14/12/2020

MODULE - 1

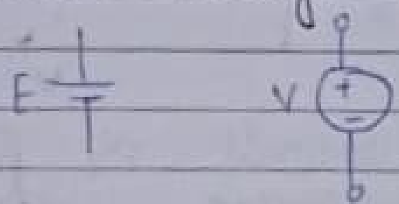
DC Circuit Analysis and Network Theorems

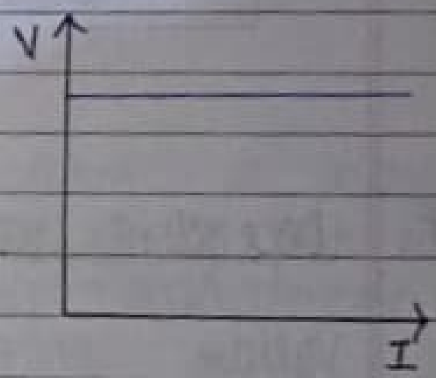
* **Sources**
- → Ideal sources
- → Practical sources

Sources can also be classified as:-
- → Voltage sources
- → Current Sources

→ **Voltage Sources**

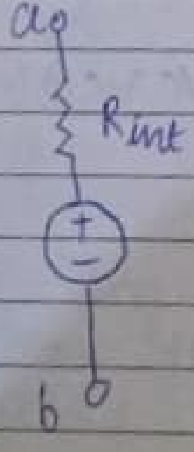
- **Ideal Voltage Sources**



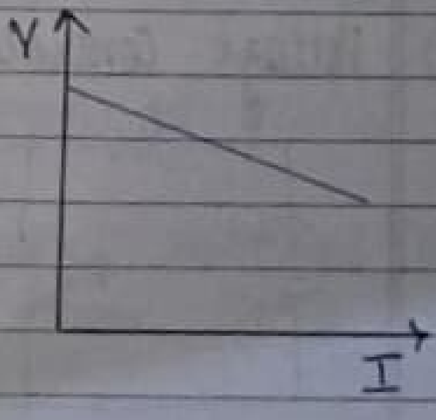


Voltage across the ideal voltage source remains constant irrespective of current.

- **Practical Voltage Sources**

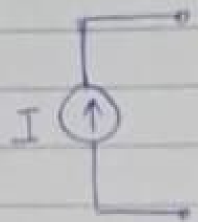


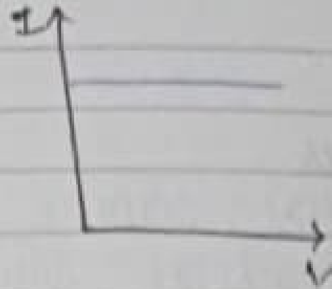
When I ↑es
V_{ab} ↓es.



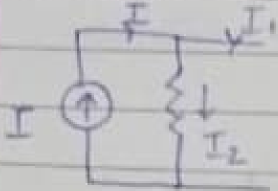
→ Current source

- **Ideal current source**

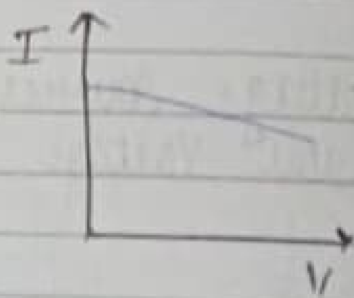




- **Practical current source**

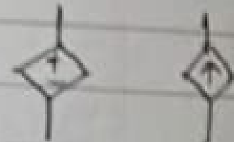


$I_1 < I$



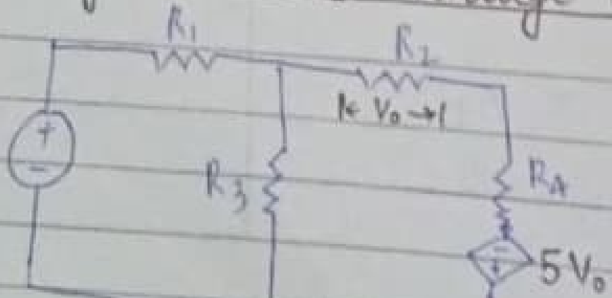
* **Dependent voltage / current source**

