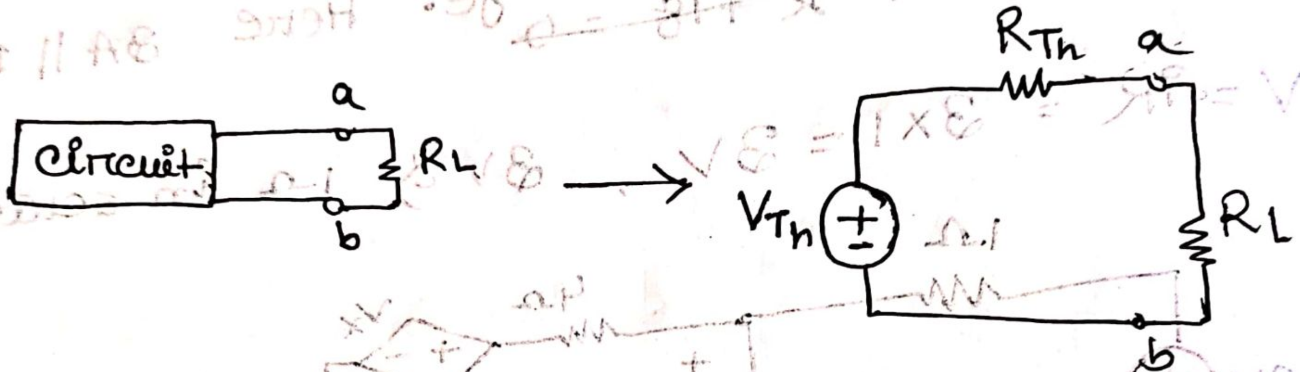
$V_x = 7.5\,V$ Ans.

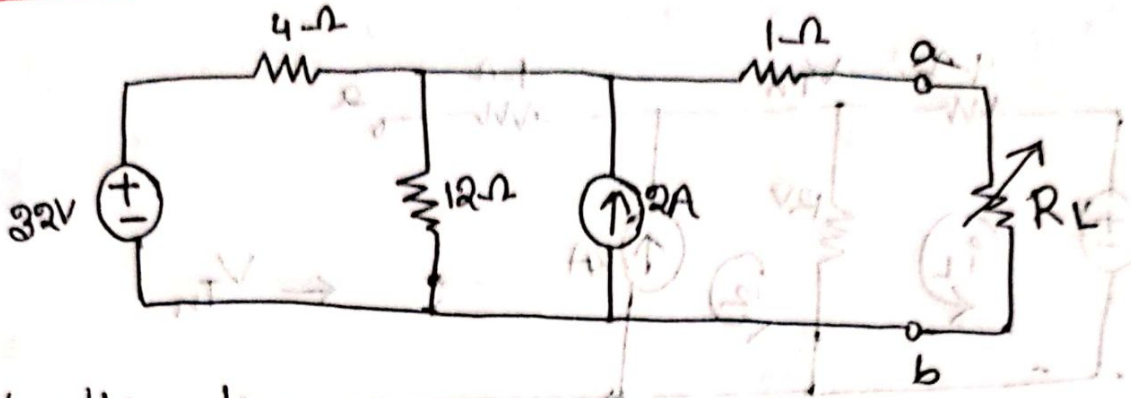
Thevenin's theorem



- V_{Th} in series with a resistor R_{Th}

R_{Th} is the input resistance at the terminals when all the independent sources are turned off.

Example → 4.8

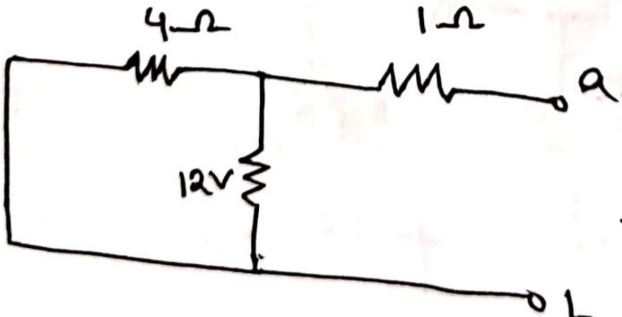


Find the thevenin equivalent circuit of the circuit to the left of the terminals a-b. then find the current though $R_L = 6, 16, 36\,\Omega$

Sol :—

we find R_{Th} by turning off 32V (replace it in a ~~open~~ short circuit) & 2A (replace it in a open circuit).

