AKTU

B.Tech I-Year

Electrical Engg.

ONE SHOT Revision

Unit-1

DC Circuits

GATEWAY CLASSES

Avinash Sir

AKTU B.Tech First Year

Fundamentals of Electrical Engineering

Unit-1 : DC Circuits

AKTU Syllabus

Electrical circuit elements (R, L and C), Concept of active and passive elements, Voltage and current sources, concept of linearity, unilateral and bilateral elements.

Kirchhoff's laws, Mesh and nodal methods of analysis.

2 marks

Active Elements & Passive Elements

① **Active Elements:-** Elements that can provide energy to the networks.

Examples: Voltage Source & Current Source , Battery

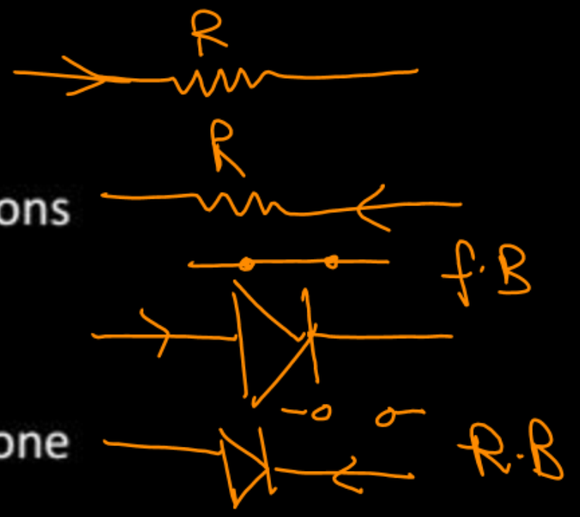
- **Passive Elements:-** Elements that can which can only receive energy, which it can either dissipate, absorb or store it in an electric field or a magnetic field.

Examples: R,L,C - Resistance - dissipate , Inductor & Capacitor → Energy store

② **Bilateral Element & Unilateral Element**

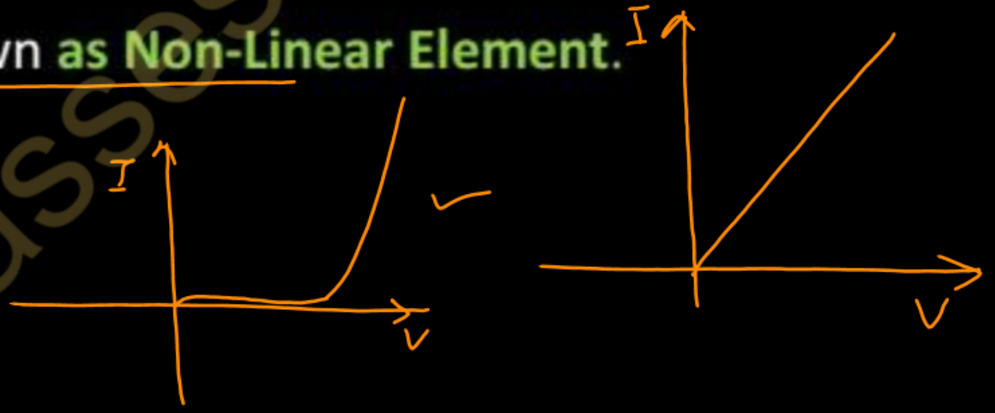
Bilateral Element:- Elements which allows current to flow from both directions are known as Bilateral Element. **(Examples: Resistance)**

Unilateral Element:- Elements which allows current to flow only from one direction are known as Unilateral Element . **(Examples: Diode)**



Linear and Non Linear Elements

(3) **Linear & Non Linear Element –** An Element is said to be **linear**, if it obeys the principle of homogeneity and superposition , Otherwise it is known **as Non-Linear Element.**



Examples: Resistance (Linear) , diodes (Non-Linear)

Semiconductor

Lumped and Distributed network

Lumped Network:-A network in which all the network elements are physically separable is known as a lumped network.

Examples: - Network having Resistance ,Inductor or Capacitor etc

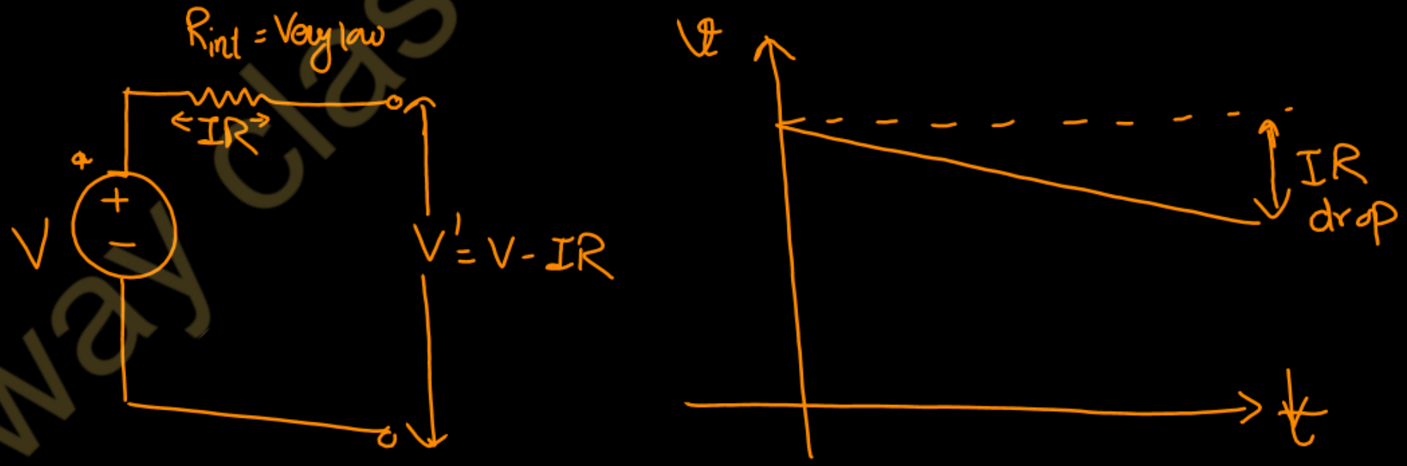
Distributed Network – A network in which network elements can not be physically separable is known as **Distributed network** like Transmission Line.