(Also called controlled source)

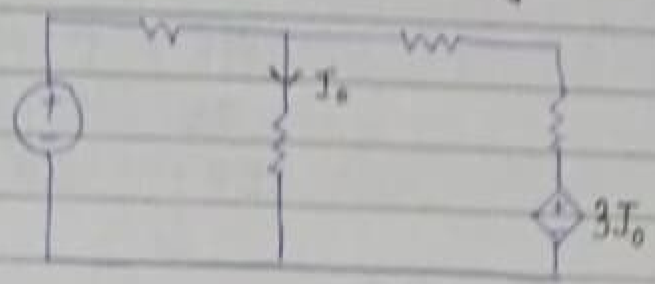


- Voltage controlled voltage source (VCVS)
- Current controlled voltage source (CCVS)
- Voltage controlled current source (VCCS)
- Current controlled current source (CCCS).

i) **Voltage controlled Voltage Source (VCVS)** -



ii) <u>Current Controlled Voltage Source (CCVS)</u> -



* <u>Unilateral / Bilateral Elements</u>

If an element changes its characteristic on changing the direction of current passing through it, it is an unilateral element.
Eg- pn junction, transistor

If the element does not change its characteristics on changing the direction of current passing through it, it is bilateral element.
Eg- Resistors, Inductors

* <u>Active / Passive Elements</u>
If any element has internal energy source to drive the ckt, then it is active element.
Eg- Voltage source, semiconductor devices.

If any element does not have internal energy source to drive the ckt, then it is passive element.
Eg- R, L, C

* Linearity

i) Homogenity

ii) Supbrposition

i) Homogeneity

$$f(ax) = a f(x)$$

Eg :- $f(x) = y = 7x$

$$f(ax) = 7(ax)$$
$$= a(7x)$$
$$= a f(x)$$

$$f(x) = 3x^2$$
$$f(ax) = 3(ax)^2$$
$$= 3a^2x^2$$
$$= a^2 f(x)$$
$$f(ax) \neq a f(x)$$

It is also called scaling property.

ii) Superposition

It is also called additive property.

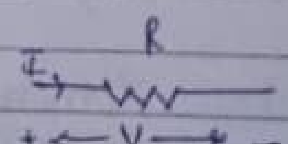
$$f(x_1 + x_2) = f(x_1) + f(x_2)$$

$$f(x) = 7x$$
$$f(x_1 + x_2) = 7(x_1 + x_2)$$
$$= 7x_1 + 7x_2$$
$$= f(x_1) + f(x_2)$$

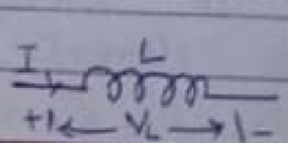
$$f(x) = 3x^2$$
$$f(x_1 + x_2) = 3(x_1 + x_2)^2$$
$$= 3x_1^2 + 3x_2^2 + 6x_1x_2$$
$$f(x_1 + x_2) \neq f(x_1) + f(x_2)$$

* R, L and C as linear elements

R :- $V = IR$



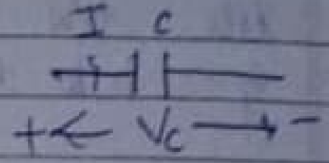
L :- $V_L = L\frac{dI}{dt}$ (Non-linear)



$I = \frac{1}{L}\int V_L dt$

$\boxed{\phi = LI}$ (linear)

