# Induction

## Static Induction

B → change

- Self induction
- Mutual Induction

## Dynamic Induction

A → changes

## Motional Induction


θ → changes

# Mutual Induction


$$B \propto i_1$$

$$B = \frac{\mu_0 N_1 i_1}{l_1}$$

$$i_1 \uparrow$$

$$B = \mu_0 n i_1$$

$$\phi_2 \propto i_1$$

$$\phi_2 \propto i_1$$

$$\phi_2 = M i_1$$

$M \rightarrow$ Co-efficient of mutual Induction

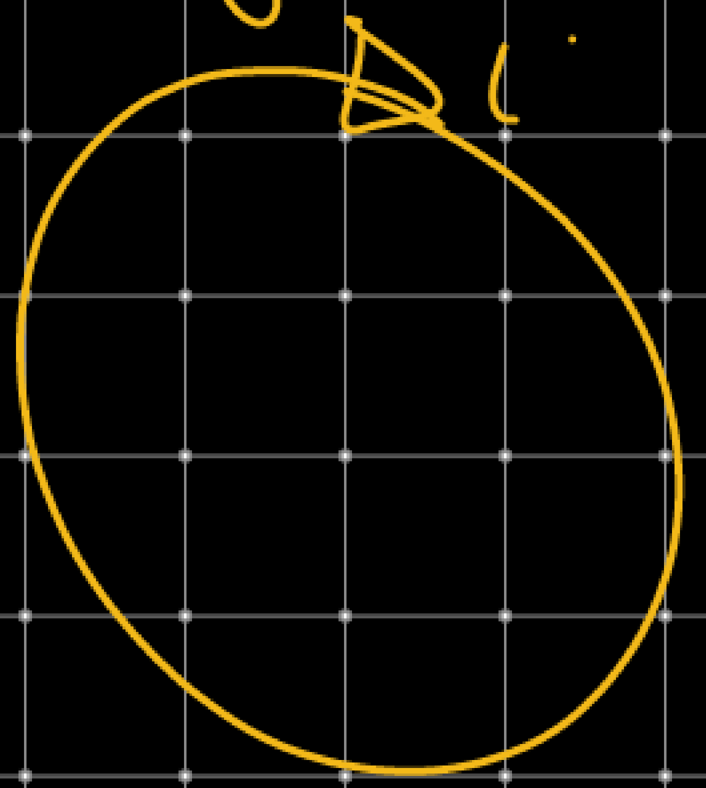
$$\boxed{M = \frac{\phi_2}{i_1}}$$

$$L = \frac{\phi}{i} = \frac{W}{A} = \text{Henry}$$

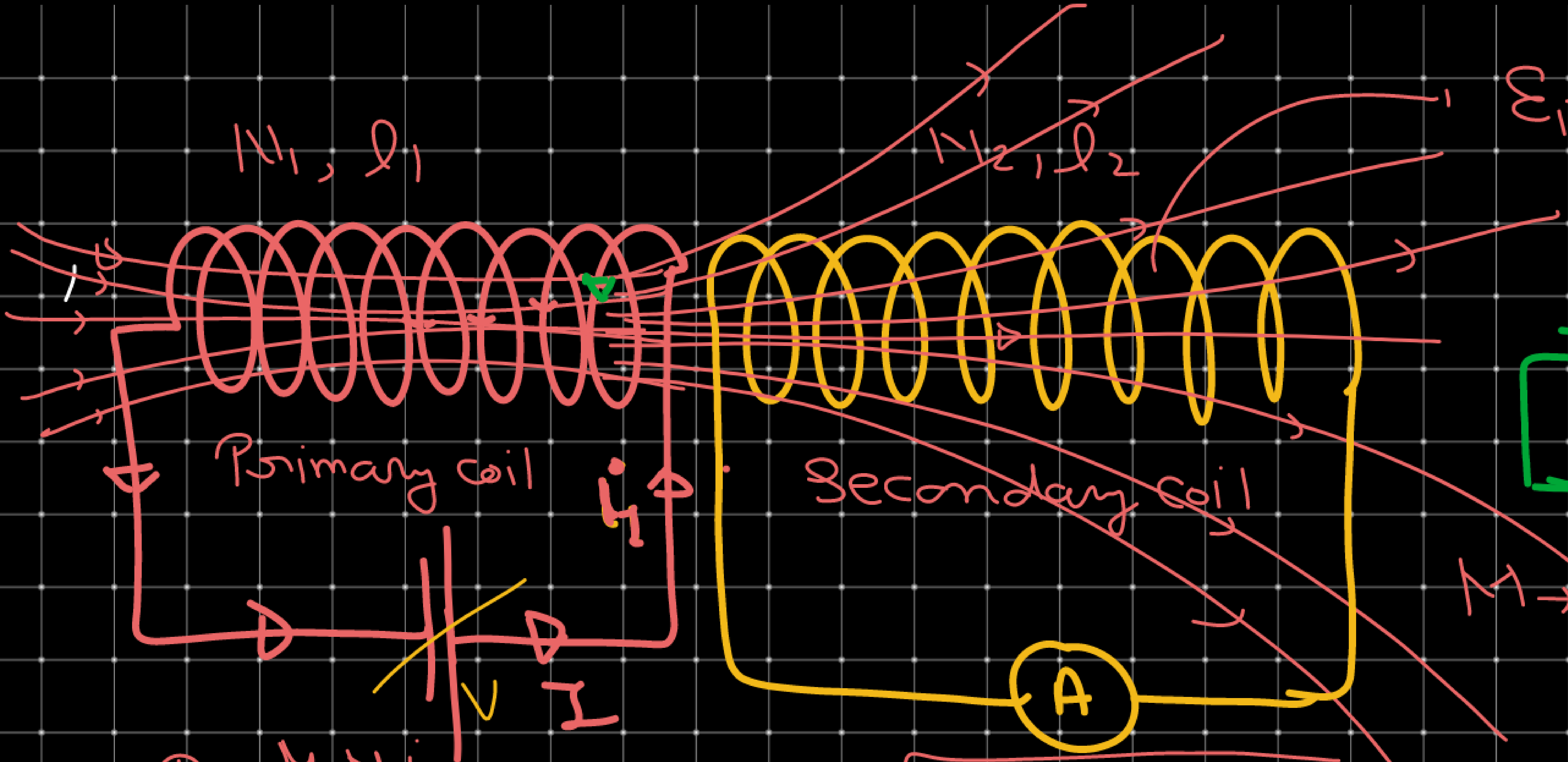
$$\phi \propto i$$

$$\phi = L i$$

$L \rightarrow$ Co-efficient of self induction



⇒ **Mutual Induction** :- When current of primary coil changes w.r.t time, due to this flux on secondary coil changes, change of flux w.r.t time in secondary coil produced induced Emf in secondary coil. This phenomenon is called Mutual induction.




$\varepsilon_{ind} = -\frac{d\phi}{dt}$

$\phi_2 \propto i_1$

$\phi_2 = M i_1$

M → Co-efficient of Mutual Induction

$B = \frac{\mu_0 N_1 i_1}{l_1}$

$B \propto i_1$

$B = \mu_0 n i_1$

$M = \frac{\phi_2}{i_1} = \frac{Wb}{Am}$ = Henry

H

$$\phi_2 = M i_1$$

$$\varepsilon_{ind} = -\frac{d\phi_2}{dt}$$

$$= -\frac{d}{dt}(M i_1)$$

$$\boxed{\varepsilon_{ind} = -M\frac{di_1}{dt}}$$

$$\left(\varepsilon_{ind} = -M\frac{di_1}{dt}\right)$$

↓

Induced Emf in Secondary coil.

