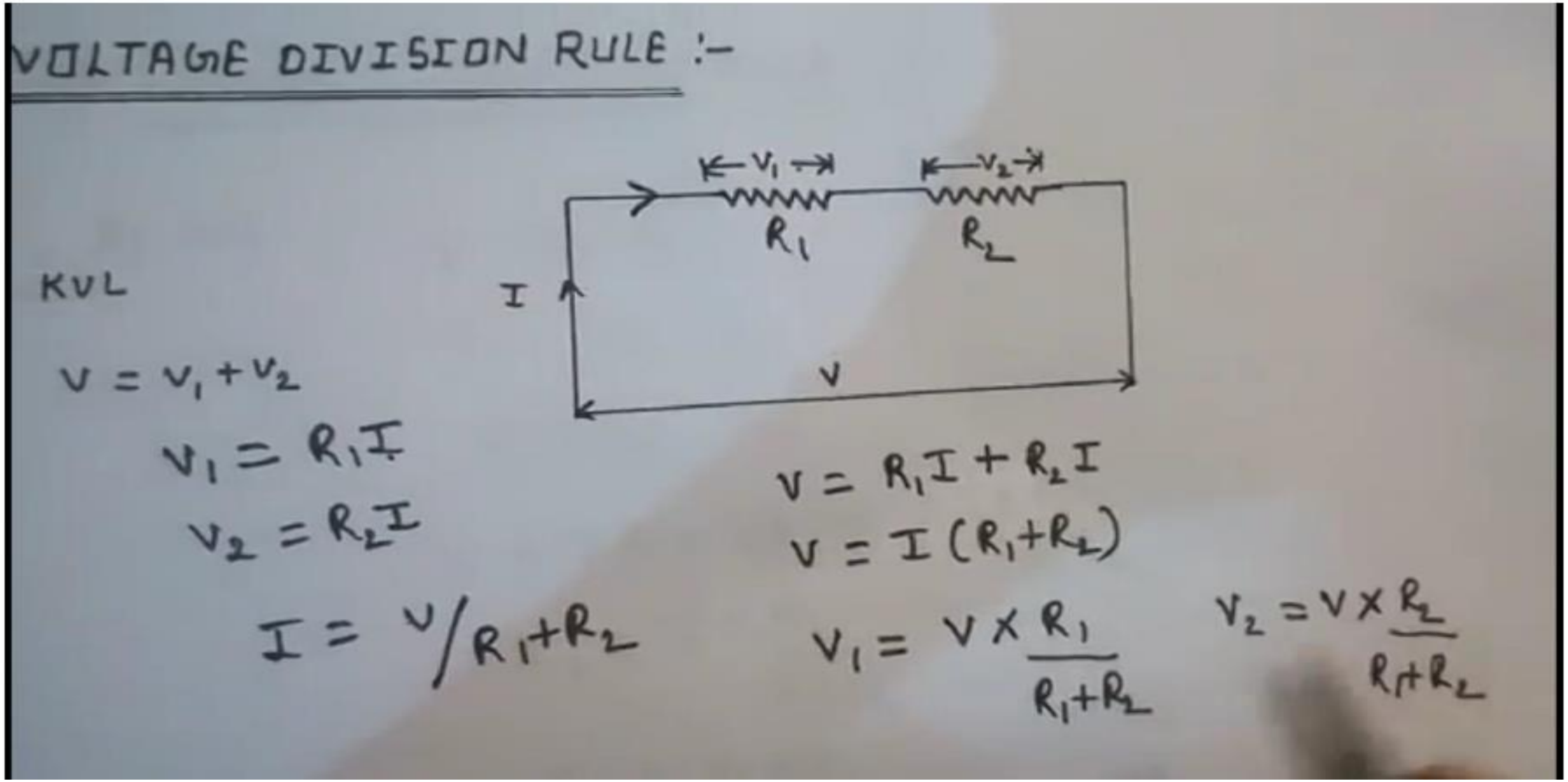
Voltage Division Rules

1. Voltage Division Rule

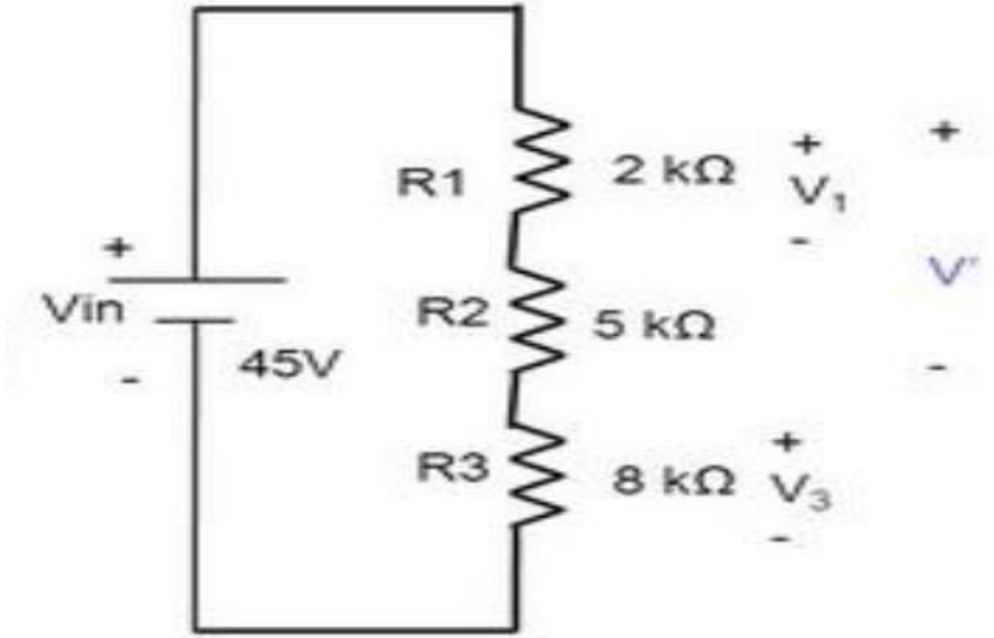
The **voltage** is divided between two series resistors in direct proportion to their resistance.