Voltage Source: Ideal and practical Voltage source

Ideal Voltage source:- Energy Source which provide constant voltage across its terminals irrespective of current drawn through its terminals.

It has Zero Internal Resistance

Practical Voltage Source:- A practical voltage source has small internal resistance due to which voltage across terminals decrease slightly with increase in current.

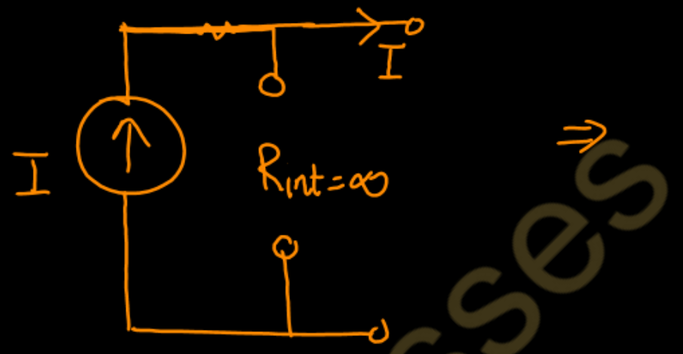


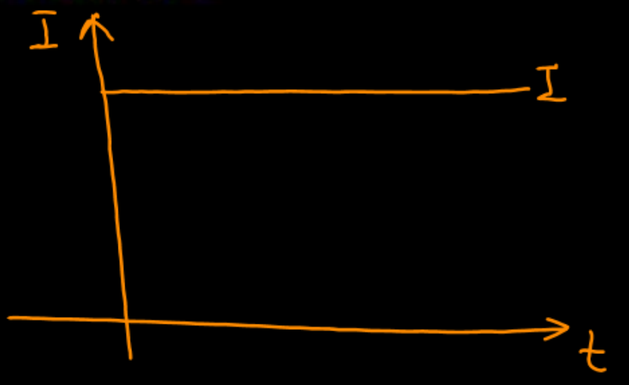
Current Source: Ideal and Practical Current source

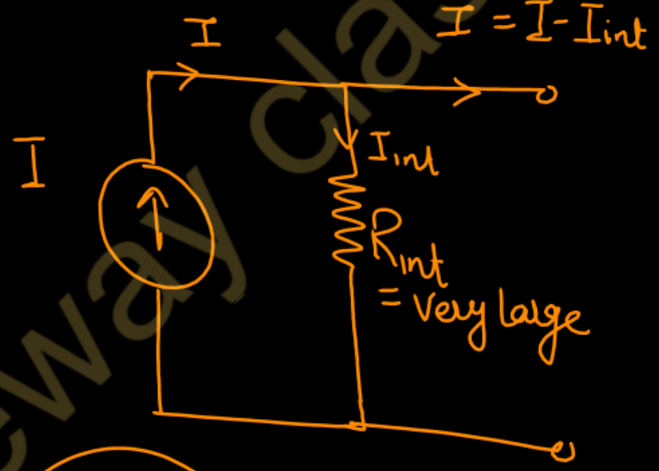
Ideal Current source:- Energy Source which provide constant Current across its terminals irrespective of current drawn through its terminals.

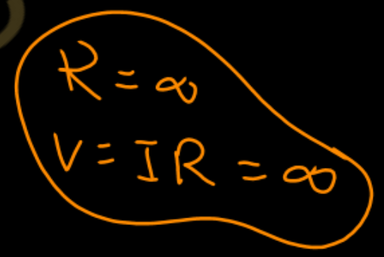
It has infinite Internal Resistance.

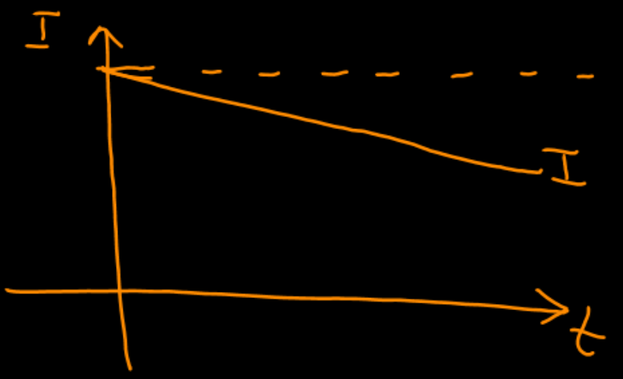
Practical Current Source:- A practical Current source has very high internal resistance due to which Current across terminals decrease slightly with increase in voltage.