$N, l, n$

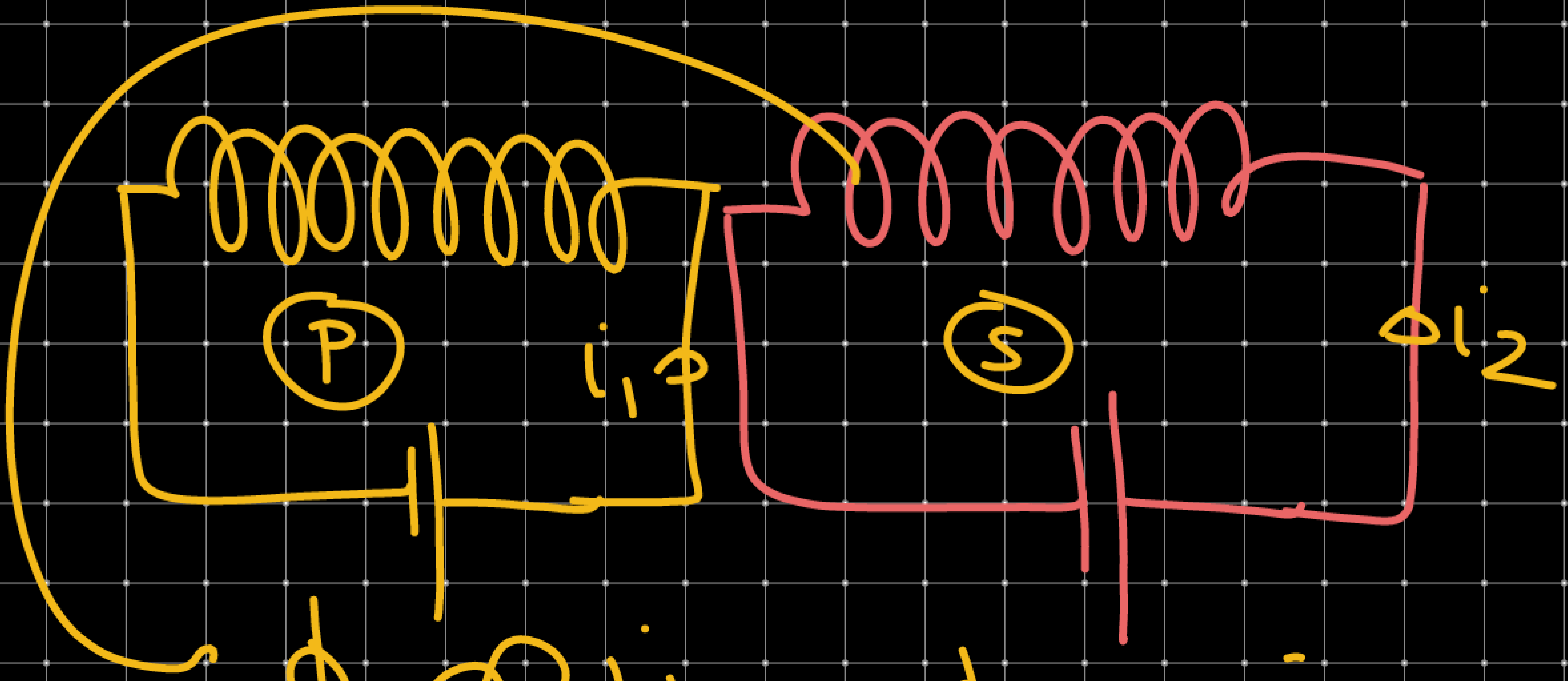

$$\boxed{\phi = Li}$$

$$B = \mu_0 n i$$

$$\phi = BA$$

$$\phi = \mu_0 n i \times \pi r^2 N$$

$$\frac{\phi}{i} = L = \mu_0 n \pi r^2 N$$




$$\phi_2 \propto i_1$$

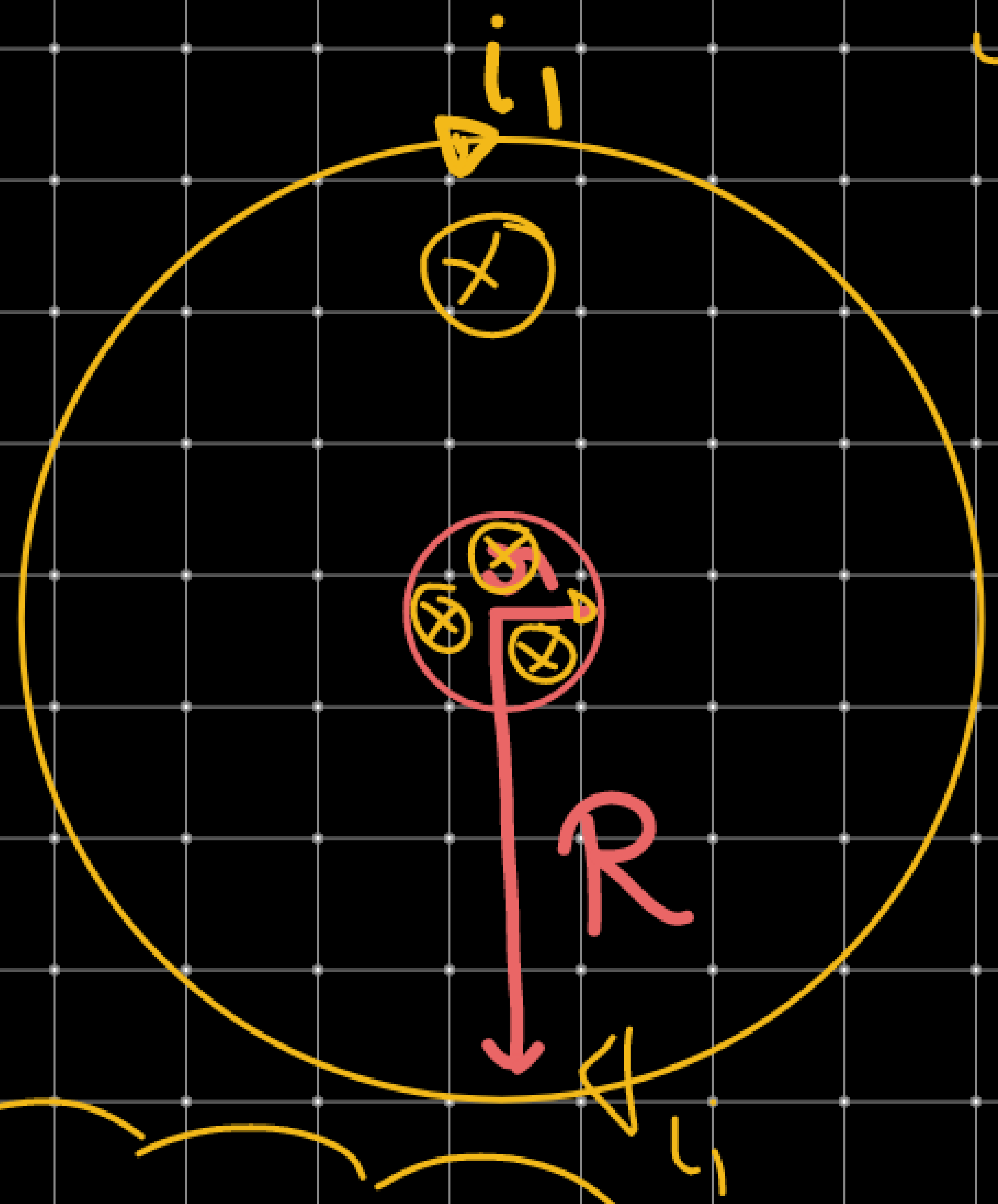
$$\phi_1 \propto i_2$$

$$\phi_2 = M i_1$$

$$\phi_1 = M i_2$$

$$M = \frac{\phi_2}{i_1} = \frac{\phi_1}{i_2}$$

Q) Find Co-efficient of Mutual Induction. [$r << R$]




① Magnetic field at Centre $= \frac{\mu_0 i_1}{2R}$

Step II: flux in secondary coil.

$$\phi_2 = \left(\frac{\mu_0 i_1}{2R}\right) \pi r^2$$

Step III:

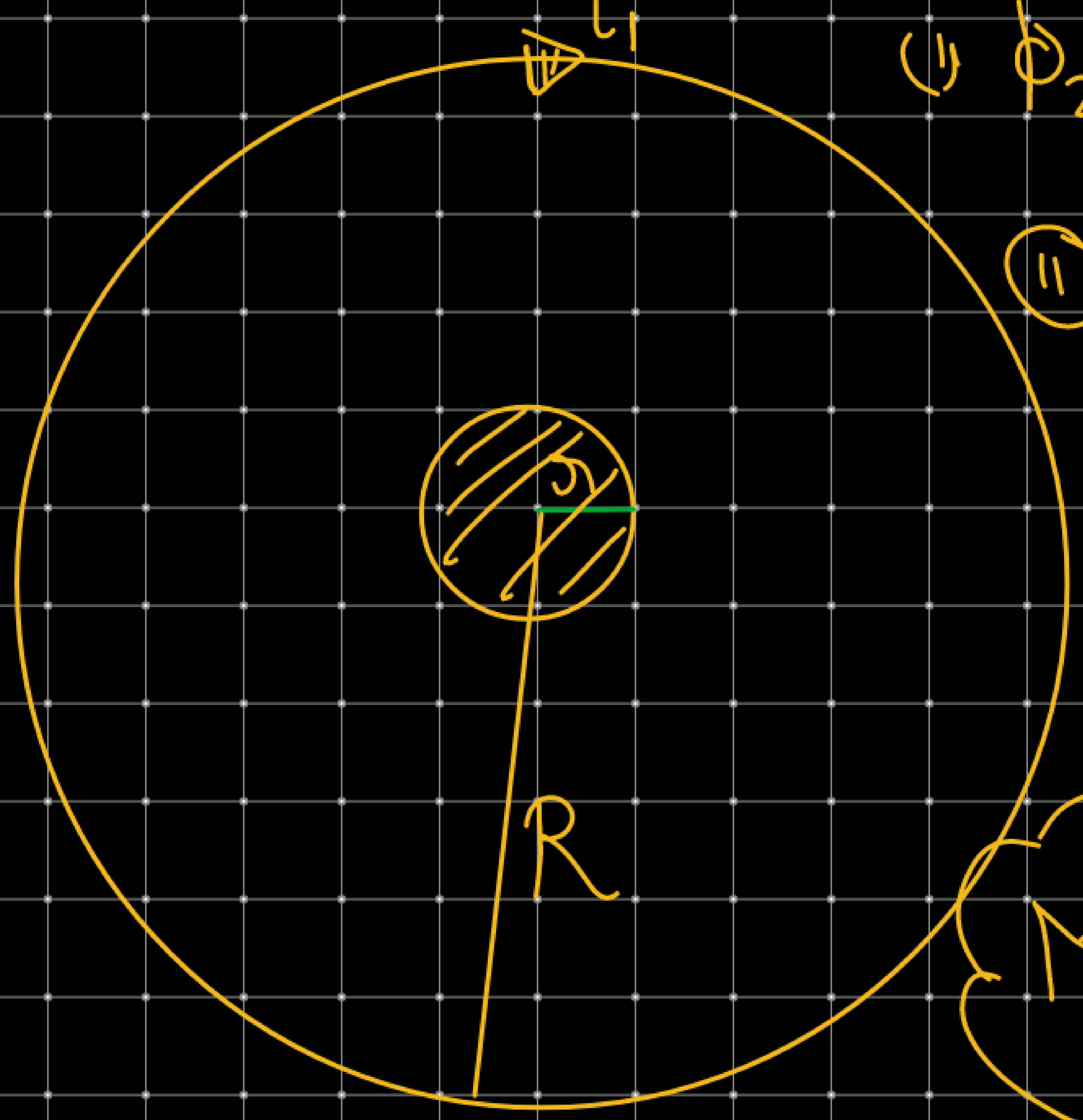
$$M = \frac{\phi_2}{i_1} = \frac{\mu_0 i_1 \pi r^2}{2R\, i_1}$$

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

$$M \propto \frac{r^2}{R}$$

# imp NEET 2021

Two concentric coils are as shown, if $r << R$ then find mutual induction.