Voltage Division Rules

Voltage Divider Rule –Example 2

Using the voltage divider rule, determine the voltage V_1 and V_3 for the series circuit



Voltage Division Rules

Voltage Divider Rule –Example 2

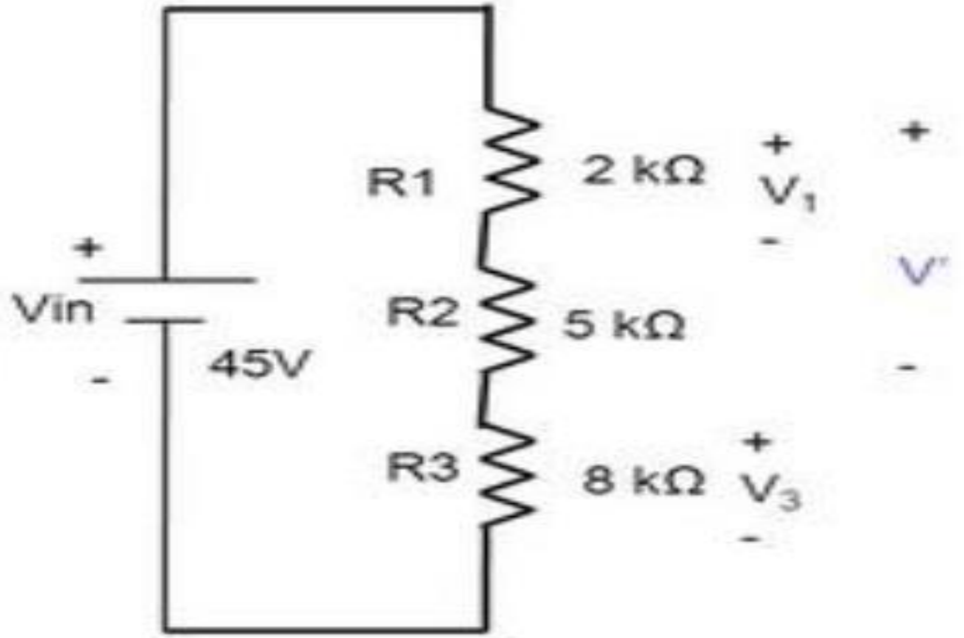
Using the voltage divider rule, determine the voltage V_1 and V_3 for the series circuit

$$V_1 = \frac{R_1 V_{in}}{R_T} = \frac{(2k\Omega)(45V)}{2k\Omega + 5k\Omega + 8k\Omega} = \frac{(2k\Omega)(45V)}{15k\Omega}$$

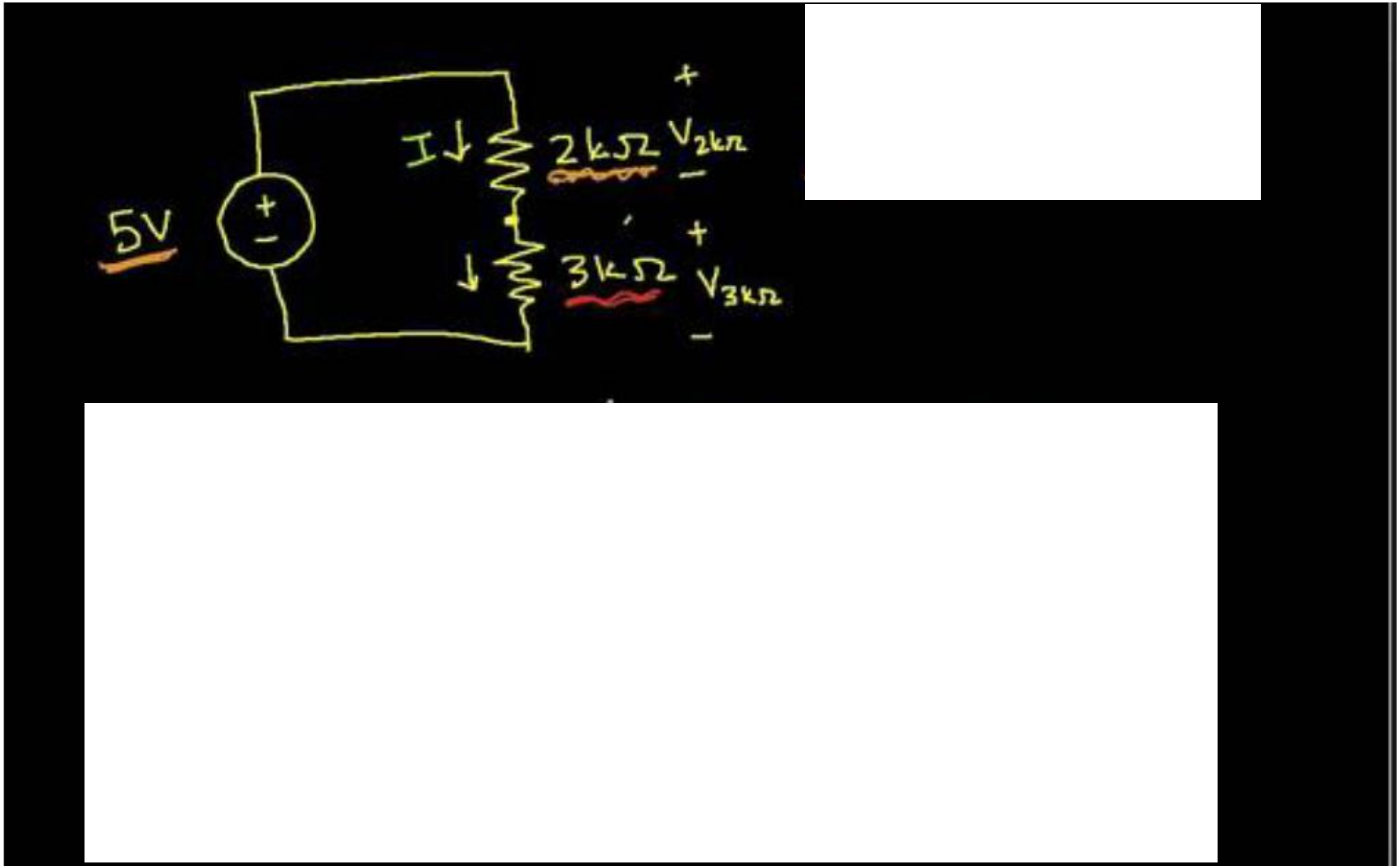
$$= \frac{(2\times 10^3\Omega)(45V)}{15\times 10^3\Omega} = \frac{90}{15} = 6V$$

$$V_3 = \frac{R_3 V_{in}}{R_T} = \frac{(8k\Omega)(45V)}{2k\Omega + 5k\Omega + 8k\Omega} = \frac{(8\times 10^3\Omega)(45V)}{15\times 10^3\Omega}$$

$$= \frac{360}{15} = 24V$$



Voltage Division Rules



Current Division Rule

Current division refers to the splitting of **current** between the branches .