KCL Node

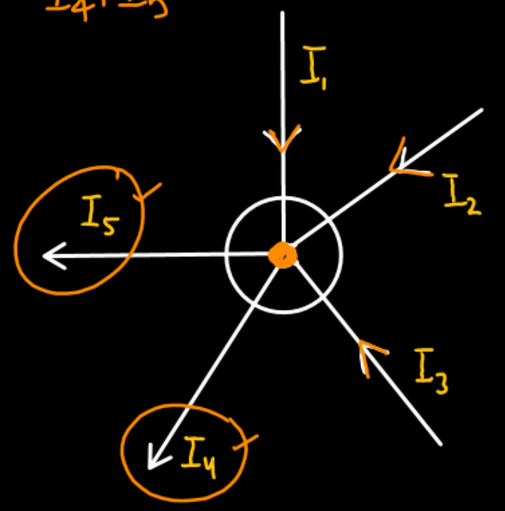
KVL Loop

$I_1+I_2+I_3 = I_4+I_5$

Kirchhoff's Current Law:- According to Kirchhoff's Current Law, algebraic sum of ALL the currents entering and leaving a node must be equal to zero, $I_{(exiting)} + I_{(entering)} = 0$.

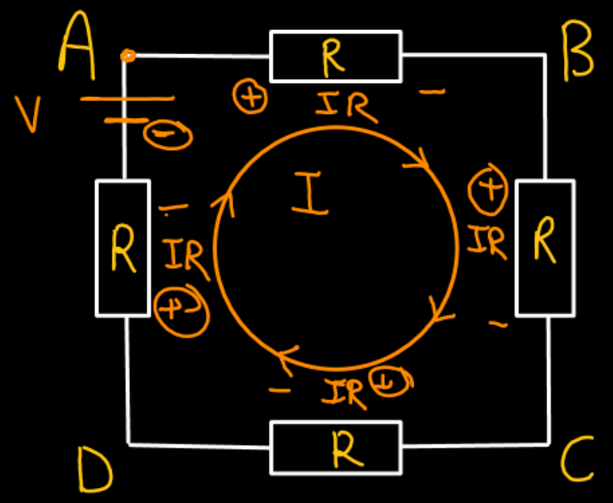
Nodal Analysis

$(I_4+I_5) - I_1 - I_2 - I_3 = 0$



Kirchhoff's Voltage Law:- According to Kirchhoff's Voltage Law, The voltage around a loop equals the sum of every voltage drop in the same loop for any closed network and equals zero.

Mesh Analysis



Why We can not apply KVL in a loop having Current Source.

Ans. NO

$IR+IR+IR+IR-V = 0$

Ques. Explain the procedure of mesh analysis with the help of an example (AKTU-2023-24)

Step-1- Identify loops in given Circuit

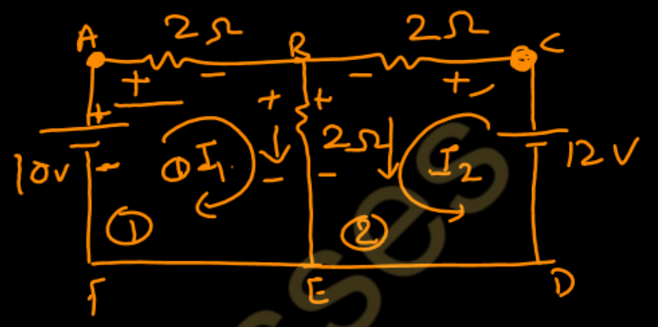
Step-2 Consider loop current in mesh (I_1, I_2)

Step-3 (optional) → mark polarity on each resistance

Step4 Apply KVL in each ~~loop~~ mesh one by one

Step 5 – Now we have one equation from each mesh

Step 6 Solve all equations to find mesh Currents.



Apply KVL in mesh ①

$$+2I_1 + 2(I_1+I_2) + -10 = 0$$

$$4I_1 + 2I_2 = 10 \quad \text{—①}$$

Apply KVL in mesh ②

$$+2I_2 + 2(I_2+I_1) = 12$$

$$2I_1 + 4I_2 = 12 \quad \text{—②}$$

$I_1 = 1.33$ A

$I_2 = 2.33$ A.

Loop → Any closed path

Mesh → Shortest closed path loop that does not contain any other loop

Ques. Explain the procedure of Nodal analysis with the help of an example.

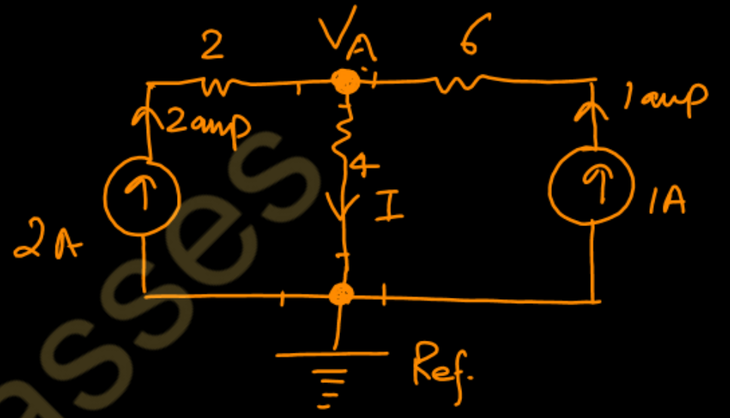
Step:→ Identify junction in the Circuit

Step-2 → Consider one junction at reference (V = 0)
and rest junction voltages should be considered

Step-3 Now assume ~~random~~ branch Current with random direction

Step-4 Now apply KCL at each node

Step-5 Solve these equations to find Node Voltages and Currents.