Finding R_{Th}



Here, 12V & 4Ω in parallel.

$$R_{Th} = \left(\frac{1}{4} + \frac{1}{12}\right)^{-1} + 1$$

$$= 4\,\Omega$$

Finding V_{Th}

we apply mesh analysis.

in L-1;

$$-32 + 4i_1 + 12i_1 - 12i_2 = 0$$

$$\Rightarrow 16i_1 - 12i_2 = 32 \quad \text{--- (1)}$$

in L-2;

$$i_2 = -2\,A$$

[As direction negative]

put value of i_2 in eq (1)

$$16i_1 - 12 \times -2 = 32$$

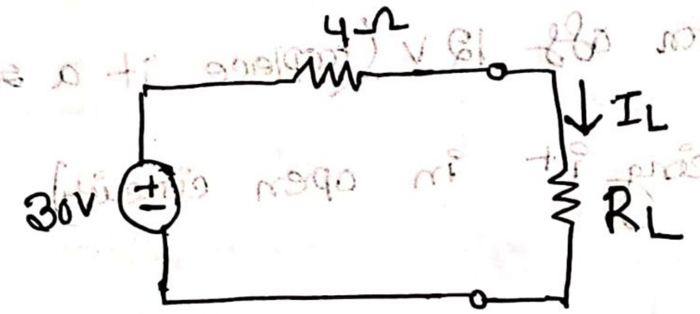
$$\Rightarrow 16i_1 = 8$$

$$\therefore i_1 = 0.5\,A$$

Now, $V_{Th} = 12i_1 - 12i_2 = 12(0.5+2)$

$$V_{Th} = 30\,V$$

thevenin equivalent circuit



$V_{Th} = 30V$

$R_{Th} = 4\Omega$

Current,

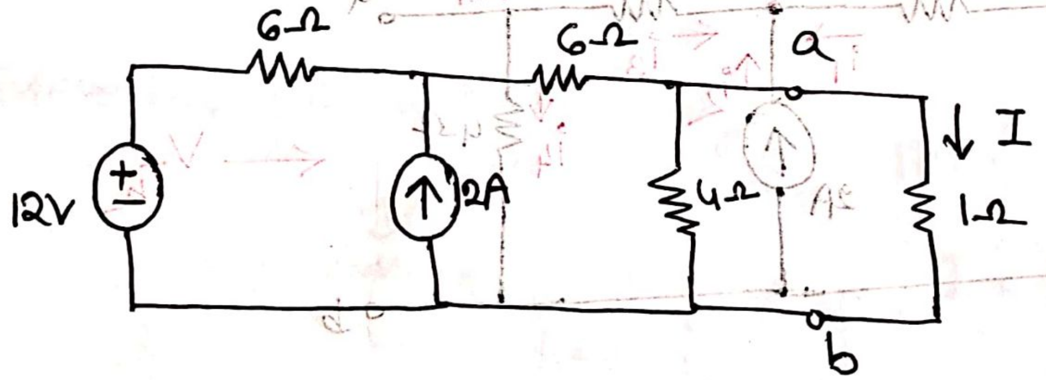
$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

when $R_L = 6$, $I_L = \frac{30}{4+6} = 3A$

$R_L = 16$, $I_L = \frac{30}{4+16} = 1.5A$

$R_L = 36$, $I_L = \frac{30}{4+36} = 0.75A$

Practice Problem → 4.8

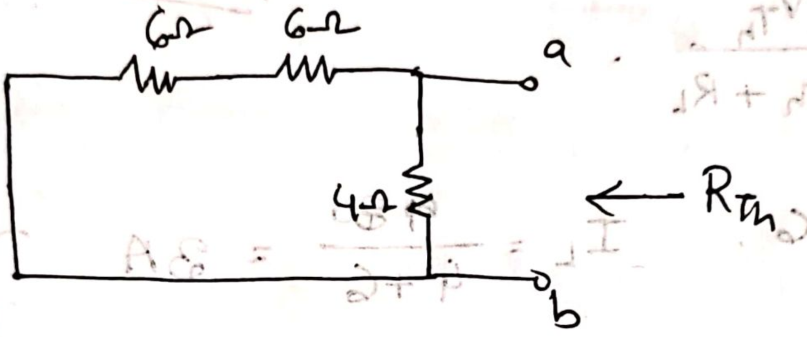


Using thevenin's therem. find equivalent circuit to the left of the terminal, then find I.

