AKTU

B. Tech I-Year

Gateway Classes

Semester -I & II

Common to All Branches

BEE101/201: FUNDAMENTALS OF ELECTRICAL ENGG.

UNIT-1 ONE SHOT : DC Circuits

Gateway Series for Engineering

- Topic Wise Entire Syllabus
- Long - Short Questions Covered
- AKTU PYQs Covered
- DPP
- Result Oriented Content

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B. Tech I-Year

Gateway Classes

BEE101 / BEE201: FUNDAMENTALS OF ELECTRICAL ENGINEERING

Unit-1

Introduction to DC Circuits

Syallbus

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.

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GATEWAY CLASSES

Electrical Engg

One Shot

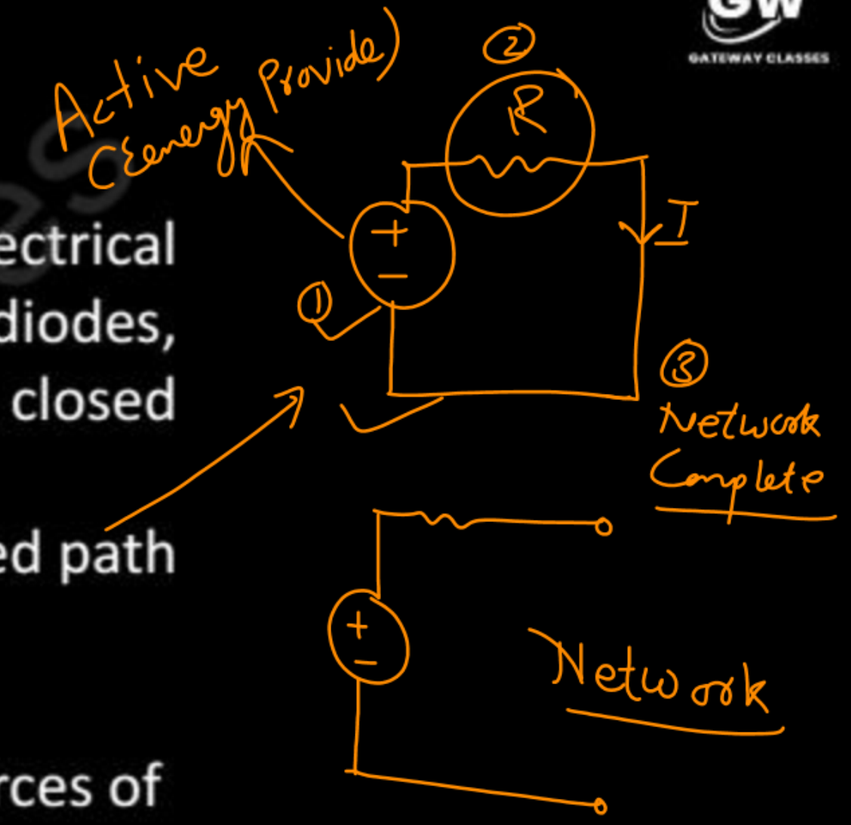
UNIT - I

Syllabus BEE-201/101

Unit -1: (DC Circuits)

- 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.

Basics of DC Circuits



Electric Circuit and Electrical Network:-

- An ***electrical network*** is an interconnection of electrical components (like sources, resistors, inductors, capacitors, diodes, transistors etc.). An electrical network need not contain a closed path for the flow of electric current.
- An ***electric circuit*** is, an electric network that contains a closed path for the flow of electric current.

Passive Network – A passive network does not contain any sources of energy. They consist only passive circuit elements like resistors, inductors and capacitors etc.

Active Network – An active network contains one or more sources of energy (like voltage source or current source), they can supply energy to the network indefinitely. ***An active network is also termed as electric circuit.***

Basics of DC Circuits

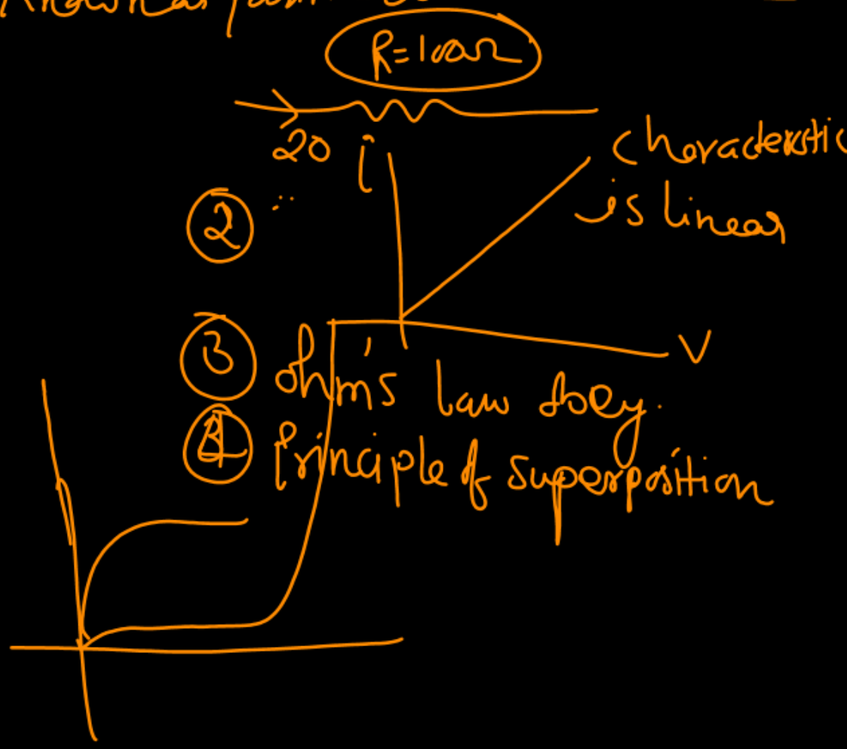
Linear & Non Linear Network – A network is said to be **linear**, if it consists of the circuit elements that obeys the principle of homogeneity and superposition , Otherwise networks is known **as Non-Linear Network.** Ex- Resistive network (Linear) , Network having diodes etc. (Non-Linear).

Lumped Network:-A network in which all the network elements are physically separable is known as a lumped network. (Ex.- R,L,C Network etc.)

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

Active Element → Elements that Can provide energy to the network. Ex. Cells, batteries etc

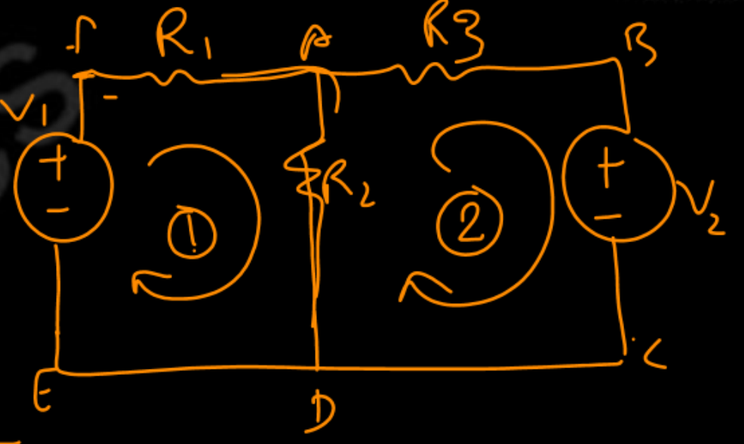
Passive Elements: Elements that can dissipate or store energy are known as passive element. R, L, C



Basics of DC Circuits

Loop = ABCDEF, ABCD, ADEF

① Mesh:-

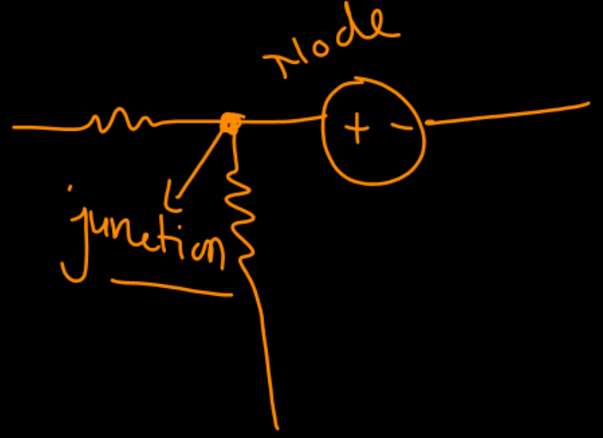


Loop And Mesh:- Any Closed path is known as loop. Any Shortest Closed Path is Known as Mesh .