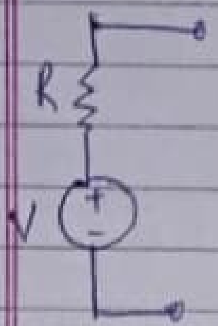
C :- $I = C\dfrac{dV_c}{dt}$



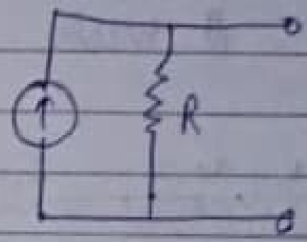
$V_c = \dfrac{1}{C}\int I\,dt$

$\boxed{Q = CV}$

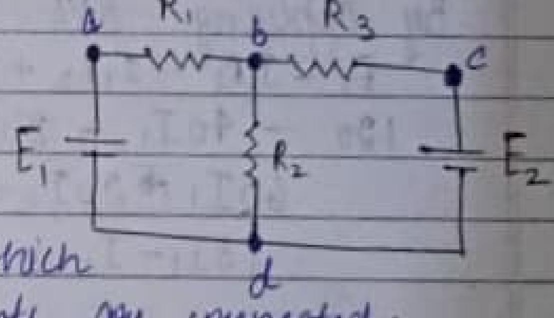
* Source Transformation



$V = IR$



* Loop Analysis



Node - A node of a circuit is an equi-potential point at which 2 or more components/elements are connected.
eg- a, b, c, d

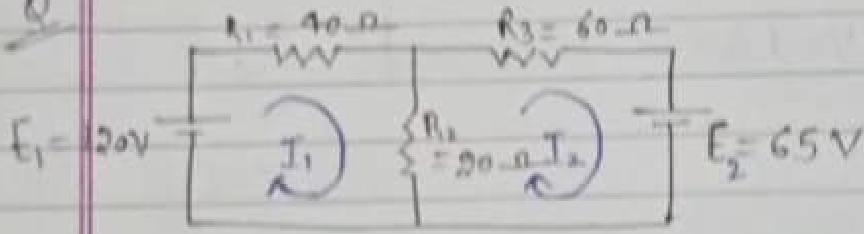
Junction A junction of a junction is an equi potential point at which 3 or more elements are connected.
eg- b, d

Branch - It is that part of the ckt which lies b/w 2 junction.
Eg - b to d, (c), b to d(1), b to d(2)

Loop - Any closed path in a ckt is a loop.
Eg - 3 loops.

Mesh - The individual / elementary loops are called mesh.
Eg - 2 mesh

Q



By applying KVL in loop 1

$$E_1 - I_1R_1 - I_1R_2 + I_2R_2 = 0$$
$$120 - 40I_1 - 20I_1 + 20I_2 = 0$$
$$60I_1 - 20I_2 = 120$$
$$\boxed{3I_1 - I_2 = 6} \quad \text{--- (1)}$$

By applying KVL in loop 2

$$-E_2 - I_2R_2 + I_1R_2 - I_2R_3 = 0$$
$$-65 - 20I_2 + 20I_1 - 60I_2 = 0$$
$$20I_1 - 80I_2 = 65$$
$$\boxed{4I_1 - 16I_2 = 13} \quad \text{--- (2)}$$

Solving (1) & (2)

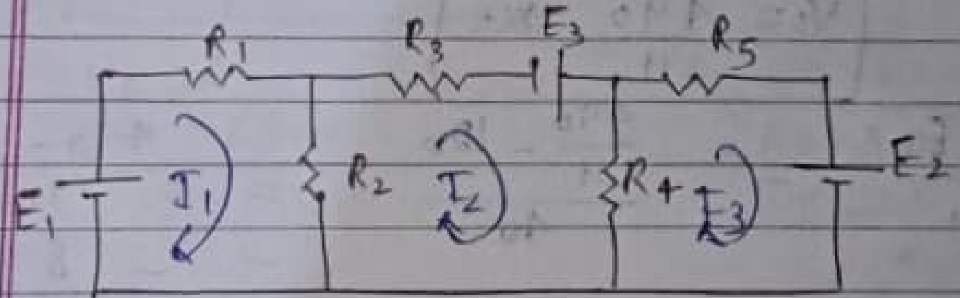
$$48 I_1 - 16 I_2 = 96$$
$$4 I_1 - 16 I_2 = 13$$
$$- \quad + \quad -$$
$$44 I_1 = 83$$