Sol :-

To find R_{Th} we turn off 12 V (replace it a short circuit) & 2A (replacing it in open circuit)

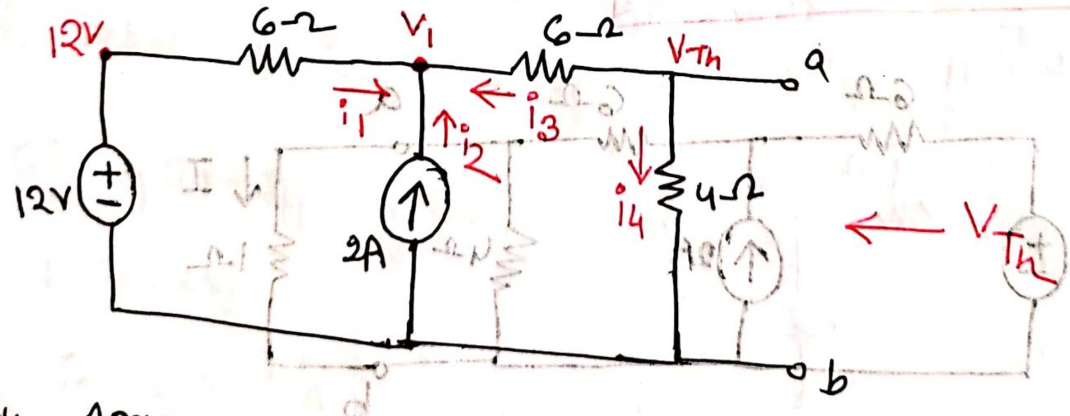
Find R_{Th}



$6\Omega + 6\Omega = 12\Omega$

$R_{Th} = \left(\frac{1}{12} + \frac{1}{4}\right)^{-1} = 3\Omega$

Find V_{Th}



By Applying Nodal Analysis,

in node - 1,

$i_1 + i_2 + i_3 = 0$

$$\Rightarrow \frac{12-V_1}{6} + 2 + \frac{V_{Th} - V_1}{6} = 0$$

$$\Rightarrow \frac{12 - V_1 + 12 + V_{Th} - V_1}{6} = 0$$

$$\therefore -2V_1 + V_{Th} = -24 \quad \text{——— (i)}$$

At node 2,

$$i_3 + i_4 = 0$$

$$\Rightarrow \frac{V_{Th} - V_1}{6} + \frac{V_{Th}}{4} = 0$$

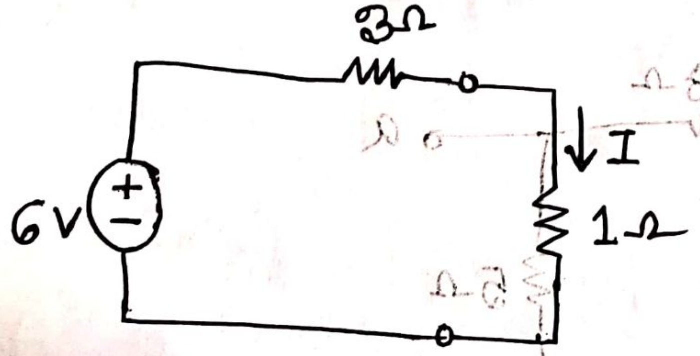
$$\Rightarrow \frac{2V_{Th} - 2V_1 + 3V_{Th}}{12} = 0$$

$$\Rightarrow -2V_1 + 5V_{Th} = 0 \quad \text{——— (ii)}$$

Solving (i) & (ii)

