24/2

Basic Electrical and Electronic Engineering

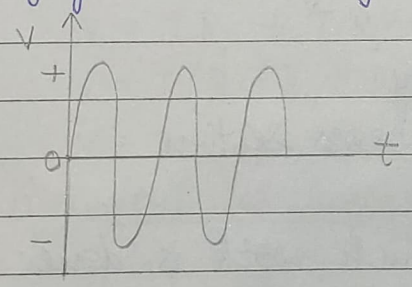
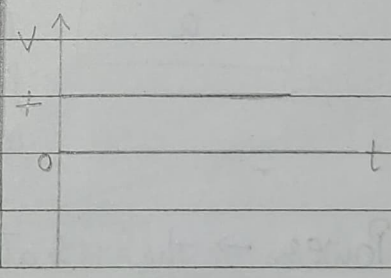
These devices work with AC — These devices work with DC

Electrical = large scale production and distribution of electrical power.

Generation → Transmittion → Distribution.

Electronics = Focus on smaller electronic circuits.

Eg; Computer, Phone.

→ Alternating Current	Direct Current
• The electric charges flow changes its direction periodically - [forward and backward].	The current electricity flows in a single direction in a steady voltage.
• The frequency of AC is dependent. Generally; it is 50 Hz or 60 Hz.	DC has no frequency or zero frequency.
• AC is capable of powering electric motors which are used on refrigerators, washing machine, etc	Cellphones, Electric vehicles, flashlights; batteries.
• 	

→ Charge → Positive charge (+)ve (Static charge)

↓

Negative charge (−)ve (Movable charge)

mass = $m = 9.11 \times 10^{-31}$ Kg

charge = 1.6×10^{-19} C

→ Current → Flow of charge within a conductor.

It is represented by I.
Units are Ampere 'A'.

$$\boxed{I = \frac{Q}{t}} \qquad \frac{1C}{sec} = 1 \text{ Ampere} \qquad (C = \text{Coulomb})$$

$$\text{Current} = \frac{\text{charge}}{\text{time}}$$

→ Voltage → It is the potential difference b/w two points in an electric field, which causes current to flow in the circuit.
It is represented by V
Units are volt 'V'.

$$\boxed{V = \frac{W}{Q}} \qquad \frac{1 \text{ Joule}}{\text{Coulomb}} = 1 \text{ volt}$$

$$\text{Voltage} = \frac{\text{work Done}}{\text{charge}}$$

→ Resistance → It is a measure of opposition to current flow in an electrical circuit.
SI unit = Ohm (Ω)

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

R = Resistance of conductor
l = length
ρ = Resistivity
a = Area of cross section

→ Power → The rate at which work is done.

$$\boxed{P = \frac{W}{t}}$$

P = Power (watt)
W = work Done (J)
t = time (s)

→ Energy → It is the ability to do work.

28/2.

→ Ohm's law →

It states that the current through a conductor b/w two points is directly proportional to the voltage across two points.

$\boxed{V = IR}$ [Temperature remains constant].

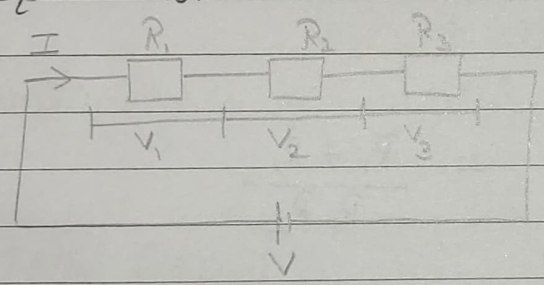
Q→ If $R = 5\,\Omega$ & $V = 2\,V$ find $I = ?$

$V = IR$

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

$0.4 = \frac{2\,A}{5} = I$

→ Series Combination →



Same current (I) flows through three resistances.

$V = V_1 + V_2 + V_3$

$V = IR_1 + IR_2 + IR_3$

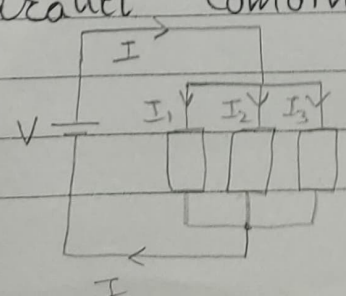
$V = I(R_1 + R_2 + R_3)$

$V = I(R_s)$

Equivalent Resistance (R_s)

$\boxed{R_s = R_1 + R_2 + R_3}$ $\boxed{R_{sn} = nR}$ n = identical resistances each of resistance R

→ Parallel Combination →



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Page No.

Same voltage (V) appears across all three resistances.

$$I = I_1 + I_2 + I_3$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

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

$$\boxed{\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$\boxed{R_{pn} = \frac{R}{n}}$$

In case only 2 resistances are connected

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2}$$

$$\boxed{R_p = \frac{R_1 R_2}{R_1 + R_2}}$$

Points

- ⊕ charge shows high Potential.
  ⊖ charge shows lows Potential.

- Electron flow -ve to +ve
  Current flow +ve to -ve
  ] opposite to each other.

esistances.

→ Potential Energy →

Electric potential is the amount of work needed to move a unit charge from a reference point to a specific point against electric field.

$$V = K\frac{q}{r}$$

V = electric Potential
K = coulomb constant
q = charge r = distance of separation

→ Drift Velocity →

The average velocity attained by charged particles in a material due to electric field.

$$v_d = \frac{I}{neA}$$

v_d = Drift velocity n = free è density
I = Current flow e = charge of è.
A = cross sectional area.

SI unit ; $\frac{m}{s} = ms^{-1}$.

→ Electric Circuit

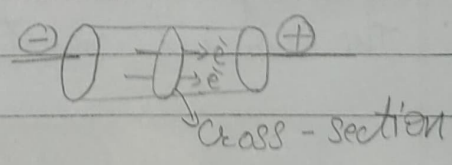
It is a network consisting of a closed loop, giving a return path for the current.

→ Electric current

The movement of electrons through a wire.

$$\text{Electric current} = \frac{\text{Total charge flow}}{\text{Time Taken}}$$

$$I = \frac{q}{t}$$



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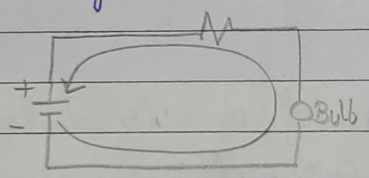
Page No.

Q→ What occurs in a wire when the circuit switch is closed?

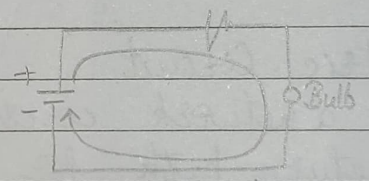
Ans→ All switches do same thing; connect wires to allow electric current to flow or disconnect wires to stop electric current from flowing. When the switch is closed, a closed loop path is created in circuit. An electric field is established instantaneously. Free è, while still randomly moving, immediately begin drifting due to electric field, resulting in net flow of charge.

closing the switch → circuit complete
↓
act as wire

→ Conventional Current →
It is the flow of positive charge from positive to negative.



Electron flow of current



Conventional flow of current

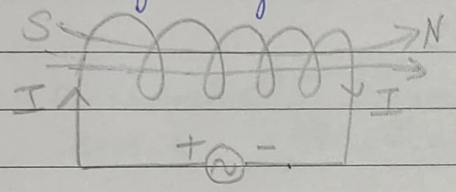
Q→ What is required in order to have an electric current flow in a circuit?

Ans: • A Voltage source.
• The circuit must be closed.

Date / /
Page No.

→ Battery [chemical cell].
A device containing series of electric cells storing chemical energy that can be converted into electrical power.

→ Inductor:
It is a passive electronic component that is used in most power electronic circuits to store energy in the form of magnetic energy when electricity is applied to it.



→ Inductance:
It is the tedency of an electrical conductor to oppose a change in the electric current flowing through it. It is denoted by (L).
S.I unit = Henry (H).

= It depends upon;
- number of wire turns in coil (N) $L \propto N$
- Coil Area $L \propto A$
- Core material $L \propto \mu$ → magnetic permeability
- Coil length $L \propto \frac{1}{l}$

$$L = \frac{\mu N^2 A}{l}$$ → Self inductance

$$L = \frac{\mu_0 \mu_r N_1 N_2 A}{l}$$

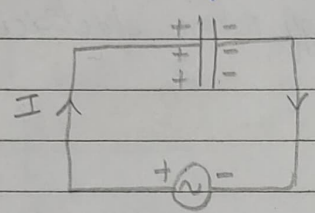
$$L_T = L_1 + L_2 - - -$$
In Series

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + - - -$$
In Parallel

1/March

Static Charge	Moving charge
Electric charge	Magnetic charge

→ Capacitor:
It is an electric component that has the ability to store energy in form of electrical charges that creates a potential difference, which is a static voltage, much like a small rechargeable battery.



→ Capacitance:
The accumulation of charges in the conductors causes a potential difference across the capacitor. The amount of charge accumulated is called the charge holding capacity of the capacitor. This holding capacity of charge is known as capacitance.

$$Q \propto V$$

$$Q = CV$$

$$\boxed{C = \frac{Q}{V}}$$

= It depends upon physical features area of capacitor plates (A), distance between plates (d) and permittivity of dielectric medium (ε).

$$\boxed{C = \frac{\epsilon \times A}{d}}$$

$$\boxed{\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots}$$

In Series

$$\boxed{C_T = C_1 + C_2 + \cdots}$$

In Parallel

2/March

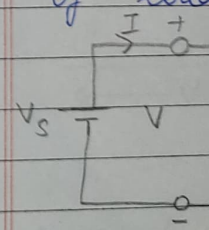
→ Electric

Independe
Sources

Voltage
Source

Curre
Source

→ Indepen
The elem
current
elsewhe
• Voltage
(a) Ideal = I
terminal
It mean
of load



V = Vs

Ideal d

2/March

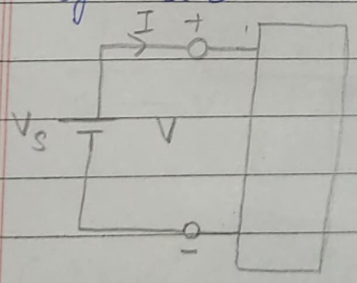
→ Electrical Energy Sources

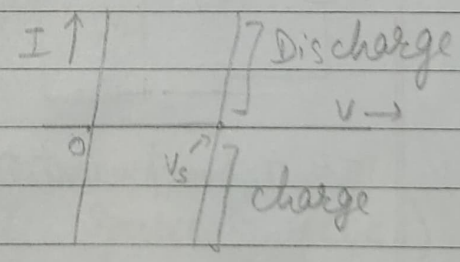
- Independent Sources
  - Voltage Source → Ideal / Practical
  - Current Source → Ideal / Practical
- Dependent Sources
  - VCVS
  - VCCS
  - CCCS
  - CCVS

→ **Independent Sources:**
The element for which both voltage and current don't depend on voltage or current elsewhere in circuit.

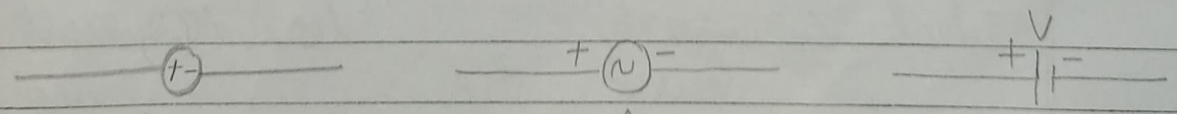
- Voltage Sources

(a) Ideal = It is defined as an energy source whose terminal voltage (V) is independent of output current (I). It means its terminal voltage is independent of load resistance (R_L) connected to it.





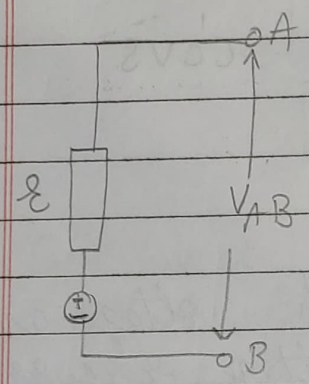
$V = V_s$ [Independent of I]

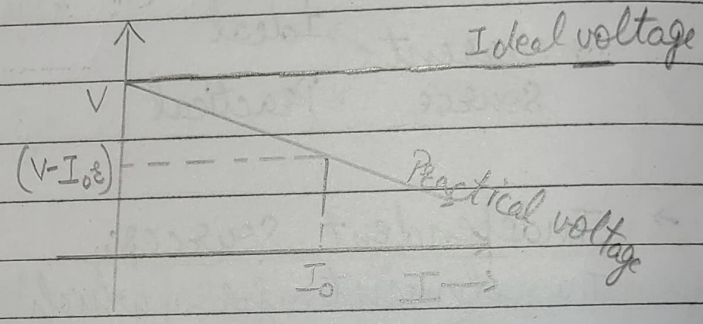


Ideal dc voltage Source. | Ideal AC voltage Source. | Ideal battery

(b) Practical = It is defined as the terminal voltage across the terminals are not constant rather it varies with output current. Internal resistance of practical voltage source has some finite value.

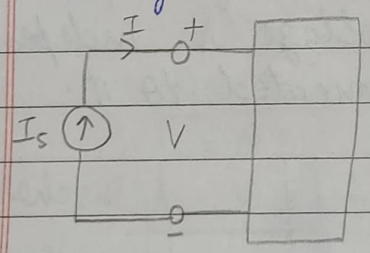
$$\underbrace{V_{AB}}_{\text{Terminal voltage}} = \underbrace{V}_{\text{Applied voltage}} - \underbrace{I}_{\text{Current}}\,\underbrace{r}_{\text{Internal resistance}}$$

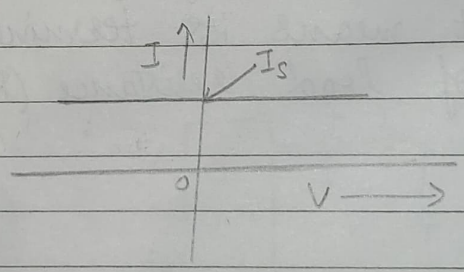




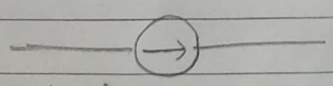
- Current Source

(a) Ideal = It is defined as source which delivers a constant current independent of its output voltage.

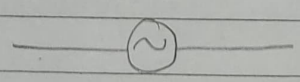




$I = I_s$ [independent of V]



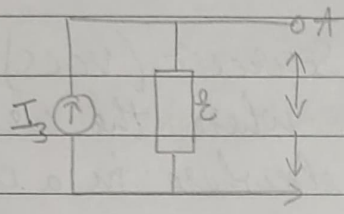
Ideal DC current Source

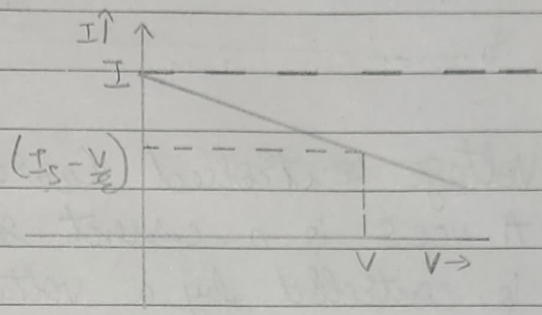


Ideal AC current Source

(b) Practical = In Practical current source, there is one parallel resistance with a current source. There is a limitation on amount of voltage supplied or voltage that can appear across the load.

Current flowing through load resistance $\left[I_0 = \underbrace{I_s}_{\text{Current Source}} - \frac{V}{R} \right.$ → Voltage across terminals, internal resistance.



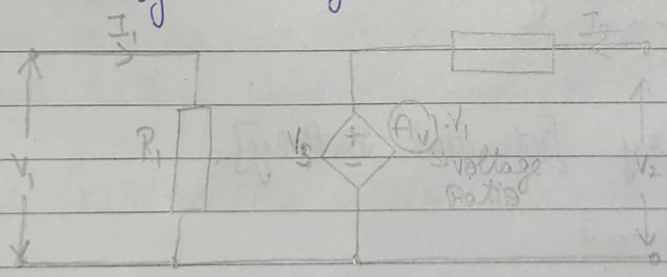


→ Dependent Sources:

The element for which either the voltage or current depends on voltage or current elsewhere in the circuit.

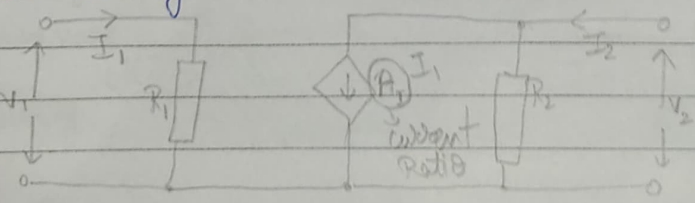
- Voltage Controlled voltage Source :- (VCVS)

  A VCVS is a voltage source where the voltage is controlled by a voltage elsewhere in a circuit.

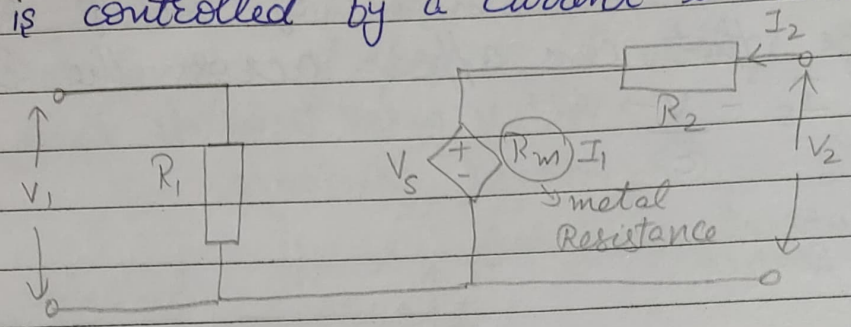


- Current controlled Current Source :- (CCCS)

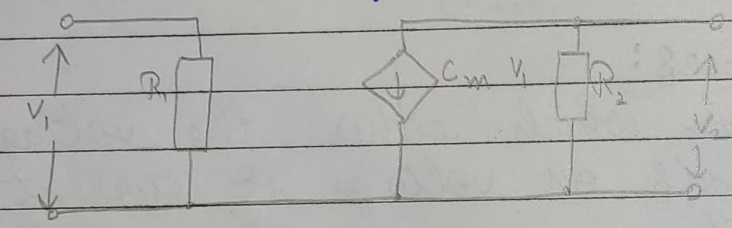
  A CCCS is a current source where the current is controlled by some other current elsewhere in a circuit.



- Current Controlled voltage Source :- (CCVS)
A CCVS is a voltage source where the voltage is controlled by a current elsewhere in a circuit.

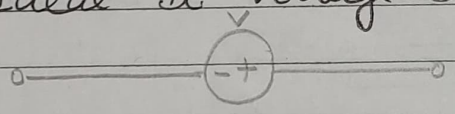


- Voltage Controlled Current Source :- (VCCS)
A VCCS is a current source where the current is controlled by a voltage elsewhere in a circuit.

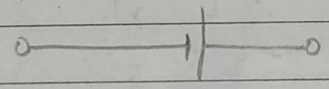


Symbols.

(a) Ideal DC voltage Source

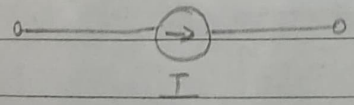


(b) Ideal Battery [Potential Battery].



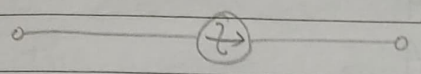
(c) Ideal AC voltage Source.

(d) Ideal DC current Source.

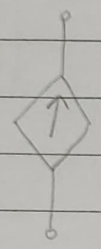


7/March

(e) Ideal AC current source.