$$\boxed{I_1 = \frac{83}{44} \text{ Amp.}}$$

$$I_2 = \cancel{6}\, 3 \times \frac{83}{44} - 6$$
$$= \frac{249 - 264}{44}$$
$$= \frac{-25}{44}$$

$$\boxed{I_2 = \frac{25}{44} \text{ Amp.}}$$ (In opp. direction we assumed)

Q



In loop 1 :-

$E_1 - I_1R_1 - I_1R_2 + I_2R_2 = 0$ — (1)

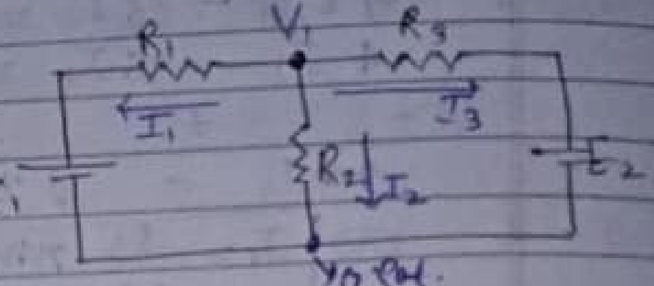
In loop 2 :-

$E_3 - I_2R_4 + I_3R_4 - I_2R_2 - I_2R_3 + I_1R_2 = 0$ — (2)

In loop 3 :-

$-E_2 - I_3R_4 + I_2R_4 - I_3R_5 = 0$ — (3)

* <u>Nodal Analysis</u> :-



Applying KCL,

$I_1 + I_2 + I_3 = 0$

$$\frac{V_1 - E_1}{R_1} + \frac{V_1 - 0}{R_2} + \frac{V_1 - E_2}{R_3} = 0$$

$E_1 = 120V$, $E_2 = 65V$

$R_1 = 40\,\Omega$, $R_2 = 20\,\Omega$, $R_3 = 60\,\Omega$

$$\frac{V_1 - 120}{40} + \frac{V_1}{20} + \frac{V_1 - 65}{60} = 0$$

$$\frac{3V_1 - 360 + 6V_1 + 2V_1 - 130}{120} = 0$$

$$11V_1 = 490$$

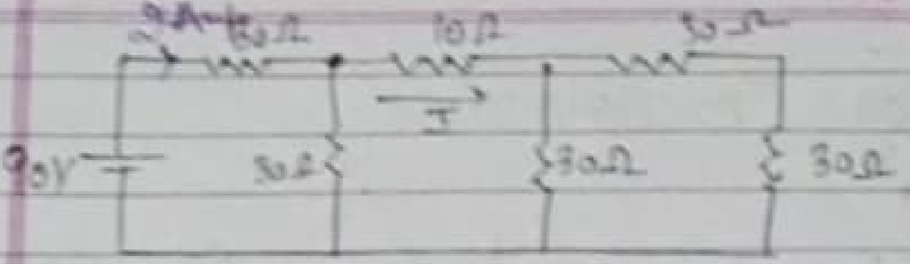
$$\boxed{V_1 = \frac{490}{11} \text{ volt}}$$

$$I_1 = \frac{V_1 - E_1}{R_1} = \frac{\frac{490}{11} - 120}{40} = \frac{490 - 1320}{11 \times 40} = -\frac{830}{440} = -\frac{83}{44} \text{ Amp.}$$

$$I_2 = \frac{V_1}{R_2} = \frac{490}{11 \times 20} = \frac{49}{22} \text{ Amp.}$$

$$I_3 = \frac{\frac{490}{11} - 65}{60} = \frac{490 - 715}{60 \times 11} = \frac{-225}{60 \times 11} = \frac{-15}{44} \text{ Amp}$$