$$V_{Th} = 6V$$

Thevenin's equivalent circuit



$$I = \frac{V}{R}$$

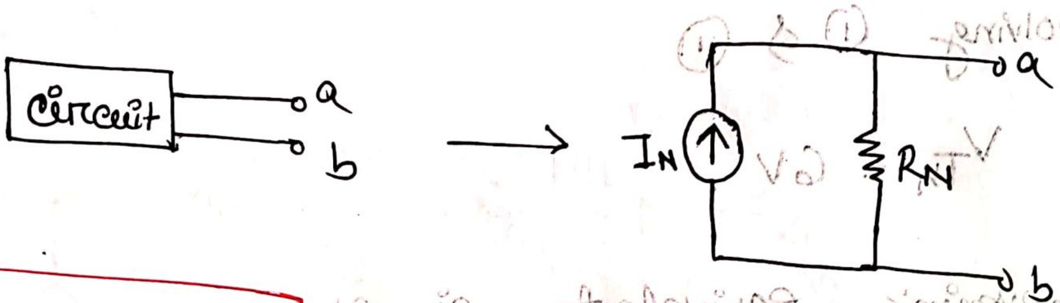
$$= \frac{6}{3+1}$$

$$I = 1.5A$$

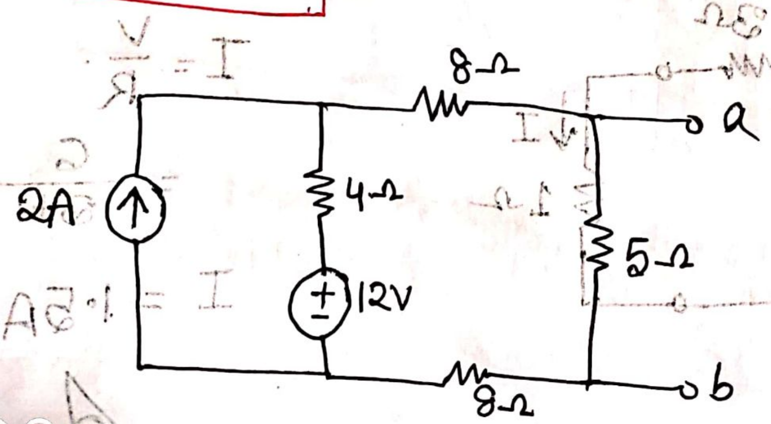
Norton's theorem

- Norton's theorem states that a linear two terminal circuit can be replaced by an equivalent circuit consisting of a current source.
- I_N in parallel with a resistor R_N
- R_N is the input resistance when all the sources are turned off.

As. $\boxed{R_N = R_{Th}}$ $\boxed{I_N = \frac{V_{Th}}{R_{Th}}}$



Example → 4.11

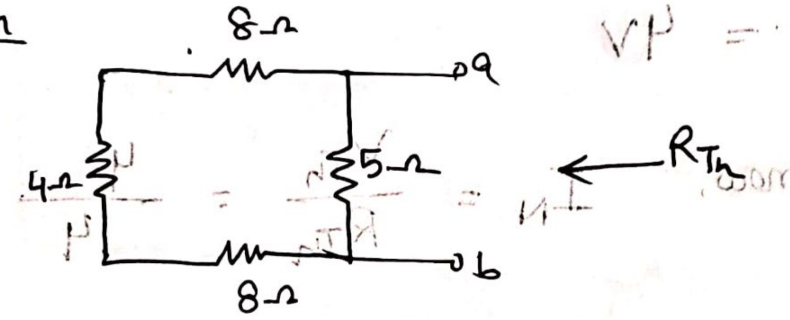


Find Norton equivalent circuit in terminal a-b

Sol ⇒

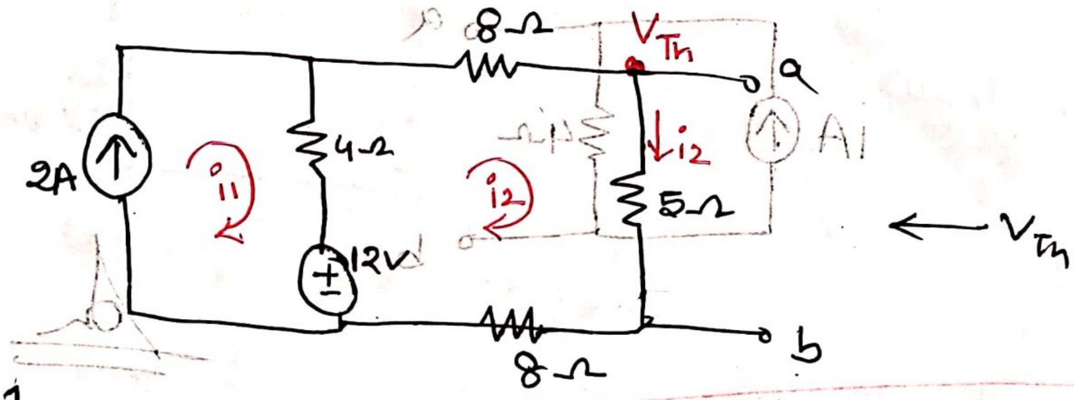
To find R_{Th} ~~tre~~ turn off 2A & 12V

