where

L_1 = self inductance of coil 1

L_2 = self inductance of coil 2

N_1 = Number of turns of coil 1

N_2 = Number of turns of coil 2

ϕ_1 = magnetic flux emanating from coil 1

ϕ_{11} = one component of ϕ_1 has coil 1 only

ϕ_{12} = another component of ϕ_1 links both coil 1 and coil 2.

Hence

$$\phi_1 = \phi_{11} + \phi_{12}$$

Although the two coils are physically seprated, they are said to be magnetically coupled.

Since the entire flux ϕ_1 links coil 1, the voltage induced in coil 1 is,

$$v_1 = N_1 \frac{d\phi_1}{dt}$$

Only flux ϕ_{12} links coil 2, so that voltage induced in coil 2 is

$$V_2 = N_2 \frac{d\phi_{12}}{dt}$$

Again, as the fluxes are caused by the current i_1, following in coil 1, we can write

$$v_1 = N_1 \frac{d\phi}{di_1} \cdot \frac{di_1}{dt} = L_1 \frac{di_1}{dt}$$

where

$$L_1 = N_1 \frac{d\phi_1}{di_1} = \text{self-inductance of coil 1}$$

Similarly

$$v_2 = N_2 \cdot \frac{d\phi_{12}}{di_1} \cdot \frac{di_1}{dt} = M_{21} \cdot \frac{di_1}{dt}$$

where $M_{21} = N_2 \cdot \frac{d\phi_{12}}{di_1}$

M_{21} = mutual inductance of coil 2 with respect to coil 1

Subscript 21 indicates that inductance M_{21} relates the voltage induced in coil 2 to the current in coil 1

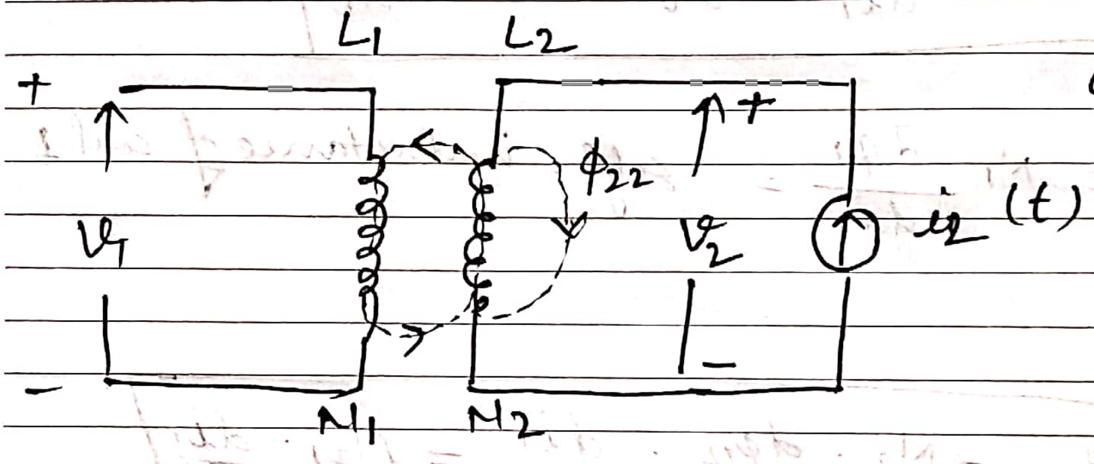
Notes Appointment

October '11

Monday	31	3	10	17	24
Tuesday		4	11	18	25
Wednesday		5	12	19	26
Thursday		6	13	20	27
Friday		7	14	21	28
Saturday	1	8	15	22	29
Sunday	2	9	16	23	30

Thus the open ckt mutual voltage (or induced voltage) across coil 2 is

$$v_2 = M_{21} \frac{di_1}{dt}$$



$\phi_2 = \phi_{22} + \phi_{21}$

fig: Mutual inductance M_{12} of coil 1 with respect to coil 2.

Summary

$$\phi_2 = \phi_{21} + \phi_{22}$$

$$v_2 = N_2 \frac{d\phi_2}{dt} = \left(N_2 \frac{d\phi_2}{di_2}\right) \frac{di_2}{dt} = L_2 \cdot \frac{di_2}{dt}$$

$$v_1 = N_1 \frac{d\phi_{21}}{dt} = \left(N_1 \frac{d\phi_{21}}{di_2}\right) \frac{di_2}{dt} = M_{12} \frac{di_2}{dt}$$

$$\therefore \quad v_1 = M_{12} \frac{di_2}{dt}$$

M_{12} and M_{21} are equal, that is

$$M_{12} = M_{21} = M$$

Keep in mind that mutual coupling only exists when the inductors or coils are in close proximity, and the circuits are driven by time varying sources.,
Recall that inductors act like short-ckt to dc

The Polarity of mutual voltage $\left(M \cdot \frac{di}{dt}\right)$ is not easy to determine, because four terminals are involved.
The choice of the correct polarity for $M\frac{di}{dt}$ is made by examining the orientation or particular way in which both coils are physically wound and applying Lenz's law in conjuction with the right hand rule.

- we will apply the dot convention in circuit analysis.

By this convention, a dot is placed in the circuit at one end of each of the two magnetically coils to indicate that the direction of the magnetic flux if current enters that dotted terminal of the coil.

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