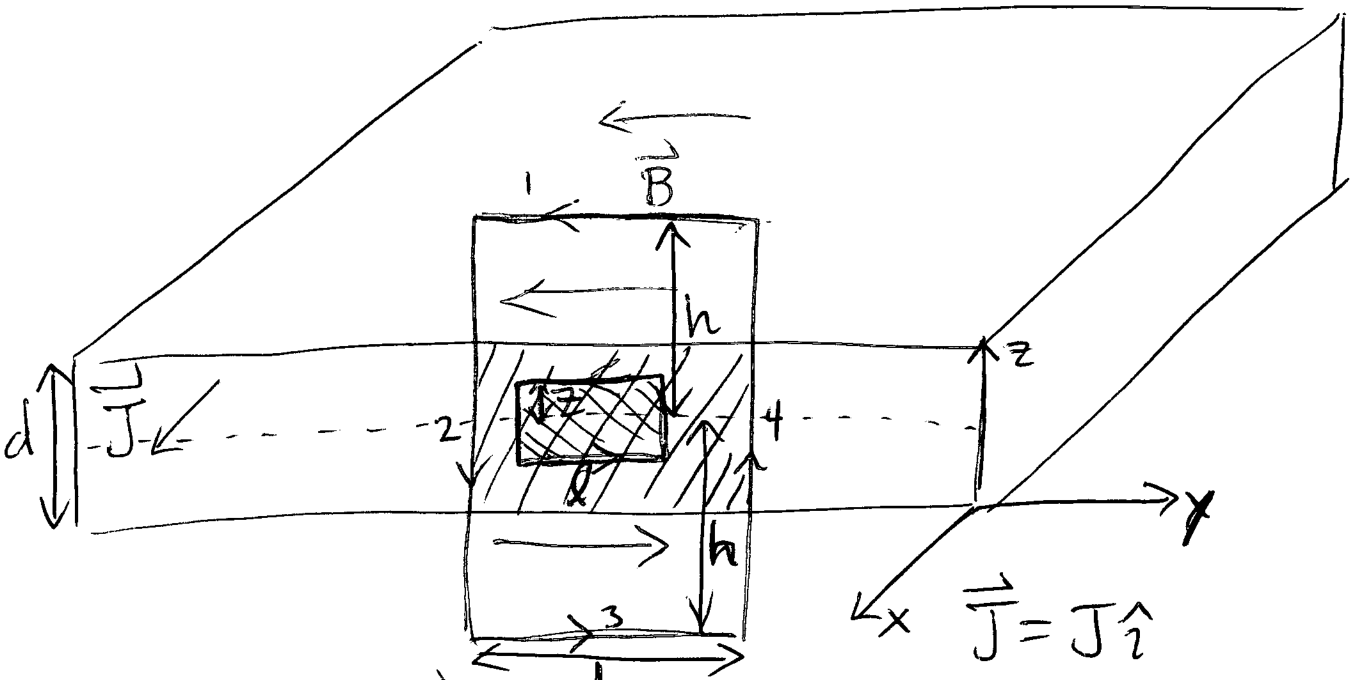
Applications of Ampère's Law



1. What is $\vec{B}$ above (or below) the slab?

$$\boxed{\oint \vec{B}\cdot d\vec{l} = \mu_0 i_{enc}}$$

$$\rightarrow \underbrace{\int_1 \vec{B}\cdot d\vec{l}}_{\int_1 B\,dl} + \underbrace{\int_2 \vec{B}\cdot d\vec{l}}_{=0} + \underbrace{\int_3 \vec{B}\cdot d\vec{l}}_{\int_3 B\,dl} + \underbrace{\int_4 \vec{B}\cdot d\vec{l}}_{=0}$$

$$2B\int dl = \mu_0 (J d L)$$

$$2B\cancel{L} = \mu_0 J d \cancel{L}$$

$$\boxed{B = \frac{\mu_0 J d}{2}}$$

strength doesn't change with height. Uniform $\vec{B}$

② What is $\vec{B}$ inside the slab?

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 i_{enc}$$

$$\int_1 \vec{B}\cdot d\vec{l} + \underbrace{\int_2 \vec{B}\cdot d\vec{l}}_{=0} + \int_3 \vec{B}\cdot d\vec{l} + \underbrace{\int_4 \vec{B}\cdot d\vec{l}}_{=0} = \mu_0 (J 2 z l)$$