Find R_{Th}



$$R_{Th} = \left(\frac{1}{8+4+8} + \frac{1}{5}\right)^{-1} = 4\,\Omega$$

Find V_{Th}



L→1,

$i_1 = 2A$

in L→2,

$$4i_2 + 8i_2 + 5i_2 + 8i_2 - 12 - 4i_1 = 0$$

$$\Rightarrow 25i_2 - 4\times 2 = 12$$

$$\Rightarrow 25i_2 = 20$$

$$\therefore i_2 = 0.8A$$

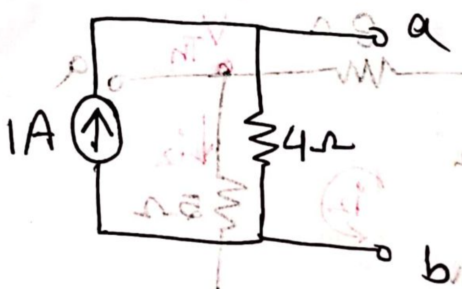
$V_{Th} = i_2 \times 5 = 0.8 \times 5$

$\Rightarrow V_{Th} = 4V$

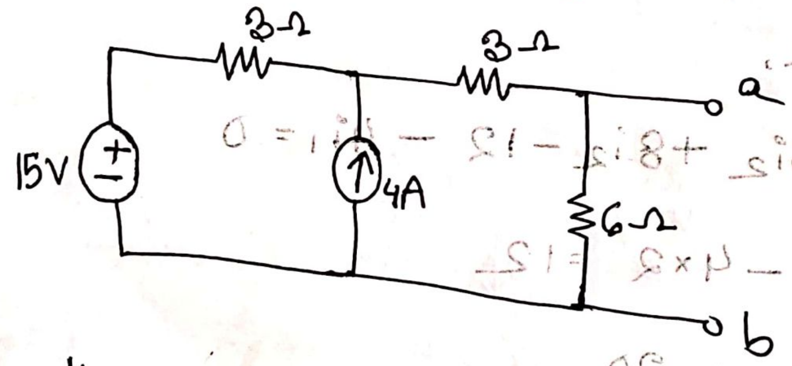
As we know, $I_N = \dfrac{V_{Th}}{R_{Th}} = \dfrac{4}{4} = 1A$

$R_N = R_{Th} = 4\Omega$

Norton equivalent circuit.



$\boxed{\text{Practice Problem} \rightarrow 4.11}$

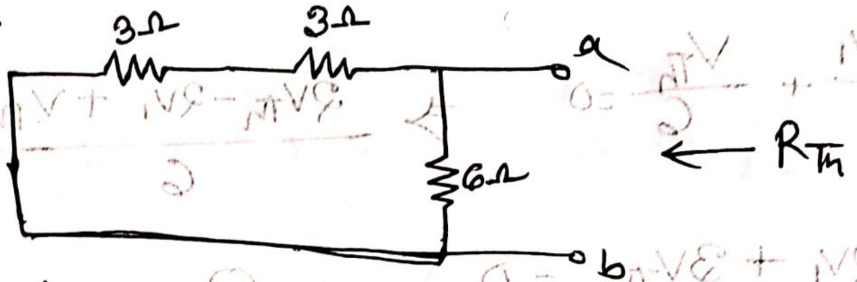


Find the Norton's equivalent circuit at terminals a-b

Sol :-

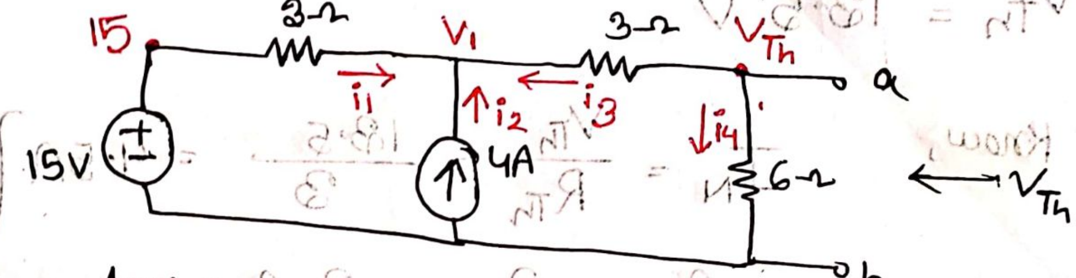
To find R_{Th} turn off 15V & 4A.

Find R_{Th}



$$R_{Th} = \left(\frac{1}{3+3} + \frac{1}{6}\right)^{-1} = 3\Omega$$

Find V_{Th}



By Applying Node Analyses.

at node 1,

$$i_1 + i_2 + i_3 = 0$$

$$\Rightarrow \frac{15-V_1}{3} + 4 + \frac{V_{Th}-V_1}{3} = 0$$

$$\Rightarrow \frac{15-V_1+12+V_{Th}-V_1}{3} = 0$$

$$\therefore -2V_1 + V_{Th} = -27 \quad \text{—} (1)$$

At node 2,

$i_3 + i_4 = 0$

$$\Rightarrow \frac{V_{Th} - V_1}{3} + \frac{V_{Th}}{6} = 0 \quad \Rightarrow \frac{2V_{Th} - 2V_1 + V_{Th}}{6} = 0$$

$$\therefore -2V_1 + 3V_{Th} = 0 \quad \text{——— (11)}$$

Solving (1) & (11)