Apply KCL at Node

$1 + 2 = I$

$\boxed{I = 3}$ amp

$I = \frac{V_A - 0}{4} = \frac{V_A}{4}$

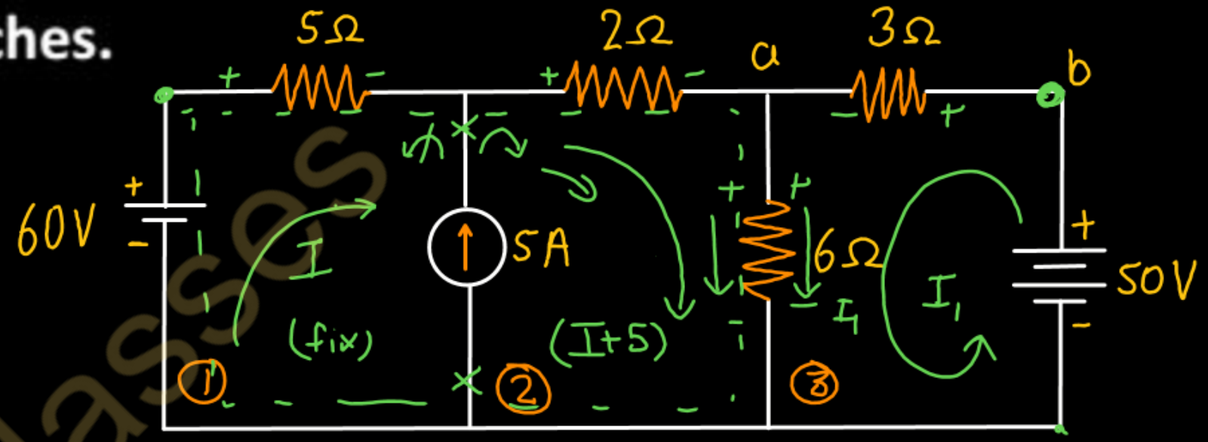
$V_A = 4I = 4 \times 3 = 12$ Volt

Junction – where 3 or more branches meets

Node → where 2 or more branches meets

Mesh Analysis(KVL): Numerical Problems

Q.1 Using Mesh Analysis Find Current in all branches.



Apply KVL in Supermesh

$$+5I + 2(I+5) + 6(I+5+I_1) - 60 = 0$$

$$5I + 2I + 10 + 6I + 30 + 6I_1 - 60 = 0$$

$$13I + 6I_1 = 20 \quad \text{—①}$$

Apply KVL in loop ③

$$+3(I_1) + 6(I_1 + I + 5) - 50 = 0$$

$$3I_1 + 6I_1 + 6I + 30 - 50 = 0$$

$$6I + 9I_1 = 20 \quad \text{—②}$$

Solve Eqn ① & ②

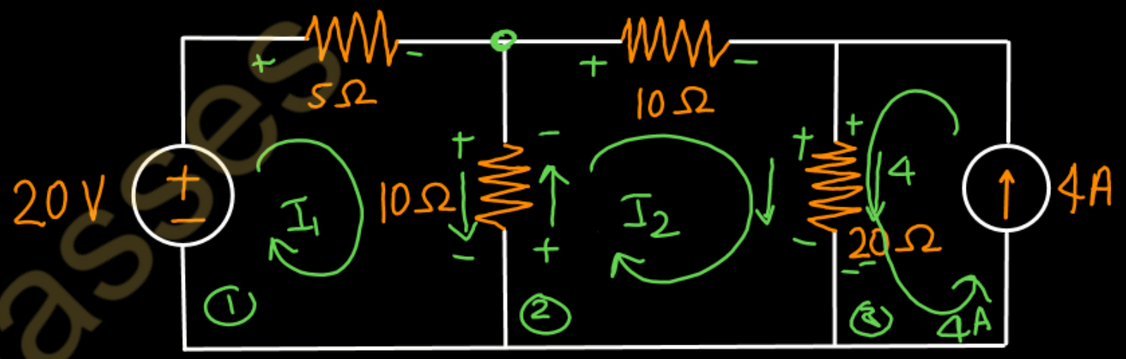
$$I = 0.74 \text{ Amp}$$

$$I_1 = 1.728 \text{ Amp}$$

By

Mesh Analysis(KVL): Numerical Problems

Q.2 Using Mesh Analysis Find Current in 20 Ω resistance. (AKTU-2023-24)



Apply KVL in Loop ①

$$5I_1 + 10(I_1 - I_2) = 20$$

$$15I_1 - 10I_2 = 20 \quad \text{—①}$$

Apply KVL in Loop ②

$$+10(I_2) + 20(I_2 + 4) + 10(I_2 - I_1) = 0$$

$$-10I_1 + 40I_2 = -80 \quad \text{—②}$$

Solve Eqn ① & ②

$$I_1 = 0$$

$$I_2 = -2 \text{ Amp}$$

$$I_{20\Omega} = I_2 + 4$$

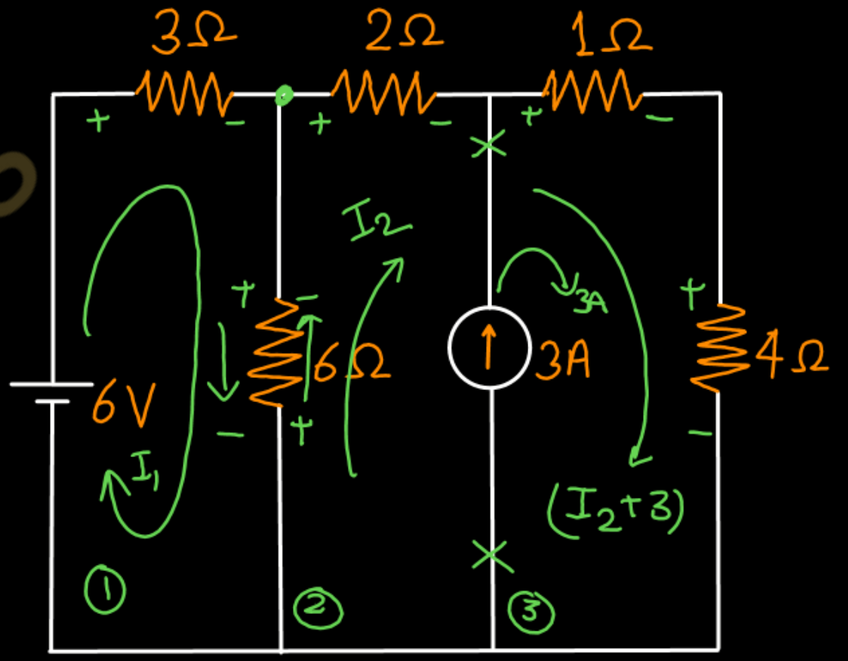
$$= -2 + 4$$

$$\boxed{I_{20\Omega} = 2 \text{ Amp}}$$

Amp

Mesh Analysis(KVL): Numerical Problems

Q.3 Using Mesh Analysis Find Current in 6 ohm Resistance.