(f). Controlled Current Source



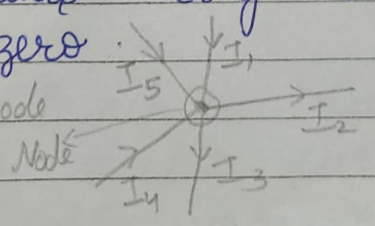
(g). Controlled (Dependent) voltage Source

⇒ Kirchhoff's Laws

- Ohm's law by itself is not sufficient to analyze circuits.
- Kirchhoff's laws can be applied to AC circuits in same way as for DC circuits provided we use phasor sums rather than algebraic sums.

→ KCL [KIRCHHOFF's CURRENT LAW]. Kirchhoff's first law / Kirchhoff's Junction law.

It is based on law of conservation of charge. It states that the algebraic sum of all the currents meeting at a point or a junction will be zero.



Current entering node
||
Current leaving node.

Current In → Positive
Current Out ← negative

$$\boxed{\Sigma I = 0}$$

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

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

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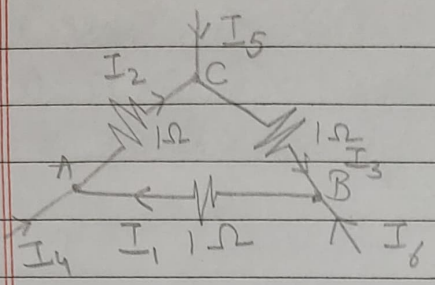
Q→



$I_1 = 2A$

$I_4 = -1A$

$I_5 = -4A$

Find $I_6 = ?$

Applying KCL at C

Incoming I = Outgoing I

$I_2 + I_5 = I_3$

$\boxed{I_2 - 4A = I_3} \rightarrow$ (I)

Applying KCL at A

$I_1 + I_4 = I_2$

$2 - 1 = I_2$

$\boxed{I_2 = 1A} \rightarrow$ (II)

Put in (I)

$I_2 - 4A = I_3$

$1 - 4 = I_3$

$\boxed{-3A = I_3}$

Applying KCL at B

$I_3 + I_6 = I_1$

$-3 + I_6 = 2$

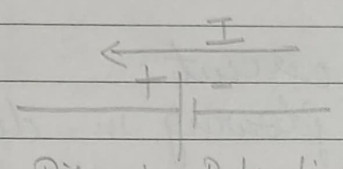
$I_6 = 2 + 3$

$\boxed{I_6 = 5A}$ #

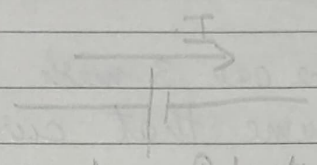
Loop law / Second law

→ KVL [Kirchoff's Voltage law].
It states that in any closed circuit or mesh, the algebraic sum of all the emf's and voltage drops will be zero.
It is based on law of conservation of energy.

$$\boxed{\Sigma \text{ Emf's} + \Sigma IR = 0}$$

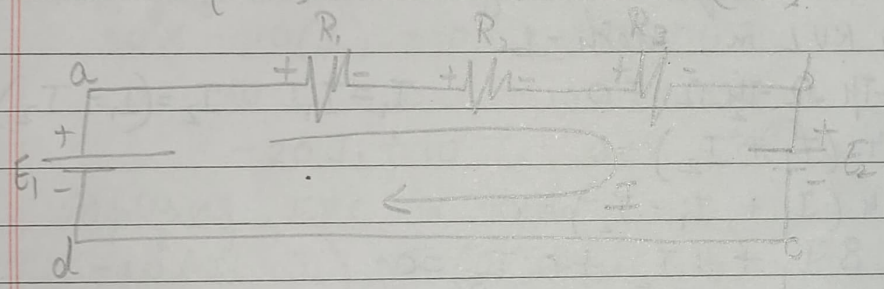


Rise in Potential (+ve)



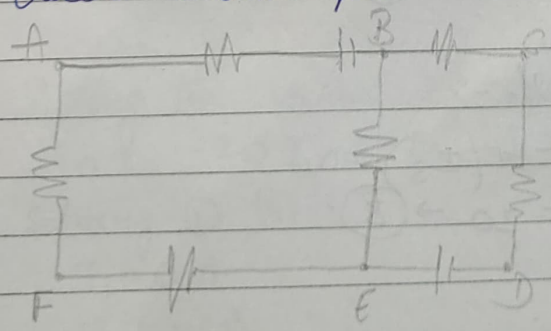
Drop in Potential / Potential Drop (−ve)

voltage



$$-IR_1 - IR_2 - IR_3 - E_2 + E_1 = 0$$

→ Mesh = It is a closed path of electrical circuit through which a current can flow but the only thing is that through that closed path there is no other closed path inside it.



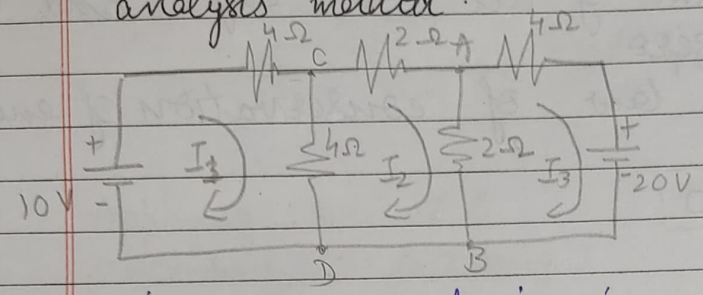
ABEF = Mesh
BCDE

ABEF
BCDE
ACDF } Loop

→ Loop = A loop is also a closed path through which electric current can flow but a loop can carry various other loops inside it.

Date / /
Page No.

Q→1. Calculate the current in branch AB of 2 Ω resistance for given circuit using mesh analysis method.



Sol→ • There are 3 mesh in given circuit.
• Assume that current is flowing in clockwise direction.
• Frame KVL equations for individual mesh.
• Applying KVL in mesh-1.

$10\,V - I_1 4\,\Omega - I_2 4\,\Omega = 0$ $\qquad I_1 = I_1 \qquad I_2 = (I_1 - I_2)$

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

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

$10 - 8I_1 + 4I_2 + 0I_3 = 0$

$-8I_1 + 4I_2 + 0I_3 = -10 \rightarrow (1)$

• Applying KVL in mesh-2.

$-2I_2 - 2(I_2 - I_3) - 4(I_2 - I_1) = 0$

$-2I_2 - 2I_2 + 2I_3 - 4I_2 + 4I_1 = 0$

$4I_1 - 8I_2 + 2I_3 = 0 \rightarrow (2)$

• Applying KVL in mesh-3

$-20V - 2(I_3 - I_2) - 4(I_3) = 0$

$0I_1 + 2I_2 - 6I_3 = 20 \rightarrow (3)$

• Solving eq (1), (2), (3).

$I_1 = 1.093\,A$

$I_2 = -0.312\,A$

$I_3 = -3.437\,A$

$I_{AB} = I_2 - I_3$

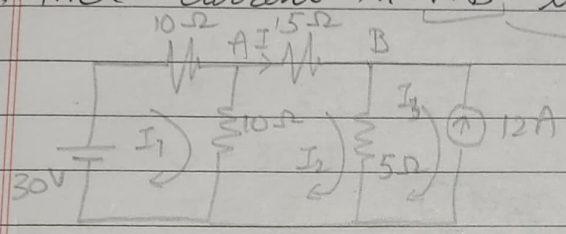
$I_{CD} = I_2 - I_1$
$= (-0.312 - 1.093)$

$I_{AB} = (-0.312 + 3.437)$

$\boxed{I_{AB} = -3.125\ A}$

$\boxed{I_{CD} = -1.405 A}$

Q→2. Find current in AB branch using mesh analysis.



$V \Rightarrow IR$
$= I_2(5) = -15\ V$

$P \Rightarrow I^2 R$
$= (-3)^2 (5) = 45W$

Sol→ 3 meshes :-

Applying KVL in mesh-1.

$30V - 10(I_1) - 10(I_1 - I_2) = 0$

$-10 I_1 - 10 I_1 + 10 I_2 = -30$

$-20 I_1 + 10 I_2 = -30V \rightarrow (1)$

Applying KVL in mesh-2.

$-10(I_2 - I_1) - 5(I_2) - 5(I_2 - I_3) = 0$

$-10 I_2 + 10 I_1 - 5 I_2 - 5 I_2 + 5 I_3 = 0$

$10 I_1 - 20 I_2 + 5 I_3 = 0 \rightarrow (2)$.

Applying in mesh-3.

$\boxed{I_3 = -12 A}$

direction is opposite

I_3 (1) Ampere

Putting the value of I_3 in (2) eq.

$10 I_1 - 20 I_2 = -60 \rightarrow (4)$

Solving (1), (4)

$I_1 = 0 A$

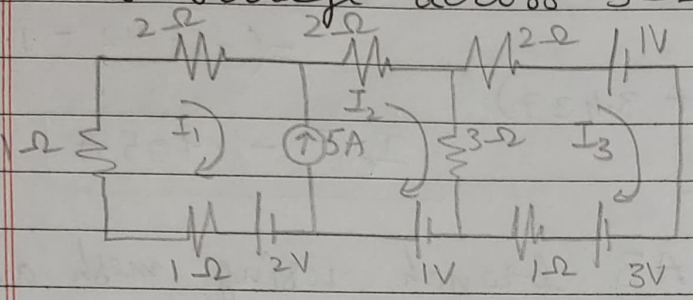
$I_2 = -3 A$

$I_3 = -12 A$

$\boxed{I' = I_2 = -3 A}$

Date / /
Page No.

Q→3. Find voltage across 3 Ω resistor using KVL.



$I_2 - I_1 = 5A$

Standard form

$-I_1 + I_2 + 0I_3 = 5A \rightarrow (1)$

For super mesh.

$-1I_1 - 1I_1 - 2I_1 - 2I_2 - 3(I_2 - I_3) + 1 + 2 = 0$

$-4I_1 - 5I_2 + 3I_3 = -3 \rightarrow (2)$

Apply KVL in mesh-3.

$-2I_3 - 1I_3 - 3(I_3 - I_2) = -2$

$0I_1 + 3I_2 - 6I_3 = -2 \rightarrow (3)$.

Solving (1), (2), (3)

$I_1 = 1.80A$

$I_2 = 3.19A$

$I_3 = 1.93A$

3Ω Resistor = voltage = ?

$V = IR$

$V = (I_2 - I_3)3$

$V = (1.26)3$

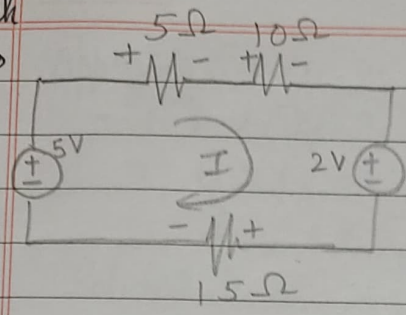
$\boxed{V = 3.781 \text{ Volts}}$.

g KVL.

= 0

9/March

Q→



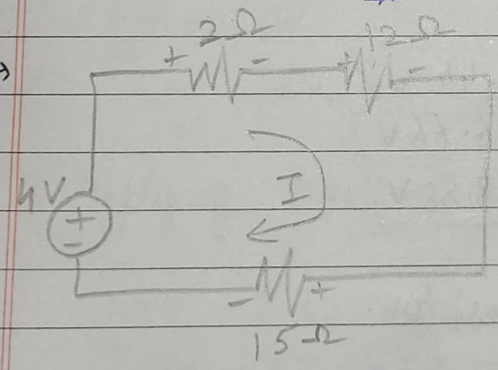
Find
(i) Current (I)
(ii) voltage Across 15 Ω

$$5 - 5(I_1) - 10(I_1) - 2 - 15(I_1)$$
$$3 = 5I + 10I + 15I$$
$$3 = 30I$$
$$I = \frac{3}{30} = \boxed{0.1A}$$

voltage Across 15 Ω

$$V = IR$$
$$= 0.1 \times 15$$
$$\boxed{V = 1.5\,V}$$ #

Q→



Find voltage across every resistor.

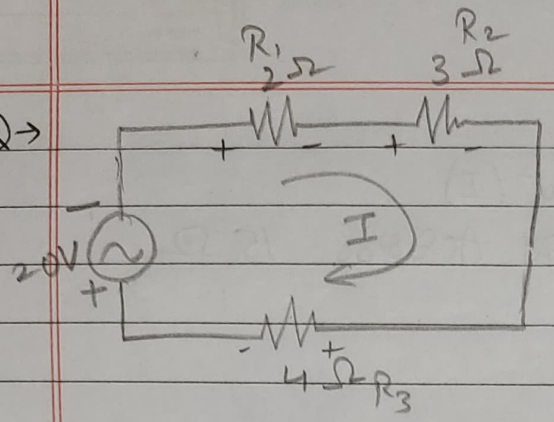
$$4 - 2(I) - 12(I) - 15(I)$$
$$4 = 2I + 12I + 15I$$
$$4 = 29I$$
$$\frac{4}{29} = I$$

0.13 ~~0.074~~ $A = I$

voltage across 2 Ω, 12 Ω, 15 Ω

$$V = IR = 0.074(2) = 0.26\,V$$
$$V = IR = 0.074(12) = 1.56\,V$$
$$V = IR = \underbrace{0.074}_{0.13}(15) = 1.95\,V$$

Q→



(i) Find I

(ii) Find voltage across R_1, R_2, R_3

clockwise

(i) $-20\,V - 2\,\Omega(I) - 3(I) - 4(I) = 0$

$-20 = 2I + 3I + 4I$

$-20 = 9I$

$\frac{-20}{9} = I$

$-2.22\,A = I$

Direction should be taken anticlockwise.

So, $I = (+ve)$.

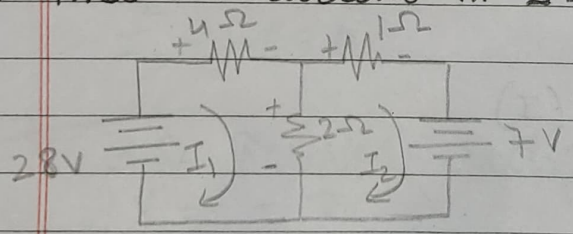
(ii) Voltage

$V_1 = IR_1 = -2.22 \times 2 = \boxed{-4.44\,V}$

$V_2 = IR_2 = -2.22 \times 3 = \boxed{-6.66\,V}$

$V_3 = IR_3 = -2.22 \times 4 = \boxed{-8.88\,V}$

Q→ Find the current in 2 Ω resistor.



Applying KVL in mesh-1.

$28 - 4(I_1) - 2(I_1 - I_2) = 0$

$28 - 4I_1 - 2I_1 + 2I_2 = 0$

$-6I_1 + 2I_2 = -28$

$6I_1 - 2I_2 = 28 \rightarrow (1)$

Applying KVL in mesh-2

$$-7 + 2(I_1 - I_2) - I_2 = 0$$

$$-7 + 2I_1 - 2I_2 - I_2 = 0$$

$$-3I_2 + 2I_1 = 7 \rightarrow (2)$$

Solving (1), (2)

$I_1 = 5A$

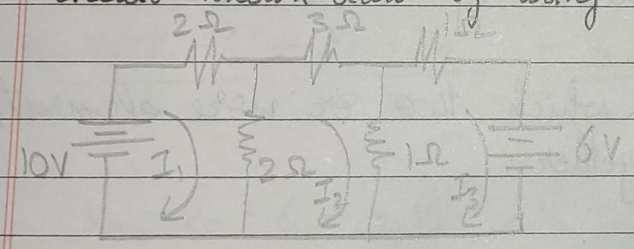
$I_2 = 1A$

I flowing through 2Ω

$2\Omega \Rightarrow I_1 - I_2$

$\Rightarrow 5 - 1 \Rightarrow \boxed{4A}$ #.

Q→ Find I and Power consumed in 3Ω resistance for the circuit shown below by using mesh analysis.



Applying KVL in mesh-1

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

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

$$10 = 4I_1 - 2I_2 \rightarrow (1)$$

Applying KVL in mesh-2

$$-2(I_2 - I_1) - 3(I_2) - 1(I_2 - I_3) = 0$$

$$-2I_2 + 2I_1 - 3I_2 - I_2 + I_3 = 0$$

$$2I_1 - 6I_2 + I_3 = 0 \rightarrow (2)$$

Applying KVL in mesh-3

$$-6 - 1(I_3 - I_2) - 1(I_3) = 0$$

$$-6 - I_3 + I_2 - I_3 = 0$$

$$-6 = 2I_3 - I_2 \rightarrow (3)$$

Solving ①, ②, ③

$$4I_1 - 2I_2 = 10$$
$$2I_1 - 6I_2 + I_3 = 0$$
$$-I_2 + 2I_3 = -6$$

$I_3 = -2.72\ A$
$I_2 = 11.54\ A$
$I_1 = 33.08\ A$

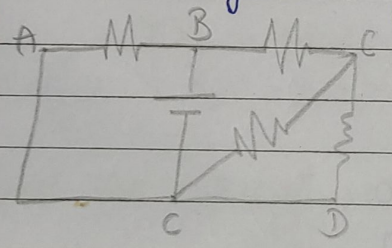
$3\Omega \Rightarrow I = I_2 = 11.54A$

Power $= P = I^2 R = (11.54)^2 (3)$
$= \boxed{399.51\ W}$

⇒ KCL

Junction :- Interaction of three or more branches together.

Node :- A point at which two or more elements are joint together.



B, C, D → node

Reference node

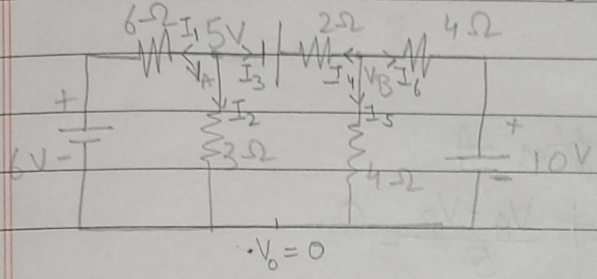
Steps for Solving Numericals Using Nodal Analysis :-

① Identify principle node or junction present in network.
② Assign a junction potential on each junction with respect to assigned reference junction having value $V_0 = 0V$.
③ Assuming all the current in outgoing direction from each junction from KCL equations.
④ Solve the equations to calculate value of junction potentials.

Date / /
Page No.

⑤ Using individual junction potentials find the value of required electrical quantity.

Q→1. Find current in 3 Ω resistor using KCL.



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

$$I_1 = \frac{V_A - V_0 - 6}{6\Omega} \; ; \; I_2 = \frac{V_A - V_0}{3} \; ; \; I_3 = \frac{V_A - V_B + 5}{2}$$

Applying KCL at junction A;

$$\frac{V_A - V_0 - 6}{6} + \frac{V_A - V_0}{3} + \frac{V_A - V_B + 5}{2} = 0$$

$$V_A - V_0 - 6 + 2V_A - 2V_0 + 3V_A - 3V_B + 15 = 0$$

$$6V_A - 3V_B = -9 \rightarrow (1)$$

Applying KCL at junction B;

$$I_4 \; \frac{V_B - V_A - 5}{2} + I_5 \; \frac{V_B - V_0}{4} + I_6 \; \frac{V_B - V_0 - 10}{4} = 0$$

$$2V_B - 2V_A - 10 + V_B - V_0 + V_B - V_0 - 10 = 4$$

$$-2V_A + 4V_B = 20 \rightarrow (2)$$

Solving (1), (2)

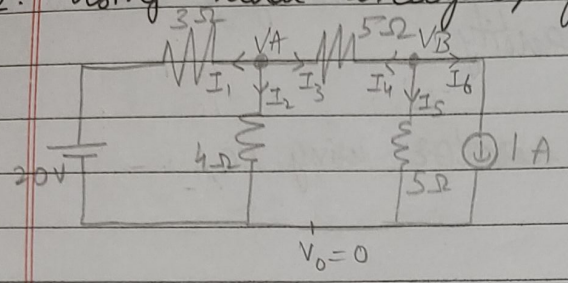
$V_A = 1.333\,V$ $\qquad$ $V_B = 5.666\,V$

$$I_{3\Omega} = \frac{V_A - V_0}{3} = \frac{1.333}{3} = \boxed{0.44\,A}$$

Date / /

Page No.