(i) $\phi_2 = \left(\frac{\mu_0 i_1}{2R}\right)\pi r^2$

(ii) $M = \frac{\phi_2}{i_1}$

$= \frac{\mu_0 i_1 \pi r^2}{2R \times i_1}$

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

$M \propto \left(\frac{r^2}{R}\right)$

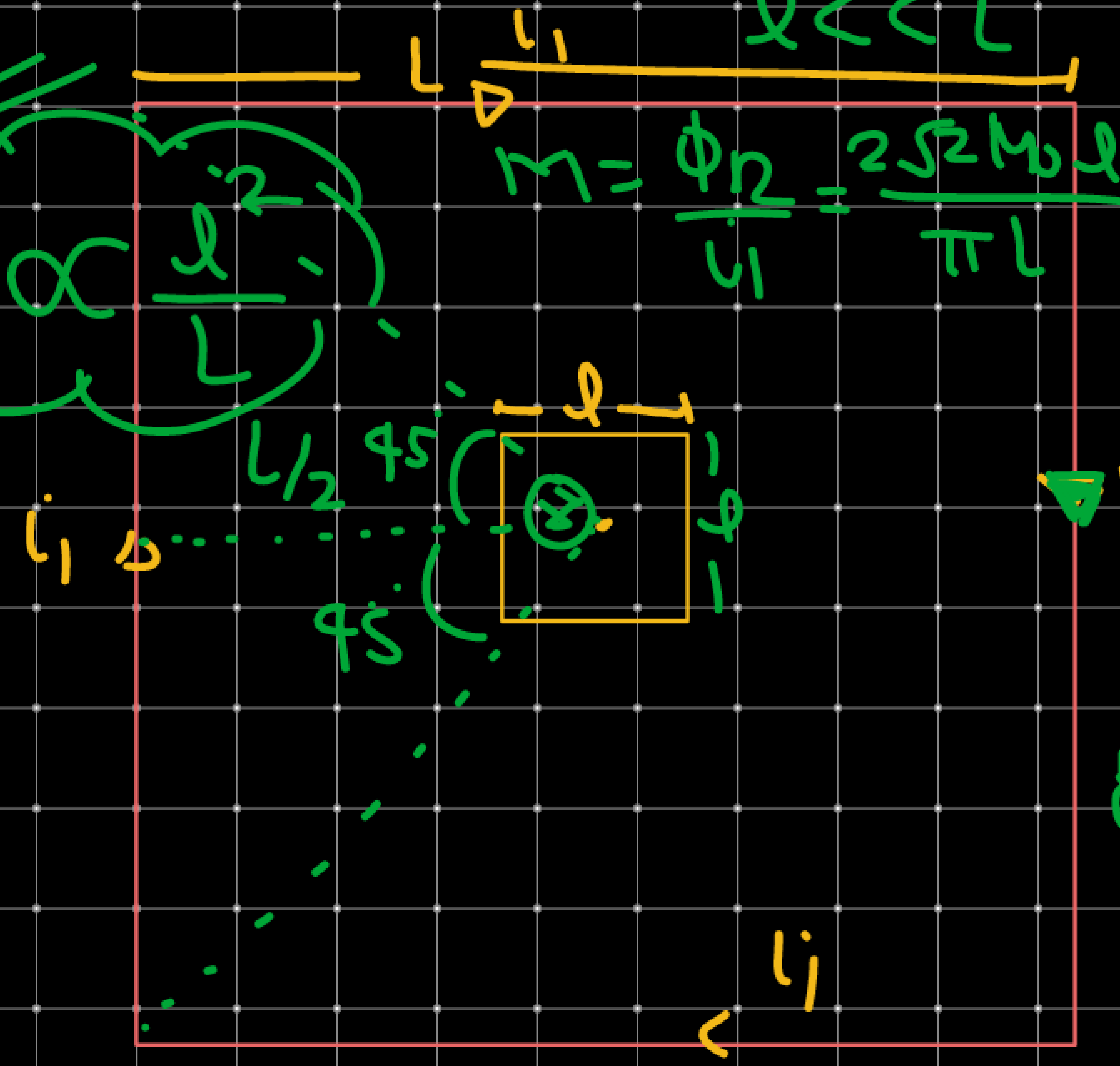
$\phi_2 = M i_1$

$\phi_1 = M i_2$

$M = \frac{\phi_2}{i_1} = \frac{\phi_1}{i_2}$

Q2) two concentric square loops are shown in figure if $l << L$, then find mutual induction.

$l << L$




$$B = \frac{4\mu_0 i_1}{4\pi L/2}\left[\sin 45 + \sin 45\right]$$