Apply KVL in Loop ①

$+3I_1 + 6(I_1 - I_2) = 6$

$9I_1 - 6I_2 = 6 \quad -①$

Apply KVL in Loop (2 & 3) (supermesh)

$2(I_2) + 1(I_2+3) + 4(I_2+3) + 6(I_2 - I_1) = 0$

$-6I_1 + 13I_2 + 15 = 0$

$-6I_1 + 13I_2 = -15 \quad —②$

Solve Eqn ① & ②

$I_1 = -0.148\ A$

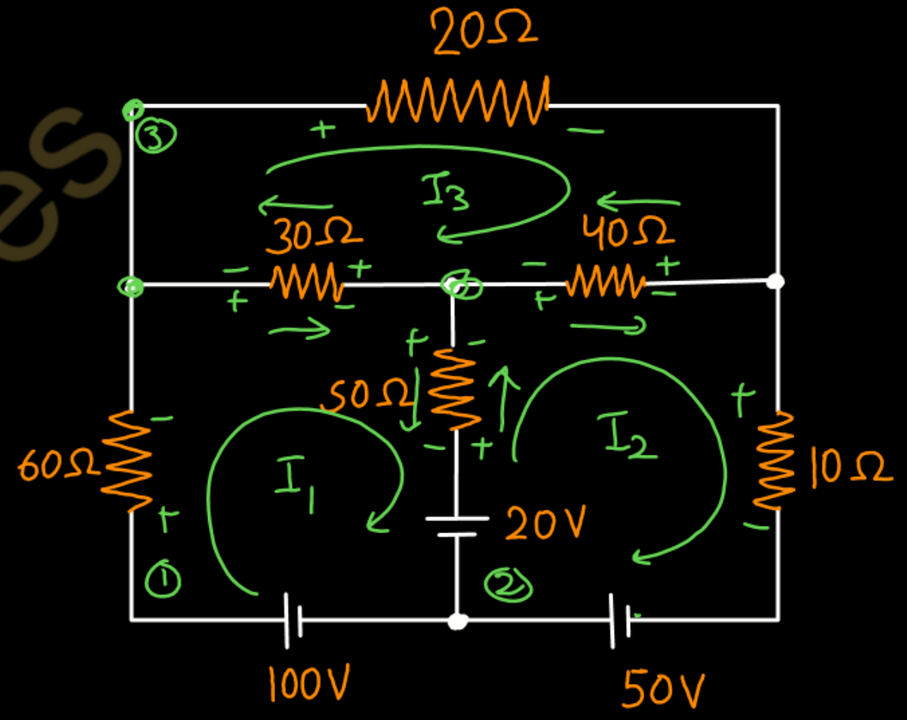
$I_2 = -1.22\ Amp$

$I_{6\Omega} = (I_1 - I_2)$

$= -0.148 + 1.22$

$I_{6\Omega} = 1.072$ ↓

Q.4 Determine the currents in all branches of the circuit as shown in below figure, using Mesh current method? (AKTU 2023-24)



Apply KVL in loop ①

$+30(I_1-I_3)+50(I_1-I_2)+20-100+60(I_1)=0$

$140I_1-50I_2-30I_3=80$ —①

Apply KVL in Loop ②

$+40(I_2-I_3)+10(I_2)-50-20+50(I_2-I_1)=0$

$-50I_1+100I_2-40I_3=70$ —②

Apply KVL in loop ③

$+20I_3+40(I_3-I_2)+30(I_3-I_1)=0$

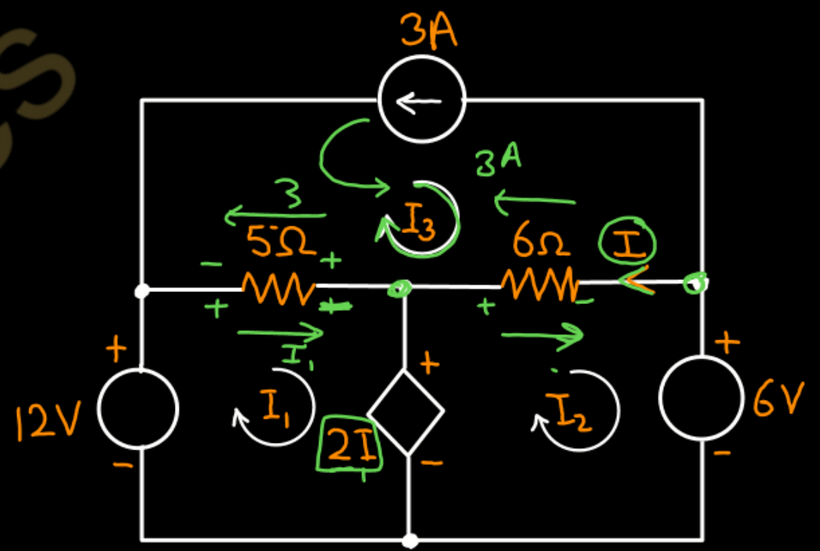
$-30I_1-40I_2+90I_3=0$ —③

Solve Eq ① , ② & ③

$I_1=1.65A$, $I_2=2.12A$, $I_3=1.49A$

Mesh Analysis

Q.5 Determine the set of Mesh equations that are required to solve the network given in below circuit diagram. AKTU 2022-23



