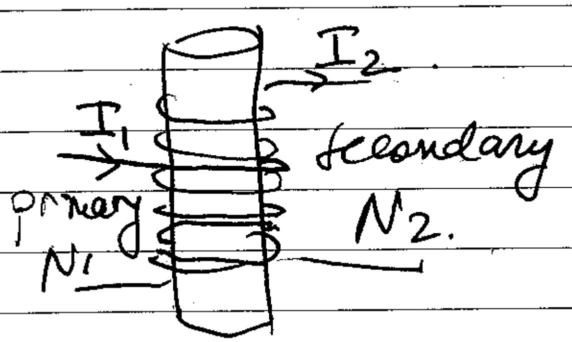
This flux is increasing so the induced current in the big loop is such that induced current in big loop has the flux pointing out of the page.
Current is CCW.

The transformer: problems 53 and 54.



Same flux passing through both coils.

$$\mathcal{E}_1 = -N_1 \frac{d\Phi}{dt} \qquad \mathcal{E}_2 = -N_2 \frac{d\Phi}{dt}$$

$$\Rightarrow \boxed{\frac{\mathcal{E}_1}{\mathcal{E}_2} = \frac{N_2}{N_1}} \Rightarrow \text{transformer}.$$

raising or lowering alternative voltages.

$$\Phi_1 = L_1 I_1 + M I_2 = N_1 \Phi$$

$$\Phi_2 = L_2 I_2 + M I_1 = N_2 \Phi$$

$$\Rightarrow \Phi_{(\text{turn})} = I_1 \frac{L_1}{N_1} + I_2 \frac{M}{N_1} = I_2 \frac{L_2}{N_2} + I_1 \frac{M}{N_2}$$

if $I_1 = 0$ $\Downarrow$ $\frac{M}{N_1} = \frac{L_2}{N_2}$.

if $I_2 = 0$ $\Downarrow$ $\frac{L_1}{N_1} = \frac{M}{N_2}$. $\Rightarrow \frac{M}{L_1} = \frac{L_2}{M}$

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

b) $-\mathcal{E}_1 = \frac{d\Phi_1}{dt} = L_1 \frac{dI_1}{dt} + M \frac{dI_2}{dt} =$

$= V_1 \cos\omega t$ -

$-\mathcal{E}_2 = \frac{d\Phi_2}{dt} = L_2 \frac{dI_2}{dt} + M \frac{dI_1}{dt} = -I_2 R.$

$L_1 L_2 \frac{dI_1}{dt} + L_2 M \frac{dI_2}{dt} = L_2 V_1 \cos\omega t.$

$L_2 \frac{dI_2}{dt} = -I_2 R - M \frac{dI_1}{dt}.$

$\Rightarrow \cancel{L_1 L_2 \frac{dI_1}{dt}} - M I_2 R - \cancel{M^2 \frac{dI_1}{dt}} = L_2 V_1 \cos\omega t.$

$\boxed{I_2(t) = -\frac{L_2 V_1}{MR} \cos\omega t}$

$L_1 \frac{dI_1}{dt} + \cancel{M}\left(\frac{L_2 V_1 \omega}{\cancel{M}R} \sin\omega t\right) = V_1 \cos\omega t.$

$\frac{dI_1}{dt} = \frac{V_1}{L_1}\left(\cos\omega t - \frac{L_2}{R} \omega \sin\omega t\right).$

$$I_1(t) = \frac{V_1}{L_1}\left(\frac{1}{\omega}\sin\omega t + \frac{L_2}{R}\cos\omega t\right).$$

$$\frac{V_{out}}{V_{in}} = \frac{I_2 R}{V_1 \cos\omega t} = \frac{-\frac{L_2 V_1 \cos\omega t \cdot R}{MR}}{V_1\cos\omega t} = -\frac{L_2}{M} = -\frac{N_2}{N_1}$$

$$P_{in} = V_{in}\cdot I_1 = V_1\cos\omega t \cdot \frac{V_1}{L_1}\cdot\left(\frac{1}{\omega}\sin\omega t + \frac{L_2}{R}\cos\omega t\right) = \frac{V_1^2}{L_1}\left(\frac{1}{\omega}\sin\omega t\cos\omega t + \frac{L_2}{R}\cos^2\omega t\right).$$

$$P_{out} = V_{out}\cdot I_2 = I_2^2\cdot R = \frac{(L_2 V_1)^2}{M^2 R}\cos^2\omega t$$

$\langle\cos^2\omega t\rangle$ averge over 1 period $= 1/2$

$\langle\sin\omega t\cos\omega t\rangle = 0.$

$$\Rightarrow \langle P_{in}\rangle = \frac{1}{2}V_1^2\left(\frac{L_2}{L_1 R}\right)$$

$$\langle P_{out}\rangle = \frac{1}{2}(V_1)^2\frac{L_2^2}{M^2 R} = \langle P_{in}\rangle.$$