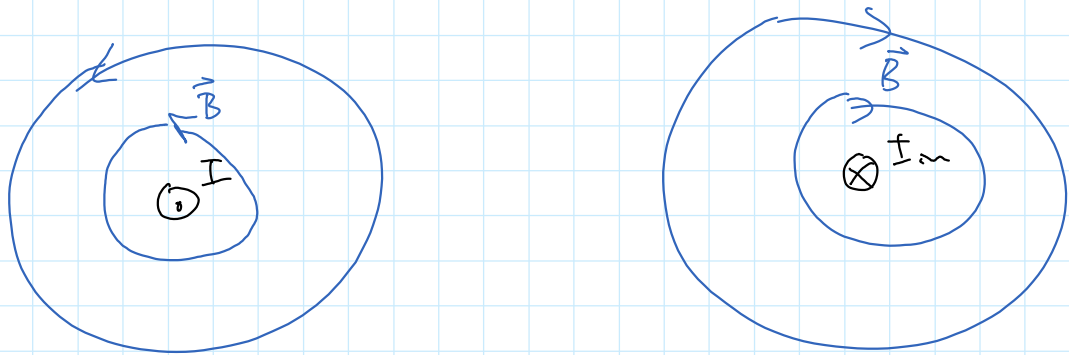
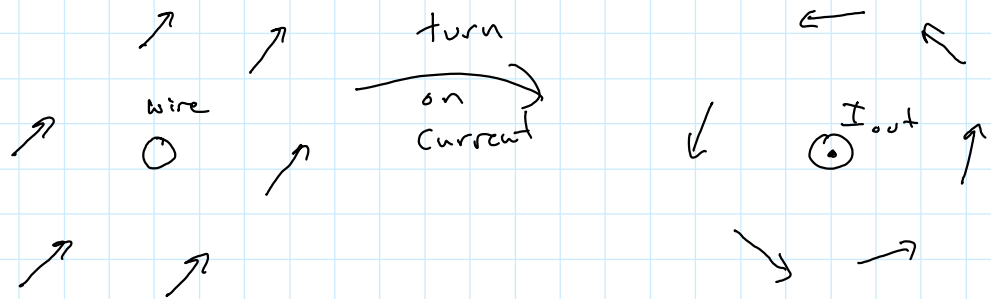
τ goes to zero



Motor \rightarrow Put in electrical energy \rightarrow
 get out mechanical energy

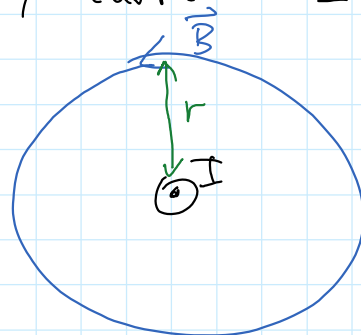
generator \rightarrow Put in mechanical energy \rightarrow
 get out electrical energy

Current causes magnetic field



Long, straight wire w/ current I :

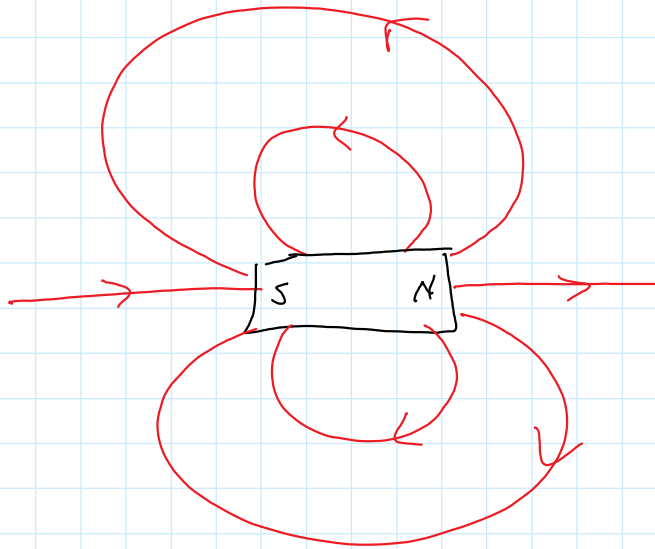
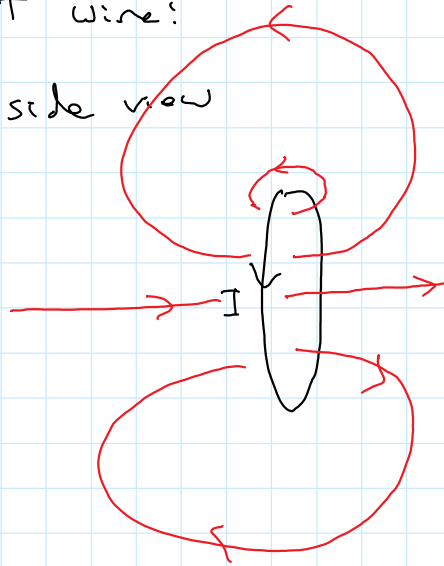
$$B = \frac{\mu_0 I}{2\pi r}$$