Q→2. Using nodal analysis, find current in 4 Ω branch.



Sol → Applying KCL at junction A

$$\frac{V_A - V_0 - 20}{3} + \frac{V_A - V_0}{4} + \frac{V_A - V_B}{5} = 0$$

$$\frac{20V_A - 400 + 15V_A + 12V_A - 12V_B}{60} = 0$$

$$47V_A - 12V_B = 400 \rightarrow (1)$$

Applying KCL at junction B

$$\frac{V_B - V_A}{5} + \frac{V_B - V_0}{5} + 1 = 0$$

$$-1V_A + 2V_B = -5 \rightarrow (2)$$

Solving eq (1), (2)

$V_A = 9.02\,V$

$V_B = 2.012\,V$

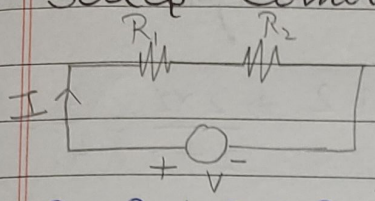
$$I_{4\Omega} = I_2 = \frac{V_A - V_0}{4}$$

$$I_{4\Omega} = \frac{9.02}{4} \rightarrow \boxed{2.255\,A}$$

Branch.

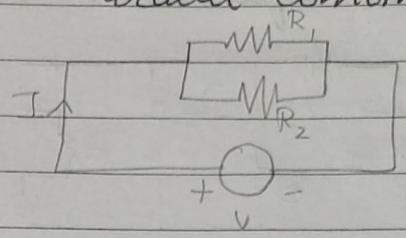
Date / /
Page No.

Series Combination



$$R_T = R_1 + R_2 + R_3 \cdots R_n$$

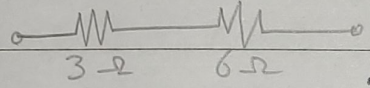
Parallel Combination



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots \frac{1}{R_n}$$

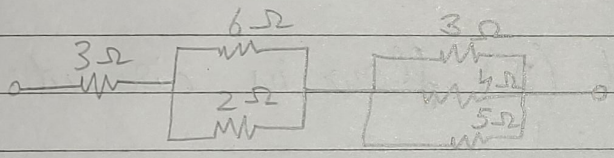
$$\boxed{1/R_T = \frac{R_1 + R_2}{R_1 R_2}} \Rightarrow \boxed{R_T = \frac{R_1 R_2}{R_1 + R_2}}$$

Q→



$R_T = 9\,\Omega$

Q→



① $6 \parallel 2 = \frac{6 \times 2}{6+2} = \frac{12}{8} = 1.5\,\Omega$

② $3 \parallel 4 \parallel 5 \Rightarrow \frac{20 + 15 + 12}{60} = \cancel{0.78}\ 1.27\,\Omega$

$R_T \Rightarrow 3\,\Omega + 1.5 + \cancel{0.7}\ 1.27$

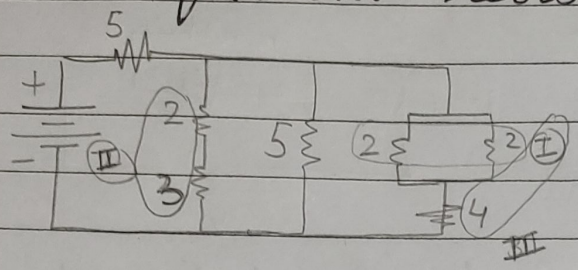
$\Rightarrow \boxed{5.77\,\Omega}$

Formulas

- $V = IR$; $I = \frac{V}{R}$; $R = \frac{V}{I}$; $P = \frac{V^2}{R}$
- Input Power = $\frac{\text{output Power}}{\text{Efficiency}}$
- 'Series' ⇒ $R_T = R_1 + R_2 \cdots$; Capacitor ⇒ $\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} \cdots$
- 'Parallel' ⇒ $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \cdots$; $C_P \Rightarrow C_1 + C_2 + \cdots$
- Capacitance of capacitor $C = \frac{Q}{V}$ $\frac{\text{Stored charge}}{\text{P.D}}$

Date / /
Page No.

Q→ Find equivalent resistance through circuit.



① $2 \parallel 2 \Rightarrow \frac{2 \times 2}{2+2} = \frac{4}{4} = 1\Omega$

② 2 series 3 $\Rightarrow 2+3 = 5\Omega$

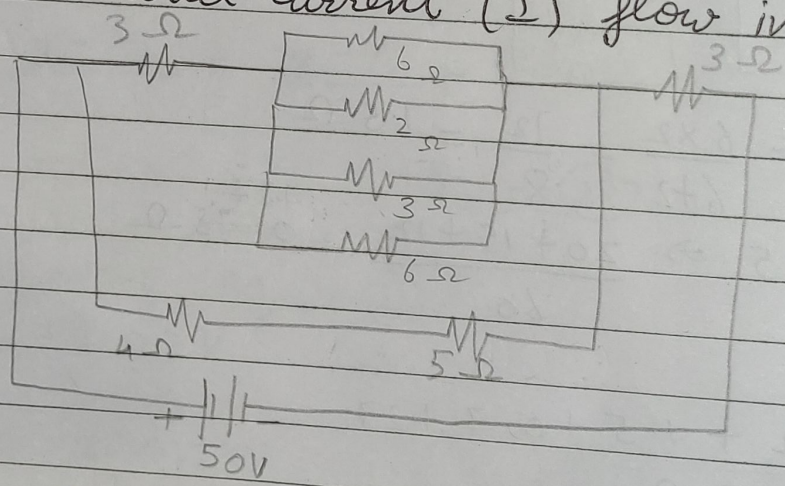
③ Series $1+4 \Rightarrow 5\Omega$

④ $5 \parallel 5 \parallel 5 \Rightarrow \frac{1}{5} + \frac{1}{5} + \frac{1}{5} = \frac{3}{5} \Rightarrow R_T \Rightarrow \frac{5}{3} = \boxed{1.66\Omega}$

⑤ 5Ω & 1.66Ω (Series)

$\boxed{R_{eq} \Rightarrow 6.66\ \Omega}$

Q→ Find total current (I) flow in circuit.



$V = I\ R$

$I = \frac{V}{R}$ $\qquad I_{Total} = \frac{V_{Total}}{R_{Total}}$

① $\frac{1}{R_T} = \frac{1}{6} + \frac{1}{2} + \frac{1}{3} + \frac{1}{6}$

$\frac{1}{R_T} = \frac{7}{6}$

$R_T = \frac{6}{7} = \boxed{0.857\ \Omega}$

② $3\,\Omega$ & $0.857\,\Omega$ (Series)
$\Rightarrow 3.857\,\Omega$

③ $4\,\Omega$ & $5\,\Omega$ (Series)
$\Rightarrow 9\,\Omega$

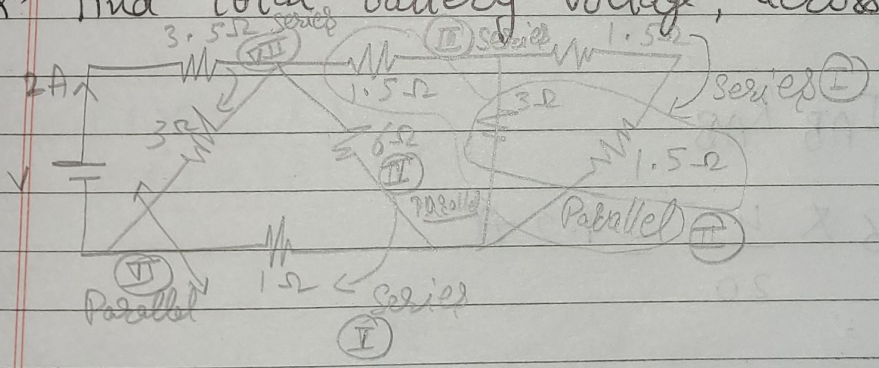
② & ③ $\rightarrow 3.857 \parallel 9\,\Omega$

$$\frac{1}{R_T} = \frac{1}{3.857} + \frac{1}{9} \Rightarrow R_T = 2.7\,\Omega$$

④ 2.7 & $3\,\Omega$ (Series)
$R_T \Rightarrow 5.7\,\Omega$

$$I_{Total} = \frac{50}{5.7} = \boxed{8.77 \text{ Amperes}}$$

Q→ Find total battery voltage, across the circuit.



I $1.5 + 1.5 = 3\,\Omega$
II $3 \parallel 3 = 1.5\,\Omega$
III $1.5 + 1.5 = 3\,\Omega$
IV $6 \parallel 3 = 2\,\Omega$
V $2 + 1 = 3\,\Omega$
VI $3 \parallel 3 = 1.5\,\Omega$
VII $3.5 + 1.5 = 5\,\Omega$

$V_T = I_T R_T$
$V_T = 2 \times 5$
$\boxed{V_T = 10\,V}$

16/March

Current Division Rule Formula → Parallel circuit

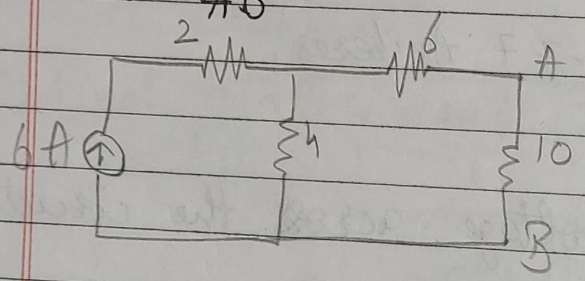
$$I_1 = I_T \left(\frac{R \text{ of opp branch}}{R \text{ of opp} + R \text{ of same branch}} \right)$$

$$I_2 = I_{Total} \left(\frac{R \text{ of opp branch}}{R \text{ of opp} + R \text{ of same branch}} \right)$$

* voltage Division Rule Formula. → Series circuit

$$V_1 = V_T \left(\frac{R \text{ at current branch}}{\text{Total } R} \right)$$

Q→ Find V_{AB}



$$V_{AB} = I_{AB} R_{AB}$$

$$I_2 = 6 \times \frac{4}{20} = 1.2 A$$

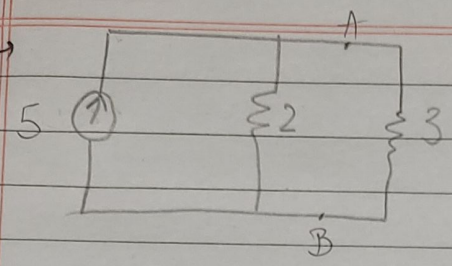
volt across AB

$$V = IR$$

$$= 1.2 \times 10$$

$$= \boxed{12 V}$$

Q→

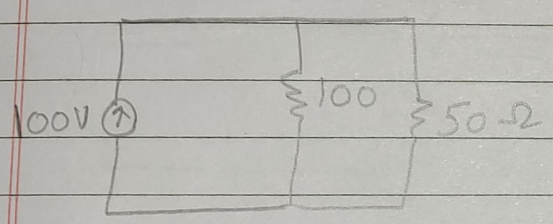


$$I_1 = 5 \times \frac{2}{2+3}$$

$$I_1 = 5 \times \frac{2}{5}$$

$\boxed{I_1 = 2A}$ → Current in 3Ω.

Q→ Find current in 50Ω

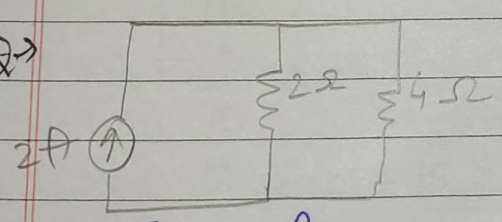


$$V = IR$$

$$100 = I \times 50$$

$$\boxed{I = 2A}$$

Q→



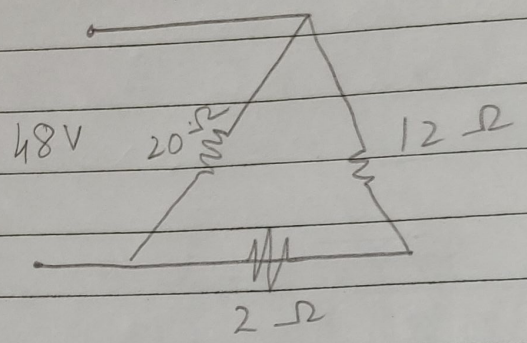
$$I_T = 2A$$

$$I_1 = 2 \times \frac{4}{6}$$

$$I_1 = \frac{4}{3} = \boxed{1.3A}$$

$$I_2 = 2 \times \frac{2}{6} = \boxed{0.6A}$$

Q→ Find current in 8 Ω.



$$I = 48 \times \frac{20}{20+20} = \frac{48 \times 20}{40} = 24A$$

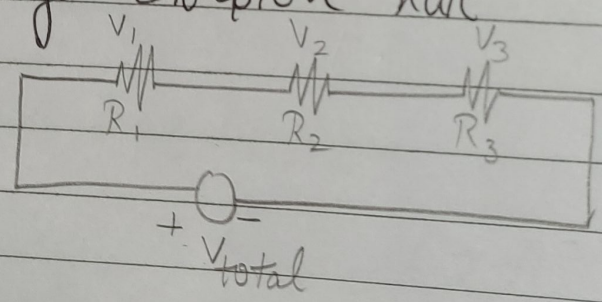
$$R_P = \frac{20 \times 20}{20+20} = \frac{400}{40} = 10\,\Omega$$

Now; $V = IR$

$48 = I\,(10)$

$\boxed{4.8A = I}$

Voltage Division Rule



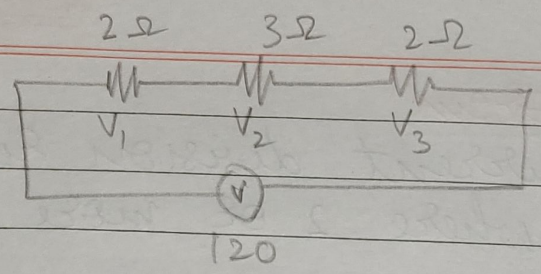
$$V_3 = \frac{R_3}{R_1+R_2+R_3} \times V_{total}$$

$$\boxed{V = \frac{\text{Resistance of that point}}{\text{Total Resistance}} \times V_{total/given}}$$

Date / /

Page No.

Q→

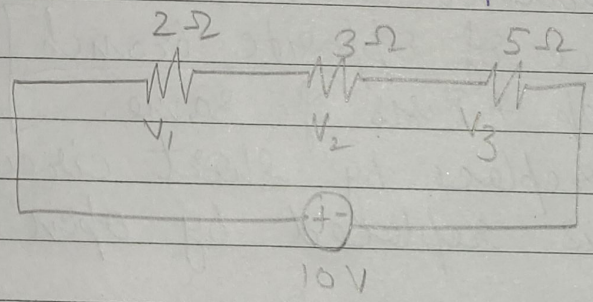


$$V_1 = \frac{2}{7} \times 120 = \frac{240}{7} = \boxed{3.4.28}$$

$$V_2 = \frac{3}{7} \times 120 = \frac{360}{7} = \boxed{51.4}$$

$$V_3 = \frac{2}{7} \times 120 = \frac{240}{7} = \boxed{3.4}$$

Q→



$$V_1 = V_T \left[\frac{R_1}{R_1 + R_2 + R_3} \right]$$

$$V_1 = \frac{2}{10} \times 10 = \boxed{2V}$$

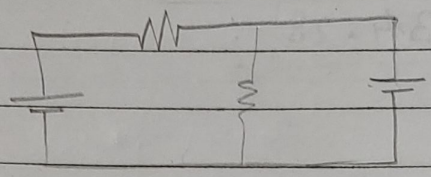
$$V_2 = \frac{3}{10} \times 10 = \boxed{3V}$$

$$V_3 = \frac{5}{10} \times 10 = \boxed{5V}$$

17/March

Superposition Theorem

It works on current division rule.
It will applicable where 2 or more voltage source.



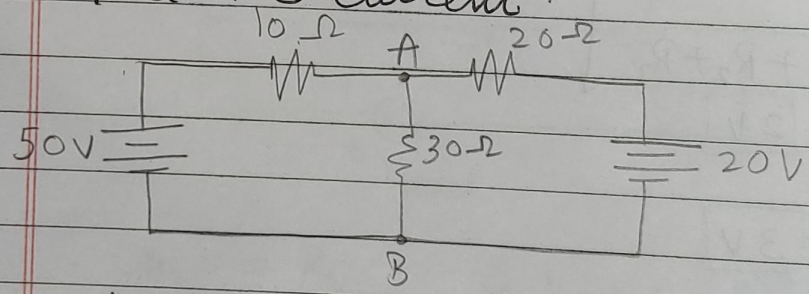
voltage Same = Short circuit
Current Source = open circuit
If we remove any source.

1). It is based on current division rule.

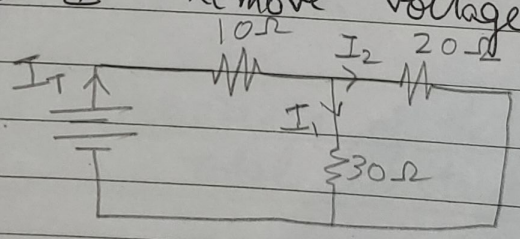
$$I = I_T \left[\frac{\text{Resistance of opposite branch}}{\text{Res of opp + Resis of same.}} \right]$$

2). voltage Source replace by short circuit & current source is replaced by open circuit

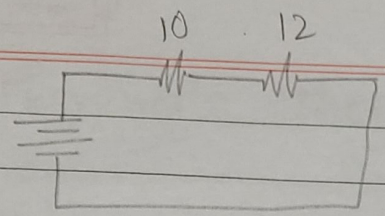
Q→ Find AB current.

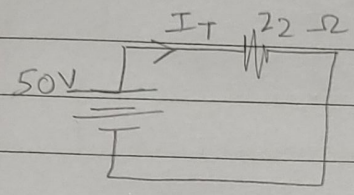


Step → I Remove voltage source 2.



$$\frac{20 \times 30}{20 + 30} = 12\,\Omega$$





$$I_T = \frac{V}{R} = \frac{50}{22} = \boxed{2.27\,A}$$

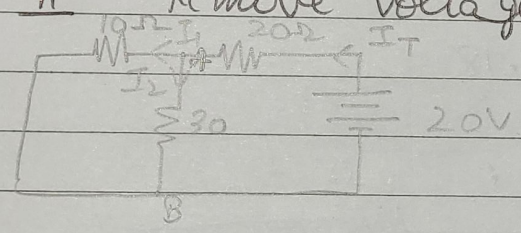
Using Current Division Rule.

$$I_1 = I_T \left(\frac{R \text{ of } o/p}{R_{o/p} + R_{same}}\right)$$

$$I_1 = 2.27 \left(\frac{20}{30+20}\right)$$

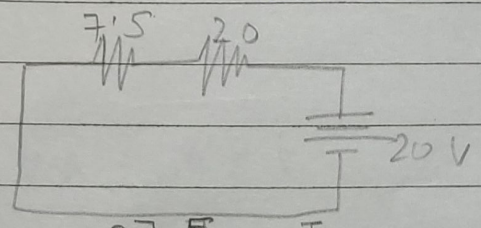
$$\boxed{I_1 = 0.908\,A}$$

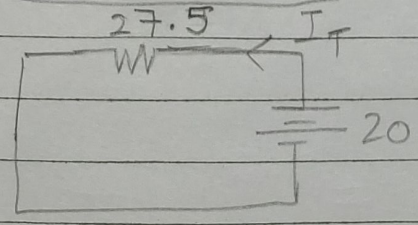
Step → II Remove Voltage Source 1.