parallel → V → same

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

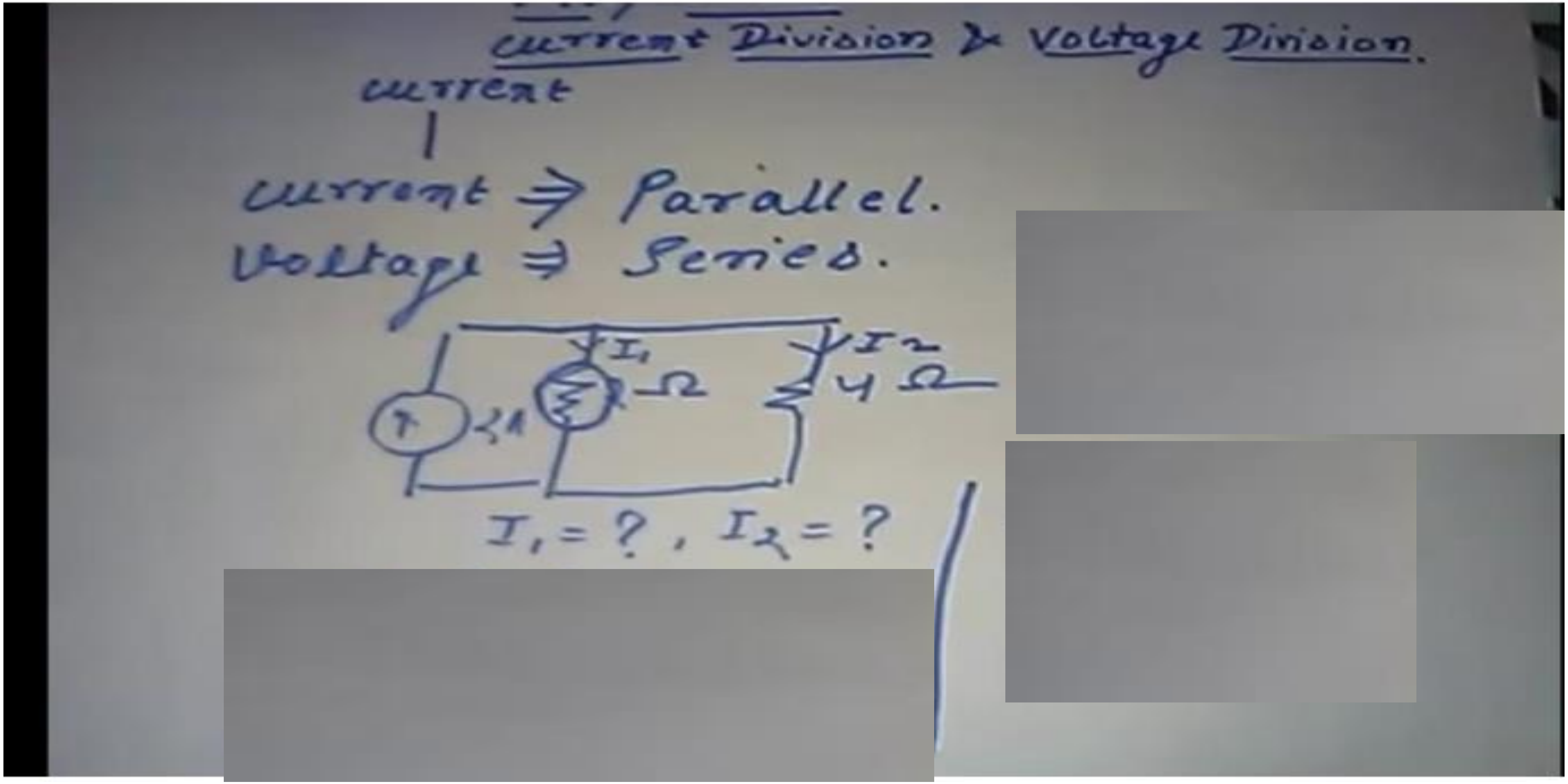
$$V = I R_{eq} \Rightarrow V = \frac{I R_1 R_2}{R_1 + R_2}$$

$$I_1 = \frac{V}{R_1} = \frac{I \cancel{R_1} R_2}{(R_1 + R_2)\cancel{R_1}} = \frac{I}{R_1 + R_2} R_2$$

$$I_2 = \frac{V}{R_2} = \frac{I}{R_1 + R_2} \cdot R_1$$

Current Division Rule

Examples-1



Current Division Rule

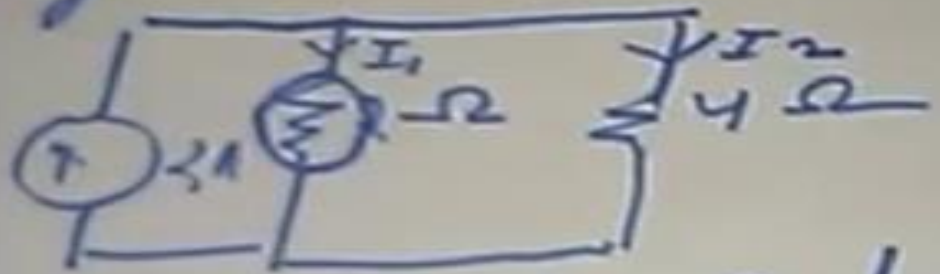
Examples-1

Current Division & Voltage Division.

current

current ⇒ Parallel.

Voltage ⇒ Series.