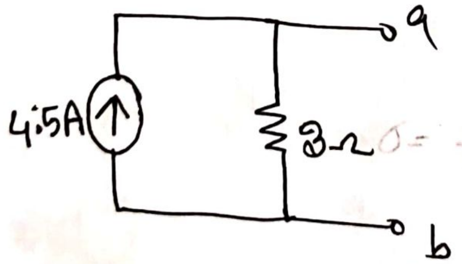
$$V_{Th} = 13.5\ V$$

we know,

$$I_N = \frac{V_{Th}}{R_{Th}} = \frac{13.5}{3} = 4.5A$$

$$R_N = R_{Th} = 3\ \Omega$$

Norton equivalent circuit

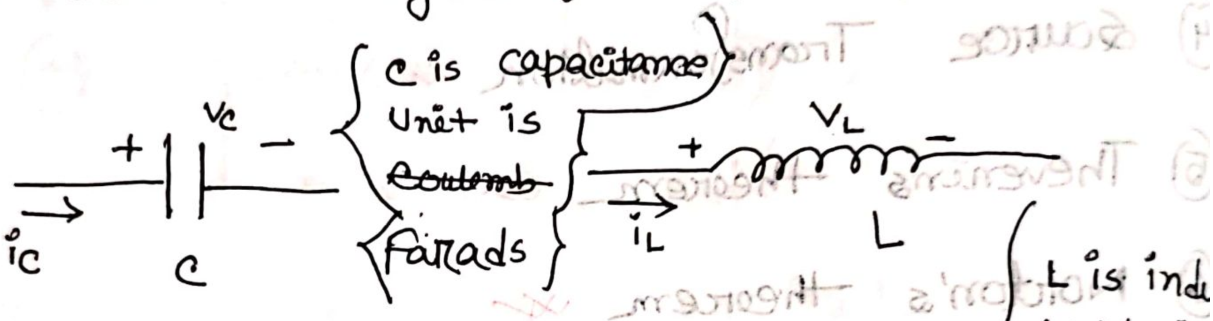


Capacitors and inductors

* Resistor is an energy dissipating element.
* Capacitors ~~are~~ and inductors are energy storing elements.

* Capacitors hold electric field (voltage)

* Inductors hold magnet field (current)



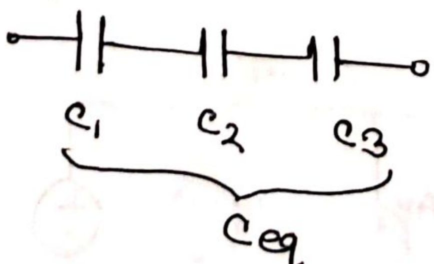
$$i_c = C \cdot \frac{dV_c}{dt} \qquad V_L = L \cdot \frac{di_L}{dt}$$

* In a DC circuit $\quad V_c = \frac{1}{C}\int i_c\, d$

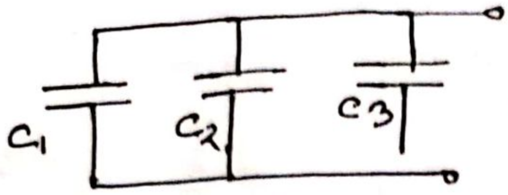
Capacitors behaves as open circuit $\quad$ capacit voltage

Inductors behaves as short circuit

* Series and parallel capacitors



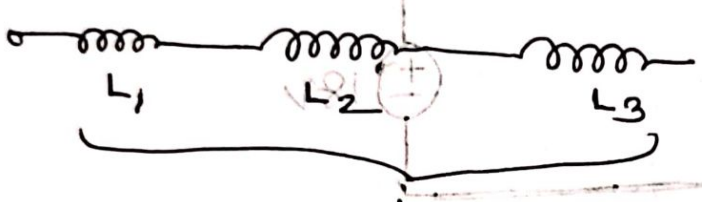
$$C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)^{-1}$$



$\leftarrow C_{eq}$

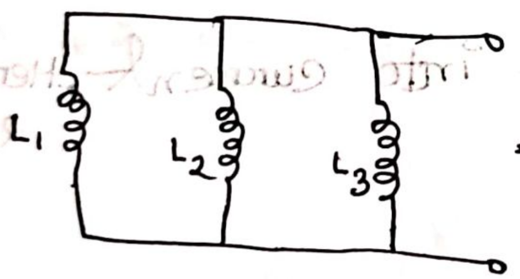
$$C_{eq} = C_1 + C_2 + C_3$$

* Series and Parallel inductors



L_{eq}

$$L_{eq} = L_1 + L_2 + L_3$$



$\leftarrow L_{eq}$

$$L_{eq} = \left(\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}\right)^{-1}$$

- A capacitor consists of two parallel conducting plates separated by an insulator.
- An inductor consists of a coil of conducting wires.