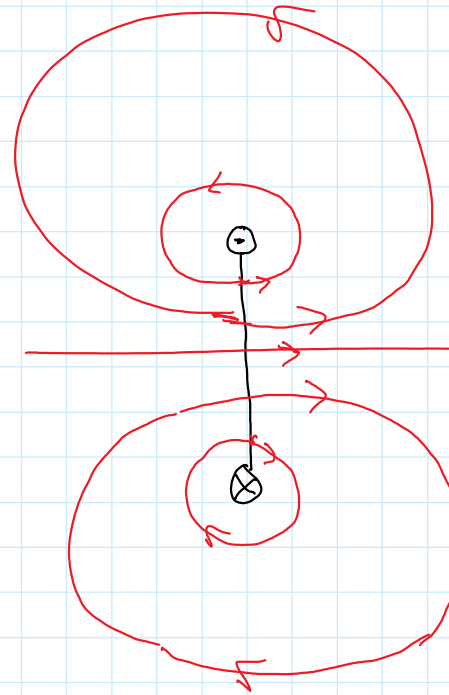
$$\begin{aligned} \mu_0 &= \text{constant} \\ &= 4\pi \times 10^{-7} \frac{\text{T}\cdot\text{m}}{\text{A}} \end{aligned}$$

Loop of wire:

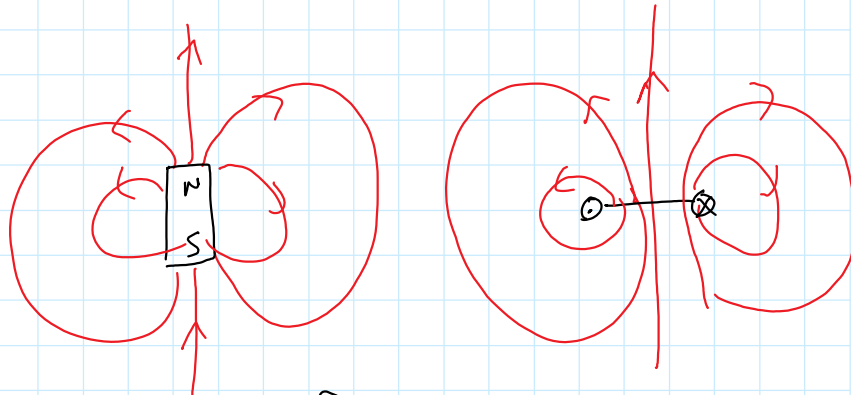
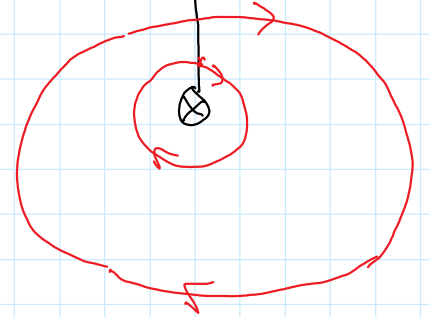
side view