Note:- Every Mesh will be a loop but it is not necessary that every loop will be a mesh.

→ A mesh does not contain any other loop in it.

①



Node and Junction:- Node is a point where two or more elements meets.

Junction is a point where three or more elements meets..

Note:- Every Junction will be a node but it is not necessary that every node will be a Junction.

Basics of DC Circuits

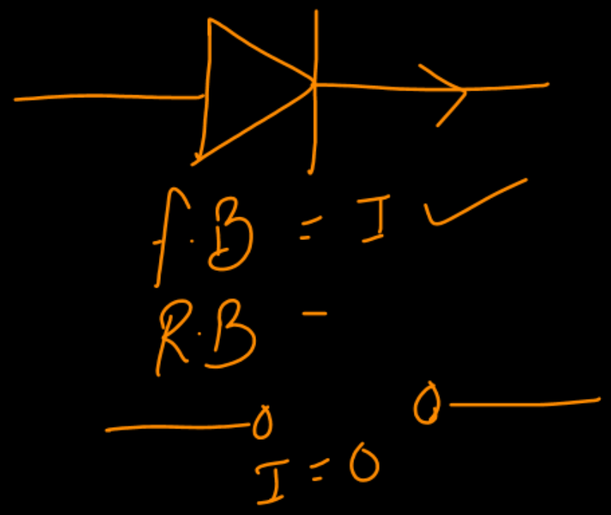
Bi → two

Active Elements:- Elements that can provide energy to the networks. **Ex. Voltage Source & Current Source**

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. **Ex. R,L,C**

Bilateral Element:- Elements which allows current to flow from both directions are known as Bilateral Element.

(Ex- Resistance).



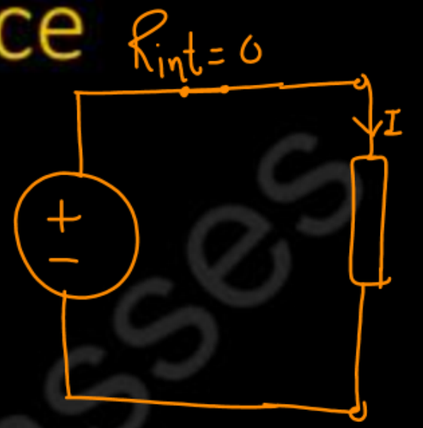
Unilateral Element:- Elements which allows current to flow only from one direction are known as Unilateral Element .

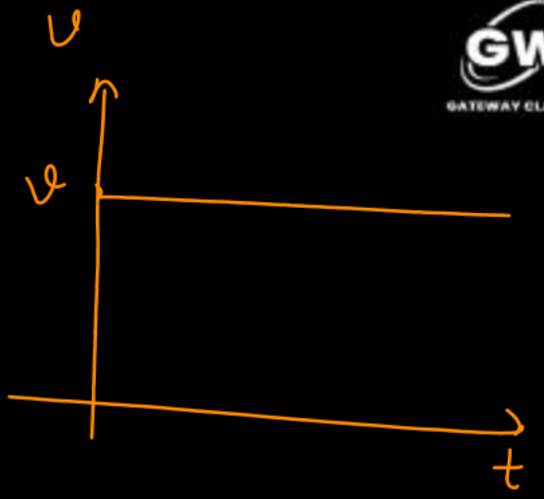
(Ex- Diode)

Voltage Source

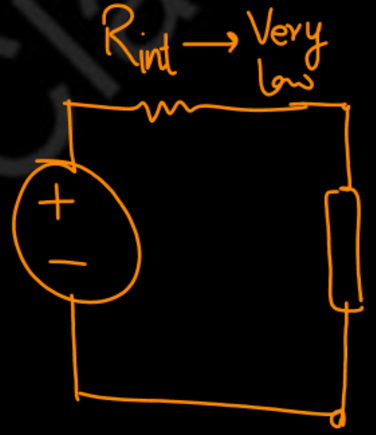
Ideal Voltage source:- Energy Source which provide constant voltage across its terminals irrespective of current drawn through its terminals.

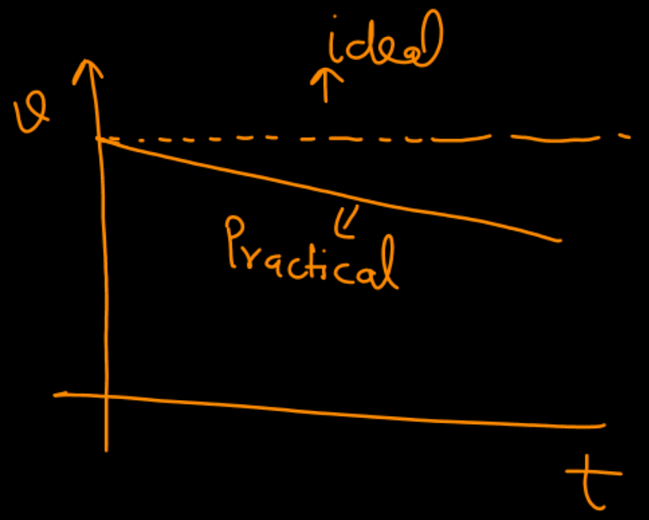
It has Zero Internal Resistance





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

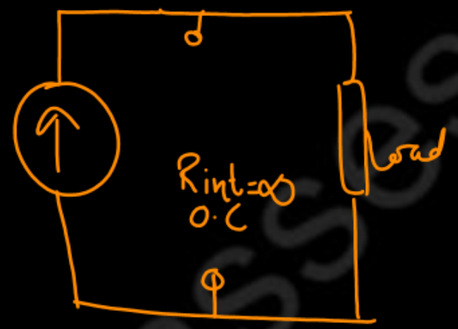


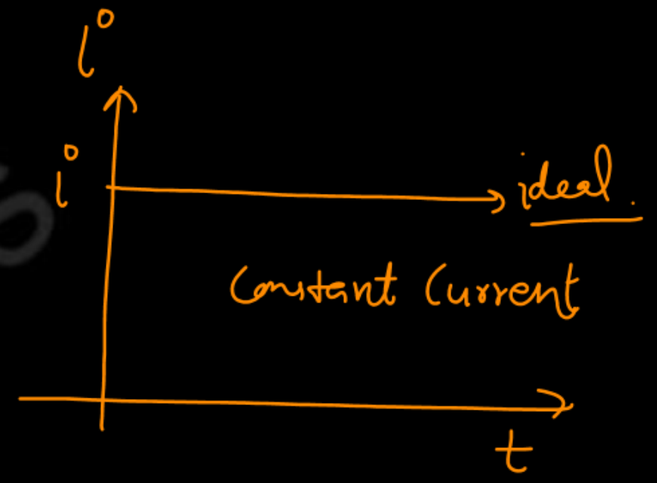


Current Source

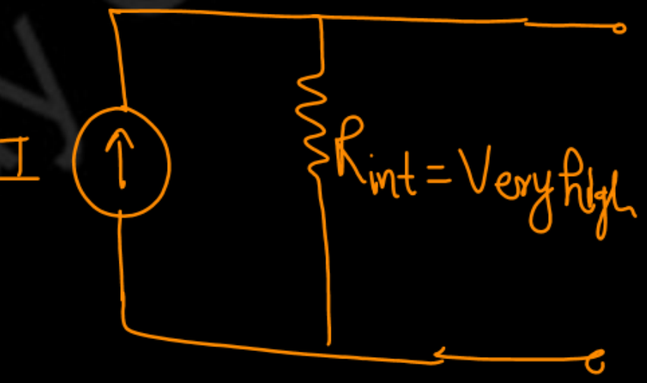
Ideal Current source:- Energy Source which provide constant Current across its terminals irrespective of current drawn through its terminals.