Apply KVL in Loop ① $I_3 = -3A$

$+2I - 12 + 5(I_1 + 3) = 0$

$2I + 5I_1 = -3$ — ①

$+0I_2$

Apply KVL in Loop ②

$+6 - 2I + 6(I_2 + 3) = 0$

$6 - 2I + 6I_2 + 18 = 0$

$-2I + 6I_2 = -24$ — ②

$0I_1 +$

Now we have

$I = -3 - I_2$

$I + 0I_1 + I_2 = -3$ — ③

$I = 0.75$

$I_1 = -0.9\ A$

$I_2 = -3.75\ A$

Ans

Nodal Analysis

Q.6 Use nodal analysis to find the currents in various resistors of the circuit shown below.

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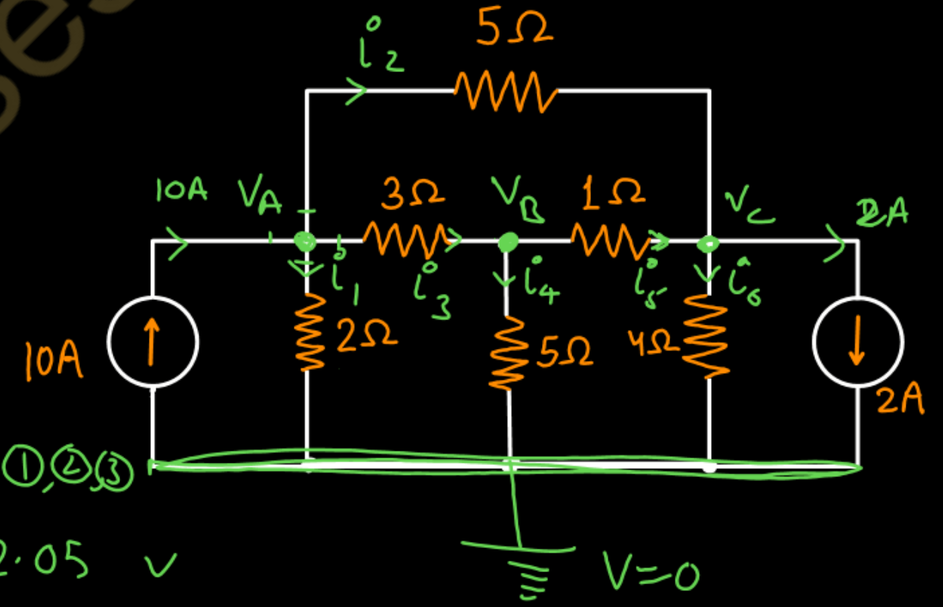
$i_1^\circ = \frac{V_A - 0}{2} = \frac{V_A}{2}$, $i_2^\circ = \frac{V_A - V_C}{5}$, $i_3^\circ = \frac{V_A - V_B}{3}$, $i_4^\circ = \frac{V_B}{5}$, $i_5^\circ = \frac{(V_B - V_C)}{1}$, $i_6^\circ = \frac{V_C}{4} = \frac{3.8}{4} =$



Apply KCL at Node (A)

$$i_1^\circ + i_2^\circ + i_3^\circ = 10$$

$$\frac{V_A}{2} + \frac{V_A - V_C}{5} + \frac{V_A - V_B}{3} = 10$$

$$V_A\left(\frac{1}{2} + \frac{1}{5} + \frac{1}{3}\right) - \frac{V_B}{3} - \frac{V_C}{5} = 10$$

$$V_A\left(\frac{31}{30}\right) - \frac{V_B}{3} - \frac{V_C}{5} = 10 \quad \text{— (1)}$$

Apply KCL at Node (B)

$$i_3^\circ = i_4 + i_5^\circ$$

$$i_3 - i_4 - i_5^\circ = 0$$

$$\frac{V_A - V_B}{3} - \frac{V_B}{5} - V_B + V_C = 0$$

$$\frac{V_A}{3} - V_B\left(\frac{1}{3} + \frac{1}{5} + 1\right) + V_C = 0$$

$$\frac{V_A}{3} - V_B\left(\frac{23}{15}\right) + V_C = 0 \quad \text{— (2)}$$

Apply KCL at Node (C)

$$i_2^\circ + i_5^\circ = i_6^\circ + 2$$

$$i_2^\circ + i_5^\circ - i_6^\circ = 2$$

$$\frac{V_A - V_C}{5} + V_B - V_C - \frac{V_C}{4} = 2$$

$$\frac{V_A}{5} + V_B - V_C\left(\frac{1}{5} + 1 + \frac{1}{4}\right) = 2$$

$$\frac{V_A}{5} + V_B - V_C\left(\frac{29}{20}\right) = 2 \quad \text{— (3)}$$

Solve eq^n (1), (2), (3)

$V_A = 12.05$ V

$V_B = 5.1$ V

$V_C = 3.8$ V

Nodal Analysis

Q.7 Determine the currents in the various branches of the circuit shown in Figure by nodal analysis? (AKTU 2022-23)

$I_1 = \frac{0 - V_B + 100}{20} = \frac{100 - V_B}{20}$, $I_2 = \frac{V_B}{10}$, $I_3 = \frac{V_B - V_C}{15}$, $I_4 = \frac{V_C}{10}$