A

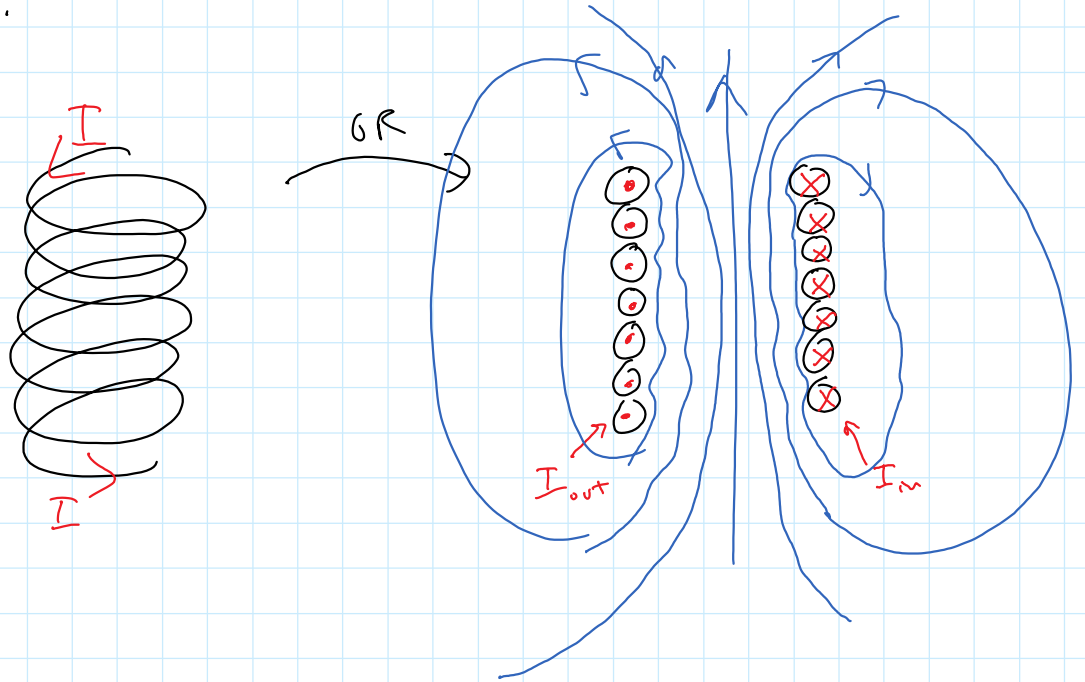


or



Same

Solenoid :



Ideal Solenoid :

turns are close together
Length \gg radius

Inside: B is constant / uniform

Outside: $B = 0$

Circular loop : at center only

$$B = N \frac{\mu_0 I}{2R}$$

$N = \#$ of turns

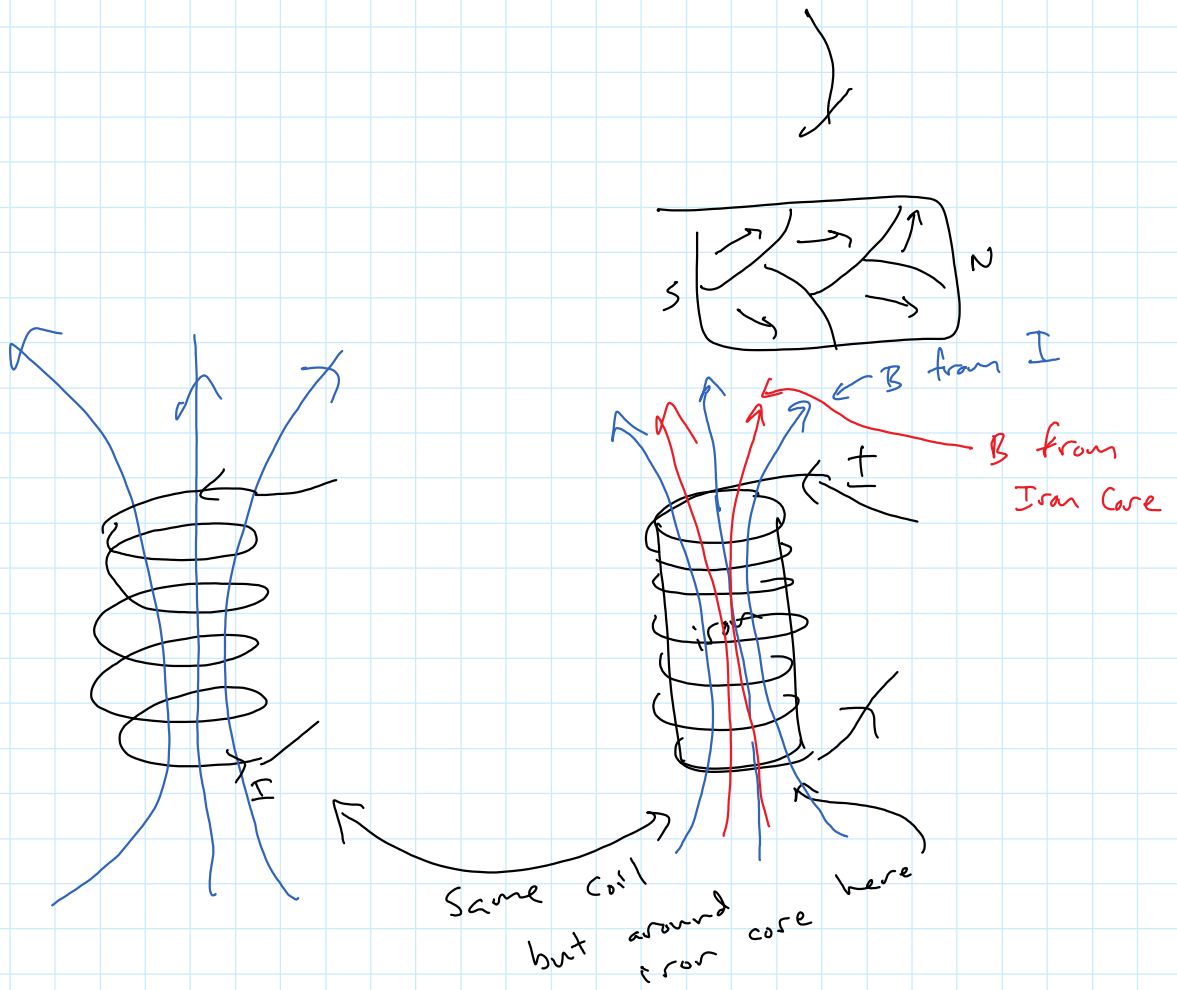
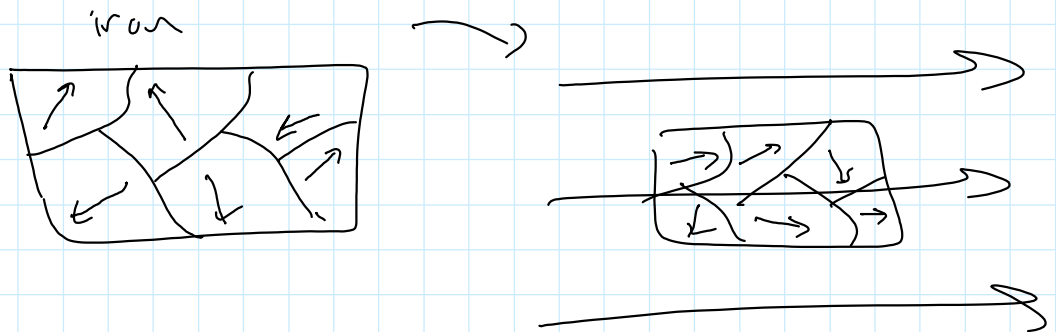
Ideal Solenoid: anywhere inside:

