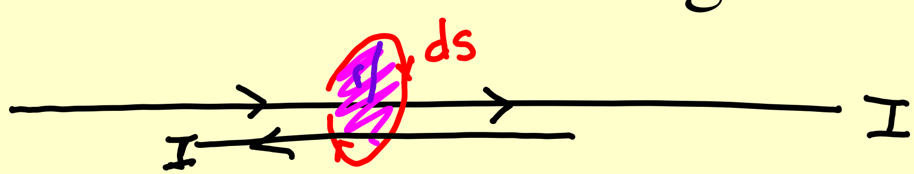
Ampere's Law & Solenoids

If I were two-faced, would I be wearing this one? *Lincoln*

Ampere's Law

- Consider a closed-loop circular path around a wire and solve for the integral of B•ds.

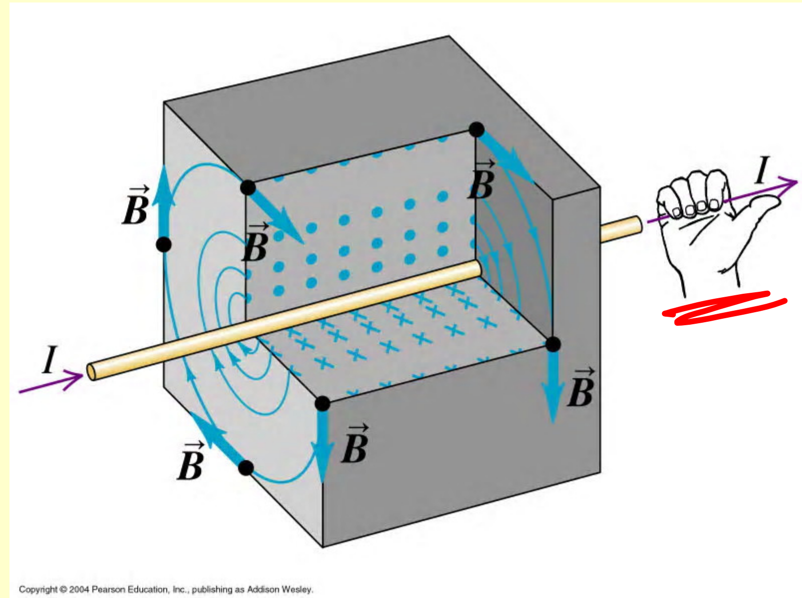


$d\vec{s} \parallel B$

$\oint B \cdot ds = B \oint ds = B(2\pi r)$

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

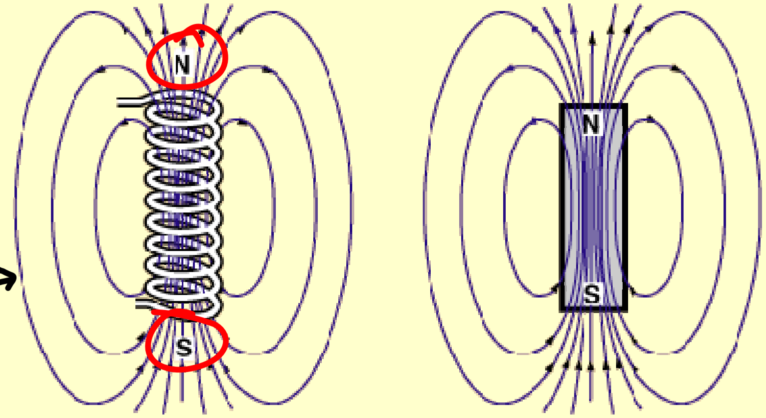
$\oint B \cdot ds = \mu_0 I$



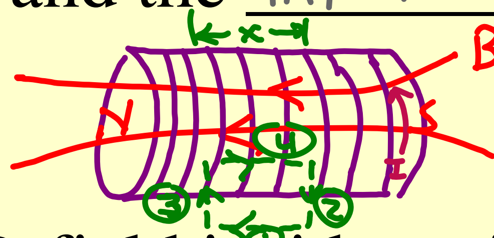
- Ampere's Law states that the line integral of B•ds around any closed path equal $\mu_o I$, where I is the total continuous current passing through any surface bounded by the closed path. $\oint B \cdot ds = \mu_0 I$ Ampere's Law

Solenoids

- What is a solenoid? long wire wound in a helix
- Draw the B-field around one. see →



- An ideal solenoid has closely spaced coils and a length that is much greater than the radius of the turns. In this case the exterior field is zero, and the interior field is uniform.



$\oint ds$ is dotted box

- Use Ampere's Law to find the B-field inside an ideal solenoid. side 1: $B=0$, 2 & 3, $B \cdot ds = 0$ b/c $B \perp ds$
- B-field strength at the opening is $\frac{1}{2}$ the B-field strength inside.