$I_1 = ?$, $I_2 = ?$

$$I_1 = \left(\frac{4}{2+4}\right) \times 2$$

$$I_1 = \frac{4}{6} \times 2 = \frac{4}{3}\ \text{Amp.}$$

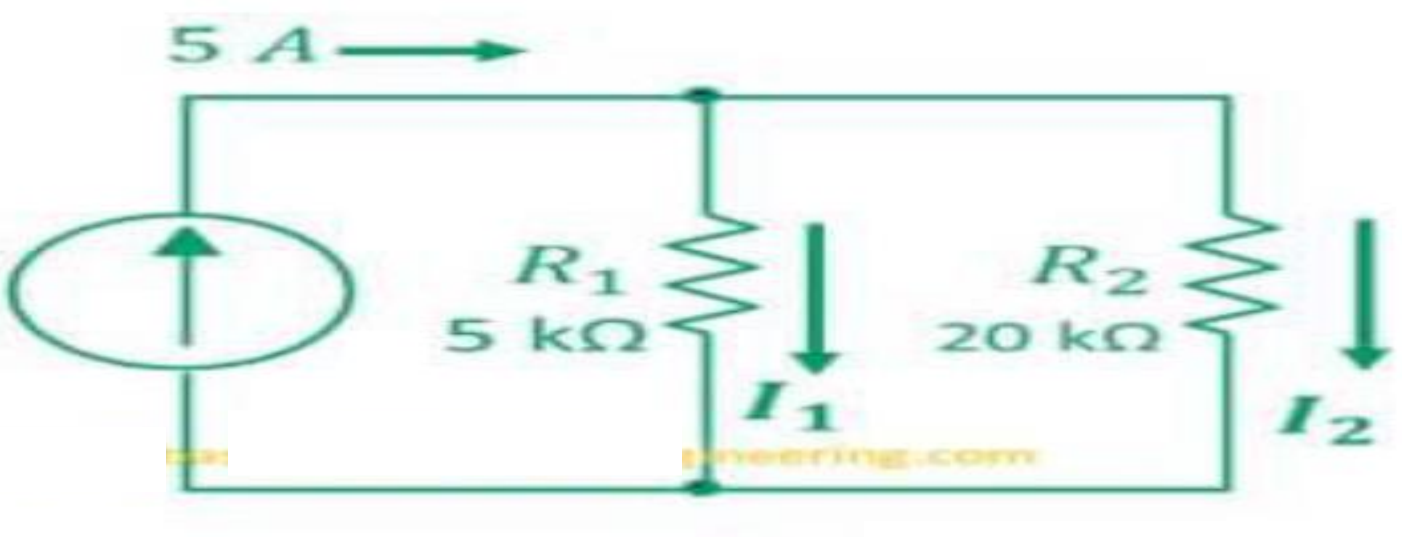
$$I = I_1 + I_2$$

$$= \frac{4}{3} + \frac{2}{3} = \frac{6}{3} = 2A$$

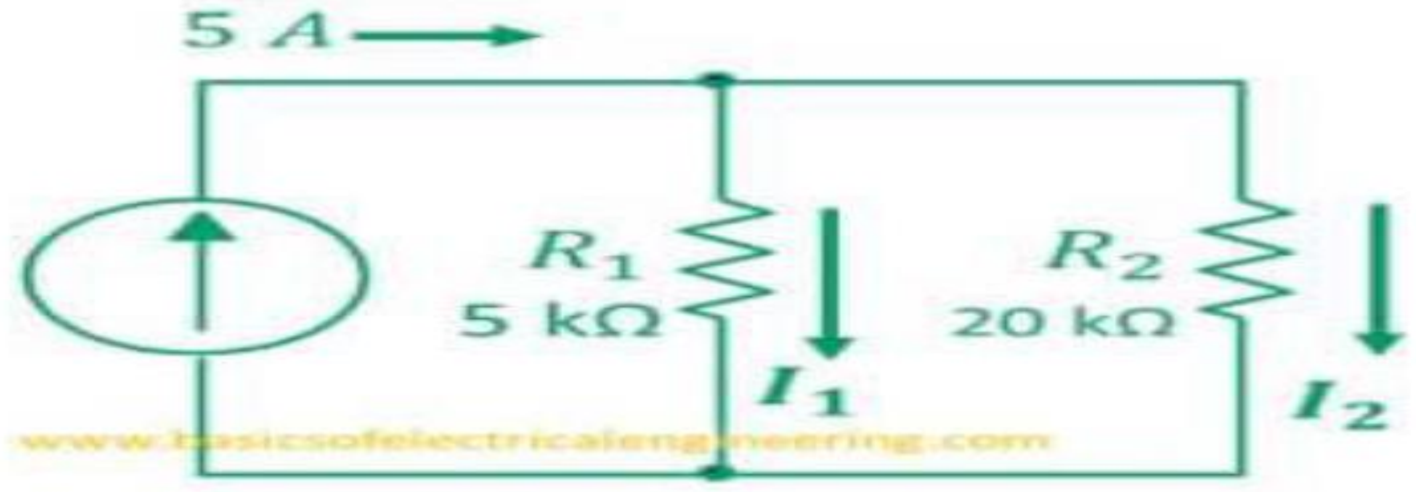
$$I_2 = \left(\frac{2}{6}\right) \times 2$$