$$B = \mu_0 n I$$

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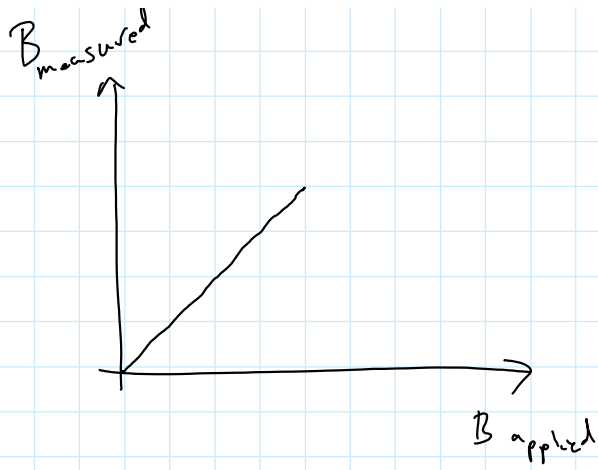
$$n = \frac{N}{L} \quad \text{turns per unit length}$$

Magnetism in matter: Ferromagnetism

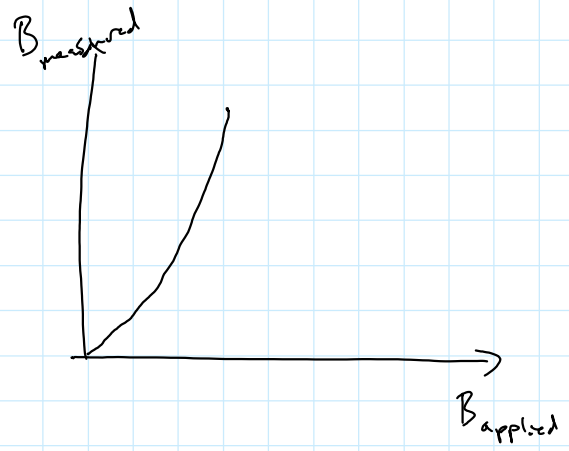


B_{measured}
↑

B_{measured}
↑

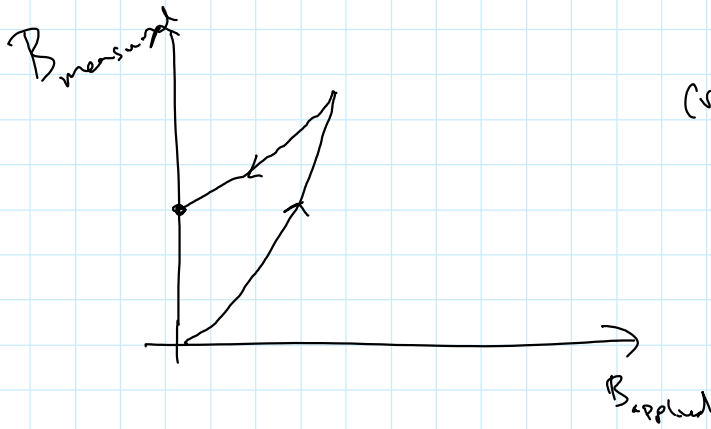


No iron core



With Iron Core

Turn off current



Created a magnet
 → domains are aligned

De-magnetizing