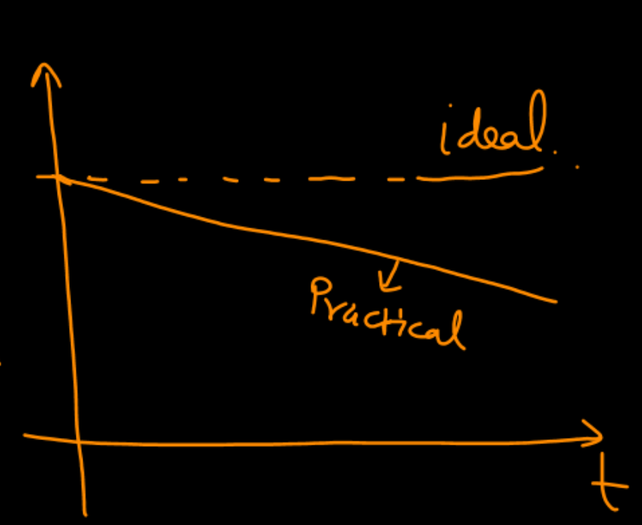
It has infinite Internal Resistance





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





Elements of Electric Circuit (Resistance)

Resistance:- Opposition to the flow of current is known as resistance.

Formula:-

$$R = \rho \frac{l}{a}$$

l → length of Conductor

a → area of Conductor

ρ → Specific resistance / Resistivity

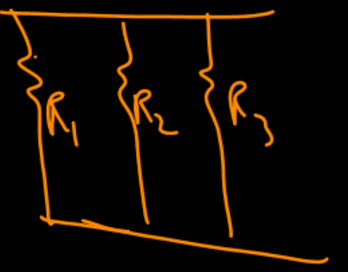
$$R = \frac{V}{I}$$

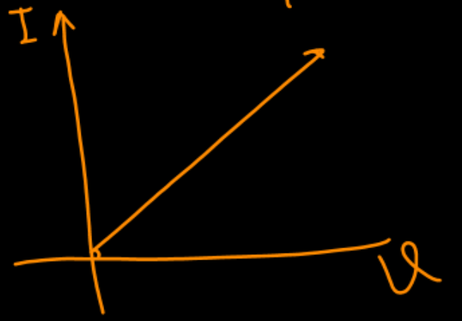
Static Element.

Memory less Element

Series → $R_{eq} = R_1 + R_2 + R_3 + \cdots$

Parallel → $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$





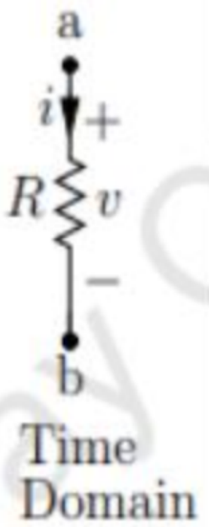
Elements of Electric Circuit (Resistance)

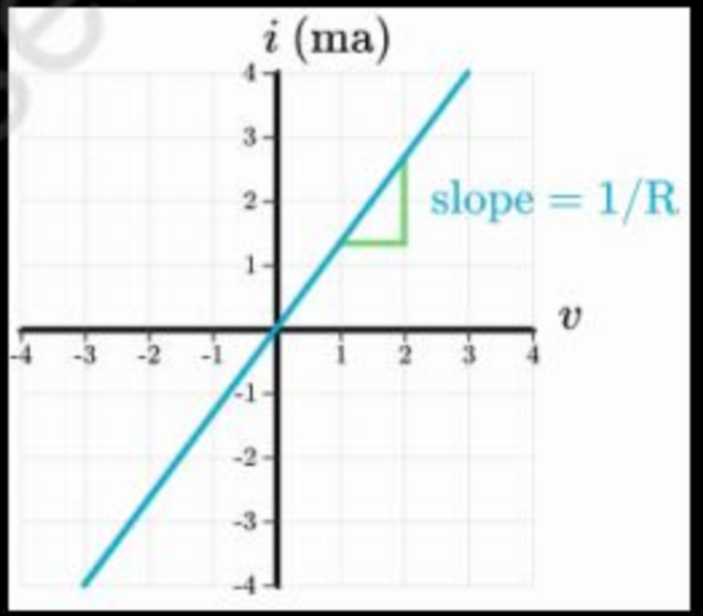
Resistance:

Time domain:

$$v(t) = Ri(t)$$

$$i(t) = \frac{v(t)}{R}$$





Resistance is a **static element** in the sense v(t) versus i(t) relationship is instantaneous.

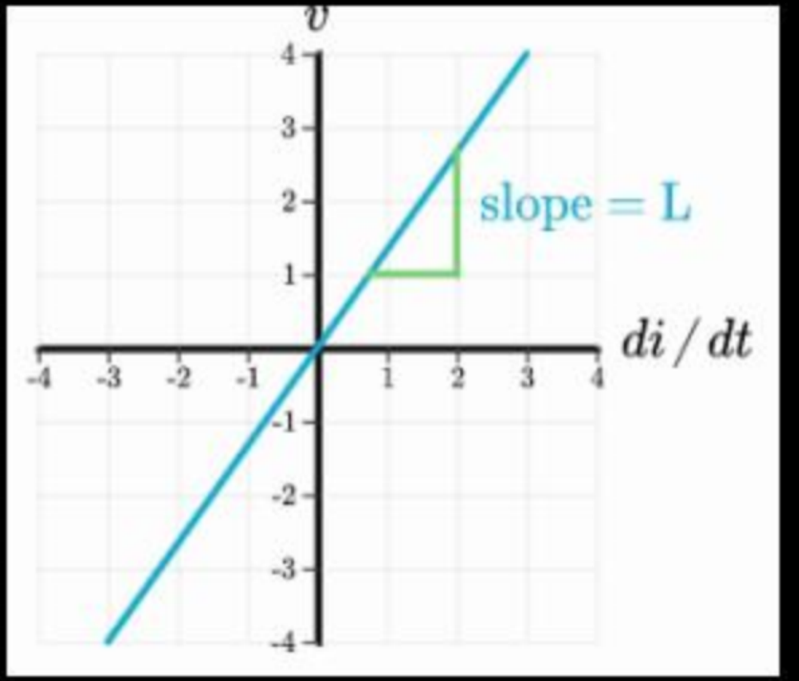
- ***Example:-*** let v(t) at time t = 2 seconds simply depends only on i(t) at t = 2 seconds and nothing else. This implies that the resistance does not know what happened in the past, in other words it does not store any energy unlike other elements C and L as we see soon.

(Inductance)

$$v = L \frac{di}{dt}$$

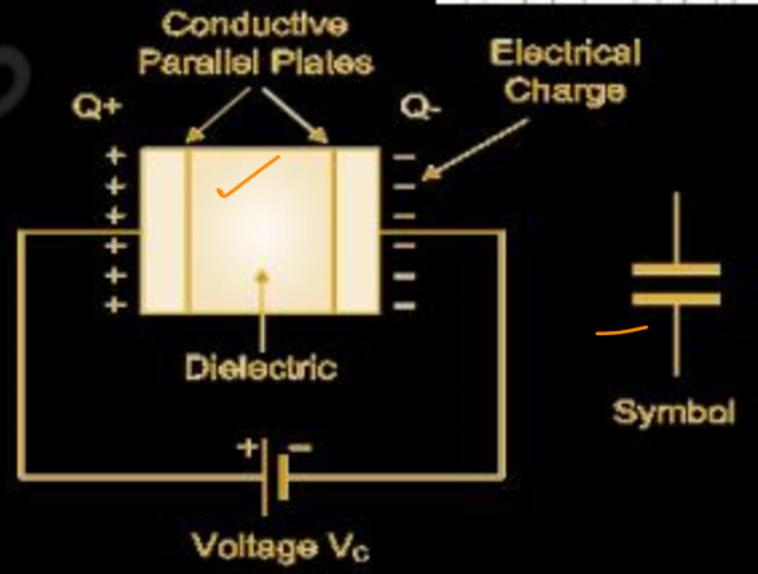
Inductor: -

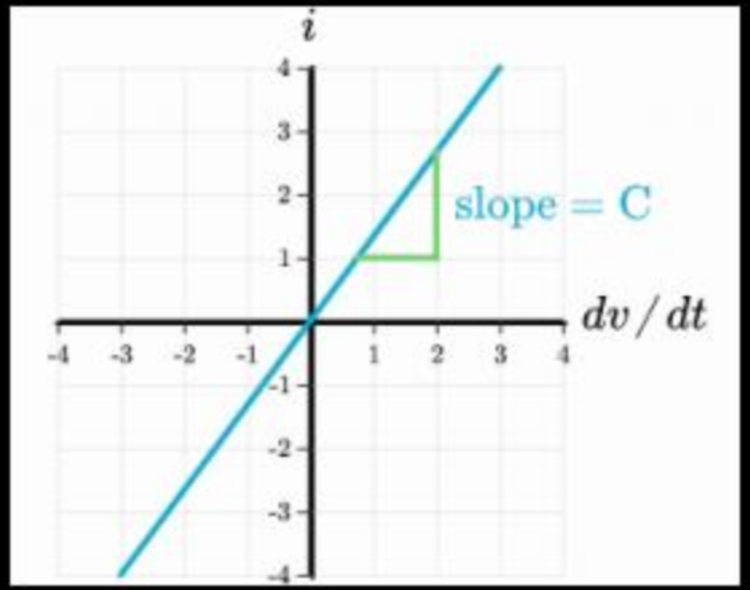
- It is a passive component that store energy in the form of magnetic energy when electricity is applied to it.
- An inductor is simply a coil of wire.
- Inductance (L) is a property of an inductor that opposes any change in magnitude or direction of current flowing through it.
- Inductance is the ration of flux linkage (Nϕ) to the current I.
- Inductance is a ***dynamic element.*** What happened in the past influences the present behavior