$$I_2 = \frac{2}{3}$$

Current Division Rule



Current Division Rule



$$I_1 = \frac{R_2}{R_1 + R_2} * I_t$$

$$I_1 = \frac{20\ k\Omega}{25\ k\Omega} * 5\ A$$

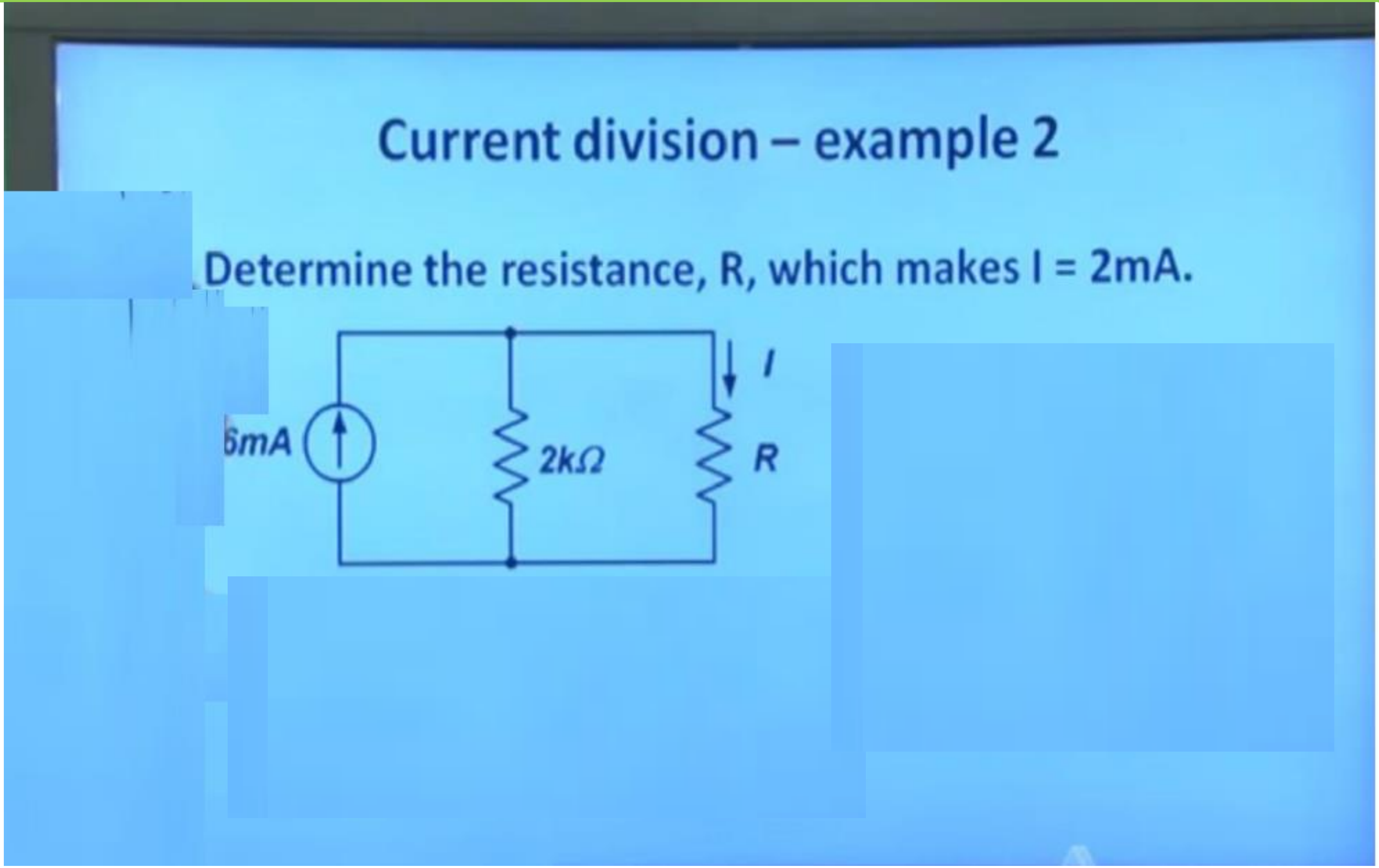
$$I_1 = 4\ A$$

$$I_2 = \frac{R_1}{R_1 + R_2} * I_t$$

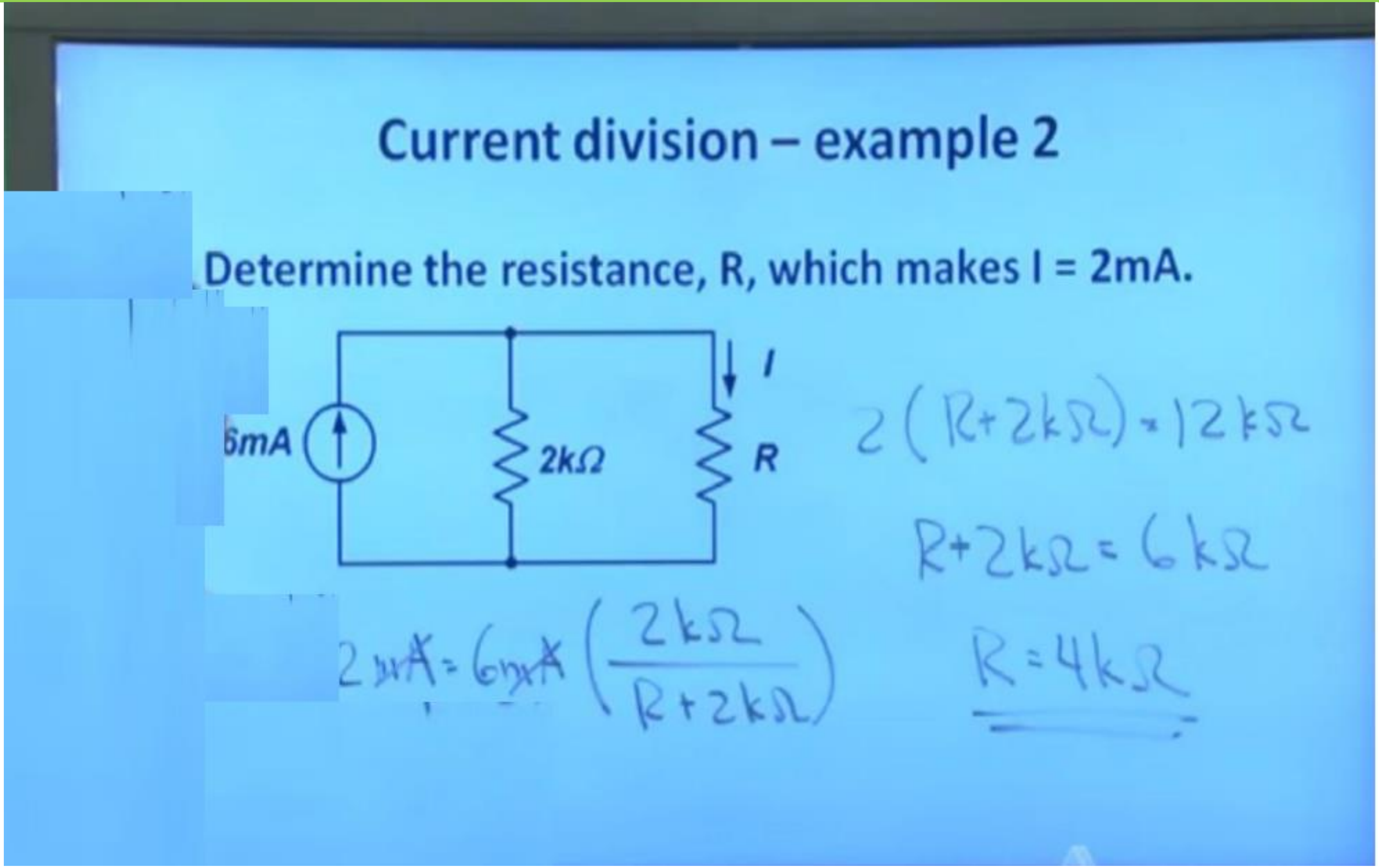
$$I_2 = \frac{5\ k\Omega}{25\ k\Omega} * 5\ A$$

$$I_2 = 1\ A$$

Current Division Rule

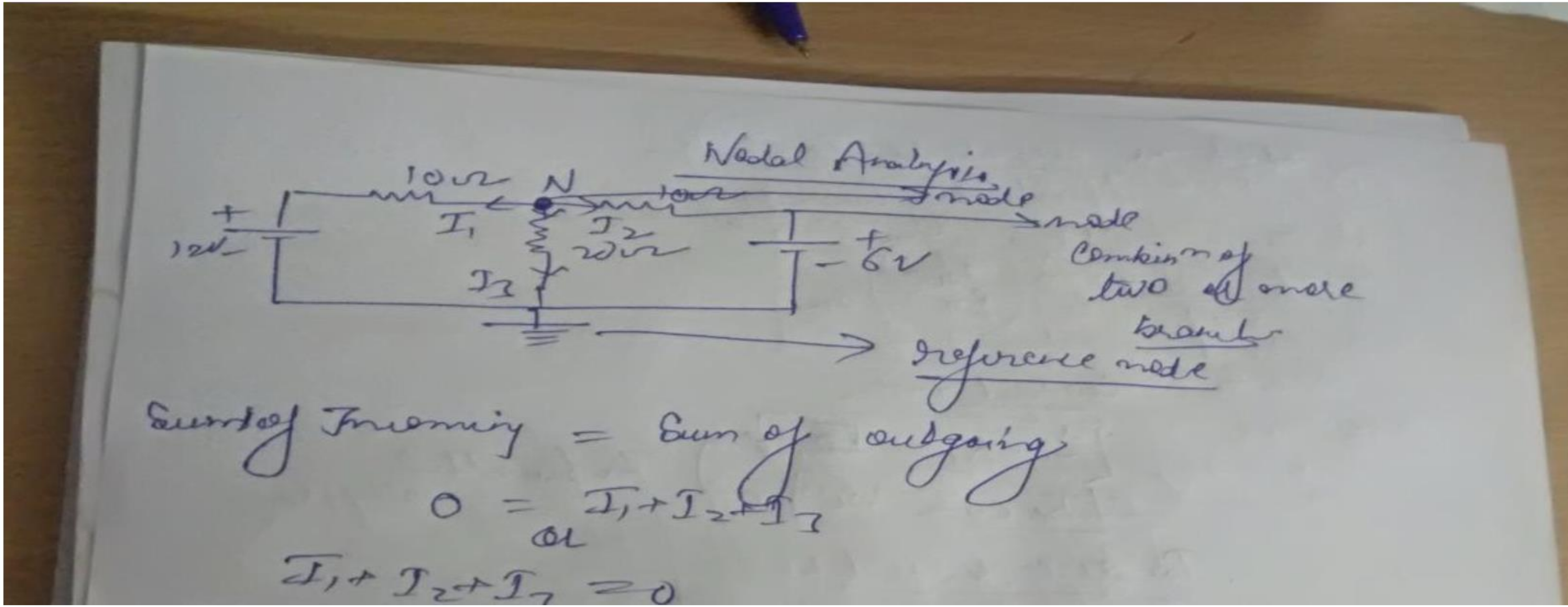


Current Division Rule



Nodal Analysis

Nodal analysis is a method that provides a general procedure for analyzing circuits using node voltages as the circuit variables. **Nodal Analysis** is also called the **Node-Voltage Method**.