$I_5 = \frac{V_C - 80}{10}$

Apply KCL at Node B

$I_1 = I_2 + I_3$

$I_1 - I_2 - I_3 = 0$

$\frac{100 - V_B}{20} - \frac{V_B}{10} - \frac{V_B - V_C}{15} = 0$

$\frac{100}{20} - V_B\left(\frac{1}{20} + \frac{1}{10} + \frac{1}{15}\right) + \frac{V_C}{15} = 0$

$-V_B\left(\frac{13}{60}\right) + \frac{V_C}{15} = -5$ — (1)

Apply KCL at Node C

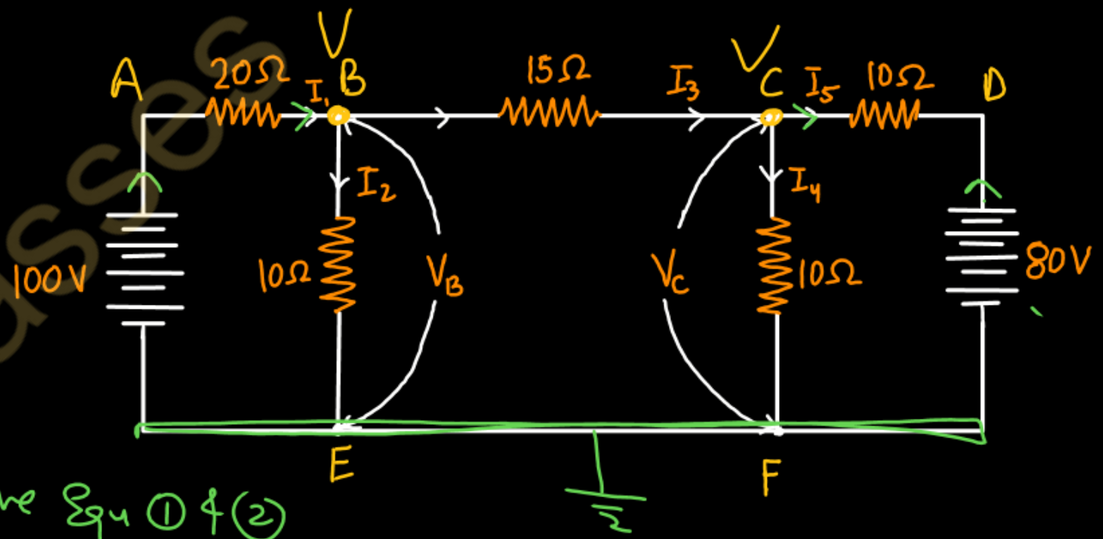
$I_3 = I_4 + I_5$

$I_3 - I_4 - I_5 = 0$

$\frac{V_B - V_C}{15} - \frac{V_C}{10} - \frac{V_C - 80}{10} = 0$

$\frac{V_B}{15} - V_C\left(\frac{1}{15} + \frac{1}{10} + \frac{1}{10}\right) = -8$

$\frac{V_B}{15} - V_C\left(\frac{8}{30}\right) = -8$ — (2)

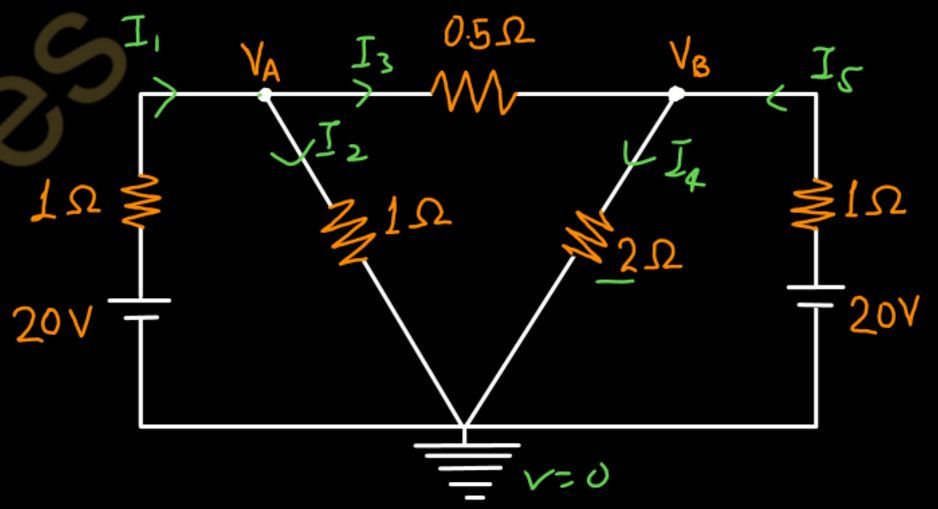


Solve Eq① & ②

$V_B = 35$ V

$V_C = 38.75$ V

Q.8 Determine the current by Nodal method, through 2 ohm resistor for the network shown below? (AKTU 2023-24)



$I_1 = \frac{20 - V_A}{1}$, $I_2 = V_A$, $I_3 = \frac{(V_A - V_B)}{0.5} = 2(V_A - V_B)$, $I_4 = \frac{V_B}{2}$, $I_5 = (20 - V_B)$

KCL at (A)

$I_1 = I_2 + I_3$

$20 - V_A = V_A + 2V_A - 2V_B$

$20 = 4V_A - 2V_B \longrightarrow (1)$

KCL at Nod (B)

$I_3 + I_5 = I_4$

$2V_A - 2V_B + 20 - V_B = 0.5V_B$

$2V_A - 3V_B - 0.5V_B = -20$

$2V_A - 3.5V_B = -20 \longrightarrow (2)$

Solve Eqn (1) & (2)