$I_T = ?$

$$= \frac{10 \times 30}{10 + 30} = \frac{300}{40} = \boxed{7.5\,\Omega}$$





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

$$= \frac{20}{27.5}$$

$$\boxed{I_T = 0.72\,A}$$

Using CDR

$$I_3 = I_T \left(\frac{R_{opp}}{R_{opp} + R_{same}} \right)$$

$$I_3 = 0.72 \left(\frac{10}{10+30} \right)$$

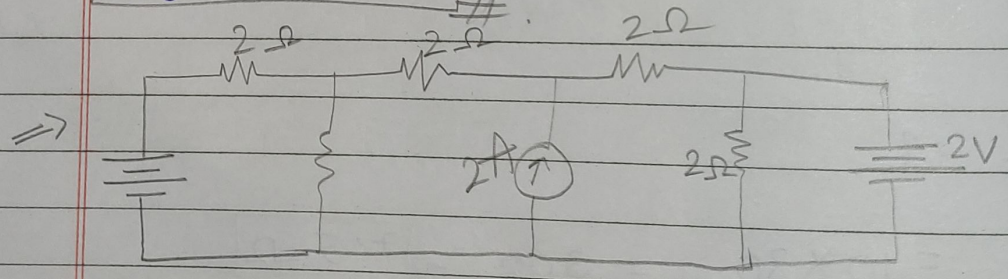
$$\boxed{I_3 = 0.189\,A}$$

Step - III.

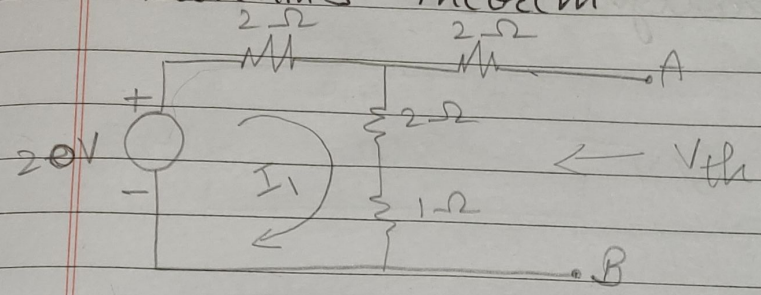
$$I_{AB} = I_1 + I_3$$

$$= 0.908 + 0.18$$

$$\boxed{I_{AB} = 1.089\,A}$$



Thevenin's Theorem.



Across AB.

Open + KVL + Vth + Rth

Step - 1 → Already Done

Step - 2 → Apply KVL

$$KVL \Rightarrow \Sigma V + IR = 0$$

$$20 + (-)I_1(2) - I_1(2) - I_1(1) = 0$$

$$20 + (-2I_1) - 2I_1 - I_1 = 0$$

$$20 - 5I_1 = 0$$

$$-5I_1 = -20$$

$$I_1 = 4A$$

$$\boxed{I_{th} = 4A}$$

Step - 3 Find Vth

$$V_{th} = I_{th} R_{th}$$

$$\boxed{V_{th} = 4(R_{th})}$$

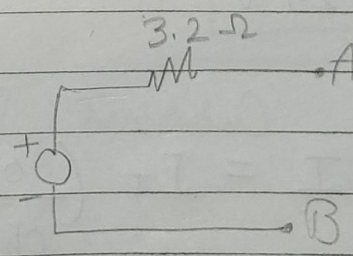
Step - 4 Find Rth

$$\frac{2 \times 3}{3+2} = \frac{6}{5} = \boxed{1.2\ \Omega} \longrightarrow 1.2 + 2\ \Omega$$

Series

⇓

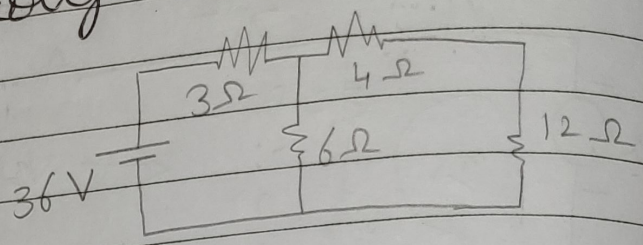
$3.2\ \Omega$



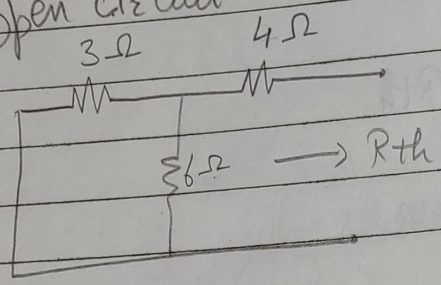
$$V_{th} = 4 \times 3.2\ \Omega$$

$$= \boxed{12.8\ V}$$

Q→ Find I through 12 Ω R of circuit.



Open circuit

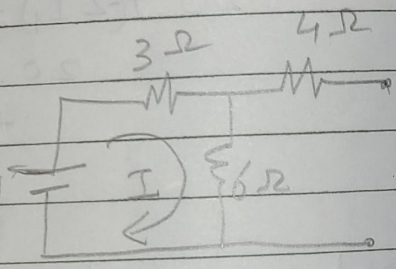


$3 \| 6 = \frac{3 \times 6}{3+6}$

$\Rightarrow \frac{18}{9} = 2$

2 and 4 Ω is series

$R_{th} = 2 + 4 \Rightarrow \boxed{6\ \Omega}$



→ Find Vth

$36 - 3(I_1) - 6I_1 = 0$

$36 - 9I_1 = 0$

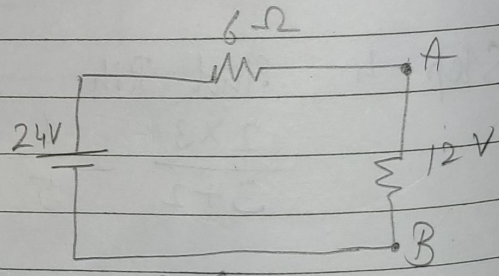
$36 = 9I_1$

$\boxed{4A = I_{th}}$

$V_{th} = I_{th} R_{th}$

$= 4 \times 6$

$\boxed{V_{th} = 24\ V}$

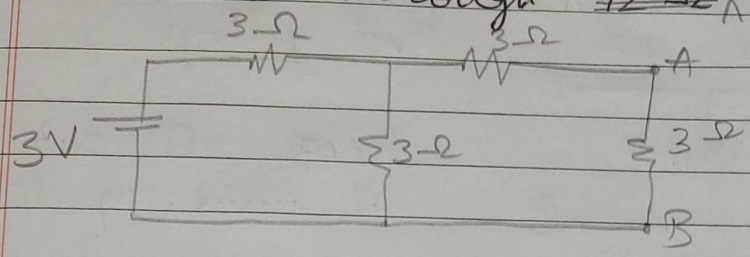


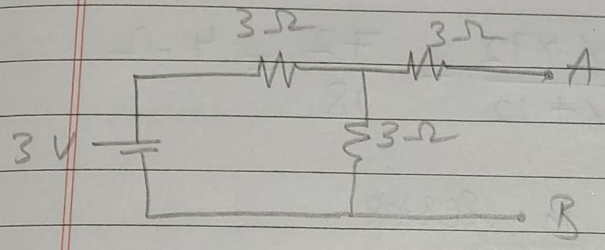
Current Division Rule.

$I = I_T \left(\frac{\text{opp } R}{\text{opp} + \text{same}} \right)$

$I = \frac{V}{R} = \frac{24}{6+12} = \boxed{1.33\ A}$

Q→ Find I through ~~12 Ω~~ AB terminal R of circuit.





$$3 \parallel 3 = \frac{3 \times 3}{3+3} = \frac{9}{6}$$

$$= \frac{3}{2} = 1.5$$

1.5 Ω and 3 Ω in series

$$R_{th} = 1.5 + 3 = \boxed{4.5\ \Omega}$$

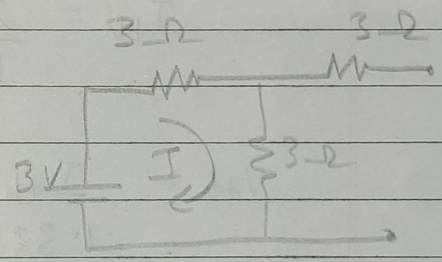
Find V_{th}

$$3 - 3(I_1) - 3I_1 = 0$$

$$3 - 6I_1 = 0$$

$$3 = 6I_1$$

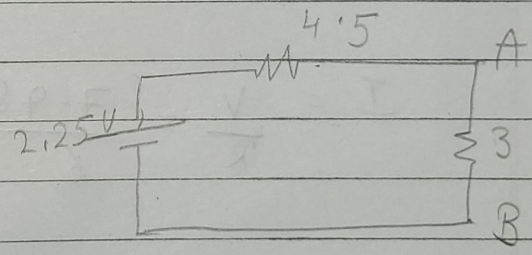
$$\frac{1}{2} = \boxed{0.5\ A = I_{th}}$$



$$V_{th} = I_{th} R_{th}$$

$$= 0.5 \times 4.5$$

$$= \boxed{2.25\ V}$$



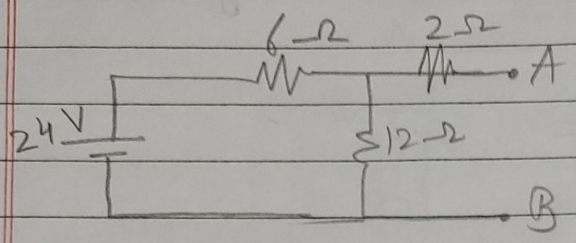
C.D.R.

$$I = I_T \left(\frac{\text{opp } R}{\text{opp} + \text{same}}\right)$$

$$I = \frac{V}{R} = \frac{2.25}{4.5+3} = \frac{2.25}{7.5} = \boxed{0.3\ A}$$

Date / /
Page No.

Q→ Find I across AB.



Find voltage

becoz no current is there in AB terminal.

$$6 \parallel 12 = \frac{6 \times 12}{6+12} = \frac{72}{18} = 4\,\Omega$$

4 Ω and 2 Ω in series

$$R_{th} = 4+2 = \boxed{6\,\Omega}$$

V_{th}

$$\Rightarrow 24\,V - 6(I_1) - 12(I_1) = 0$$

$$24 = 18\,I_1$$

$$I_{th} = \frac{24}{18} = \boxed{1.33A}$$

$$V_{th} = I_{th} \times R_{th}$$

$$= 1.33 \times 6$$

$$\boxed{V_{th} = 7.98\,V}$$

$$I = \frac{V}{R} = \frac{7.98}{6} = \boxed{1.33A}$$

24/2

Basic Electrical and Electronic Engineering

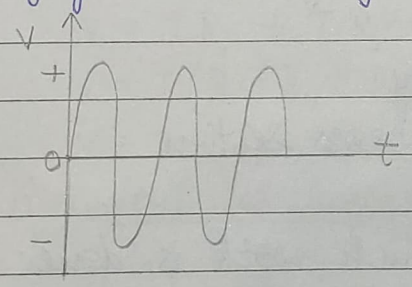
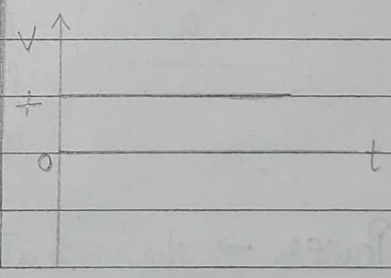
These devices work with AC — These devices work with DC

Electrical = large scale production and distribution of electrical power.

Generation → Transmittion → Distribution.

Electronics = Focus on smaller electronic circuits.

Eg; Computer, Phone.

→ Alternating Current	Direct Current
• The electric charges flow changes its direction periodically - [forward and backward].	The current electricity flows in a single direction in a steady voltage.
• The frequency of AC is dependent. Generally; it is 50 Hz or 60 Hz.	DC has no frequency or zero frequency.
• AC is capable of powering electric motors which are used on refrigerators, washing machine, etc	Cellphones, Electric vehicles, flashlights; batteries.
• 	

→ Charge → Positive charge (+)ve (Static charge)

↓

Negative charge (−)ve (Movable charge)

mass = $m = 9.11 \times 10^{-31}$ Kg

charge = 1.6×10^{-19} C

→ Current → Flow of charge within a conductor.

It is represented by I.
Units are Ampere 'A'.

$$\boxed{I = \frac{Q}{t}} \qquad \frac{1C}{sec} = 1 \text{ Ampere} \qquad (C = \text{Coulomb})$$

$$\text{Current} = \frac{\text{charge}}{\text{time}}$$

→ Voltage → It is the potential difference b/w two points in an electric field, which causes current to flow in the circuit.
It is represented by V
Units are volt 'V'.

$$\boxed{V = \frac{W}{Q}} \qquad \frac{1 \text{ Joule}}{\text{Coulomb}} = 1 \text{ volt}$$

$$\text{Voltage} = \frac{\text{work Done}}{\text{charge}}$$

→ Resistance → It is a measure of opposition to current flow in an electrical circuit.
SI unit = Ohm (Ω)

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

R = Resistance of conductor
l = length
ρ = Resistivity
a = Area of cross section

→ Power → The rate at which work is done.

$$\boxed{P = \frac{W}{t}}$$

P = Power (watt)
W = work Done (J)
t = time (s)

→ Energy → It is the ability to do work.

28/2.

→ Ohm's law →

It states that the current through a conductor b/w two points is directly proportional to the voltage across two points.

$\boxed{V = IR}$ [Temperature remains constant].

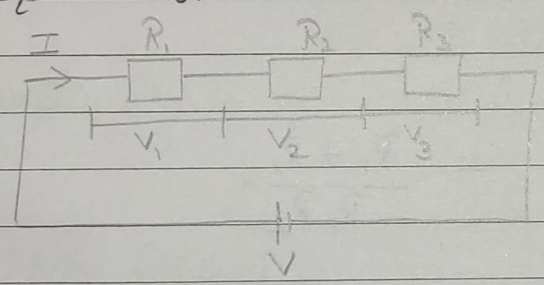
Q→ If $R = 5\,\Omega$ & $V = 2\,V$ find $I = ?$

$V = IR$

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

$0.4 = \frac{2\,A}{5} = I$

→ Series Combination →



Same current (I) flows through three resistances.

$V = V_1 + V_2 + V_3$

$V = IR_1 + IR_2 + IR_3$

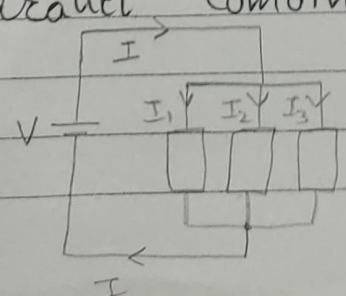
$V = I(R_1 + R_2 + R_3)$

$V = I(R_s)$

Equivalent Resistance (R_s)

$\boxed{R_s = R_1 + R_2 + R_3}$ $\boxed{R_{sn} = nR}$ n = identical resistances each of resistance R

→ Parallel Combination →



Date / /
Page No.

Same voltage (V) appears across all three resistances.

$$I = I_1 + I_2 + I_3$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

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

$$\boxed{\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$\boxed{R_{pn} = \frac{R}{n}}$$

In case only 2 resistances are connected

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2}$$

$$\boxed{R_p = \frac{R_1 R_2}{R_1 + R_2}}$$

Points

- ⊕ charge shows high Potential.
  ⊖ charge shows lows Potential.

- Electron flow -ve to +ve
  Current flow +ve to -ve
  ] opposite to each other.

esistances.

→ Potential Energy →

Electric potential is the amount of work needed to move a unit charge from a reference point to a specific point against electric field.

$$V = K\frac{q}{r}$$

V = electric Potential
K = coulomb constant
q = charge r = distance of separation

→ Drift Velocity →

The average velocity attained by charged particles in a material due to electric field.

$$v_d = \frac{I}{neA}$$

v_d = Drift velocity n = free è density
I = Current flow e = charge of è.
A = cross sectional area.

SI unit ; $\frac{m}{s} = ms^{-1}$.

→ Electric Circuit

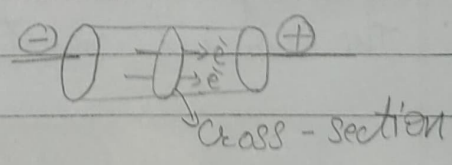
It is a network consisting of a closed loop, giving a return path for the current.

→ Electric current

The movement of electrons through a wire.

$$\text{Electric current} = \frac{\text{Total charge flow}}{\text{Time Taken}}$$

$$I = \frac{q}{t}$$



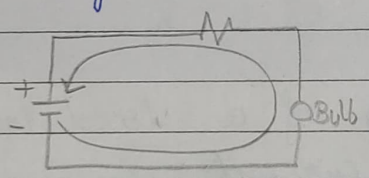
Date / /
Page No.

Q→ What occurs in a wire when the circuit switch is closed?

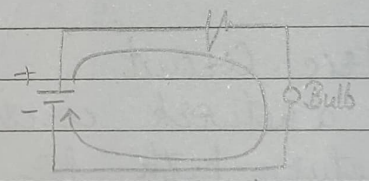
Ans→ All switches do same thing; connect wires to allow electric current to flow or disconnect wires to stop electric current from flowing. When the switch is closed, a closed loop path is created in circuit. An electric field is established instantaneously. Free è, while still randomly moving, immediately begin drifting due to electric field, resulting in net flow of charge.

closing the switch → circuit complete
↓
act as wire

→ Conventional Current →
It is the flow of positive charge from positive to negative.



Electron flow of current



Conventional flow of current

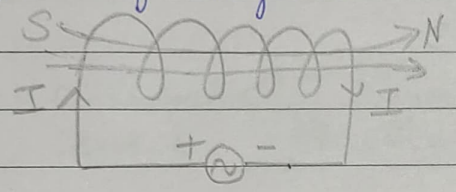
Q→ What is required in order to have an electric current flow in a circuit?

Ans: • A Voltage source.
• The circuit must be closed.

Date / /
Page No.

→ Battery [chemical cell].
A device containing series of electric cells storing chemical energy that can be converted into electrical power.

→ Inductor:
It is a passive electronic component that is used in most power electronic circuits to store energy in the form of magnetic energy when electricity is applied to it.



→ Inductance:
It is the tedency of an electrical conductor to oppose a change in the electric current flowing through it. It is denoted by (L).
S.I unit = Henry (H).

= It depends upon;
- number of wire turns in coil (N) $L \propto N$
- Coil Area $L \propto A$
- Core material $L \propto \mu$ → magnetic permeability
- Coil length $L \propto \frac{1}{l}$

$$L = \frac{\mu N^2 A}{l}$$ → Self inductance

$$L = \frac{\mu_0 \mu_r N_1 N_2 A}{l}$$

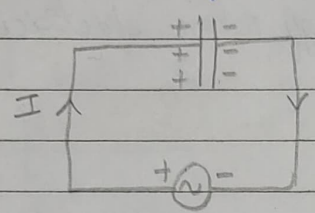
$$L_T = L_1 + L_2 - - -$$
In Series

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + - - -$$
In Parallel

1/March

Static Charge	Moving charge
Electric charge	Magnetic charge

→ Capacitor:
It is an electric component that has the ability to store energy in form of electrical charges that creates a potential difference, which is a static voltage, much like a small rechargeable battery.