Capacitor's & Inductors

Capacitors

in series.

$$C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)^{-1}$$

in parallel,

$$C_{eq} = C_1 + C_2$$

Inductors

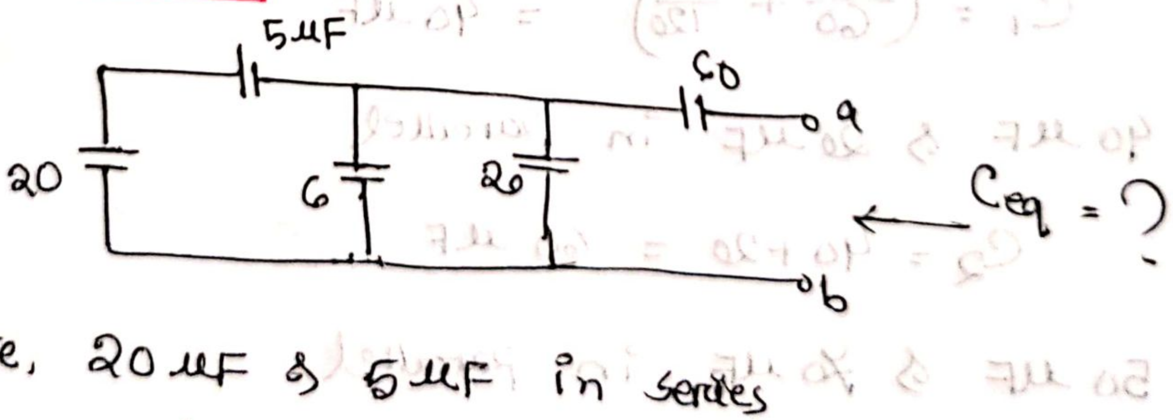
in series

$$L_{eq} = L_1 + L_2$$

in parallel.

$$L_{eq} = \left(\frac{1}{L_1} + \frac{1}{L_2}\right)^{-1}$$

Example→6·6



Here, 20 μF & 5 μF in series

$$C_{eq_1} = \left(\frac{1}{20} + \frac{1}{5}\right)^{-1} = 4\ \mu F$$

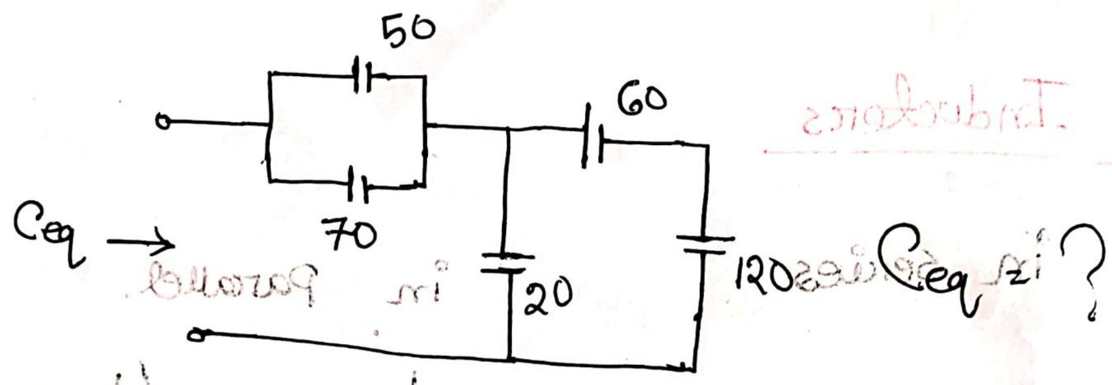
4 μF, 6 μF, 20 μF in parallel

$C_2 = 4+6+20 = 30\ \mu F$

$30\ \mu F$ & $60\ \mu F$ in series.

$$C_{eq} = \left(\frac{1}{30} + \frac{1}{60}\right)^{-1} = 20\ \mu F \quad \text{Ans}$$

$\boxed{\text{Practice Problem} \rightarrow 6.6}$



C_{eq} is ?

Sol:

$60\ \mu F$ & $120\ \mu F$ in series

$$C_1 = \left(\frac{1}{60} + \frac{1}{120}\right)^{-1} = 40\ \mu F$$

$40\ \mu F$ & $20\ \mu F$ in parallel

$$C_2 = 40+20 = 60\ \mu F$$

$50\ \mu F$ & $70\ \mu F$ in parallel

$$C_3 = 50+70 = 120\ \mu F$$

C_2 & C_3 ($60\ \mu F$ & $120\ \mu F$) in series.

$$C_{eq} = \left(\frac{1}{60} + \frac{1}{120}\right)^{-1} = 40\ \mu F \quad \text{Ans}$$