$i = C\frac{dv}{dt}$ (Capacitance)

- The capacitor is a component which has the ability or **"capacity" to store energy** in the form of an electrical charge producing a potential difference (*Static Voltage*) across its plates, much like a small rechargeable battery.
- A capacitor consists of two or more parallel conductive (metal) plates electrically separated either by air or by some form of a good insulating material.
- This insulating material could be waxed paper, mica, ceramic, plastic or some form of a liquid gel as used in electrolytic capacitors.
- Insulating layer between a capacitors plates is commonly called the **Dielectric**.
- What happened in the past influences the present behavior. This implies that the capacitance is ***a dynamic element.***



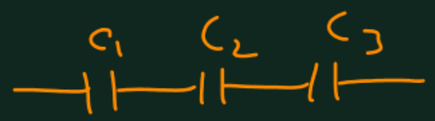


Inductor

Series $= L_1 + L_2 + L_3$

Parallel $= \frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$

Capacitor



Series

$$\text{Series} = \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots -$$

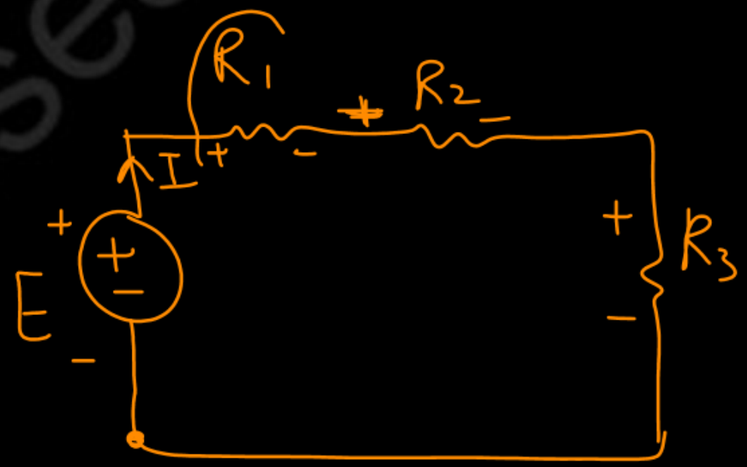
$$\text{Parallel} \rightarrow C_{eq} = C_1 + C_2 + C_3 + \text{—}$$

Kirchhoff's Voltage Law (KVL)

Kirchhoff's Voltage Law (KVL);- According to KVL "**algebraic sum of all the voltages around any closed loop in a circuit is equal to zero**".

$$\Sigma(\vec{E} + \vec{IR}) = 0$$

$$\underbrace{-E}_{-E} + \underbrace{IR_1}_{V_1} + \underbrace{IR_2}_{V_2} + \underbrace{IR_3}_{V_3} = 0$$



Current in Resis = 0

Mesh Analysis(KVL)

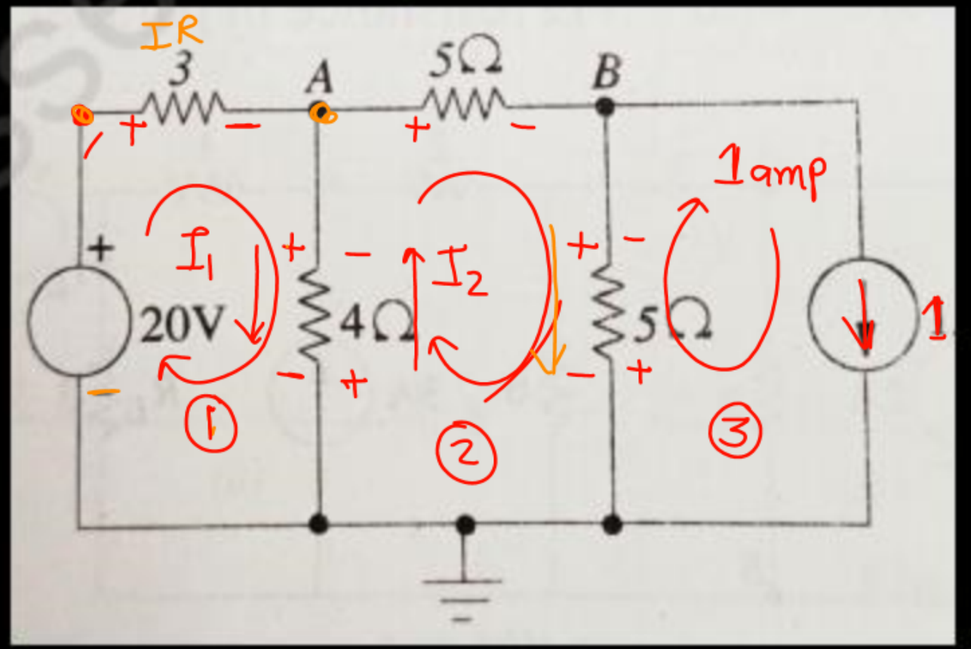
① find mesh.
Mode → Eqn → ②

Mesh

Methods for solving electric Network Using KVL (Mesh Analysis)

Similar question in AKTU- 2021-22

Ex.- Using Mesh Analysis Find Current in all branches.



1. Loop Current Method →

Apply KVL in loop ①

$$+3I_1 + 4(I_1 - I_2) - 20 = 0$$

$$7I_1 - 4I_2 = 20 \quad \text{—①}$$

Apply KVL in mesh ②,

$$+5I_2 + 5(I_2 - 1) + 4(I_2 - I_1) = 0$$

$$-4I_1 + 14I_2 = 5 \quad \text{—②}$$

Solv Eqn ① & ②

$I_1 = 3.658$ amp

$I_2 = 1.40$ amp

$I_{4\Omega} = I_1 - I_2$

$= 3.65 - 1.40$

$= 2.25$ amp ↓

Kirchhoff's Voltage Law (KVL)

Ex.- Using Mesh Analysis Find Current in all branches.