$$= \frac{2\mu_0 i_1}{\pi L} \times 2 \times \frac{1}{\sqrt{2}}$$

$$B = \frac{2\sqrt{2}\mu_0 i_1}{\pi L}$$

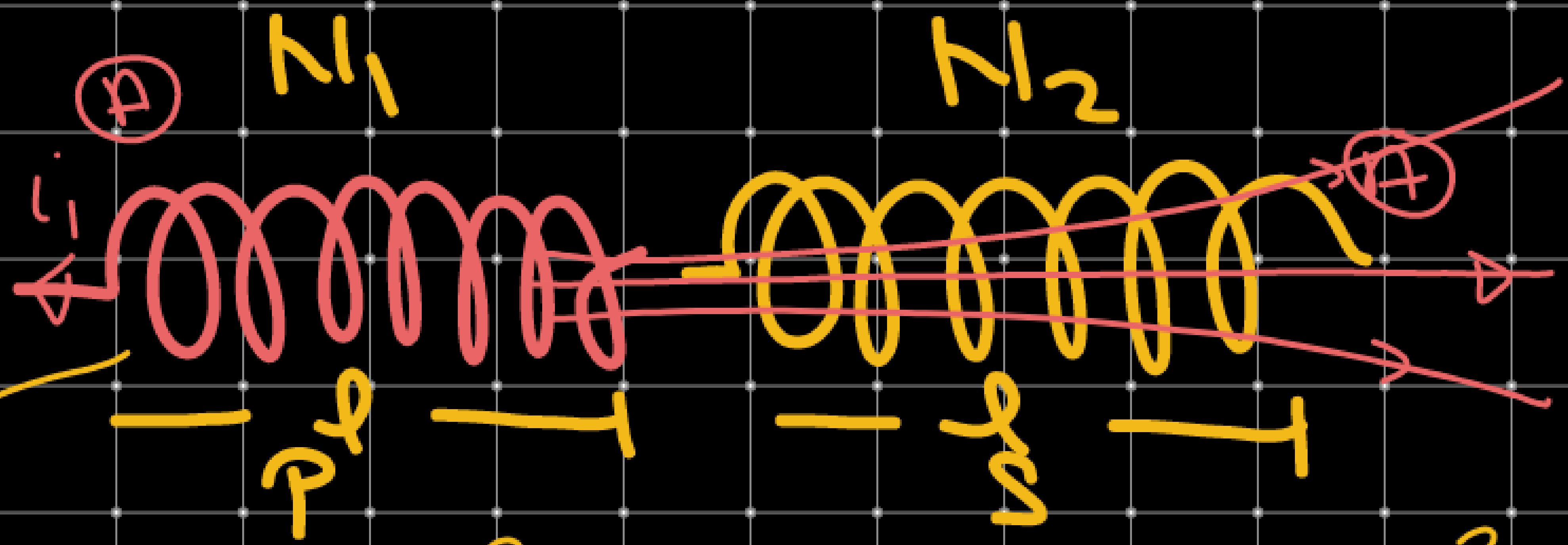
$$\phi_2 = B \times l^2$$

$$\phi_2 = \frac{2\sqrt{2}\mu_0 i_1}{\pi L} \times l^2$$

$$M = \frac{\phi_2}{i_1} = \frac{2\sqrt{2}\mu_0 l^2}{\pi L}$$

imp: $M \propto \frac{l^2}{L}$

#




$$\phi_2 = N_2 B A$$

$$\phi_2 = N_2 \times \frac{\mu_0 N_1 i_1}{l} \times A$$

$$\frac{\phi_2}{i_1} = M = \frac{\mu_0 N_1 N_2 A}{l}$$

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

⇒ If All MFL on primary coil goes from secondary coil.