→ Capacitance:
The accumulation of charges in the conductors causes a potential difference across the capacitor. The amount of charge accumulated is called the charge holding capacity of the capacitor. This holding capacity of charge is known as capacitance.

$$Q \propto V$$

$$Q = CV$$

$$\boxed{C = \frac{Q}{V}}$$

= It depends upon physical features area of capacitor plates (A), distance between plates (d) and permittivity of dielectric medium (ε).

$$\boxed{C = \frac{\epsilon \times A}{d}}$$

$$\boxed{\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots}$$

In Series

$$\boxed{C_T = C_1 + C_2 + \cdots}$$

In Parallel

2/March

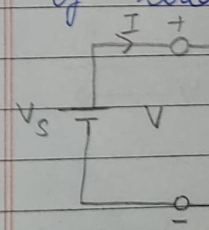
→ Electric

Independe
Sources

Voltage
Source

Curre
Source

→ Indepen
The elem
current
elsewhe
• Voltage
(a) Ideal = I
terminal
It mean
of load



V = Vs

Ideal d

2/March

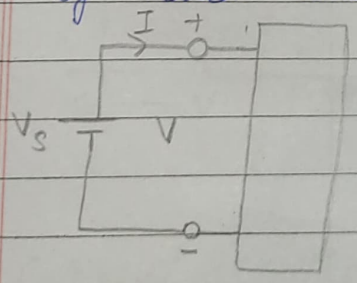
→ Electrical Energy Sources

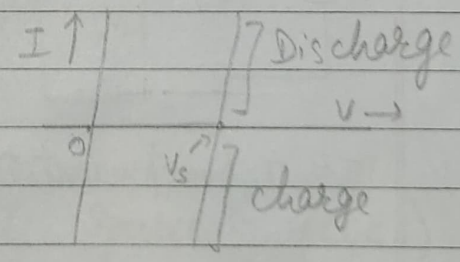
- Independent Sources
  - Voltage Source → Ideal / Practical
  - Current Source → Ideal / Practical
- Dependent Sources
  - VCVS
  - VCCS
  - CCCS
  - CCVS

→ **Independent Sources:**
The element for which both voltage and current don't depend on voltage or current elsewhere in circuit.

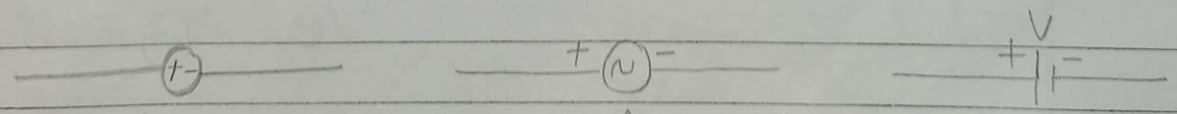
- Voltage Sources

(a) Ideal = It is defined as an energy source whose terminal voltage (V) is independent of output current (I). It means its terminal voltage is independent of load resistance (R_L) connected to it.





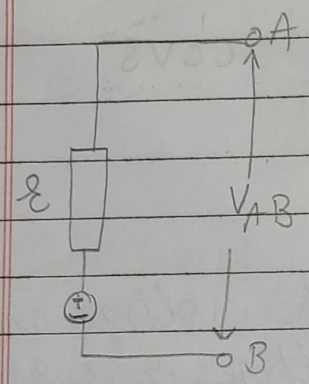
$V = V_s$ [Independent of I]

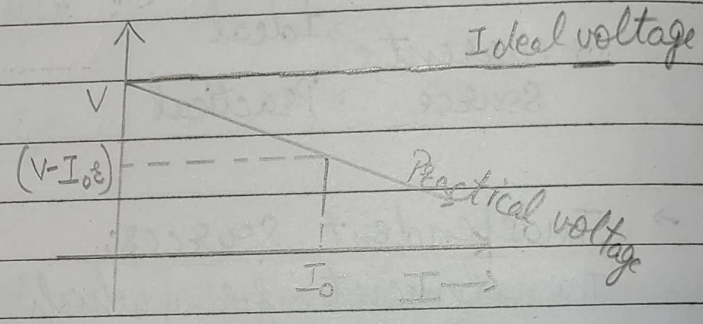


Ideal dc voltage Source. | Ideal AC voltage Source. | Ideal battery

(b) Practical = It is defined as the terminal voltage across the terminals are not constant rather it varies with output current. Internal resistance of practical voltage source has some finite value.

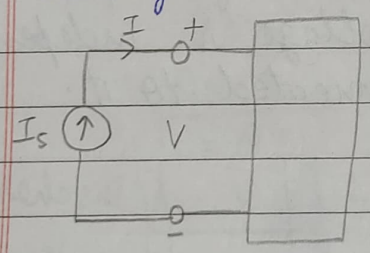
$$\underbrace{V_{AB}}_{\text{Terminal voltage}} = \underbrace{V}_{\text{Applied voltage}} - \underbrace{I}_{\text{Current}}\,\underbrace{r}_{\text{Internal resistance}}$$

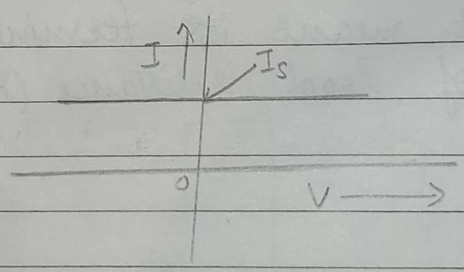




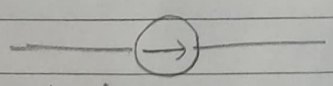
- Current Source

(a) Ideal = It is defined as source which delivers a constant current independent of its output voltage.

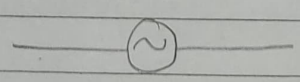




$I = I_s$ [independent of V]



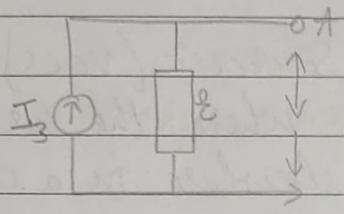
Ideal DC current Source

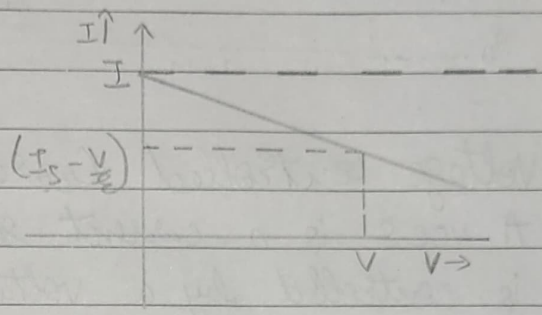


Ideal AC current Source

(b) Practical = In Practical current source, there is one parallel resistance with a current source. There is a limitation on amount of voltage supplied or voltage that can appear across the load.

Current flowing through load resistance $\left[I_0 = \underbrace{I_s}_{\text{Current Source}} - \frac{V}{R} \right.$ → Voltage across terminals, internal resistance.



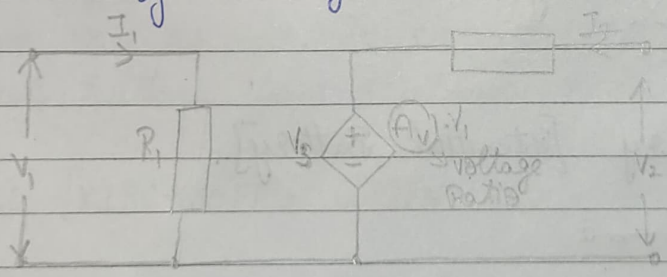


→ Dependent Sources:

The element for which either the voltage or current depends on voltage or current elsewhere in the circuit.

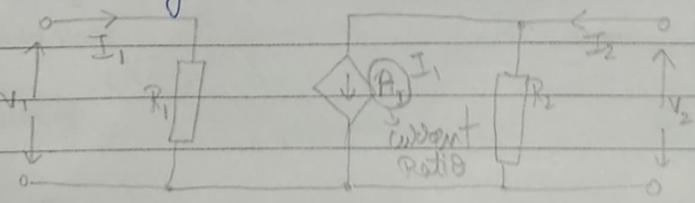
- Voltage Controlled voltage Source :- (VCVS)

  A VCVS is a voltage source where the voltage is controlled by a voltage elsewhere in a circuit.

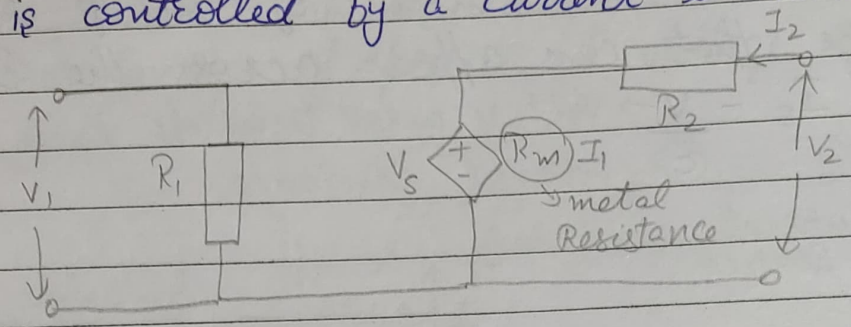


- Current controlled Current Source :- (CCCS)

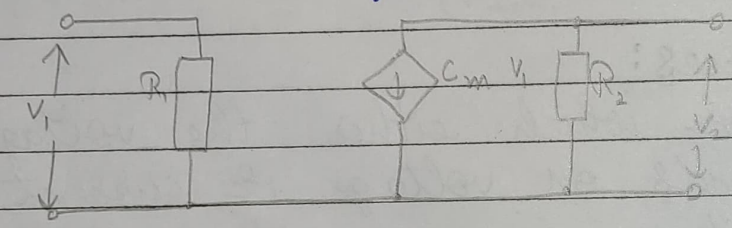
  A CCCS is a current source where the current is controlled by some other current elsewhere in a circuit.



- Current Controlled voltage Source :- (CCVS)
A CCVS is a voltage source where the voltage is controlled by a current elsewhere in a circuit.

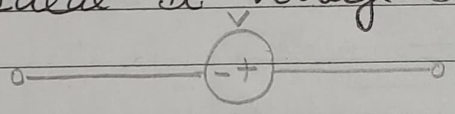


- Voltage Controlled Current Source :- (VCCS)
A VCCS is a current source where the current is controlled by a voltage elsewhere in a circuit.

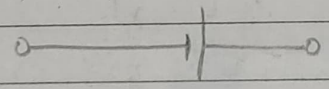


Symbols.

(a) Ideal DC voltage Source

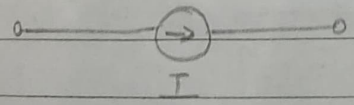


(b) Ideal Battery [Potential Battery].



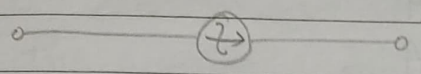
(c) Ideal AC voltage Source.

(d) Ideal DC current Source.

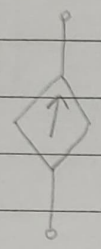


7/March

(e) Ideal AC current source.



(f). Controlled Current Source



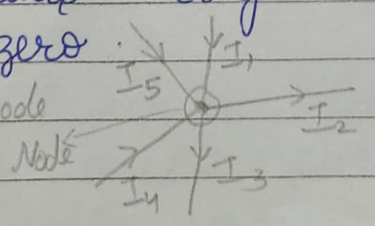
(g). Controlled (Dependent) voltage Source

⇒ Kirchhoff's Laws

- Ohm's law by itself is not sufficient to analyze circuits.
- Kirchhoff's laws can be applied to AC circuits in same way as for DC circuits provided we use phasor sums rather than algebraic sums.

→ KCL [KIRCHHOFF's CURRENT LAW]. Kirchhoff's first law / Kirchhoff's Junction law.

It is based on law of conservation of charge. It states that the algebraic sum of all the currents meeting at a point or a junction will be zero.



Current entering node
||
Current leaving node.

Current In → Positive
Current Out ← negative

$$\boxed{\Sigma I = 0}$$

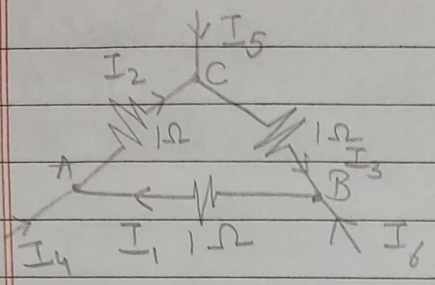
$$I_1 + I_4 + I_5 - I_2 - I_3 = 0$$

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

Date / /

Page No.

Q→



$I_1 = 2A$

$I_4 = -1A$

$I_5 = -4A$

Find $I_6 = ?$

Applying KCL at C

Incoming I = Outgoing I

$I_2 + I_5 = I_3$

$\boxed{I_2 - 4A = I_3} \rightarrow$ (I)

Applying KCL at A

$I_1 + I_4 = I_2$

$2 - 1 = I_2$

$\boxed{I_2 = 1A} \rightarrow$ (II)

Put in (I)

$I_2 - 4A = I_3$

$1 - 4 = I_3$

$\boxed{-3A = I_3}$

Applying KCL at B

$I_3 + I_6 = I_1$

$-3 + I_6 = 2$

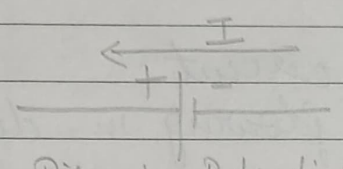
$I_6 = 2 + 3$

$\boxed{I_6 = 5A}$ #

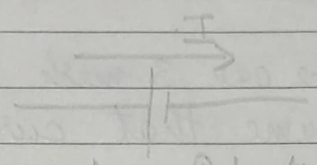
Loop law / Second law

→ KVL [Kirchoff's Voltage law].
It states that in any closed circuit or mesh, the algebraic sum of all the emf's and voltage drops will be zero.
It is based on law of conservation of energy.

$$\boxed{\Sigma \text{ Emf's} + \Sigma IR = 0}$$

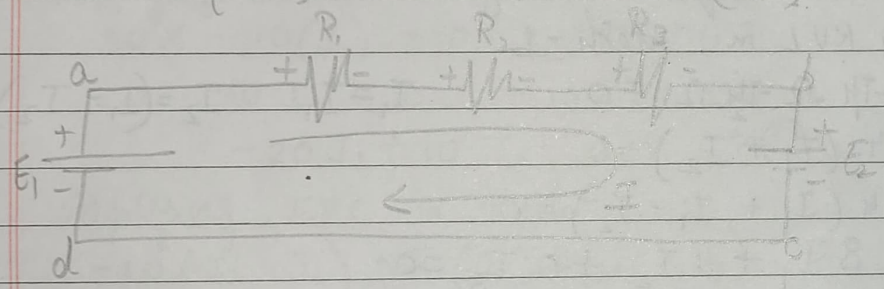


Rise in Potential (+ve)



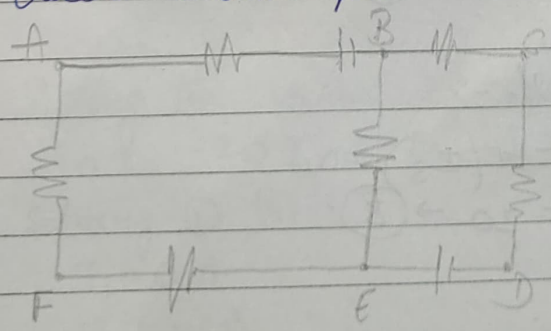
Drop in Potential / Potential Drop (−ve)

voltage



$$-IR_1 - IR_2 - IR_3 - E_2 + E_1 = 0$$

→ Mesh = It is a closed path of electrical circuit through which a current can flow but the only thing is that through that closed path there is no other closed path inside it.



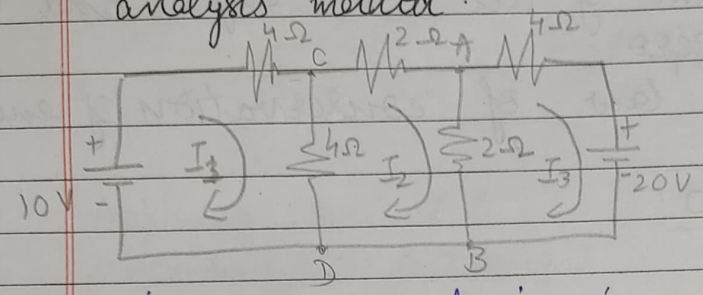
ABEF = Mesh
BCDE

ABEF
BCDE
ACDF } Loop

→ Loop = A loop is also a closed path through which electric current can flow but a loop can carry various other loops inside it.

Date / /
Page No.

Q→1. Calculate the current in branch AB of 2 Ω resistance for given circuit using mesh analysis method.



Sol→ • There are 3 mesh in given circuit.
• Assume that current is flowing in clockwise direction.
• Frame KVL equations for individual mesh.
• Applying KVL in mesh-1.

$10\,V - I_1 4\,\Omega - I_2 4\,\Omega = 0$ $\qquad I_1 = I_1 \qquad I_2 = (I_1 - I_2)$

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

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

$10 - 8I_1 + 4I_2 + 0I_3 = 0$

$-8I_1 + 4I_2 + 0I_3 = -10 \rightarrow (1)$

• Applying KVL in mesh-2.

$-2I_2 - 2(I_2 - I_3) - 4(I_2 - I_1) = 0$

$-2I_2 - 2I_2 + 2I_3 - 4I_2 + 4I_1 = 0$

$4I_1 - 8I_2 + 2I_3 = 0 \rightarrow (2)$

• Applying KVL in mesh-3

$-20V - 2(I_3 - I_2) - 4(I_3) = 0$

$0I_1 + 2I_2 - 6I_3 = 20 \rightarrow (3)$

• Solving eq (1), (2), (3).

$I_1 = 1.093\,A$

$I_2 = -0.312\,A$

$I_3 = -3.437\,A$

$I_{AB} = I_2 - I_3$

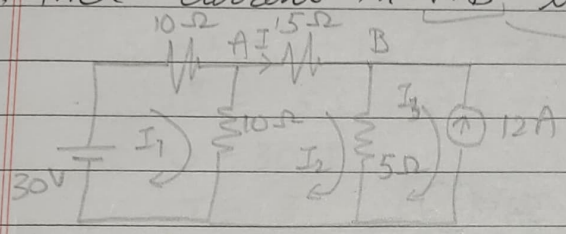
$I_{CD} = I_2 - I_1$
$= (-0.312 - 1.093)$

$I_{AB} = (-0.312 + 3.437)$

$\boxed{I_{AB} = -3.125\ A}$

$\boxed{I_{CD} = -1.405 A}$

Q→2. Find current in AB branch using mesh analysis.



$V \Rightarrow IR$
$= I_2(5) = -15\ V$

$P \Rightarrow I^2 R$
$= (-3)^2 (5) = 45W$

Sol→ 3 meshes :-

Applying KVL in mesh-1.

$30V - 10(I_1) - 10(I_1 - I_2) = 0$

$-10 I_1 - 10 I_1 + 10 I_2 = -30$

$-20 I_1 + 10 I_2 = -30V \rightarrow (1)$

Applying KVL in mesh-2.

$-10(I_2 - I_1) - 5(I_2) - 5(I_2 - I_3) = 0$

$-10 I_2 + 10 I_1 - 5 I_2 - 5 I_2 + 5 I_3 = 0$

$10 I_1 - 20 I_2 + 5 I_3 = 0 \rightarrow (2)$.

Applying in mesh-3.

$\boxed{I_3 = -12 A}$

direction is opposite

I_3 (1) Ampere

Putting the value of I_3 in (2) eq.

