(D1)

$N\phi = LI$ (definition of inductance)

$L = \frac{N\phi}{I}$ = total flux leage / current that generated it

Solenoid self inductance

$L_1 = \frac{\mu_0 N_1^2 A}{l}$ $L_2 = \frac{\mu_0 N_2^2 A}{l}$

Mutual Inductance

$M = \frac{\mu_0 N_1 N_2 A}{l}$

$\Rightarrow L_1 L_2 = M^2$

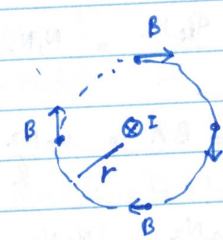
$\therefore M = \sqrt{L_1 L_2}$

Since coupling is not perfect, introduce k

$M = k\sqrt{L_1 L_2}$

Ampere's Law

(Current flowing straight line)



$\mu_0 I = \oint \vec{B} \cdot \vec{dl}$

$B \parallel dl$

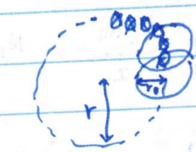
$\therefore \vec{B} \cdot \vec{dl} = B dl$

$\mu_0 I = \oint B dl$

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

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

(Current flowing in loop)



For current flowing in loop you can think of $2\pi r$ ⊗ and sum them to find total

$B = \frac{\mu_0 I}{2\pi r_0} 2\pi r = \mu_0 I$ at center $r_0 = r$

For N turns $B = \mu_0 N I$ where $N = n/l$ l, n turns

Now, this B will create flux linkage

$\phi_B = BA = (\mu_0 N I)(\pi r^2)$ flux linkage per each then

$N\phi_B = N^2 \mu_0 I \pi r^2$ total flux linkage

$\frac{N\phi_B}{I} = N^2 \mu_0 \pi r^2$ self-inductance

$L_1 - \frac{M^2}{L_2} = L_1 - \frac{K^2 L_1 L_2}{L_2} = 0$ if $K = 1$ $(1-K^2)L$

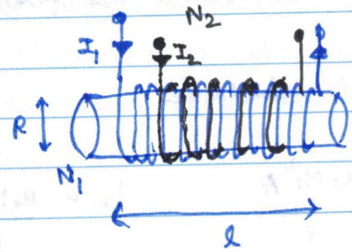
$K^2 L$

D2

$\Phi_{21} = BA = \mu_0 N_1 I_1 . A$

$\frac{N_2 \Phi_{21}}{I_1} = \mu_0 N_1 N_2 . A$ Mutual inductance

Summary



Source $B = \mu_0 \frac{N_1}{l} I_1$

Self link $\Phi_{11} = BA = \mu_0 \frac{N_1}{l} \pi R^2 I_1$

Self L $L_1 = \frac{\Phi_{11} N_1}{I_1} = N_1 N_1 . \frac{\mu_0}{l} . \pi R^2$

Mutual link $\Phi_{21} = BA = \frac{\mu_0 N_1}{l} I_1 . \pi R^2$

Mutual M_{21} $M_{21} = \frac{\Phi_{21} N_2}{I_1} = N_1 N_2 . \frac{\mu_0}{l} . \pi R^2$

Self link $\Phi_{22} = BA = \frac{\mu_0 N_2}{l} \pi R^2 I_2$

Self L $L_2 = \frac{\Phi_{22} N_2}{I_2} = N_2 N_2 . \frac{\mu_0}{l} . \pi R^2$

mutual link $\Phi_{12} = BA = \frac{\mu_0 N_2}{l} . \pi R^2 . I_2$

Mutual M_{12} $M_{12} = \frac{\Phi_{12} N_1}{I_2} = N_1 N_2 . \frac{\mu_0}{l} . \pi R^2$

$\Rightarrow$ $L_1 = N_1^2 . \frac{\mu_0}{l} . \pi R^2$ $L_2 = N_2^2 . \frac{\mu_0}{l} . \pi R^2$ $M_{12} = M_{21} = M = \frac{N_1 N_2 \mu_0}{l} \pi$

$\Rightarrow L_1 L_2 = M^2$

$\Rightarrow M = \sqrt{L_1 L_2}$

Introduce imperfect coupling

$\rightarrow M = K \sqrt{L_1 L_2}$