$$B_p = \mu_0 n_1 i_1$$

$$B_p = \frac{\mu_0 N_1 i_1}{l}$$

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

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

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

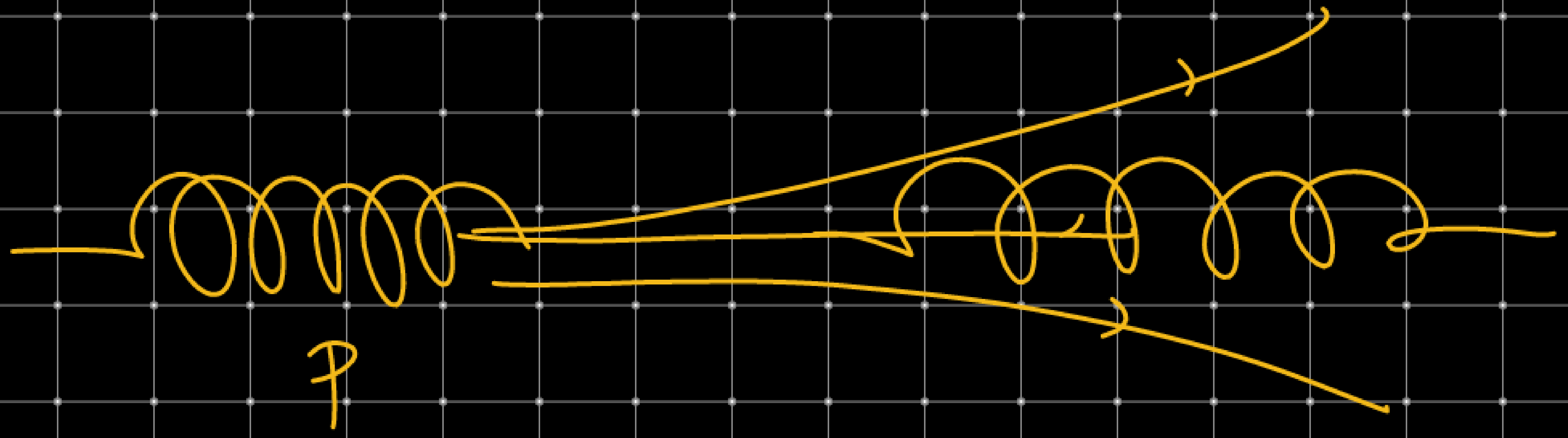