Inductors

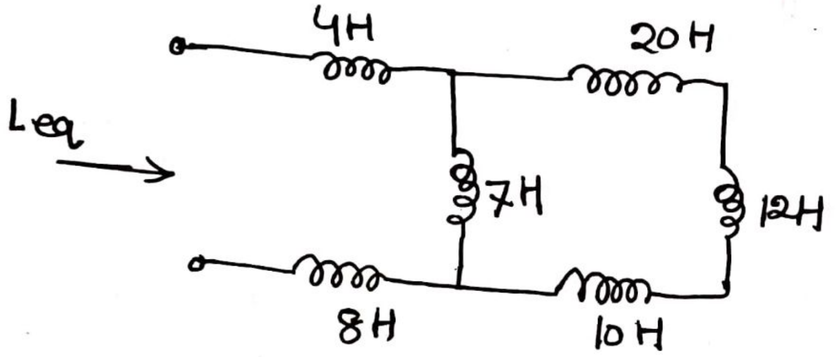
in series

$$L_{eq} = L_1 + L_2$$

in parallel

$$L_{eq} = \left(\frac{1}{L_1} + \frac{1}{L_2}\right)^{-1}$$

Example → 6·11



$L_{eq} = ?$

Soln

20H, 12H, 10Ω in series.

$$L_1 = 20 + 12 + 10 = 42 \text{ H}$$

42H & 7H in parallel

$$L_2 = \left(\frac{1}{42} + \frac{1}{7}\right)^{-1} = 6 \text{ H}$$

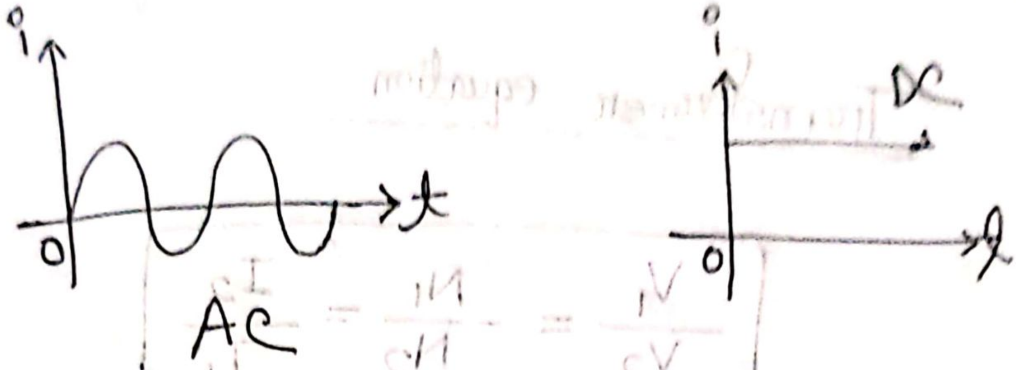
4H, 6H & 8H in series.

$$L_{eq} = 4 + 6 + 8 = 18 \text{ H}$$

Ans

* Difference between AC & DC Power

AC (Alternating Current)	DC (Direct Current)
(i) Current changes it's direction.	(i) Current doesn't change it's direction
(ii) Capacitors & inductors work as impedance	(ii) capacitors behave like an open circuit, inductor behave like a short circuit
(iii) Has complex power. Thus contains imaginary part	(iii) Doesn't contain any imaginary part only contains real part
(iv) Used in conventional power supply. Ex→(Refrigerator, Fan, AC)	(iv) Used in conventional household electronics Ex→(Mobile, Laptop).



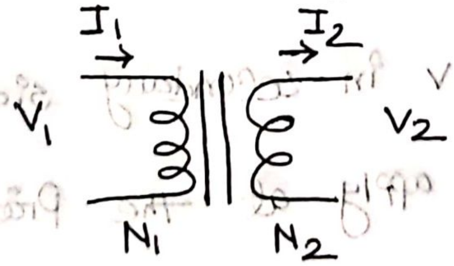
Transformers.

One level AC → Another level AC

Definition

An apparators for reducing or increasing the voltage of an alternating current.

* Transformer is used to step up or step down AC voltage.



N_1 = No. of turns in Primary winding

N_2 = No of turns in secondary winding

$\left(\frac{N_1}{N_2}\right)$ is called turns ratio.

Transformer equation

$$\boxed{\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}}$$

$$\therefore \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

$$\Rightarrow V_1 \cdot I_1 = V_2 \cdot I_2$$

$$\Rightarrow P_1 = P_2$$

P_1: Power in the Primary side

P_2: Power in the secondary side

Problem

A transformer has a trans ratio of 10:1. If we want to get 100 V in secondary side, How much voltage should we apply at the Primary side?

Sol:

$\frac{N_1}{N_2} = \frac{10}{1}$

$V_2 = 100V$

$V_1 = ?$

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\Rightarrow \frac{V_1}{V_2} = \frac{10}{1}$$

$$\Rightarrow V_1 = 100 \times 10 = 1000V$$

Ans