$10 I_1 - 20 I_2 = -60 \rightarrow (4)$

Solving (1), (4)

$I_1 = 0 A$

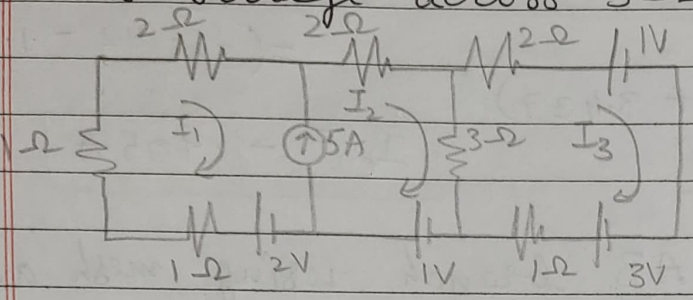
$I_2 = -3 A$

$I_3 = -12 A$

$\boxed{I' = I_2 = -3 A}$

Date / /
Page No.

Q→3. Find voltage across 3 Ω resistor using KVL.



$I_2 - I_1 = 5A$

Standard form

$-I_1 + I_2 + 0I_3 = 5A \rightarrow (1)$

For super mesh.

$-1I_1 - 1I_1 - 2I_1 - 2I_2 - 3(I_2 - I_3) + 1 + 2 = 0$

$-4I_1 - 5I_2 + 3I_3 = -3 \rightarrow (2)$

Apply KVL in mesh-3.

$-2I_3 - 1I_3 - 3(I_3 - I_2) = -2$

$0I_1 + 3I_2 - 6I_3 = -2 \rightarrow (3)$.

Solving (1), (2), (3)

$I_1 = 1.80A$

$I_2 = 3.19A$

$I_3 = 1.93A$

3Ω Resistor = voltage = ?

$V = IR$

$V = (I_2 - I_3)3$

$V = (1.26)3$

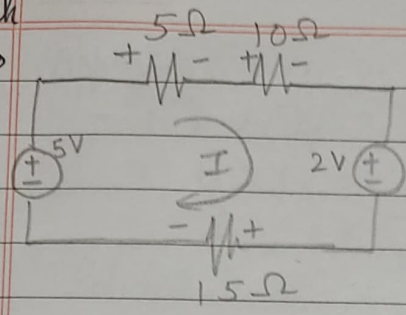
$\boxed{V = 3.781 \text{ Volts}}$.

g KVL.

= 0

9/March

Q→



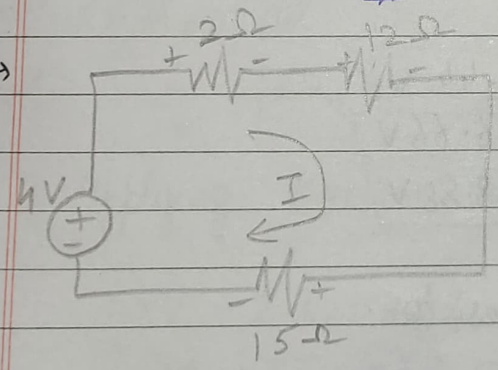
Find
(i) Current (I)
(ii) voltage Across 15 Ω

$$5 - 5(I_1) - 10(I_1) - 2 - 15(I_1)$$
$$3 = 5I + 10I + 15I$$
$$3 = 30I$$
$$I = \frac{3}{30} = \boxed{0.1A}$$

voltage Across 15 Ω

$$V = IR$$
$$= 0.1 \times 15$$
$$\boxed{V = 1.5\,V}$$ #

Q→



Find voltage across every resistor.

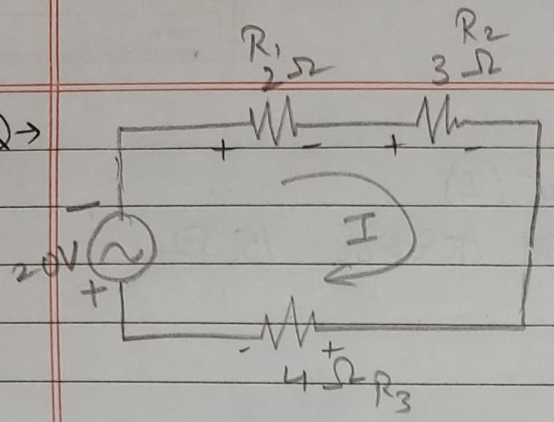
$$4 - 2(I) - 12(I) - 15(I)$$
$$4 = 2I + 12I + 15I$$
$$4 = 29I$$
$$\frac{4}{29} = I$$

0.13 ~~0.074~~ $A = I$

voltage across 2 Ω, 12 Ω, 15 Ω

$$V = IR = 0.074(2) = 0.26\,V$$
$$V = IR = 0.074(12) = 1.56\,V$$
$$V = IR = \underbrace{0.074}_{0.13}(15) = 1.95\,V$$

Q→



(i) Find I

(ii) Find voltage across R_1, R_2, R_3

clockwise

(i) $-20\,V - 2\,\Omega(I) - 3(I) - 4(I) = 0$

$-20 = 2I + 3I + 4I$

$-20 = 9I$

$\frac{-20}{9} = I$

$-2.22\,A = I$

Direction should be taken anticlockwise.

So, $I = (+ve)$.

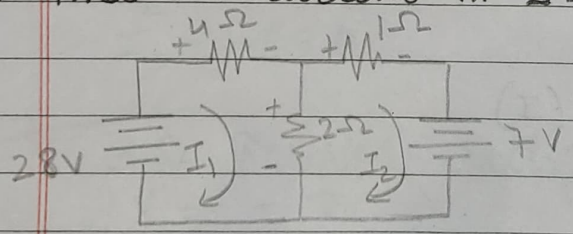
(ii) Voltage

$V_1 = IR_1 = -2.22 \times 2 = \boxed{-4.44\,V}$

$V_2 = IR_2 = -2.22 \times 3 = \boxed{-6.66\,V}$

$V_3 = IR_3 = -2.22 \times 4 = \boxed{-8.88\,V}$

Q→ Find the current in 2 Ω resistor.



Applying KVL in mesh-1.

$28 - 4(I_1) - 2(I_1 - I_2) = 0$

$28 - 4I_1 - 2I_1 + 2I_2 = 0$

$-6I_1 + 2I_2 = -28$

$6I_1 - 2I_2 = 28 \rightarrow (1)$

Applying KVL in mesh-2

$$-7 + 2(I_1 - I_2) - I_2 = 0$$

$$-7 + 2I_1 - 2I_2 - I_2 = 0$$

$$-3I_2 + 2I_1 = 7 \rightarrow (2)$$

Solving (1), (2)

$I_1 = 5A$

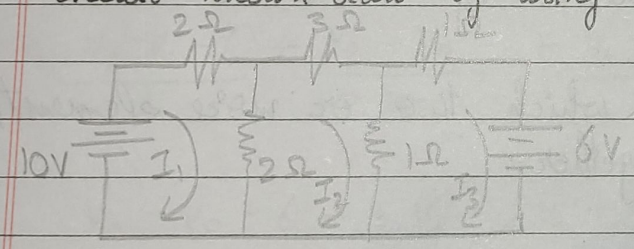
$I_2 = 1A$

I flowing through 2Ω

$2\Omega \Rightarrow I_1 - I_2$

$\Rightarrow 5 - 1 \Rightarrow \boxed{4A}$ #.

Q→ Find I and Power consumed in 3Ω resistance for the circuit shown below by using mesh analysis.



Applying KVL in mesh-1

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

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

$$10 = 4I_1 - 2I_2 \rightarrow (1)$$

Applying KVL in mesh-2

$$-2(I_2 - I_1) - 3(I_2) - 1(I_2 - I_3) = 0$$

$$-2I_2 + 2I_1 - 3I_2 - I_2 + I_3 = 0$$

$$2I_1 - 6I_2 + I_3 = 0 \rightarrow (2)$$

Applying KVL in mesh-3

$$-6 - 1(I_3 - I_2) - 1(I_3) = 0$$

$$-6 - I_3 + I_2 - I_3 = 0$$

$$-6 = 2I_3 - I_2 \rightarrow (3)$$

Solving ①, ②, ③

$$4I_1 - 2I_2 = 10$$
$$2I_1 - 6I_2 + I_3 = 0$$
$$-I_2 + 2I_3 = -6$$

$I_3 = -2.72\ A$
$I_2 = 11.54\ A$
$I_1 = 33.08\ A$

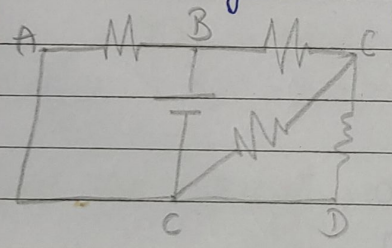
$3\Omega \Rightarrow I = I_2 = 11.54A$

Power $= P = I^2 R = (11.54)^2 (3)$
$= \boxed{399.51\ W}$

⇒ KCL

Junction :- Interaction of three or more branches together.

Node :- A point at which two or more elements are joint together.



B, C, D → node

Reference node

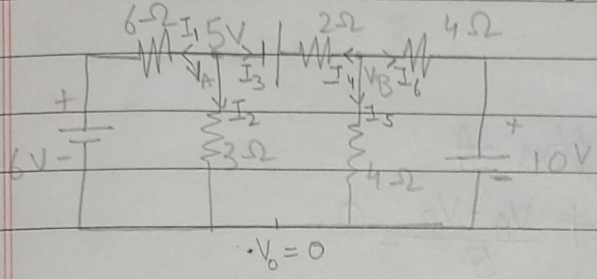
Steps for Solving Numericals Using Nodal Analysis :-

① Identify principle node or junction present in network.
② Assign a junction potential on each junction with respect to assigned reference junction having value $V_0 = 0V$.
③ Assuming all the current in outgoing direction from each junction from KCL equations.
④ Solve the equations to calculate value of junction potentials.

Date / /
Page No.

⑤ Using individual junction potentials find the value of required electrical quantity.

Q→1. Find current in 3 Ω resistor using KCL.



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

$$I_1 = \frac{V_A - V_0 - 6}{6\Omega} \; ; \; I_2 = \frac{V_A - V_0}{3} \; ; \; I_3 = \frac{V_A - V_B + 5}{2}$$

Applying KCL at junction A;

$$\frac{V_A - V_0 - 6}{6} + \frac{V_A - V_0}{3} + \frac{V_A - V_B + 5}{2} = 0$$

$$V_A - V_0 - 6 + 2V_A - 2V_0 + 3V_A - 3V_B + 15 = 0$$

$$6V_A - 3V_B = -9 \rightarrow (1)$$

Applying KCL at junction B;

$$I_4 \; \frac{V_B - V_A - 5}{2} + I_5 \; \frac{V_B - V_0}{4} + I_6 \; \frac{V_B - V_0 - 10}{4} = 0$$

$$2V_B - 2V_A - 10 + V_B - V_0 + V_B - V_0 - 10 = 4$$

$$-2V_A + 4V_B = 20 \rightarrow (2)$$

Solving (1), (2)

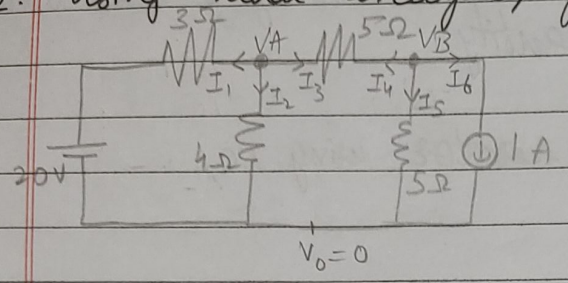
$V_A = 1.333\,V$ $\qquad$ $V_B = 5.666\,V$

$$I_{3\Omega} = \frac{V_A - V_0}{3} = \frac{1.333}{3} = \boxed{0.44\,A}$$

Date / /

Page No.

Q→2. Using nodal analysis, find current in 4 Ω branch.



Sol → Applying KCL at junction A

$$\frac{V_A - V_0 - 20}{3} + \frac{V_A - V_0}{4} + \frac{V_A - V_B}{5} = 0$$

$$\frac{20V_A - 400 + 15V_A + 12V_A - 12V_B}{60} = 0$$

$$47V_A - 12V_B = 400 \rightarrow (1)$$

Applying KCL at junction B

$$\frac{V_B - V_A}{5} + \frac{V_B - V_0}{5} + 1 = 0$$

$$-1V_A + 2V_B = -5 \rightarrow (2)$$

Solving eq (1), (2)

$V_A = 9.02\,V$

$V_B = 2.012\,V$

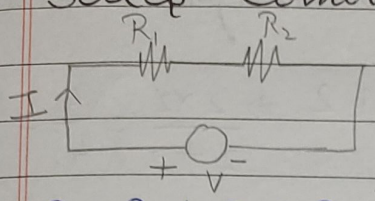
$$I_{4\Omega} = I_2 = \frac{V_A - V_0}{4}$$

$$I_{4\Omega} = \frac{9.02}{4} \rightarrow \boxed{2.255\,A}$$

Branch.

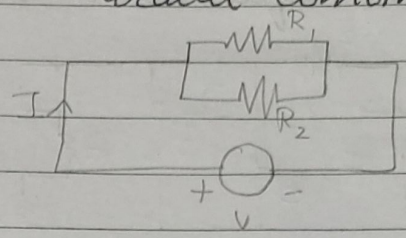
Date / /
Page No.

Series Combination



$$R_T = R_1 + R_2 + R_3 \cdots R_n$$

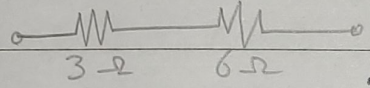
Parallel Combination



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots \frac{1}{R_n}$$

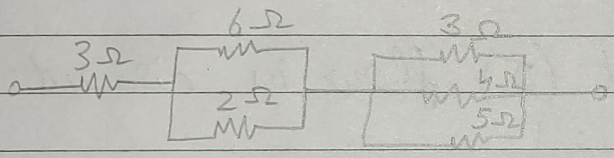
$$\boxed{1/R_T = \frac{R_1 + R_2}{R_1 R_2}} \Rightarrow \boxed{R_T = \frac{R_1 R_2}{R_1 + R_2}}$$

Q→



$R_T = 9\,\Omega$

Q→



① $6 \parallel 2 = \frac{6 \times 2}{6+2} = \frac{12}{8} = 1.5\,\Omega$

② $3 \parallel 4 \parallel 5 \Rightarrow \frac{20 + 15 + 12}{60} = \cancel{0.78}\ 1.27\,\Omega$

$R_T \Rightarrow 3\,\Omega + 1.5 + \cancel{0.7}\ 1.27$

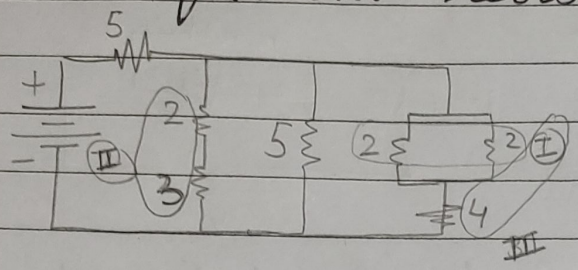
$\Rightarrow \boxed{5.77\,\Omega}$

Formulas

- $V = IR$; $I = \frac{V}{R}$; $R = \frac{V}{I}$; $P = \frac{V^2}{R}$
- Input Power = $\frac{\text{output Power}}{\text{Efficiency}}$
- 'Series' ⇒ $R_T = R_1 + R_2 \cdots$; Capacitor ⇒ $\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} \cdots$
- 'Parallel' ⇒ $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \cdots$; $C_P \Rightarrow C_1 + C_2 + \cdots$
- Capacitance of capacitor $C = \frac{Q}{V}$ $\frac{\text{Stored charge}}{\text{P.D}}$

Date / /
Page No.

Q→ Find equivalent resistance through circuit.



① $2 \parallel 2 \Rightarrow \frac{2 \times 2}{2+2} = \frac{4}{4} = 1\Omega$

② 2 series 3 $\Rightarrow 2+3 = 5\Omega$

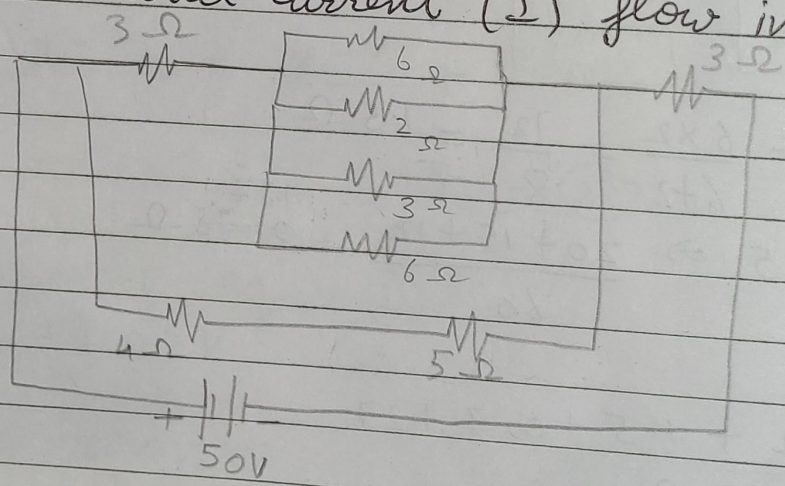
③ Series $1+4 \Rightarrow 5\Omega$

④ $5 \parallel 5 \parallel 5 \Rightarrow \frac{1}{5} + \frac{1}{5} + \frac{1}{5} = \frac{3}{5} \Rightarrow R_T \Rightarrow \frac{5}{3} = \boxed{1.66\Omega}$

⑤ 5Ω & 1.66Ω (Series)

$\boxed{R_{eq} \Rightarrow 6.66\ \Omega}$

Q→ Find total current (I) flow in circuit.



$V = I\ R$

$I = \frac{V}{R}$ $\qquad I_{Total} = \frac{V_{Total}}{R_{Total}}$

① $\frac{1}{R_T} = \frac{1}{6} + \frac{1}{2} + \frac{1}{3} + \frac{1}{6}$

$\frac{1}{R_T} = \frac{7}{6}$

$R_T = \frac{6}{7} = \boxed{0.857\ \Omega}$

② $3\,\Omega$ & $0.857\,\Omega$ (Series)
$\Rightarrow 3.857\,\Omega$

③ $4\,\Omega$ & $5\,\Omega$ (Series)
$\Rightarrow 9\,\Omega$

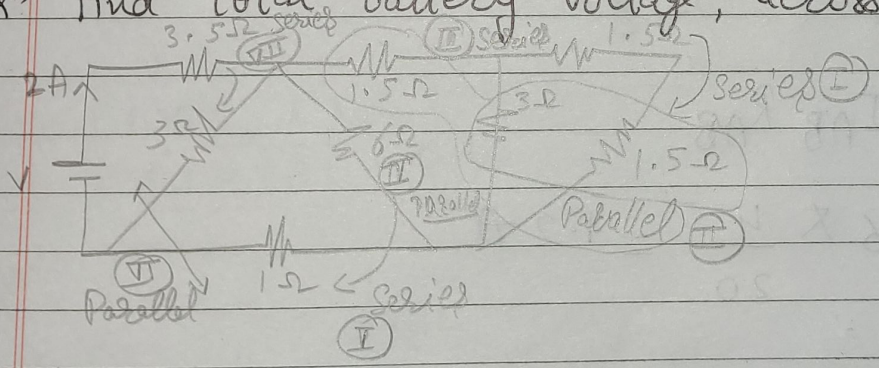
② & ③ $\rightarrow 3.857 \parallel 9\,\Omega$

$$\frac{1}{R_T} = \frac{1}{3.857} + \frac{1}{9} \Rightarrow R_T = 2.7\,\Omega$$

④ 2.7 & $3\,\Omega$ (Series)
$R_T \Rightarrow 5.7\,\Omega$

$$I_{Total} = \frac{50}{5.7} = \boxed{8.77 \text{ Amperes}}$$

Q→ Find total battery voltage, across the circuit.