$$L_2 = \frac{\mu_0 N_2^2 A}{l}$$

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

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

$$M = 1\sqrt{L_1 L_2}$$

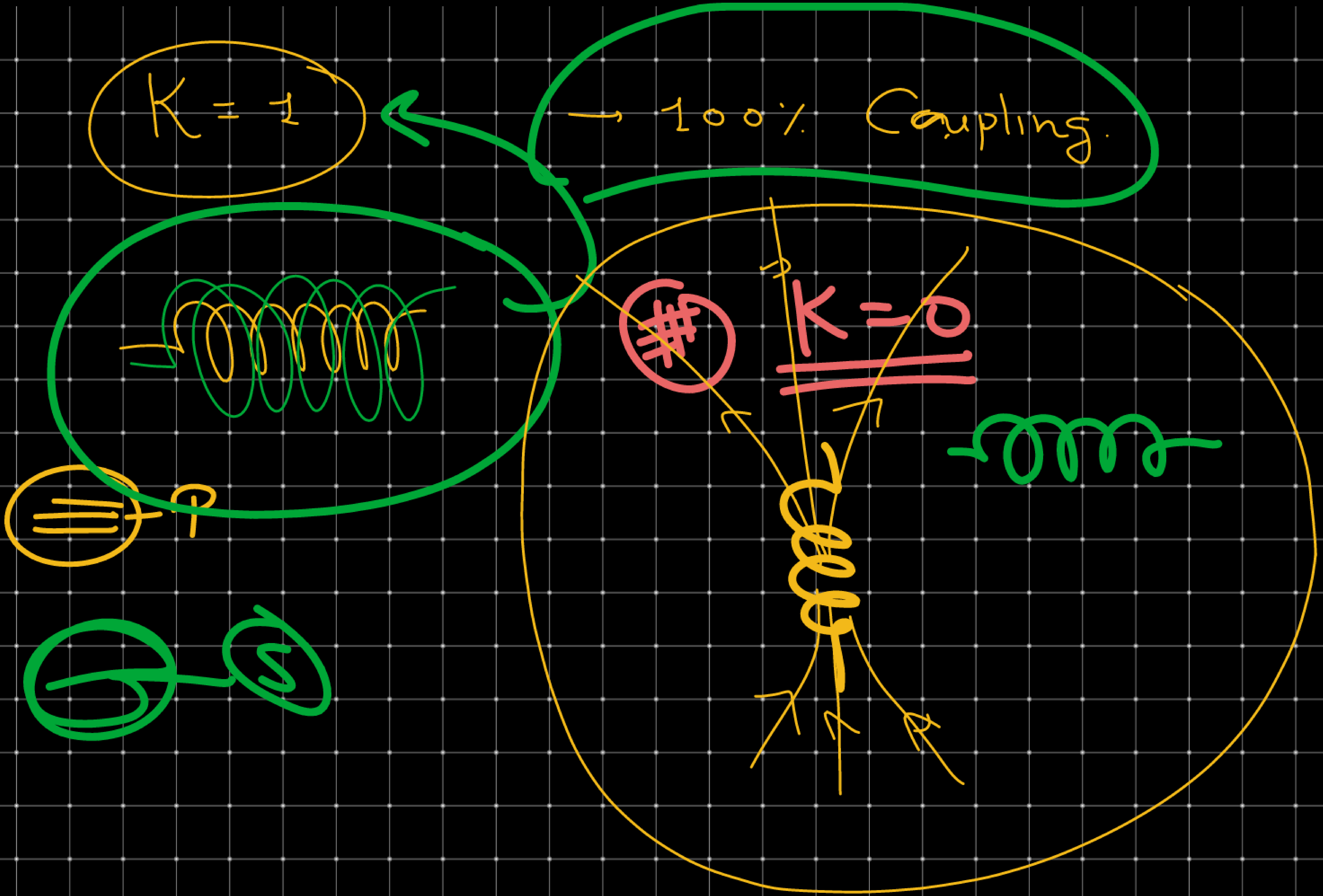
$\Rightarrow$ 100% Coupling

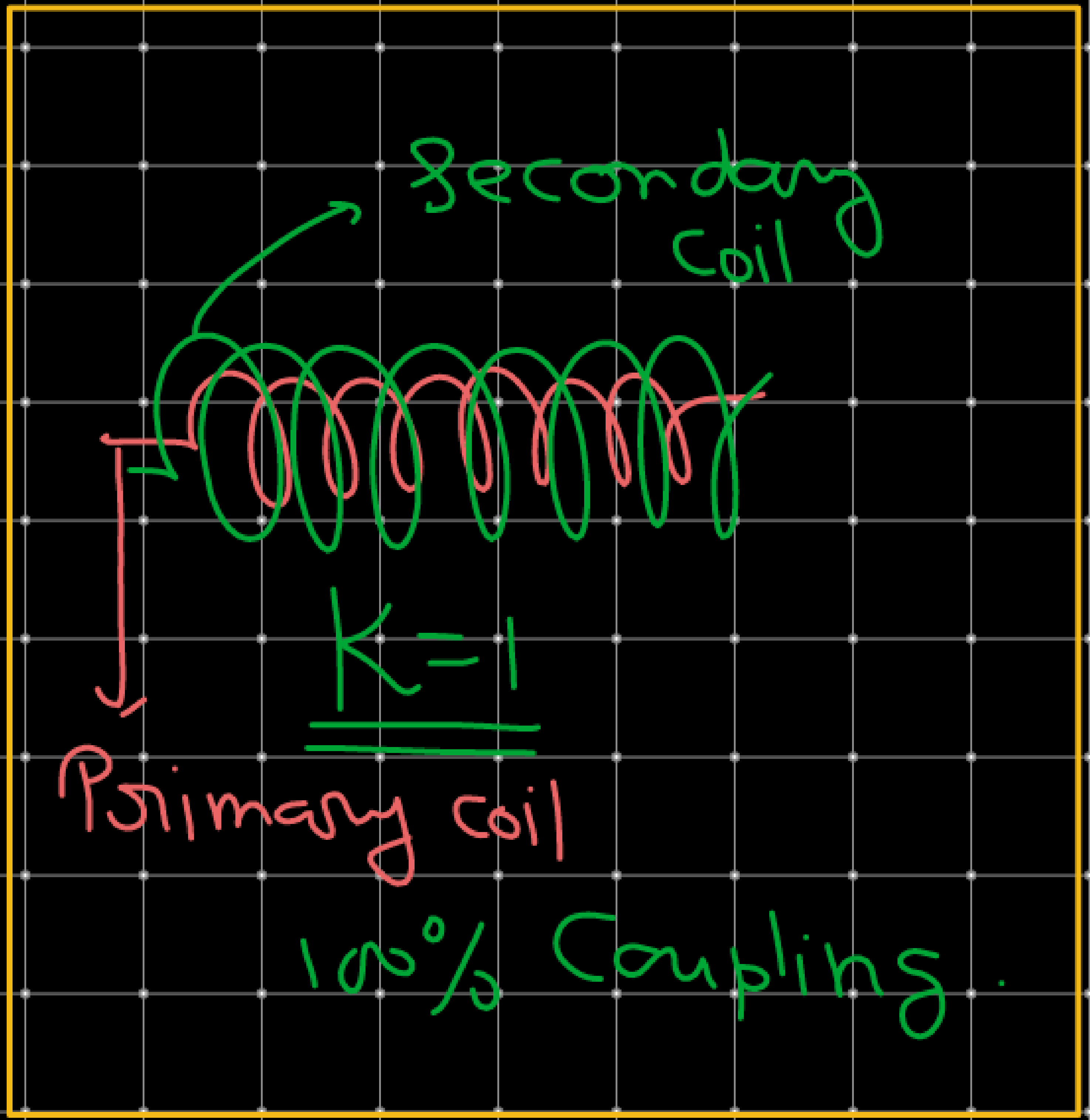