Nodal Analysis

or

$I_1 + I_2 + I_3 = 0$

$$\boxed{\frac{N-12}{10} + \frac{N-0}{20} + \frac{N-6}{10} = 0}$$

$$\frac{2N-24+N+2N-12}{20} = 0$$

$$\boxed{5N-36=0}$$

$$\boxed{N = \frac{36}{5} \Rightarrow 7.2V}$$

$$I_1 = \frac{N-12}{10} \Rightarrow \frac{7.2-12}{10} \Rightarrow \frac{-4.8}{10} \Rightarrow -.48$$

$-.48$

or

$.48$

$$I_2 = \frac{N}{20} \Rightarrow \frac{7.2}{20} \Rightarrow .36A$$

$$I_3 = \frac{N-6}{10} \Rightarrow \frac{7.2-6}{10} \Rightarrow \frac{1.2}{10} \Rightarrow .12A$$

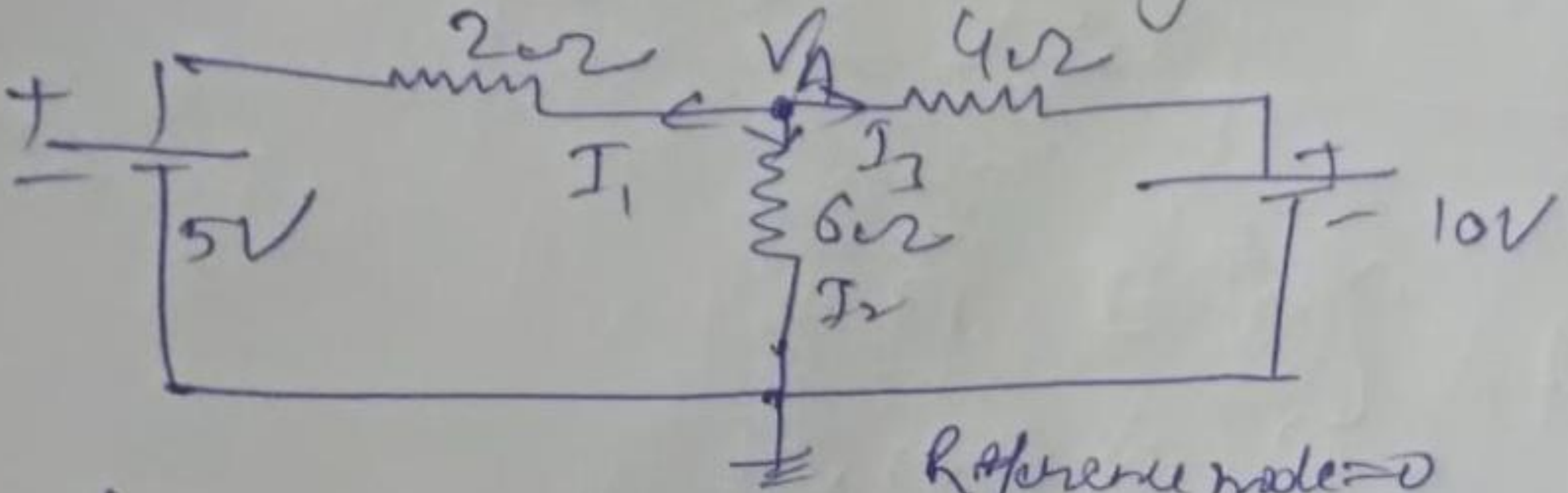
Nodal Analysis

2

~~Nodal Voltage Analysis~~

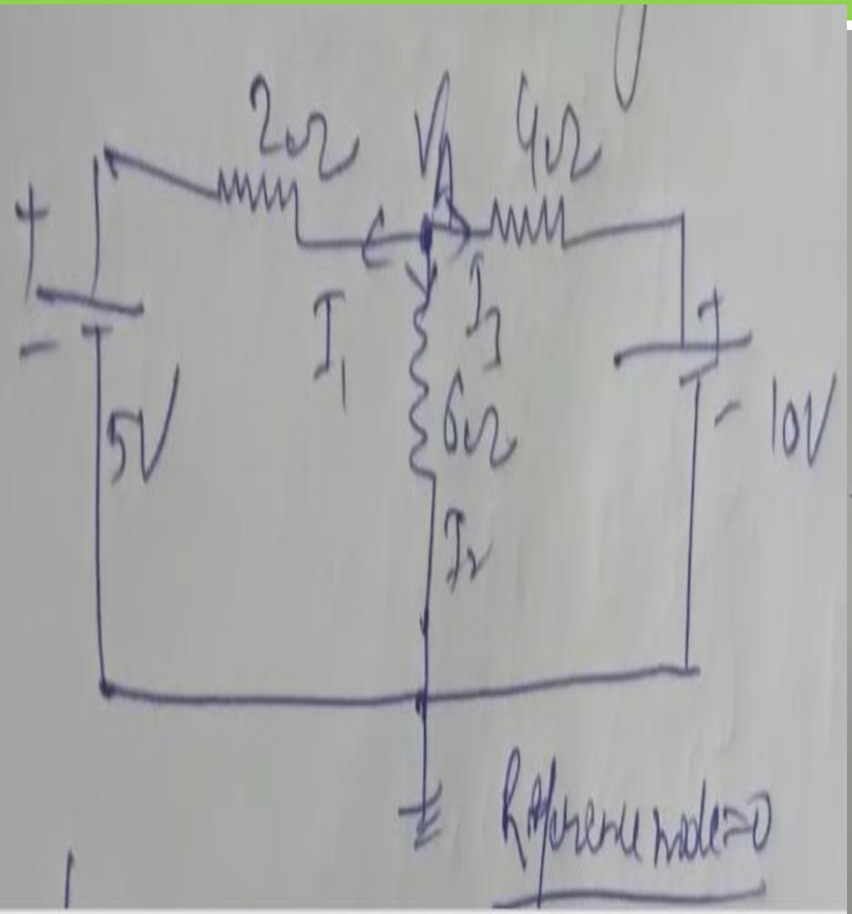
Nodal Analysis

Nodal Voltage



Reference node = 0

Nodal Analysis



(outgoing)

$$I_1 + I_2 + I_3 = 0 \quad \{\text{Incoming}\}$$

$$\frac{V_A - 5}{2} + \frac{V_A}{6} + \frac{V_A - 10}{4} = 0$$

$$\frac{6V_A - 30 + 2V_A + 3V_A - 30}{12} = 0$$

$$11V_A - 60 = 0$$

$$\boxed{V_A = \frac{60}{11}} \Rightarrow 5.45$$

$$I_1 = \frac{\frac{60}{11} - 5}{2} \Rightarrow \frac{.45}{2} \Rightarrow .2272A$$