$V_A = 11\ V$

$V_B = 12\ V$

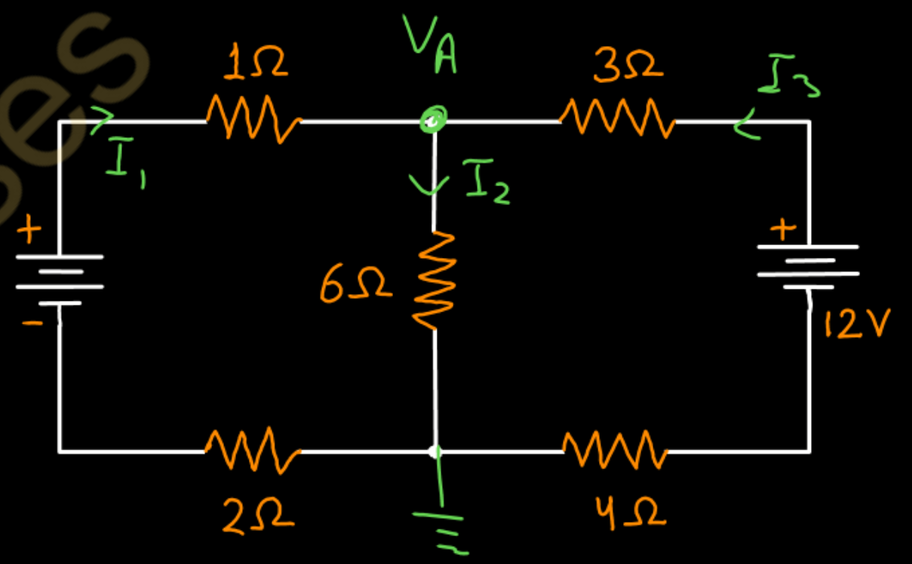
$I_4 = \frac{V_B}{2} = \frac{12}{2} = 6\ amp$ Ans

Q.9 Calculate the current across 6Ω resistor in the following circuit using: (AKTU 2023-24)

~~Mesh Analysis~~

Nodal Analysis

$I_1 = \frac{(18 - V_A)}{3}$, $I_2 = \frac{V_A}{6}$, $I_3 = \frac{12 - V_A}{7}$



Apply KCL at Node

$I_1 + I_3 - I_2 = 0$

$\left(\frac{18 - V_A}{3}\right) + \left(\frac{12 - V_A}{7}\right) - \frac{V_A}{6} = 0$

$\frac{18}{3} - \frac{V_A}{3} + \frac{12}{7} - \frac{V_A}{7} - \frac{V_A}{6} = 0$

$7.71 - V_A\left(\frac{1}{3} + \frac{1}{7} + \frac{1}{6}\right) = 0$

$7.71 = 0.64\, V_A$

$V_A = 11.99 \simeq 12\,V$

$I_2 = \frac{V_A}{6} = \frac{12}{6} = 2\,amp$

Q.10 Find the value of current in 8Ω resistance using Nodal Analysis

$I_1 = \frac{15 - V_B}{20}$, $I_2 = \frac{15 - V_B}{8}$, $I_3 = \frac{V_B - 0 + 25}{20} = \frac{V_B + 25}{20}$

Apply KCL at Node

$$I_1 + I_2 - I_3 = 0$$

$$\frac{15 - V_B}{20} + \frac{15 - V_B}{8} - \frac{V_B + 25}{20} = 0$$

$$\left(\frac{15}{20} + \frac{15}{8} - \frac{25}{20}\right) - V_B\left(\frac{1}{20} + \frac{1}{8} + \frac{1}{20}\right) = 0$$

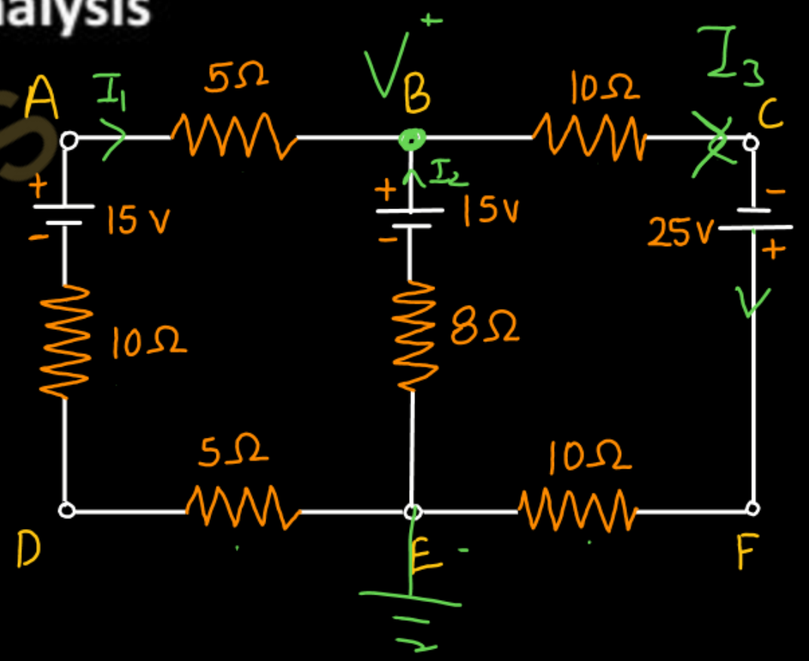
$$1.375 - V_B(0.225) = 0$$

$$V_B = \frac{1.375}{0.225} = 6.11 \text{ Volt}$$

$I_{8\Omega} = I_2 = \frac{15 - 6.11}{8}$

$= 1.11$ Amp

Ans



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