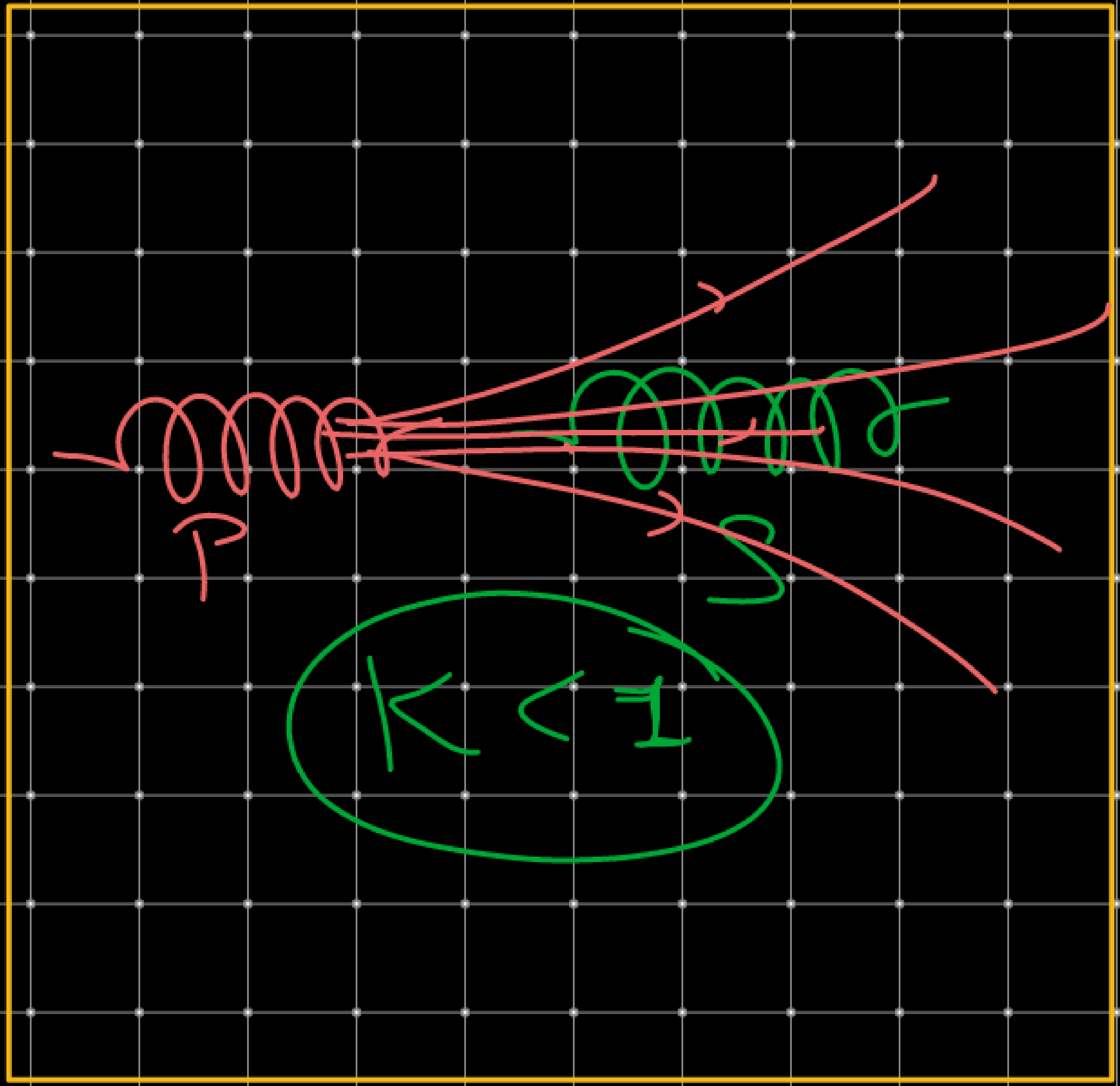

⇒ General relation b/w M, $L_1$ & $L_2$

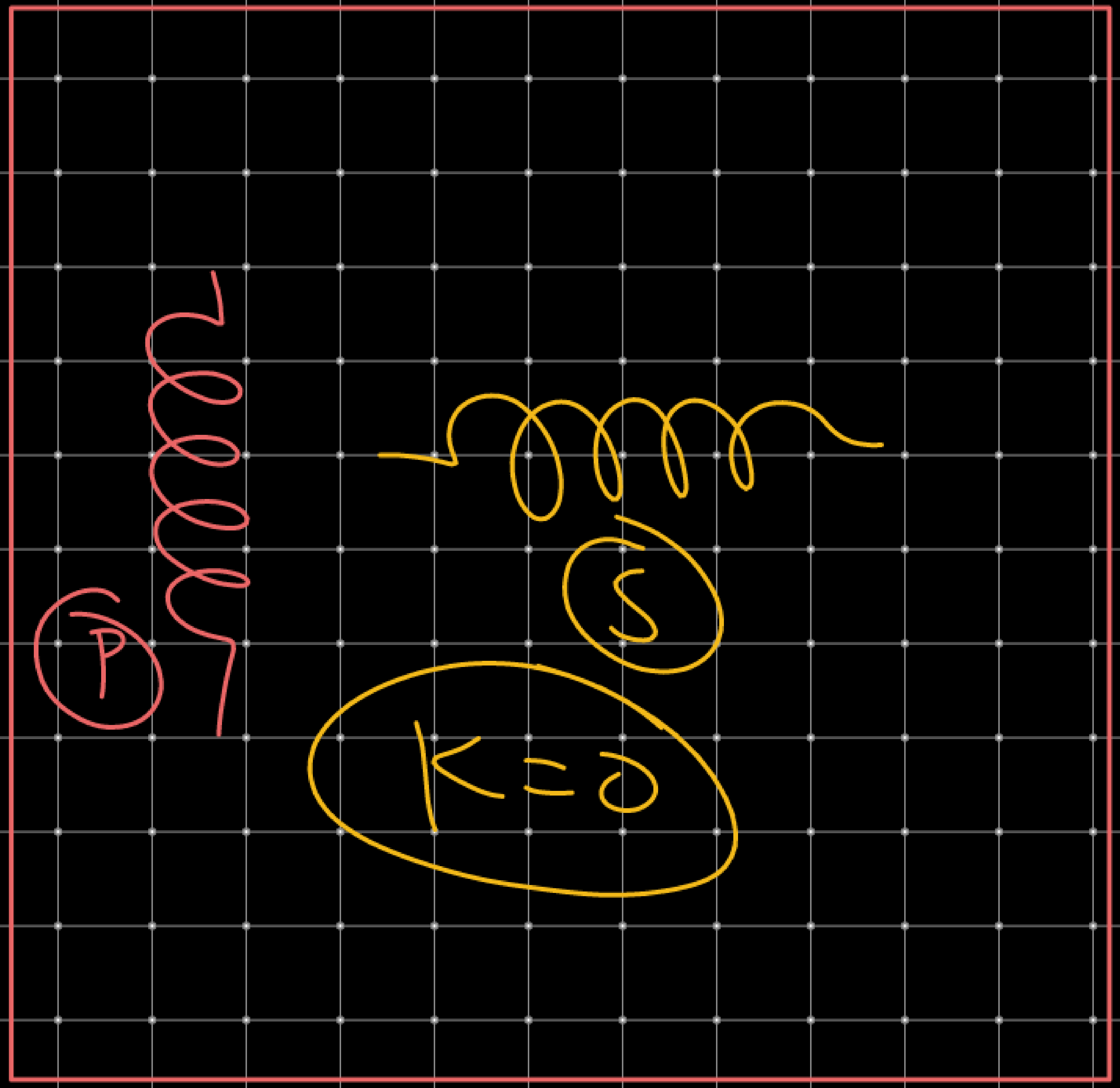
$$M = K\sqrt{L_1 L_2}$$

K → Coupling factor


K = 1
→ 100% Coupling.
K = 0
P
S


Secondary
coil
K=1
Primary coil
100% Coupling


P
S
K < 1



P
S
K=0