$$.9090$$

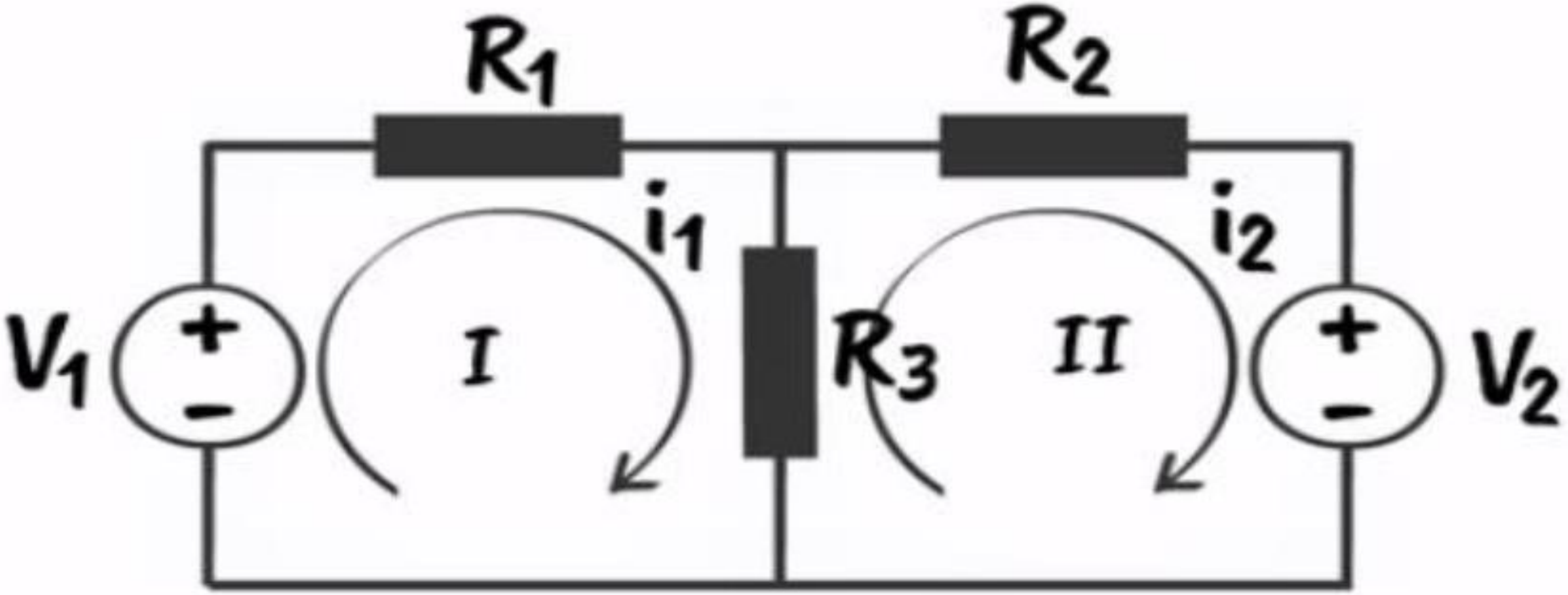
$$I_2 = \frac{60}{11 \times 6} \Rightarrow$$

$$I_3 = \frac{\frac{60}{11} - 10}{4} \Rightarrow \frac{5.45 - 10}{4} \Rightarrow \frac{-4.55}{4} \Rightarrow -1.13$$

so 1.13

Mesh Analysis

Mesh analysis is a method that is used to solve circuits for the currents at any place in the electrical circuit.