Q



Find I

$\frac{1}{R} = \frac{1}{30} + \frac{1}{60} = \frac{3}{60}$, $R = 20\ \Omega$

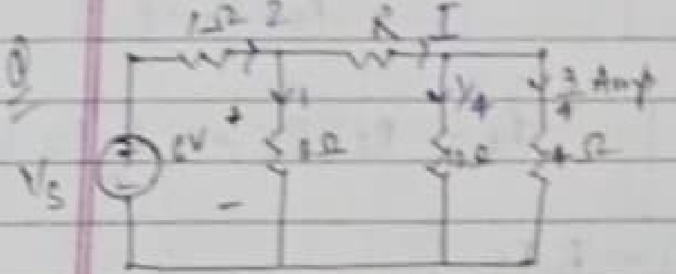
Total $R = 45\ \Omega$

$V = I'R$

$I' = 90/45 = 2$ Amp

$I = \frac{I'}{2} = \frac{2}{2} = \underline{1 \text{ Amp}}$

Q



Find i) R & V_s
ii) Power output of source V_s.

$V = IR$

i) $6 = 1(R+3)$

$\boxed{R = 3\ \Omega}$

$\frac{1}{R_p} = \frac{1}{12} + \frac{1}{4}$

$\boxed{R_p = 3\ \Omega}$

$12 \times I' = 4 \times \frac{3}{4}$

$I' = \frac{1}{4}$

$I = \frac{1}{4} + \frac{3}{4} = 1\ \Omega$

$V_s = IR$

$= 2 \times 4$

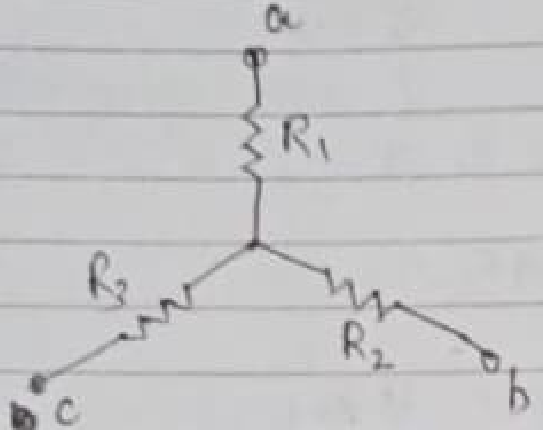
$\boxed{V_s = 8 \text{ Volt}}$

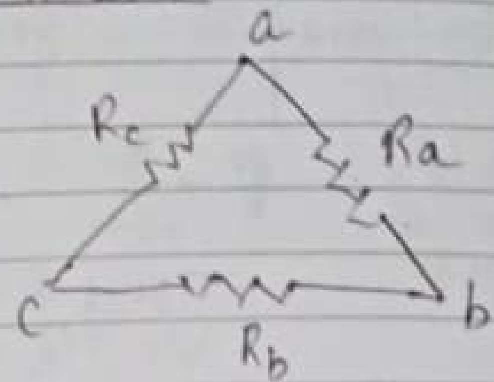
ii) Power $= V_s \times I$

$= 8 \times 2$

$\boxed{P = 16 \text{ watt}}$

* Star - Delta Transformation





$$\boxed{R_1 = \frac{R_a R_c}{R_a + R_b + R_c}}$$

$$\boxed{R_2 = \frac{R_a R_b}{R_a + R_b + R_c}}$$

$$\boxed{R_3 = \frac{R_b R_c}{R_a + R_b + R_c}}$$

$$\boxed{R_a = R_1 + R_2 + \frac{R_1 R_2}{R_3}}$$

$$\boxed{R_b = R_2 + R_3 + \frac{R_2 R_3}{R_1}}$$

$$\boxed{R_c = R_3 + R_1 + \frac{R_1 R_3}{R_2}}$$