I $1.5 + 1.5 = 3\,\Omega$
II $3 \parallel 3 = 1.5\,\Omega$
III $1.5 + 1.5 = 3\,\Omega$
IV $6 \parallel 3 = 2\,\Omega$
V $2 + 1 = 3\,\Omega$
VI $3 \parallel 3 = 1.5\,\Omega$
VII $3.5 + 1.5 = 5\,\Omega$

$V_T = I_T R_T$
$V_T = 2 \times 5$
$\boxed{V_T = 10\,V}$

16/March

Current Division Rule Formula → Parallel circuit

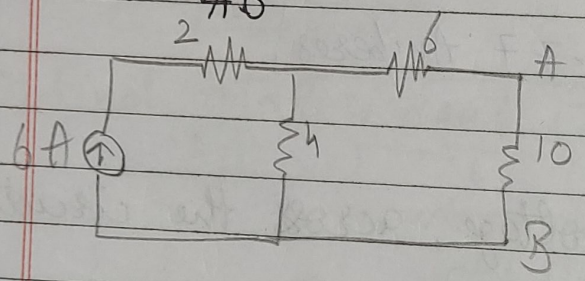
$$I_1 = I_T \left(\frac{R \text{ of opp branch}}{R \text{ of opp} + R \text{ of same branch}} \right)$$

$$I_2 = I_{Total} \left(\frac{R \text{ of opp branch}}{R \text{ of opp} + R \text{ of same branch}} \right)$$

* voltage Division Rule Formula. → Series circuit

$$V_1 = V_T \left(\frac{R \text{ at current branch}}{\text{Total } R} \right)$$

Q→ Find V_{AB}



$$V_{AB} = I_{AB} R_{AB}$$

$$I_2 = 6 \times \frac{4}{20} = 1.2 A$$

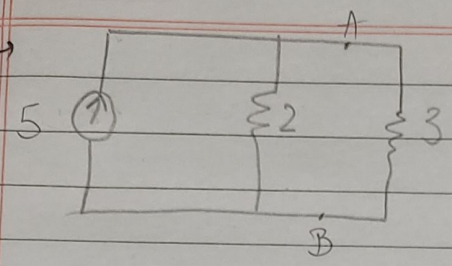
volt across AB

$$V = IR$$

$$= 1.2 \times 10$$

$$= \boxed{12 V}$$

Q→

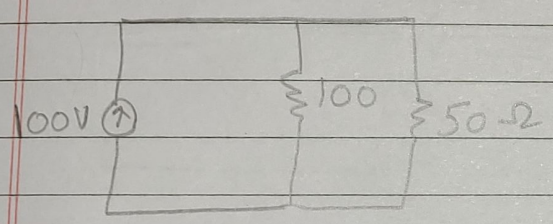


$$I_1 = 5 \times \frac{2}{2+3}$$

$$I_1 = 5 \times \frac{2}{5}$$

$\boxed{I_1 = 2A}$ → Current in 3Ω.

Q→ Find current in 50Ω

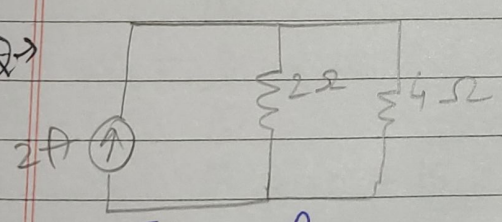


$$V = IR$$

$$100 = I \times 50$$

$$\boxed{I = 2A}$$

Q→



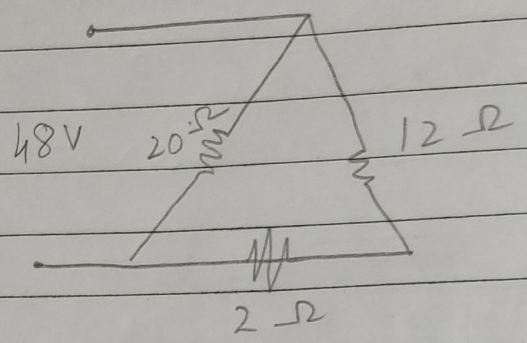
$$I_T = 2A$$

$$I_1 = 2 \times \frac{4}{6}$$

$$I_1 = \frac{4}{3} = \boxed{1.3A}$$

$$I_2 = 2 \times \frac{2}{6} = \boxed{0.6A}$$

Q→ Find current in 8 Ω.



$$I = 48 \times \frac{20}{20+20} = \frac{48 \times 20}{40} = 24A$$

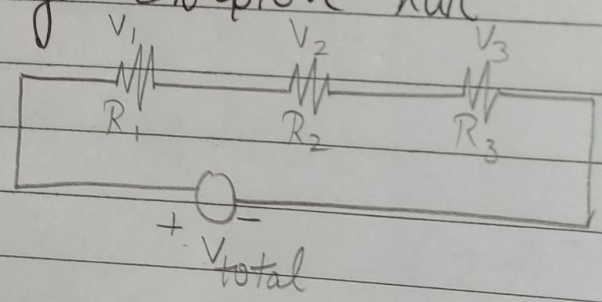
$$R_P = \frac{20 \times 20}{20+20} = \frac{400}{40} = 10\,\Omega$$

Now; $V = IR$

$48 = I\,(10)$

$\boxed{4.8A = I}$

Voltage Division Rule



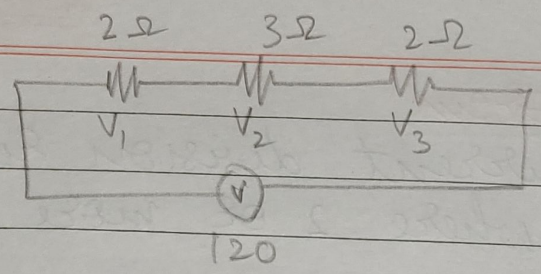
$$V_3 = \frac{R_3}{R_1+R_2+R_3} \times V_{total}$$

$$\boxed{V = \frac{\text{Resistance of that point}}{\text{Total Resistance}} \times V_{total/given}}$$

Date / /

Page No.

Q→

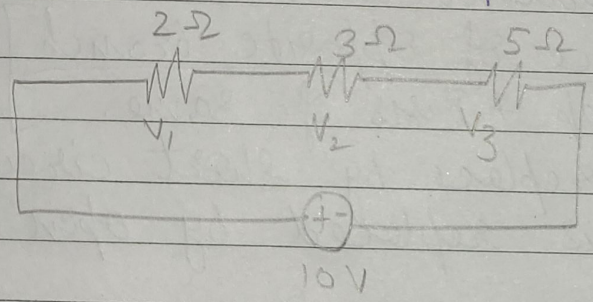


$$V_1 = \frac{2}{7} \times 120 = \frac{240}{7} = \boxed{3.4.28}$$

$$V_2 = \frac{3}{7} \times 120 = \frac{360}{7} = \boxed{51.4}$$

$$V_3 = \frac{2}{7} \times 120 = \frac{240}{7} = \boxed{3.4}$$

Q→



$$V_1 = V_T \left[\frac{R_1}{R_1 + R_2 + R_3} \right]$$

$$V_1 = \frac{2}{10} \times 10 = \boxed{2V}$$

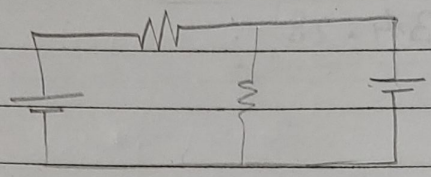
$$V_2 = \frac{3}{10} \times 10 = \boxed{3V}$$

$$V_3 = \frac{5}{10} \times 10 = \boxed{5V}$$

17/March

Superposition Theorem

It works on current division rule.
It will applicable where 2 or more voltage source.



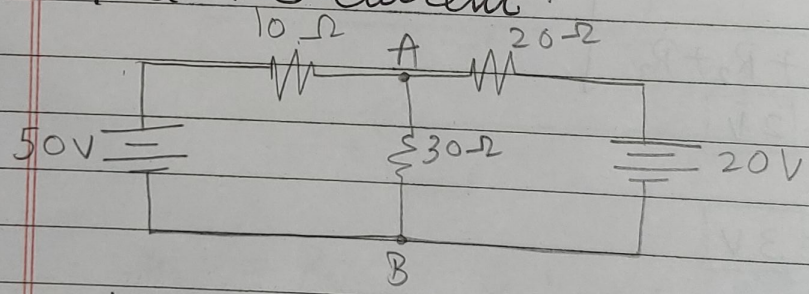
voltage Same = Short circuit
Current Source = open circuit
If we remove any source.

1). It is based on current division rule.

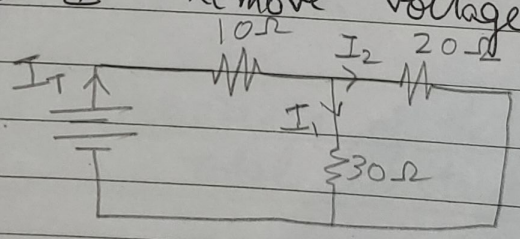
$$I = I_T \left[\frac{\text{Resistance of opposite branch}}{\text{Res of opp + Resis of same.}} \right]$$

2). voltage Source replace by short circuit & current source is replaced by open circuit

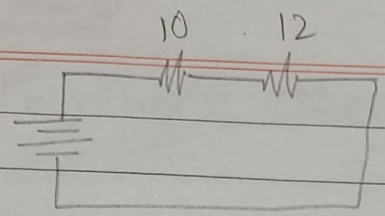
Q→ Find AB current.

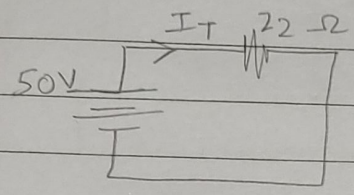


Step → I Remove voltage source 2.



$$\frac{20 \times 30}{20 + 30} = 12\,\Omega$$





$$I_T = \frac{V}{R} = \frac{50}{22} = \boxed{2.27\,A}$$

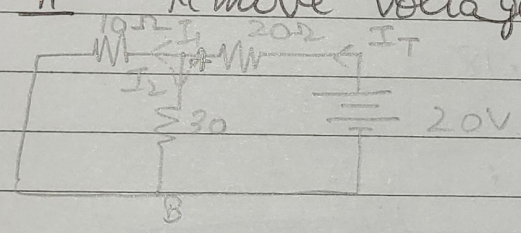
Using Current Division Rule.

$$I_1 = I_T \left(\frac{R \text{ of } o/p}{R_{o/p} + R_{same}}\right)$$

$$I_1 = 2.27 \left(\frac{20}{30+20}\right)$$

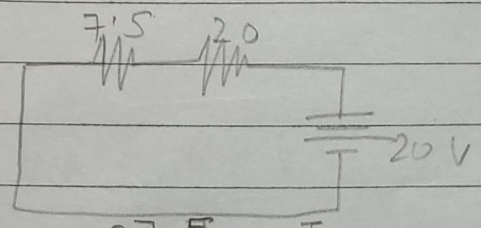
$$\boxed{I_1 = 0.908\,A}$$

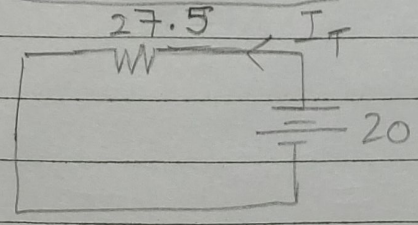
Step → II Remove Voltage Source 1.



$I_T = ?$

$$= \frac{10 \times 30}{10 + 30} = \frac{300}{40} = \boxed{7.5\,\Omega}$$





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

$$= \frac{20}{27.5}$$

$$\boxed{I_T = 0.72\,A}$$

Using CDR

$$I_3 = I_T \left(\frac{R_{opp}}{R_{opp} + R_{same}} \right)$$

$$I_3 = 0.72 \left(\frac{10}{10+30} \right)$$

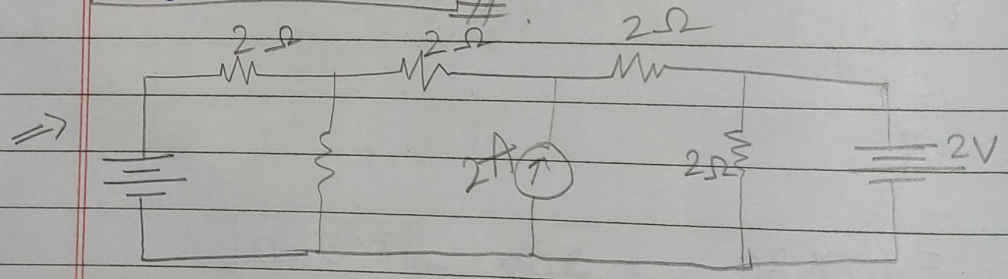
$$\boxed{I_3 = 0.189\,A}$$

Step - III.

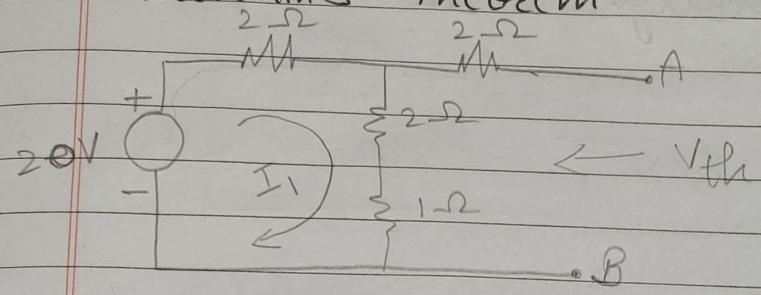
$$I_{AB} = I_1 + I_3$$

$$= 0.908 + 0.18$$

$$\boxed{I_{AB} = 1.089\,A}$$



Thevenin's Theorem.



Across AB.

Open + KVL + Vth + Rth

Step - 1 → Already Done

Step - 2 → Apply KVL

$$KVL \Rightarrow \Sigma V + IR = 0$$

$$20 + (-)I_1(2) - I_1(2) - I_1(1) = 0$$

$$20 + (-2I_1) - 2I_1 - I_1 = 0$$

$$20 - 5I_1 = 0$$

$$-5I_1 = -20$$

$$I_1 = 4A$$

$$\boxed{I_{th} = 4A}$$

Step - 3 Find Vth

$$V_{th} = I_{th} R_{th}$$

$$\boxed{V_{th} = 4(R_{th})}$$

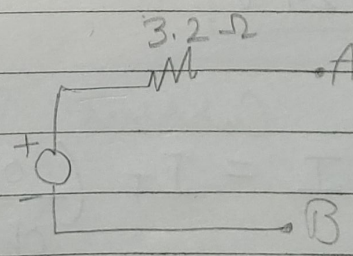
Step - 4 Find Rth

$$\frac{2 \times 3}{3+2} = \frac{6}{5} = \boxed{1.2\ \Omega} \longrightarrow 1.2 + 2\ \Omega$$

Series

⇓

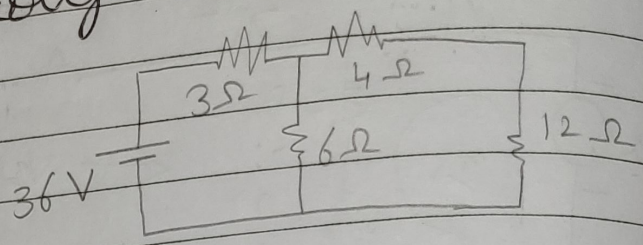
$3.2\ \Omega$



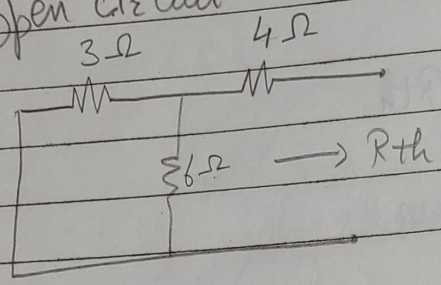
$$V_{th} = 4 \times 3.2\ \Omega$$

$$= \boxed{12.8\ V}$$

Q→ Find I through 12 Ω R of circuit.



Open circuit

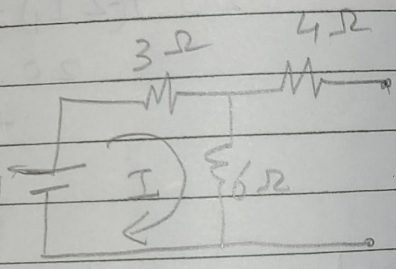


$3 \| 6 = \frac{3 \times 6}{3+6}$

$\Rightarrow \frac{18}{9} = 2$

2 and 4 Ω is series

$R_{th} = 2 + 4 \Rightarrow \boxed{6\ \Omega}$



→ Find Vth

$36 - 3(I_1) - 6I_1 = 0$

$36 - 9I_1 = 0$

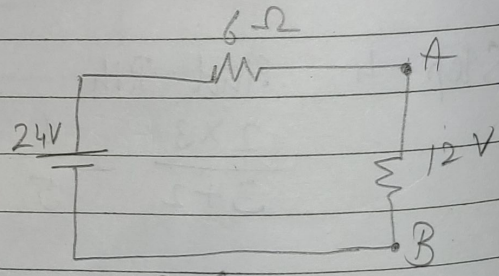
$36 = 9I_1$

$\boxed{4A = I_{th}}$

$V_{th} = I_{th} R_{th}$

$= 4 \times 6$

$\boxed{V_{th} = 24\ V}$

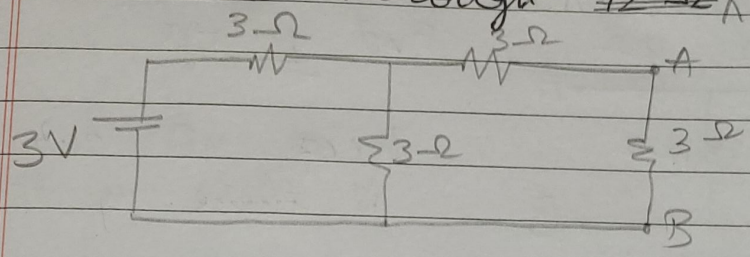


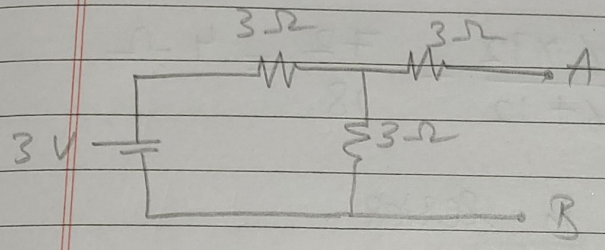
Current Division Rule.

$I = I_T \left(\frac{\text{opp } R}{\text{opp} + \text{same}} \right)$

$I = \frac{V}{R} = \frac{24}{6+12} = \boxed{1.33\ A}$

Q→ Find I through ~~12 Ω~~ AB terminal R of circuit.





$$3 \parallel 3 = \frac{3 \times 3}{3+3} = \frac{9}{6}$$

$$= \frac{3}{2} = 1.5$$

1.5 Ω and 3 Ω in series

$$R_{th} = 1.5 + 3 = \boxed{4.5\ \Omega}$$

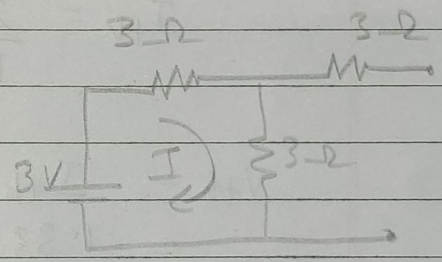
Find V_{th}

$$3 - 3(I_1) - 3I_1 = 0$$

$$3 - 6I_1 = 0$$

$$3 = 6I_1$$

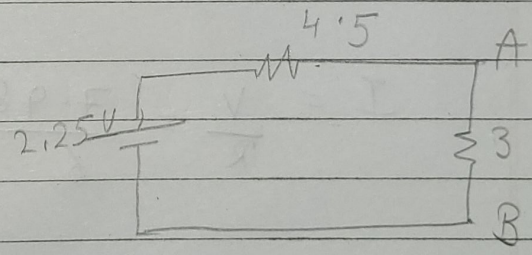
$$\frac{1}{2} = \boxed{0.5\ A = I_{th}}$$



$$V_{th} = I_{th} R_{th}$$

$$= 0.5 \times 4.5$$

$$= \boxed{2.25\ V}$$



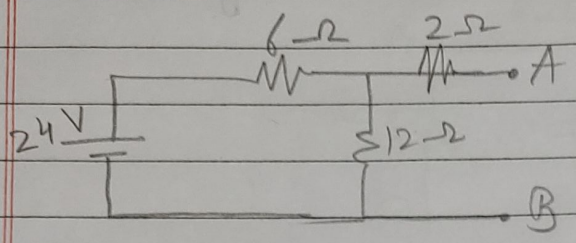
C.D.R.

$$I = I_T \left(\frac{\text{opp } R}{\text{opp} + \text{same}}\right)$$

$$I = \frac{V}{R} = \frac{2.25}{4.5+3} = \frac{2.25}{7.5} = \boxed{0.3\ A}$$

Date / /
Page No.