Similar question in AKTU- 2021-22

1. Branch Current Method

Apply KVL in loop ①

$+3I + 4(I - I_1) - 20 = 0$

$7I - 4I_1 = 20$ — ①

Apply KVL in Mesh ②,

$5I_1 + 5(I_1 - 1) - 4(I - I_1) = 0$

$-4I + 14I_1 = 5$ — ②

Solve Eq ① & ②

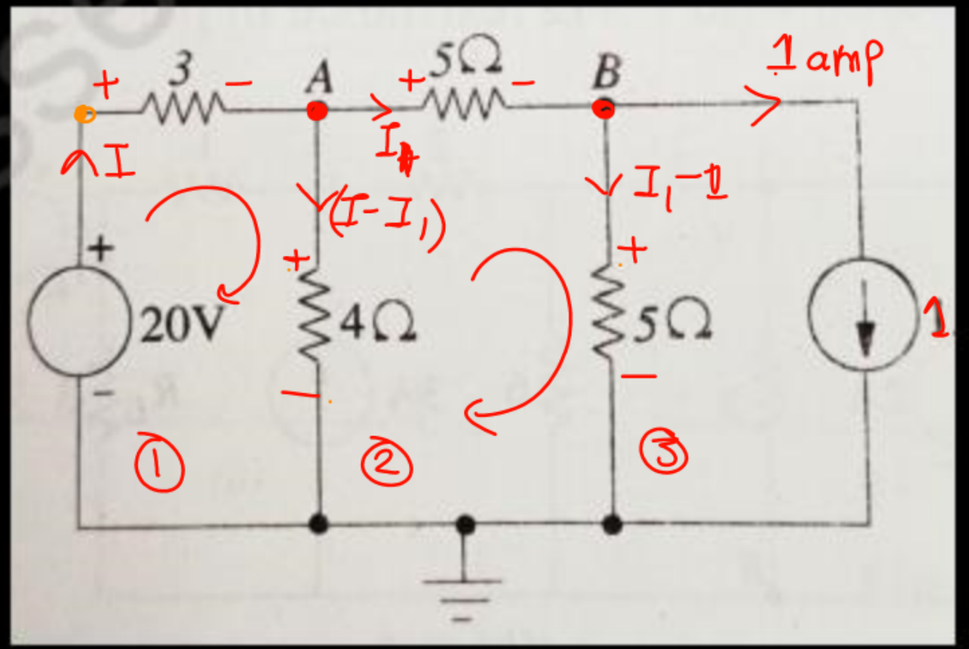
$I = 3.65$

$I_1 = 1.40$

$I_4 = I - I_1$

$= 3.65 - 1.40$

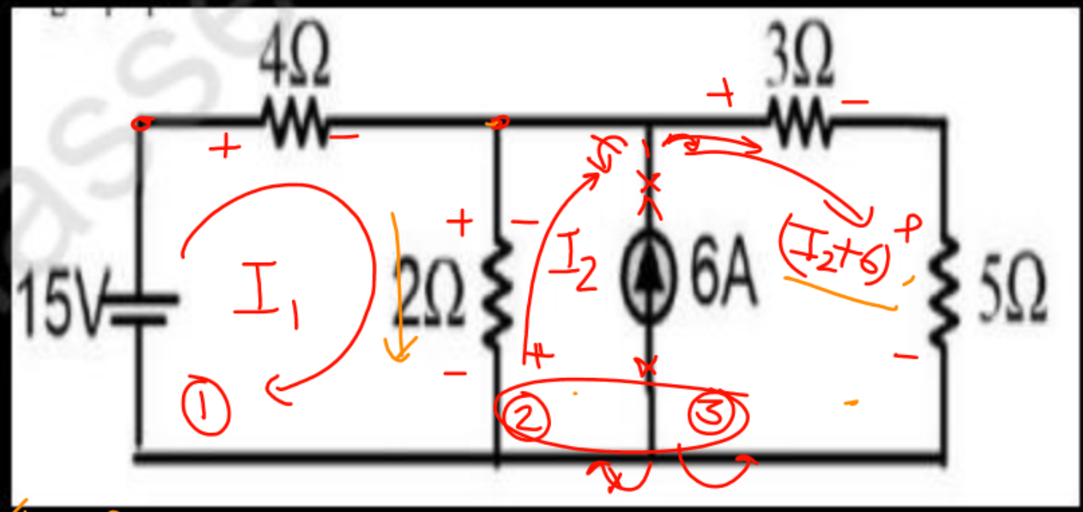
$= 2.25$ amp



Mesh Analysis (Concept of Super Mesh)

Ex.- Using Mesh Analysis Find Current in 5 Ohm.

AKTU- 2021-22 C.O., 2019-20, 2018-19



if any Current Source is Common b/w two mesh. Then These two meshes are Combined and Known as Super mesh.

Apply KVL in Loop ①

$$+4I_1 + 2(I_1 - I_2) - 15 = 0$$

$$6I_1 - 2I_2 = 15 \quad -①$$

Apply KVL in Supermesh,

$$+3(I_2+6) + 5(I_2+6) + 2(I_2 - I_1) = 0$$

$$-2I_1 + 10I_2 = -48 \quad -②$$

Solve Eqn ① & ②

$I_1 = 0.96$ amp

$I_2 = -4.6$ amp.

$I_{5\Omega} = I_2 + 6$

$= -4.6 + 6 = 1.4$ amp.

Ans

Mesh Analysis

Ques. Find Current in 1 ohm Resistance using Mesh Analysis. AKTU 2021-22

Apply KVL in loop ①

$$+2(I-1)+1(I+3)-4=0$$

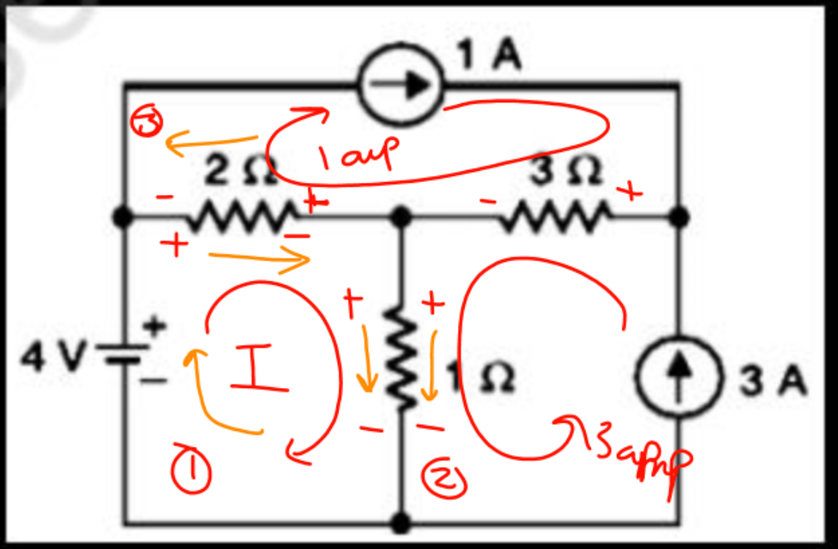
$$3I-2+3-4=0$$

$$3I=3$$

$$\boxed{I=1\text{ amp}}$$

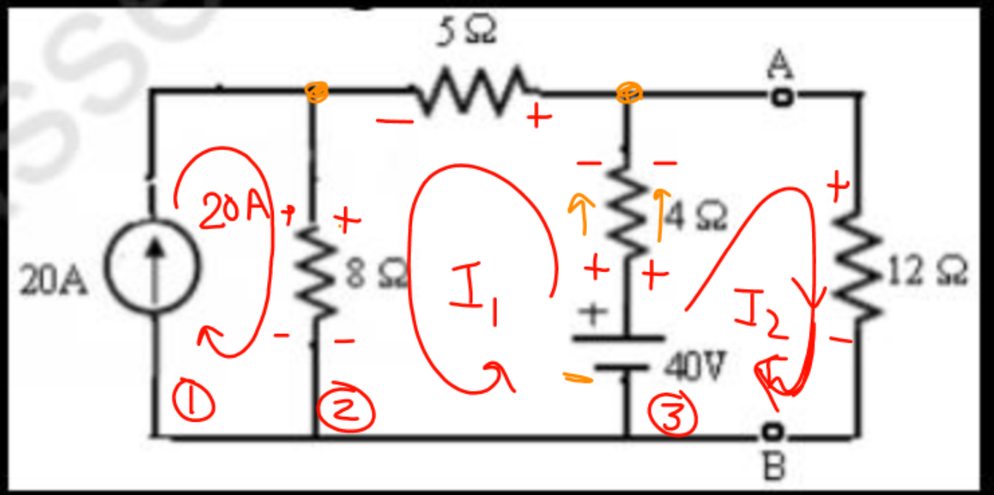
$$I_{1\Omega}=I+3$$

$$=1+3=4\text{ amp}$$ Ans



Mesh Analysis

Ex. Using Mesh Analysis Find Current in 12 ohm Resistance. AKTU- 2018-19.



