Define $\mu_0 = 4\pi k'$

$\mu_0 =$ "permeability of vacuum"

$\mu_0 = 4\pi \times 10^{-7}$ wb $A^{-1} m^{-1}$

$$\boxed{\oint \vec{B} \cdot d\vec{l} = \mu_0 I}$$ AMPÈRE'S LAW

Can be shown that this is ind. of path

1) B tangent to path then

$$\int_a^b \vec{B} \cdot d\vec{l} = Bl$$

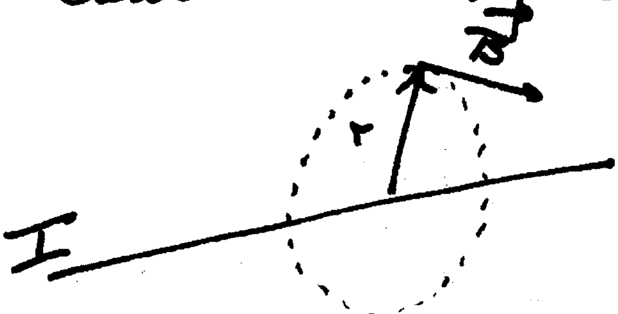
2) B $\perp$ to path

$$\int_b^c \vec{B} \cdot d\vec{l} = 0$$

3) B is total magnetic field at a given point. In general part of B is due to I interior to path, part outside. If path has no I interior B is not necessarily zero everywhere but $\oint \vec{B} \cdot d\vec{l} = 0$

AMPERE'S LAW

Consider a long straight conductor



$$B = 2k'\frac{I}{r}$$

$$\oint \vec{B}\cdot d\vec{l} = \int B\,dl$$

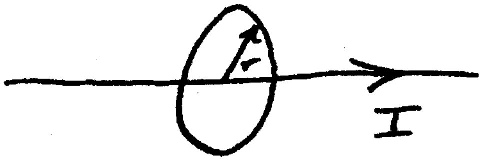
since $B \parallel dl$ at any point

$$= \int_0^{2\pi}\left(\frac{2k'I}{r}\right)(r\,d\theta) = 2k'I\int_0^{2\pi} d\theta$$

$$\oint \vec{B}\cdot d\vec{l} = 4\pi k' I$$

APPLICATIONS

1) LONG STRAIGHT CONDUCTOR



Symmetry $\Rightarrow$ circular path centered on wire

$\Rightarrow$ USE BIOT LAW TO DETERMIN $\vec{B}$ DIRECTION

$(I\vec{dl} \times \hat{r})$

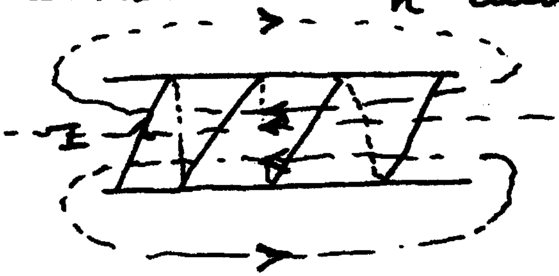
$$\oint \vec{B}\cdot\vec{dl} = B\int dl = B\cdot 2\pi r = \mu_0 I$$

Choice of path $\Rightarrow$ B is const + in direction of path

This is just circumference

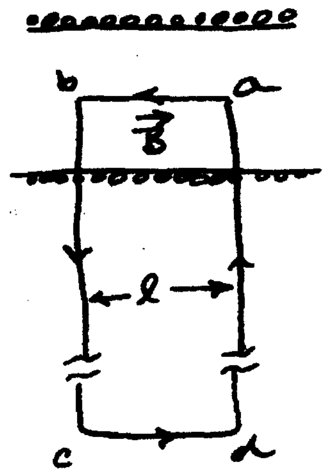
$$\boxed{B = \frac{\mu_0}{2\pi}\frac{I}{r} = \frac{2k' I}{r}}$$

2) SOLENOID   n turns of wire per unit length



Field of single loop at center will be axial. Field lines must reconnect outside cylinder

Consider the following path



$a \to b$ B is uniform, path $\parallel \vec B$

$b \to c$, $d \to a$ B is undetermined but field lines are $\perp$ path

$c \to d$ Take this far enough away that $B = 0$

Then

$$\oint \vec B \cdot d\vec l = \int_a^b \vec B \cdot d\vec l + \underbrace{\cancel{\int_b^c \vec B \cdot d\vec l}}_{0} + \underbrace{\cancel{\int_c^d \vec B \cdot d\vec l}}_{0} + \cancel{\int_d^a \vec B \cdot d\vec l}$$

Since $\vec B \perp d\vec l$ Since $B = 0$ Since $B \perp d\vec l$

$$\oint \vec B \cdot d\vec l = \int_a^b \vec B \cdot d\vec l = B l$$ since $\vec B \parallel d\vec l$ + B is uniform along ab

$$B l = \mu_0 I_{tot}$$

$$= \mu_0 (n l I)$$

$$\boxed{B = \mu_0 n I}$$