Q→ Find I across AB.



Find voltage

becoz no current is there in AB terminal.

$$6 \parallel 12 = \frac{6 \times 12}{6+12} = \frac{72}{18} = 4\,\Omega$$

4 Ω and 2 Ω in series

$$R_{th} = 4+2 = \boxed{6\,\Omega}$$

V_{th}

$$\Rightarrow 24\,V - 6(I_1) - 12(I_1) = 0$$

$$24 = 18\,I_1$$

$$I_{th} = \frac{24}{18} = \boxed{1.33A}$$

$$V_{th} = I_{th} \times R_{th}$$

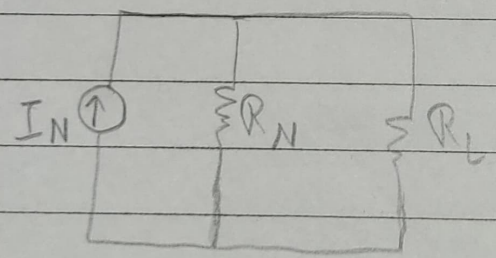
$$= 1.33 \times 6$$

$$\boxed{V_{th} = 7.98\,V}$$

$$I = \frac{V}{R} = \frac{7.98}{6} = \boxed{1.33A}$$

Norton's Theorem

According to Norton's theorem any linear bilateral network irrespective of its complexity can be reduced into a Norton's equivalent circuit having a Norton's short circuit 'I_N' in parallel with Norton's equivalent resistance R_N in parallel with load resistor R_L.



$$I_L = \frac{I_N R_N}{R_N + R_L}$$

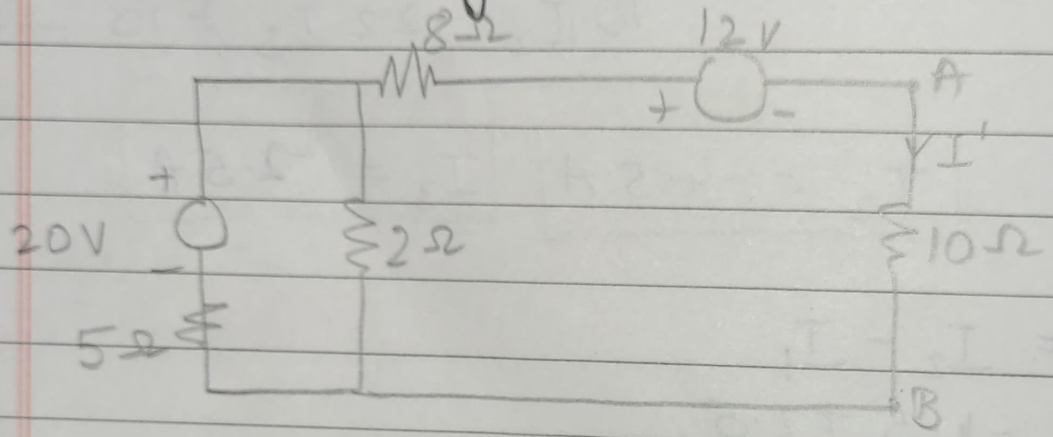
Date / /
Page No.

Steps for Solving Norton's Theorem:-

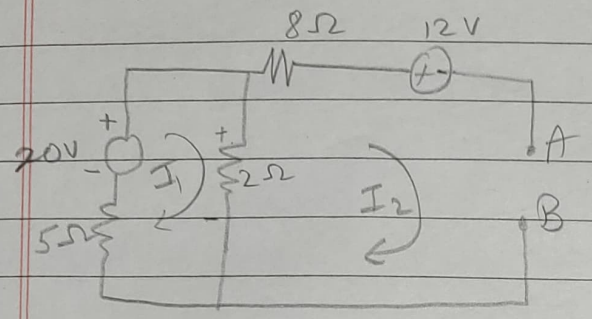
1. Identify the load resistor R_L.
2. Replace R_L with short circuit branch.
3. The current flowing through this short circuit branch will be the Norton's current I_N.
4. Remove R_L and replace all the active source by their internal resistance.
5. The equivalent resistance across the two open ends will be the Norton's resistance R_N.
6. Draw the Norton's equivalent circuit.
7. Calculate I_L using the identity.

$$\boxed{I_L = \frac{I_N R_N}{R_N + R_L}}$$

Q→ Find I' using Norton's Theorem.



$R_L = 10\,\Omega$



Apply KVL in mesh-1

$$-20V = -2(I_1 - I_2) - 5I_1$$

$$-20V = -7I_1 + 2I_2 \rightarrow (1)$$

Applying KVL in mesh-2

$$-12V = 8I_2 + 2(I_2 - I_1)$$

$$-12V = 8I_2 + 2I_2 - 2I_1$$

$$-12V = 10I_2 - 2I_1 \rightarrow (2)$$

Solving (1), (2).

$$\cancel{-86I_2 = 124\,V}$$

$$\cancel{I_2 = -1.87\,A}$$

$$-66I_2 = 44$$

$$\boxed{I_2 = 0.66\,A}$$

$$\cancel{-7I_1 = -12 - 18.7}$$

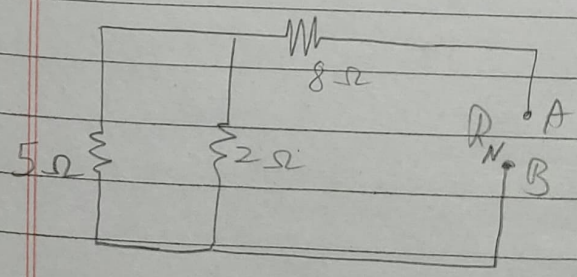
$$\cancel{I_1 = -\frac{52}{2} = 26\,A}$$

$$-7I_1 + 2I_2 = -20V$$

$$-7I_1 = -20 - 1.32$$

$$\boxed{I_1 = 3.04A}$$

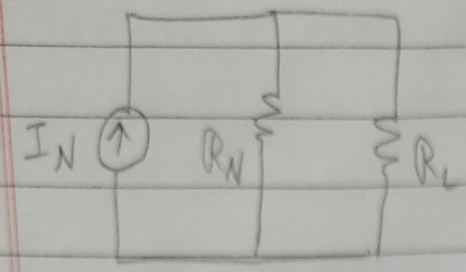
$$\boxed{I_N = I_2 = 0.66\,A}$$



$5 \| 2$

$$\Rightarrow \frac{5 \times 2}{5+2} = \frac{10}{7}$$

$$R_N = 1.42 + 8 = \boxed{9.42\,\Omega}$$



$$I_L = \frac{I_N R_N}{R_N + R_L}$$

$$I_L = \frac{0.66\,(9.42)}{9.42 + 10}$$

$$I_L = \frac{6.2172}{19.42} = \boxed{0.320\ A}$$

→ Resistance ⇒ $R = \rho \frac{l}{a}$

⇒ Laws of Resistance

1. $R \propto l$ → Directly proportional to length
2. $R \propto \frac{1}{a}$ Inversely proportional to area.
3. Resistance of wire depends upon nature of material of wire is made.
4. It also depends upon temperature of wire.

→ Resistivity (ρ) ⇒

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

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

$$\rho = \frac{ohm \times m^2}{m^1} \Rightarrow \boxed{ohm.m}$$

The resistance offered by one metre length of wire of given material having an area of cross-section of one square metre is called 'resistivity'.

* It depends upon nature of material used in wire.

→ Conductance ⇒ The ease to the flow of current. It is the reciprocal of resistance.

$$G = \frac{1}{R} = \frac{1 \times a}{\rho l} = \boxed{\frac{\sigma a}{l}}$$

Unit ⇒ mho ($\mho$)

→ Conductivity = Property/ Nature of material due to which it allows current to flow through it.

$$\sigma = G\frac{l}{a}$$

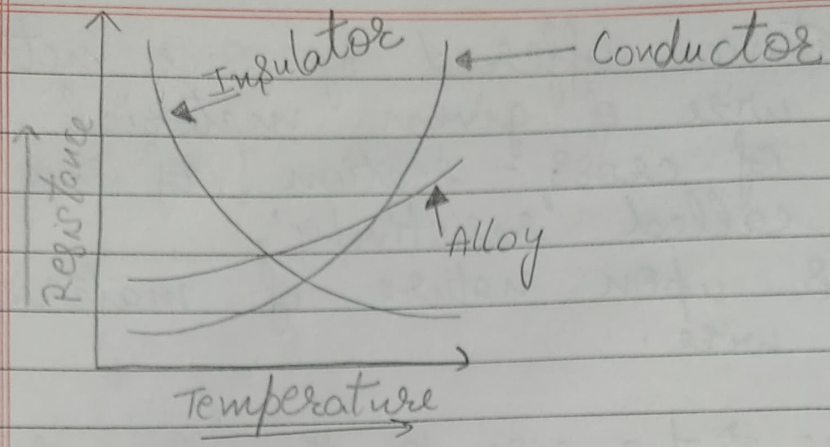
$$\sigma = \frac{\text{mho} \times m}{m^2} = \boxed{\text{mho}/m}$$

⇒ Effect of Temperature On Resistance.

(i) Pure Metals ⇒ Resistance increases with increase in temperature.
Pure metals have positive temperature co-efficient of resistance.

(ii) Alloys ⇒ Resistance increases with increase in temperature But the increase is very small and irregular.

(iii) Semiconductors / Insulators ⇒ Resistance decreases with increase in temperature. The decrease is non uniform.



⇒ Temperature Co-efficient Of Resistance

Change in electrical resistance of a substance with respect to per degree change in temperature.

Relation Between Temperature and Resistances.

Let us consider a conductor; whose Resistance

at $0°C \rightarrow R_0$

at $T°C \rightarrow R_T$

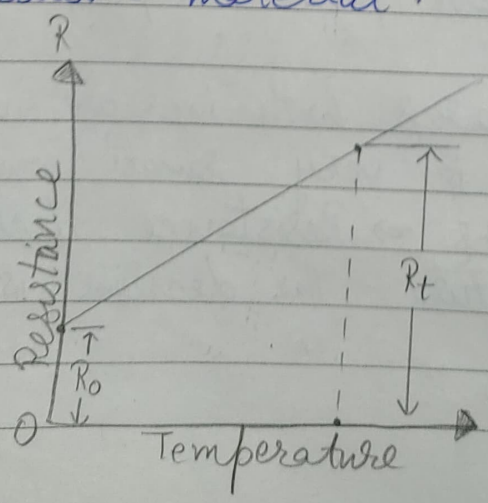
Relation;

$$R_T = R_0 [1 + \alpha (T - T_0)]$$

$$R_T = R_0 [1 + \alpha (\Delta T)]$$

$\alpha \rightarrow$ Constant ⇒ Temperature co-efficient of resistance at $0°C$.

Its value depend upon the nature of resistor material.



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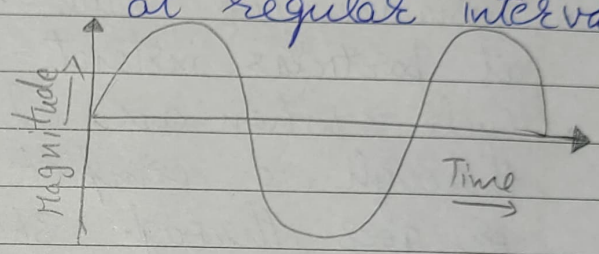
Unit → 2

AC Circuits

Alternating Voltage — A voltage that varies in both magnitude and polarity with respect to time.

Current — A type of electrical current; in which direction of flow of è switches back and forth at regular intervals.

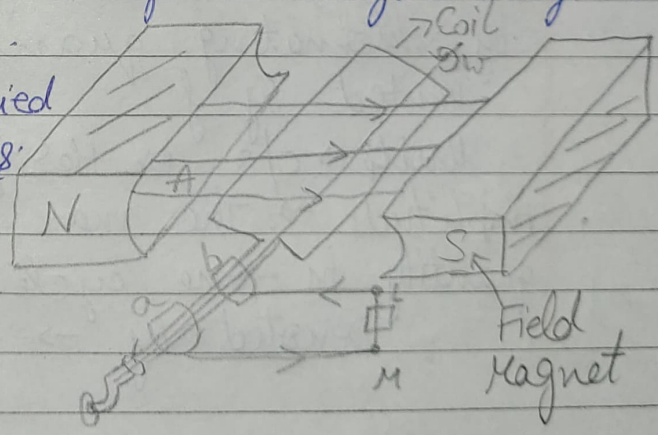


→ Generation Of Alternating Voltage and Current.

An Alternating voltage can be generated either by;

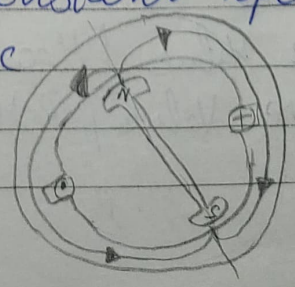
(i) Rotating a coil in uniform magnetic field at constant speed.

It is generally applied in small a.c. generators.



(ii) by rotating a uniform magnetic field within a stationary coil at constant speed.

It is applied in large a.c generators.



In both the cases; magnetic field is cut by conductors and emf is induced in them.

Important Terms :-

- Wave form → The shape of curve obtained by plotting instantaneous values of alternating quantity (voltage or current) along y-axis and time or angle ($\theta = \omega t$) along x-axis.
- Instantaneous Value (e/i) → The value of an alternating at particular instant of time in the cycle.
- Cycle → When an alternating quantity goes through a complete set of +ve and -ve values or goes through 360 electrical degrees; it is said to have completed one cycle.
- Alternation → One half cycle.
  180 Electrical Degrees.
- Time Period (T) → The time taken in sec to complete one cycle by alternating quantity.
- Frequency → Number of cycles made per sec by alternating quantity.
  Denoted by f
  Units → c/s or Hertz (Hz).
- Amplitude → The max value attained by alternating quantity in one cycle.
  Denoted by → E_m (V_m) → Max value of voltage
  I_m → Max value of current.

(Peak value / Max value)

⇒ Values Of Alternating Voltage and Current

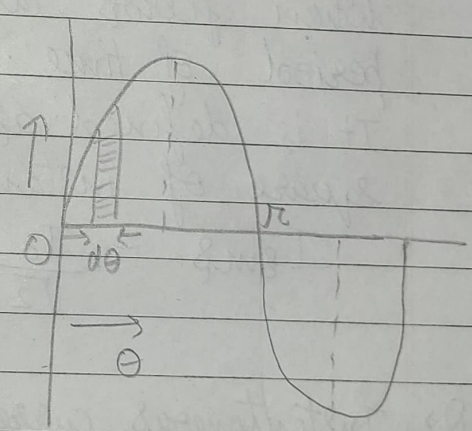
1. Peak Value
2. Average Value / Mean Value
3. Effective Value / R.M.S Value.

1. Peak Value -> The max value attained by alternating quantity during one cycle. This is also called max value / crest value / Amplitude.
A Sinusoidal Alternating quantity obtains max value at 90°.
Alternating voltage -> E_m
Alternating Current -> I_m
It is imp in case of testing dielectric strength of insulating materials.

2. Average Value -> The arithmetic average of all instantaneous values considered of an alternating quantity over one cycle.
Average Value over a complete cycle is zero.
-> Average Value Of Sinusoidal current.

$i = I_m \sin\theta$

$\theta = \omega t$; $I_m = I_0$



$I = I_0 \sin \omega t$

$I_{av} = \frac{I}{T} = \frac{q}{T}$

$dq = I \cdot dt$

$\int_0^{T/2} dq = \int_0^{T/2} I_0 \sin \omega t \, dt$

$q = I_0 \left[\frac{-\cos \omega t}{\omega} \right]_0^{T/2}$

$q = \frac{-I_0}{2\pi/T} \left[\cos \frac{2\pi t}{T} \right]_0^{T/2}$

$q = \frac{-I_0 T}{2\pi} \left[\cos \pi - \cos 0 \right]$

$q = \frac{-I_0 T}{2\pi} \left[-1 - 1 \right] = \frac{I_0 T}{\pi}$

Date / /
Page No.

$$I_{av} = \frac{q}{t}$$

$$= \frac{I_0 T}{\pi t} \qquad [t \to T/2]$$

$$\Rightarrow \frac{2 I_0 \cancel{T}}{\pi \cancel{T}}$$

$$I_{av} \Rightarrow \frac{2 I_0}{\pi}$$

$$\boxed{I_{av} = 0.637 I_0}$$

#

3. Effective /R.M.S Value → The steady current, which when flows through a resistor of known resistance for a given period of time than as a result the same quantity of heat is produced by alternating current when flows through same resistor for same period of time.

It is defined as square root of mean of square of instantaneous values.

$$I_{rms} = \frac{I_0}{\sqrt{2}} = \boxed{0.707 I_0}$$

#

Q→ Instantaneous current is given by;
$i = 20 \sin 314t$. Find rms and average value of a.c.

Sol→ $I = I_0 \sin \omega t$

$I_0 = 20A$

$\omega = 314$

$$I_{rms} \Rightarrow I_0 (0.707)$$
$$= 20 (0.707)$$
$$= 14.14A$$

$$I_{av} = 0.637 I_0$$
$$= 0.637 (20)$$
$$= 12.74 A$$

Date / /
Page No.

Q→ Equation is $I = 42.42 \sin 628t$
Determine.
(i) Max value (ii) Frequency (iii) RMS value (iv) Average value (v) Form Factor.

Sol→ $I = I_0 \sin \omega t$
$I = 42.42 \sin 628t$
$I_0 = 42.42\ A$
$\omega = 628$ rad/sec

(i) Max value $= I_0 = \boxed{42.42\ A}$

(ii) Frequency (f)
$\omega = 2\pi f$
$f = \frac{\omega}{2\pi} = \frac{628}{2 \times 3.14} \Rightarrow \boxed{314\ Hz}$

(iii) RMS value $\Rightarrow I_0 (0.707)$
$\Rightarrow 42.42 \times 0.707$
$\Rightarrow \boxed{29.99\ A}$

(iv) Average value $\Rightarrow 0.637\ I_0$
$\Rightarrow 0.637\ (42.42)$
$\Rightarrow \boxed{27.02\ A}$

(v) Form factor $\Rightarrow \frac{I_{rms}}{I_{av}}$
$\Rightarrow \frac{29.99}{27.02}$
$\Rightarrow \boxed{1.10}$ #

⇒ Formulas

- $I_{rms} = \frac{I_{max}}{\sqrt{2}} \Rightarrow 0.707\ I_{max}$
- Form Factor $= \frac{I_{rms}}{I_{avg}} \Big| \frac{E_{rms}}{E_{avg}}$
- Peak Factor $= \frac{I_{max}}{I_{rms}}$
- Average value $= \frac{2 I_0}{\pi} \Rightarrow 0.637\ I_0$
- Frequency $\Rightarrow \omega = 2\pi f$