Apply KVL in mesh ②

$+8(I_1+20)-40+4(I_1+I_2)+5(I_1)=0$

$17I_1+4I_2=-120$ — ①

Apply KVL in mesh ③

$+12(I_2)-40+4(I_2+I_1)=0$

$4I_1+16I_2=40$ — ②

Solve Eq ① & ②

$I_1=-8.125$

$I_2=4.53$

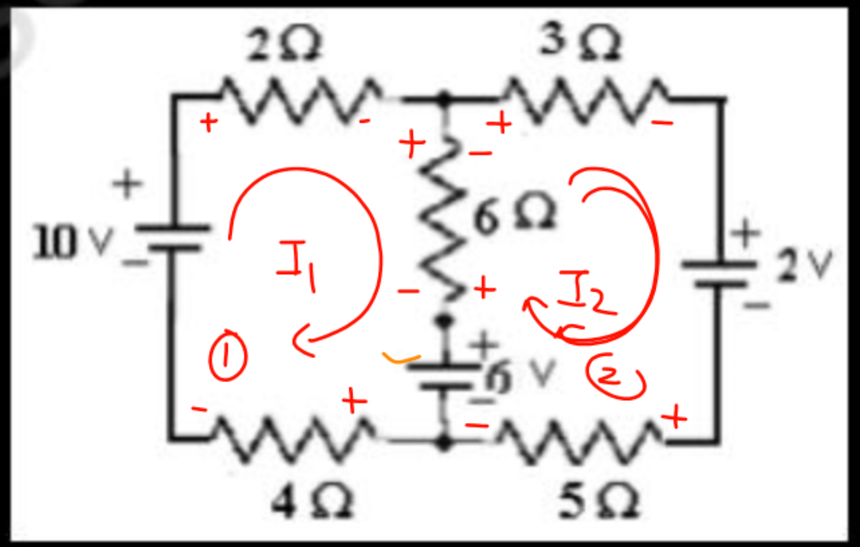
$I_{12\Omega}=I_2$

$=4.53$

Ans

Mesh Analysis

Ex.- Using Mesh Analysis Find Current in 6 Ohm. AKTU- 2021-22 C.O.



Apply KVL in mesh ①

$$2I_1 + 6(I_1 - I_2) + 6 + 4(I_1) - 10 = 0$$

$$12I_1 - 6I_2 = 4 \quad \text{— ①}$$

Apply KVL in mesh ②

$$3I_2 + 2 + 5(I_2) - 6 + 6(I_2 - I_1) = 0$$

$$-6I_1 + 14I_2 = 4 \quad \text{— ②}$$

Solve Eq ① & ②

$I_1 = 0.6$ A

$I_2 = 0.54$ A

$I_6 = I_1 - I_2$

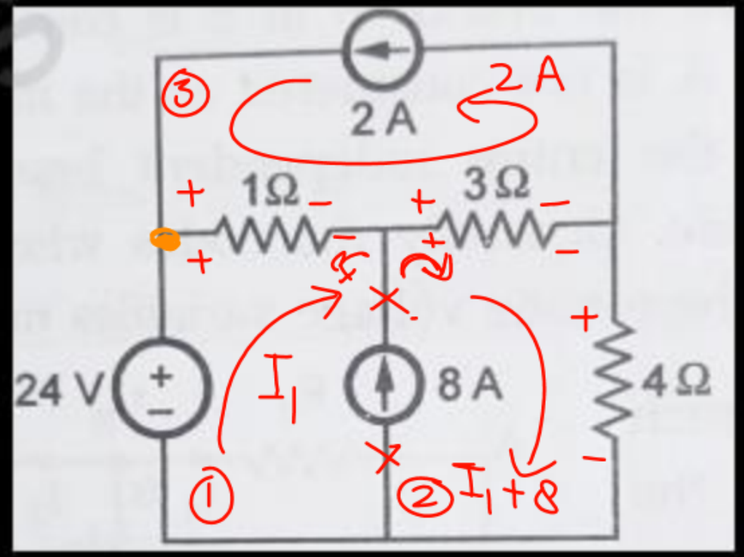
$= 0.6 - 0.54$

$= 0.06$ A

Ans

Mesh Analysis

Ex. Using Mesh Analysis Find Current in 2 ohm Resistance.



Apply KVL in Supermesh.

$$1(I_1+2)+3(I_1+8+2)+4(I_1+8)-24=0$$

$$I_1+2+3I_1+30+4I_1+32-24=0$$

$$8I_1=-40$$

$$\boxed{I_1=-5\,A}$$

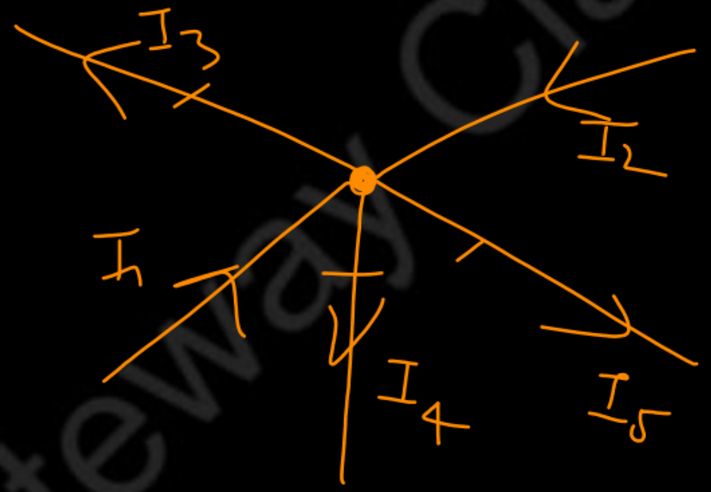
$$I_{3\Omega}=I_1+8+2$$
$$=-5+8+2$$
$$=+5\,A$$ R

Kirchhoff's Current Law (KCL)

Kirchhoff's Current Law (KCL):- According to KCL *"Algebraic sum of all the Current at a node is always equal to zero"*

Or

"Sum of incoming current at a node is always equal to the sum of outgoing currents from that node.".



$$I_1 + I_2 = I_3 + I_4 + I_5$$

Nodal Analysis

find Junction (current divide)
– Consider Ref. Node

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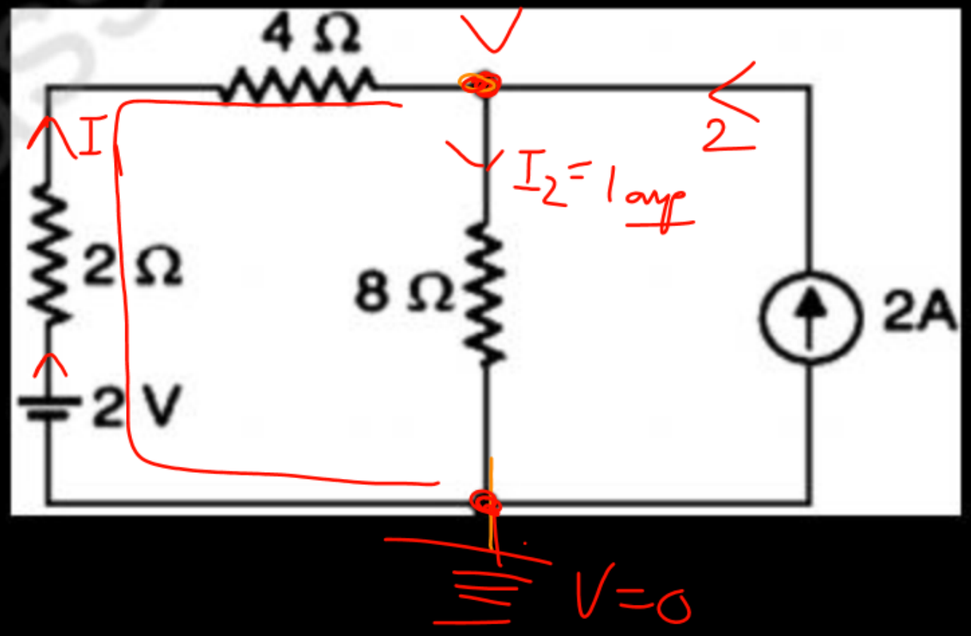
Examples:-Using Nodal Analysis Find Current in 8 ohm Resistance.