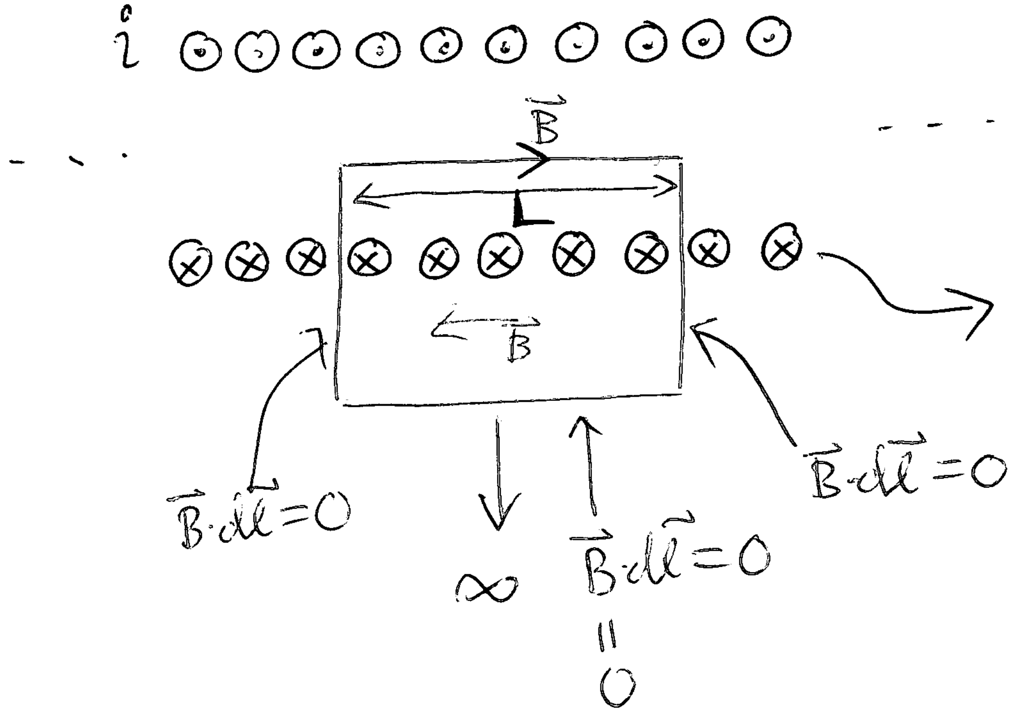
$$\cancel{2} B \cancel{l} = \mu_0 (J \cancel{2} z \cancel{l})$$

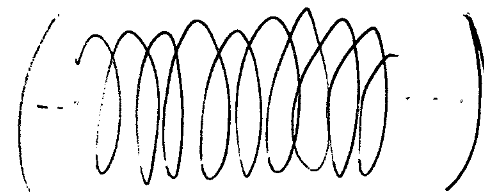
$$\boxed{B = \mu_0 J z}$$ linear in z.

Note: when $z = \frac{d}{2}$ $\quad B = \frac{\mu_0 J d}{2}$

This agrees with previous result.

B-field of a solenoid.





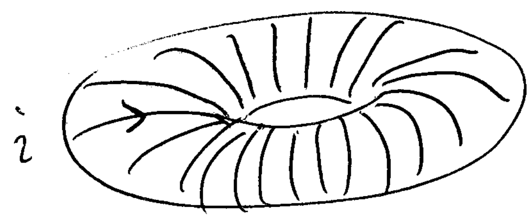
$n = \#$ turns per length

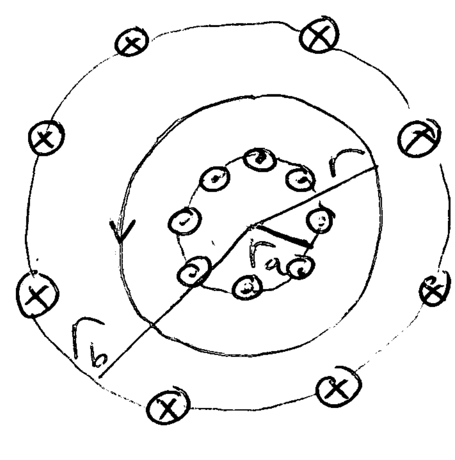
$$\oint \vec{B}\cdot d\vec{l} = \mu_0 i_{enc} \qquad i_{enc} = Ni = (nL)i$$

$$\int_1 \vec{B}\cdot d\vec{l} = B\cancel{L} = \mu_0 n \cancel{L} i$$

$$B = \mu_0 n i$$ uniform B-field inside.

Toroid:





$$\oint \vec{B}\cdot d\vec{l} = \mu_0 i_{enc}$$

$$B \oint dl = \mu_0 N i$$

↑ keep in terms of N

$$B(2\pi r) = \mu_0 N i$$

$$B = \frac{\mu_0 N i}{2\pi r} \qquad r_a < r < r_b$$

$r < r_a$: $B = 0$ b/c $i_{enc} = 0$

$r > r_b$: $B = 0$ b/c $i_{enc} = 0$