$\oint_4 B \cdot ds = \mu_0 I$

$B x = \mu_0 N_1 I$ where N_1 is # of coil through $\oint ds$

$$B = \mu_0 \frac{N_1}{x} I = \mu_0 n I$$

, $n = \frac{N}{l}$ where N is total # of coils & l is length of solenoid

Examples

1. A long wire of radius R carries I_o that is uniformly distributed through its cross-section. Calculate B for $r \geq R$ and $r < R$.
2. A thin, infinite sheet lying in yz plane carries linear current density J_s, which represents the current per unit length measured along z axis. Find B near sheet.
3. Use figure to find F exerted by wire 1 on the top of the loop.
4. Toroid

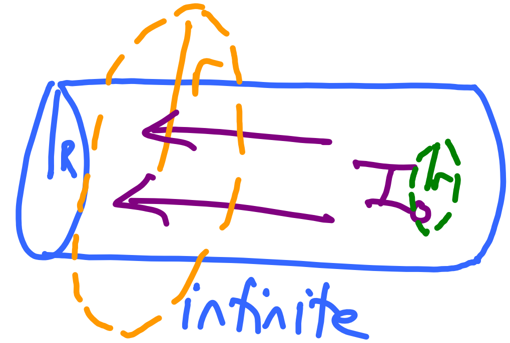
1.

$r > R$

$\oint B \cdot ds = \mu_0 I$

$B(2\pi r) = \mu_0 I$

$$B = \frac{\mu_0 I_0}{2\pi r}$$ like a wire



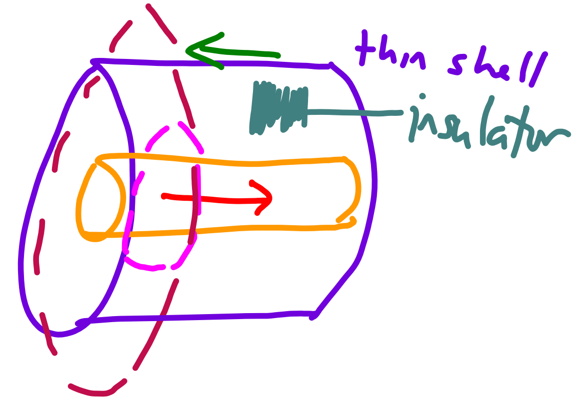
$r < R$

$$\frac{I}{I_0} = \frac{\pi r^2}{\pi R^2} \Rightarrow I = \frac{I_0 r^2}{R^2}$$

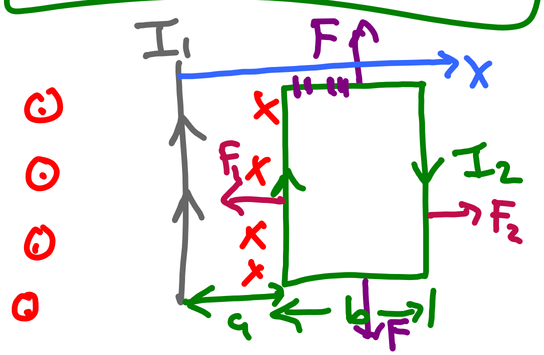
$\oint B \cdot ds = \mu_0 I$

$$B(2\pi r) = \mu_0 \left(\frac{I_0 r^2}{R^2} \right)$$

$$B = \frac{\mu_0 I_0}{2\pi R^2} r$$



3.



$$B_1 = \frac{\mu_0 I_1}{2\pi x}$$

$F_1 > F_2$

$F = I l B$ on top

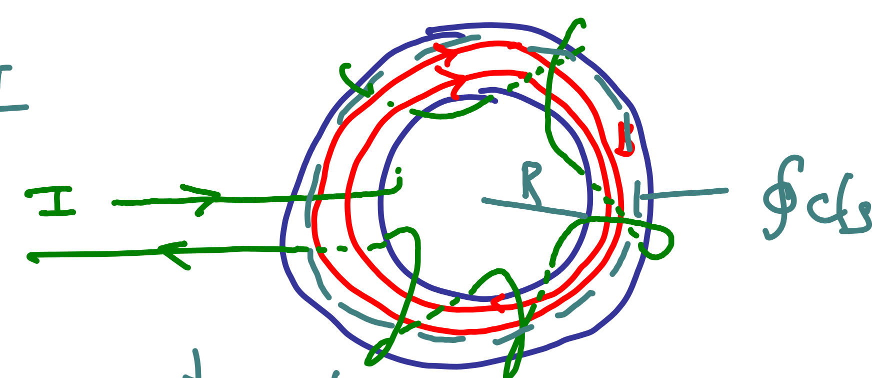
$$F_{top} = I_2 \int_a^{a+b} \left(\frac{\mu_0 I_1}{2\pi x} \right) dx$$

$$F = \frac{\mu_0 I_1 I_2}{2\pi} \ln\left(\frac{a+b}{a}\right)$$

4. $\oint B \cdot ds = \mu_0 I$

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

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



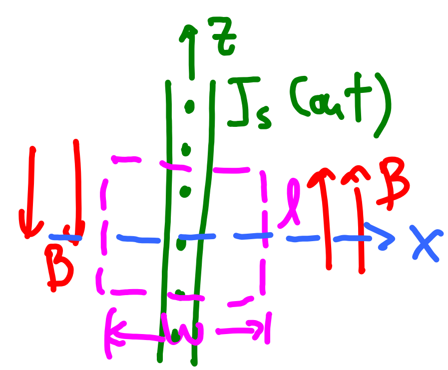
N - total coils on toroid.

2. Net $I = J_s l$

$B = 0$ along W

B constant along l

$\oint B \cdot ds = \mu_0 I = \mu_0 J_s l$



$$B(2\ell) = \mu_0 J_s \ell$$

$$\boxed{B = \mu_0 \frac{J_s}{2}}$$ independent of distance.