$$I_1 = \frac{0-V+2}{6} = \frac{2-V}{6}$$

$$I_2 = \frac{V-0}{8} = \frac{V}{8}$$

$$I_8 = I_2 = \frac{V}{8} = \frac{8}{8} = 1\ \text{amp}$$



Apply KCL at Node

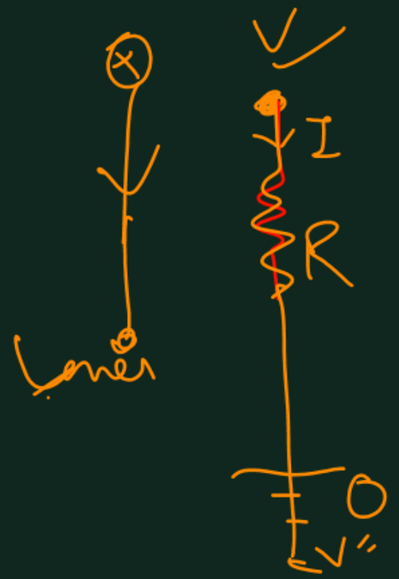
$$2 + I = I_2$$

$$2 = I_2 - I = \frac{V}{8} - \frac{2-V}{6} = \frac{3V-8+4V}{24}$$

$$7V - 8 = 48$$

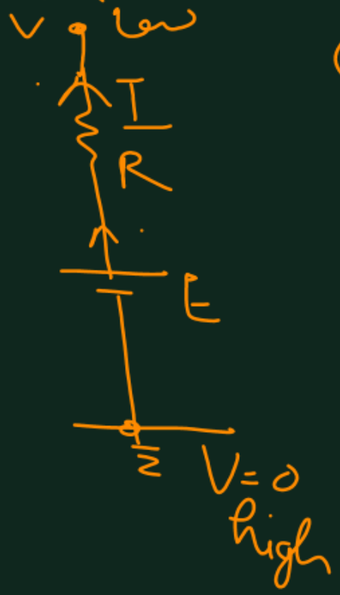
$$7V = 56$$

$$V = \frac{56}{7} 8 = 8\ \text{Volt}$$



$$= I = \frac{V - 0}{R}$$

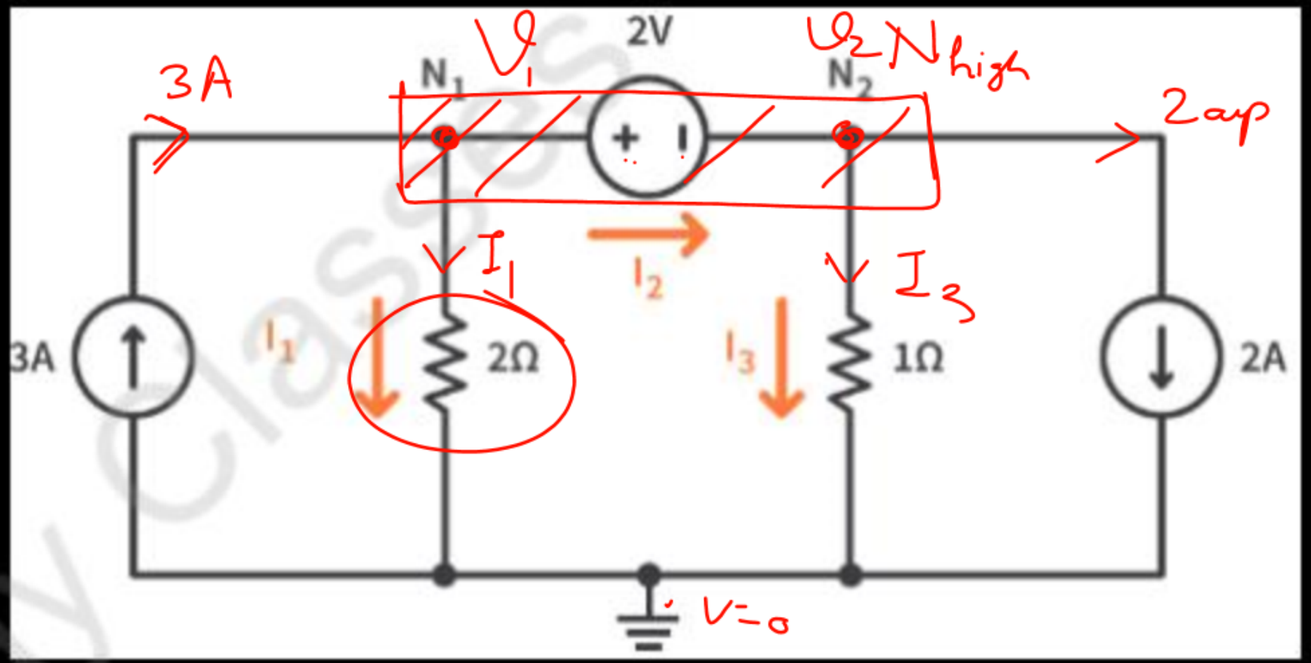
$$\frac{V - 0 - E}{R}$$



$$\frac{0 - V + E}{R}$$

Concept of Super Node

Ex. Using Nodal Analysis Find Current in 2 ohm Resistance.



$$3 = I_1 + I_3 + 2$$

$$3 = \left(\frac{V_1 - 0}{2}\right) + \left(\frac{V_2 - 0}{1}\right) + 2$$

$$3 = \frac{V_1}{2} + V_2 + 2$$

$$3 = \frac{V_1 + 2V_2 + 4}{2}$$

$$V_1 + 2V_2 = 6 - 4 = 2$$

$$\boxed{V_1 + 2V_2 = 2}$$

$$V_1 - V_2 = 2 \quad \text{---(2)}$$

$$V_1 = 2$$

$$V_2 = 0$$

$$I_1 = \frac{V_1}{2} = \frac{2}{2} = 1\text{amp}$$

Nodal Analysis

Ex.- Using Nodal Analysis Find Current in all branches. AKTU- 2021-22

Apply KCL at ①

$15 = I_1 + I_2$

$V_1 + V_1 - V_0 = 15$

$2V_1 - V_0 = 15$ — ①

Apply KCL at ②

$I_2 = I_3 + I_4$

$V_1 - V_0 = \frac{V_0}{4} + \frac{V_0 - 10}{4}$

$4(V_1 - V_0) = 2V_0 - 10$

$4V_1 - 6V_0 = -10$ — ②

Solve Eq ① & ②

$V_1 = 12.5\ V$

$V_0 = 10\ V$

$I_1 = \frac{V_1 - 0}{1} = V_1 = 12.5A$

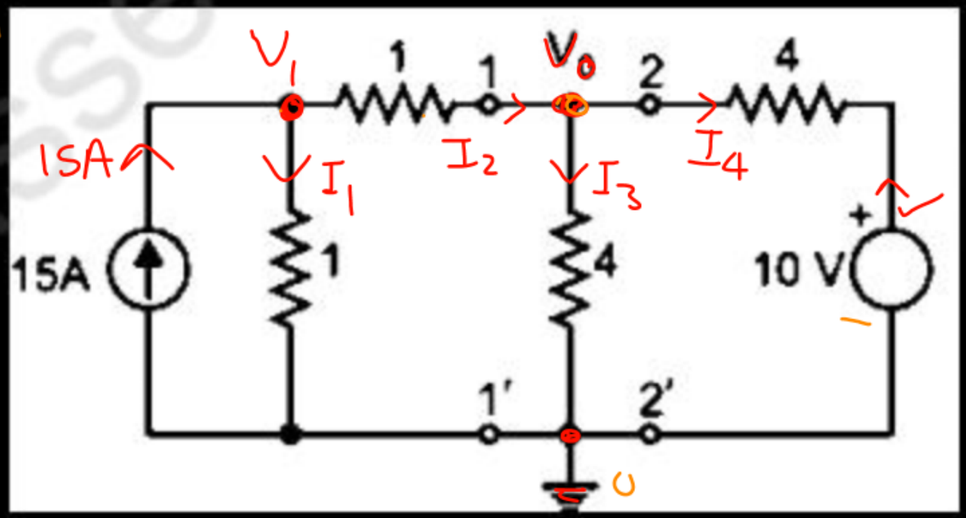
$I_2 = \frac{V_1 - V_0}{1} = 2.5$

$I_3 = \frac{V_0}{4} = \frac{10}{4} = 2.5$

$I_4 = \frac{V_0 - 0 - 10V}{4}$

$= \frac{V_0 - 10}{4}$

$\boxed{I_4 = 0}$



Nodal Analysis

Ex.- Using Nodal Analysis Find Current in 50 ohm. AKTU- 2021-22

$$I_1 + I_2 + 120 + 40 = 0$$

$$I_1 + I_2 = -160$$

$$\frac{V_1}{50} + \frac{V_2}{150} = -160 \quad \text{—— (1)}$$

from Supernode

$$V_2 - V_1 = 10 \quad \text{— (2)}$$

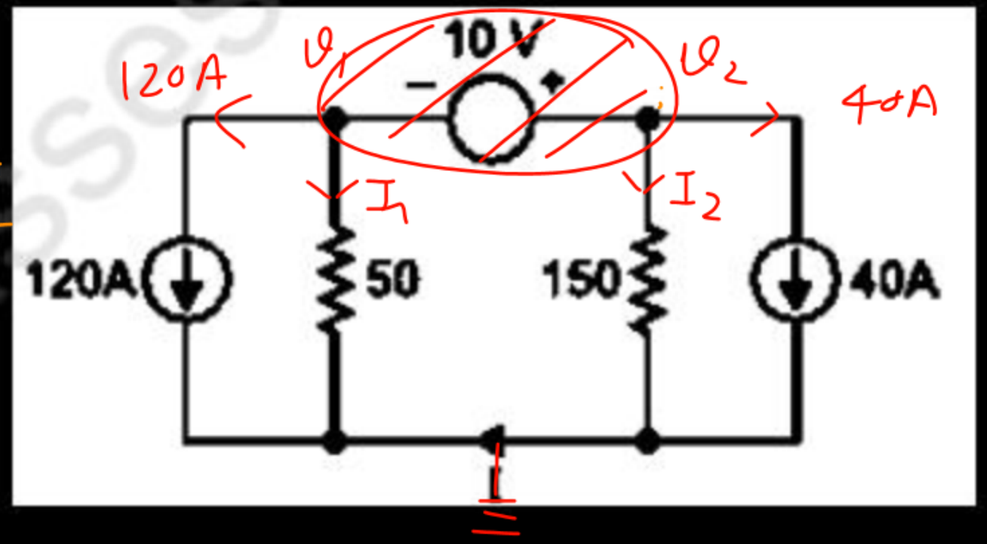
$$V_1 = -6002.5 \text{ V}$$

$$V_2 = -5992.5 \text{ V}$$

$$I_1 = \frac{V_1}{50} = \frac{-6002.5}{50} = -120.05 \text{ A}$$

Ans

$$I_2 = \frac{V_2}{150}$$



Nodal Analysis

Ex. Using Nodal Analysis Find Current in 8 ohm Resistance. AKTU-2021-22

$$I_1 + I_2 + I_3 + 2 = 0$$

$$\frac{90 - V_1}{20} + \frac{60 - V_1}{12} - \frac{V_1}{8} = -2$$

$$\frac{90}{20} - \frac{V_1}{20} + \frac{60}{12} - \frac{V_1}{12} - \frac{V_1}{8} = -2$$

$$-\frac{V_1}{20} - \frac{V_1}{12} - \frac{V_1}{8} = -2 - 9.5$$

$$+0.258\, V_1 = +11.5$$

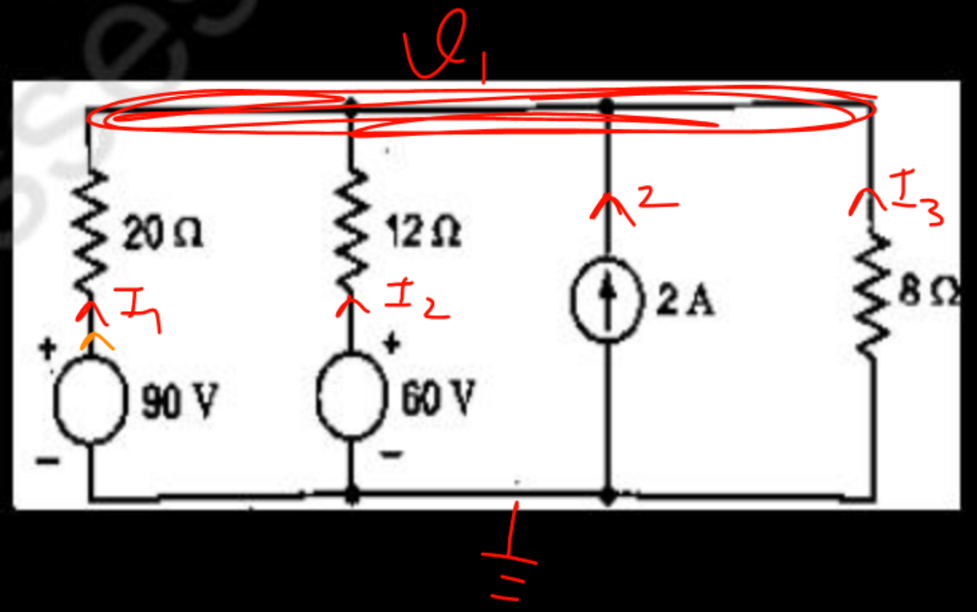
$$V_1 = 44.51 \text{ Volt}$$

$$I_1 = \frac{0 - V_1 + 90}{20} = \frac{90 - V_1}{20}$$

$$I_2 = \frac{60 - V_1}{12}$$

$$I_3 = \frac{-V_1}{8} = -\frac{44.51}{8}$$

$$= -5.56 \text{ A}$$



Nodal Analysis

Ex. Using Nodal Analysis Find Current in r2 Resistance. AKTU- 2021-22

$$I_1 = I_2 + I_3 + I_4$$

$$\frac{50 - v_1}{20} = \frac{v_1}{100} + \frac{v_1}{120} + \frac{v_1 - 20}{30}$$

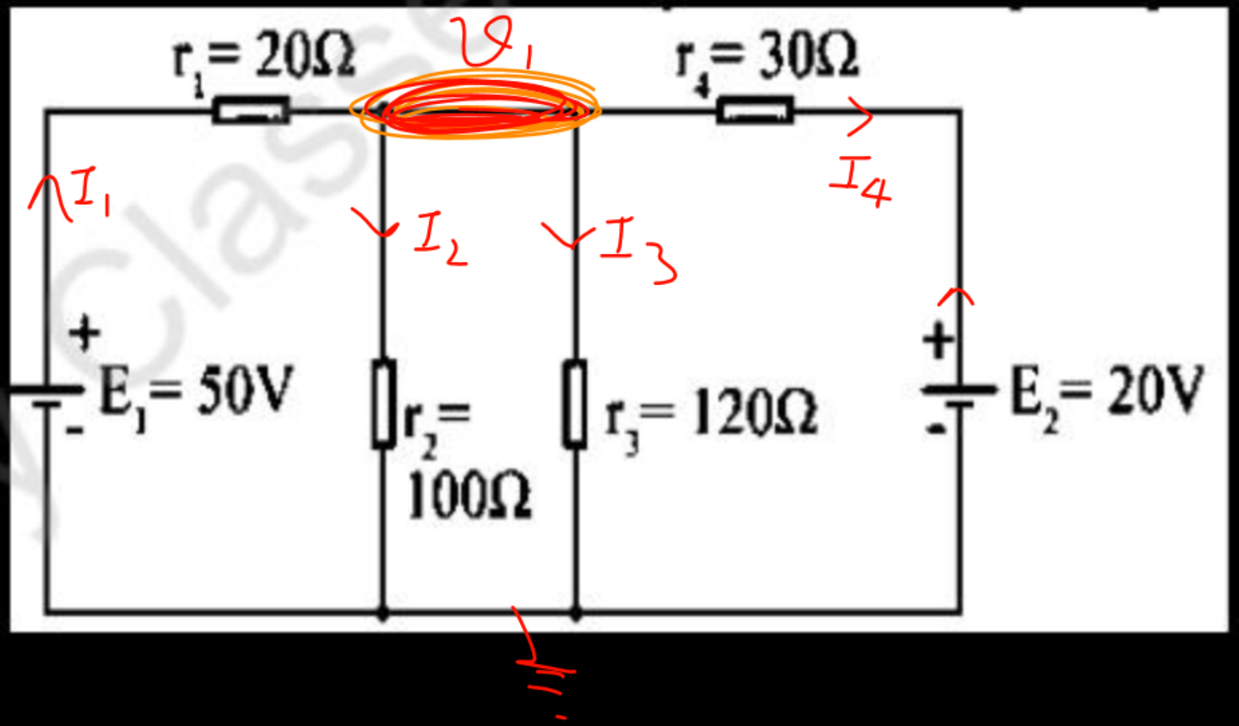
$v_1 = ?$

$$I_1 = \frac{50 - v_1}{20}$$

$$I_2 = \frac{v_1}{100}$$

$$I_3 = \frac{v_1}{120}$$

$$I_4 = \frac{v_1 - 20}{30}$$



PYQ AKTU

Q.1 What Is E.M.F? **(AKTU-2021-22)**

Q.2 Differentiate between EMF and Potential Difference.? **(AKTU-2021-22)**

Q.3 Why Linearity is important? **(AKTU-2021-22)**

Q.4 Can we apply KVL in a loop containing a current source? Give answer with reason. **(AKTU-2018-19)**

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