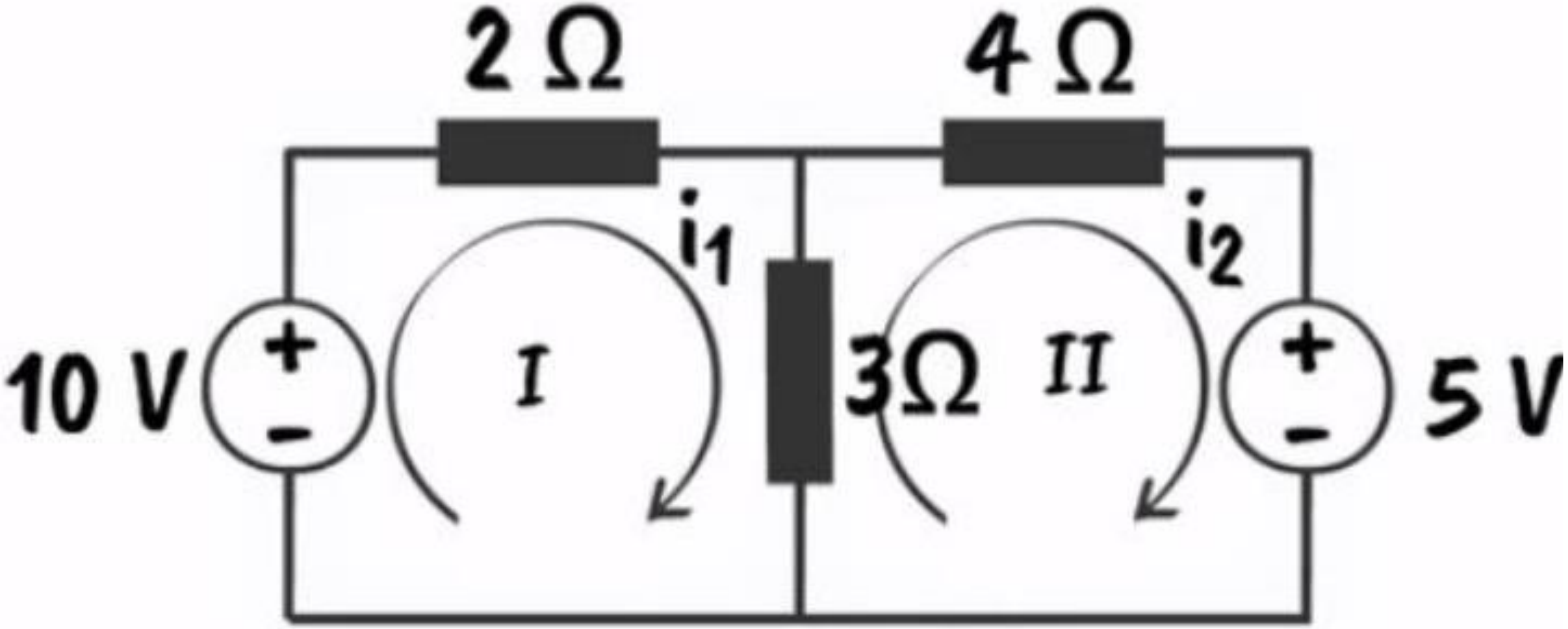


KVL

$$V_1 - i_1R_1 - (i_1 - i_2)R_3 = 0 \text{ ---(1)}$$

$$-(i_2 - i_1)R_3 - i_2R_2 - V_2 = 0 \text{ ---(2)}$$

Mesh Analysis

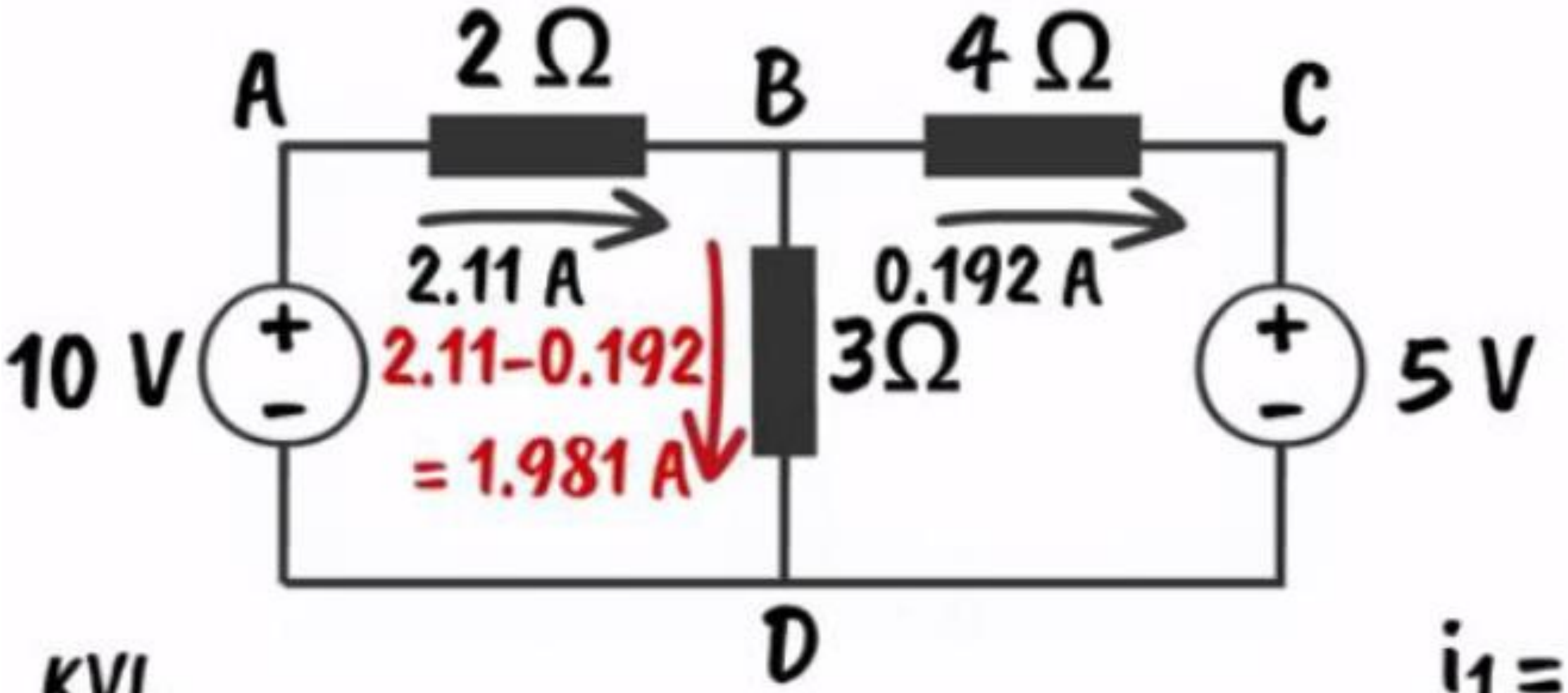


KVL

$$10 - i_1 2 - (i_1 - i_2)\,3 = 0 \text{ ---(3)}$$

$$-(i_2 - i_1)\,3 - i_2 4 - 5 = 0 \text{ ---(4)}$$

Mesh Analysis



KVL

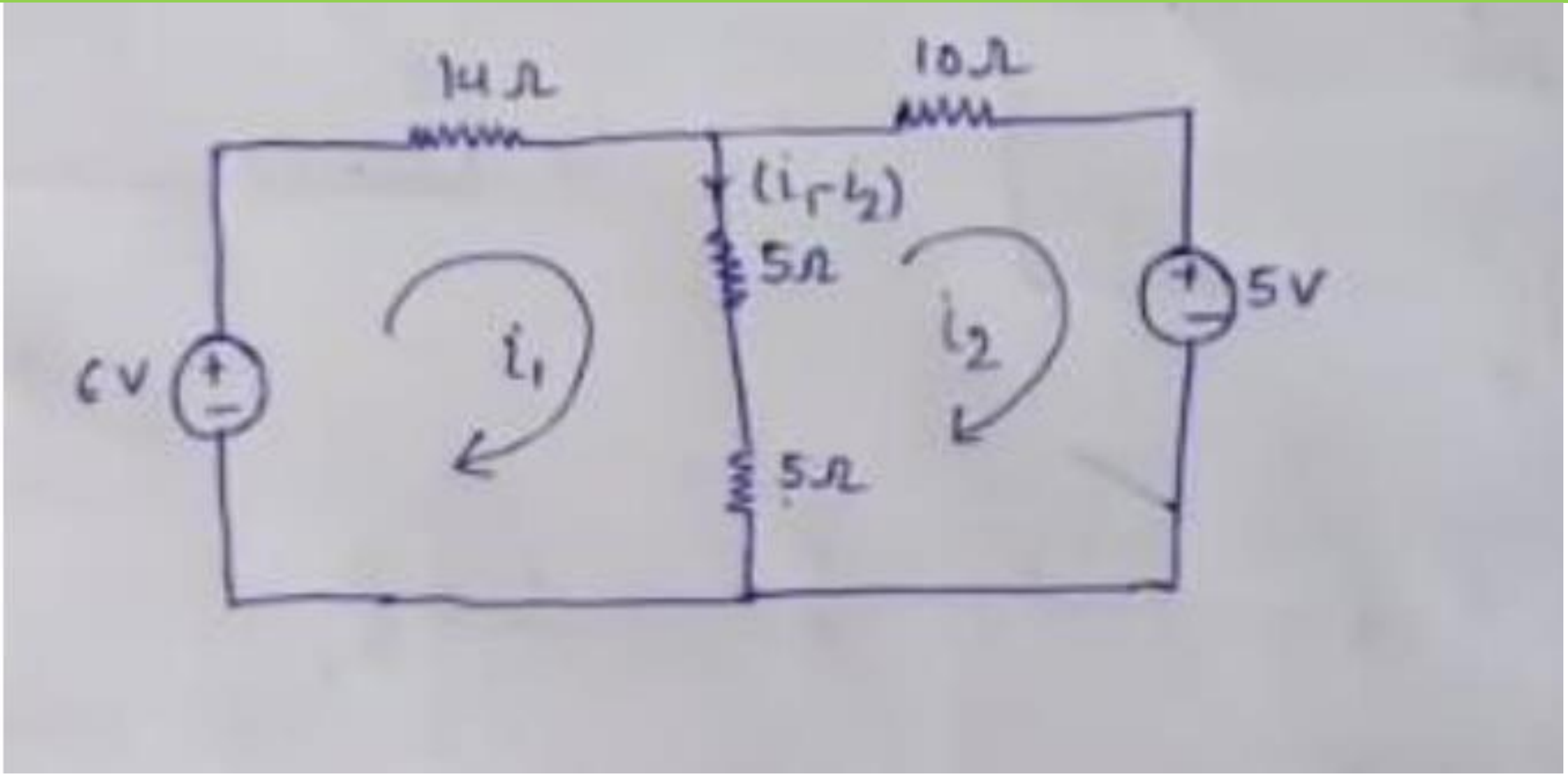
$$10 - i_1 2 - (i_1 - i_2)\,3 = 0 \text{ ---(3)}$$

$$-(i_2 - i_1)\,3 - i_2 4 - 5 = 0 \text{ ---(4)}$$

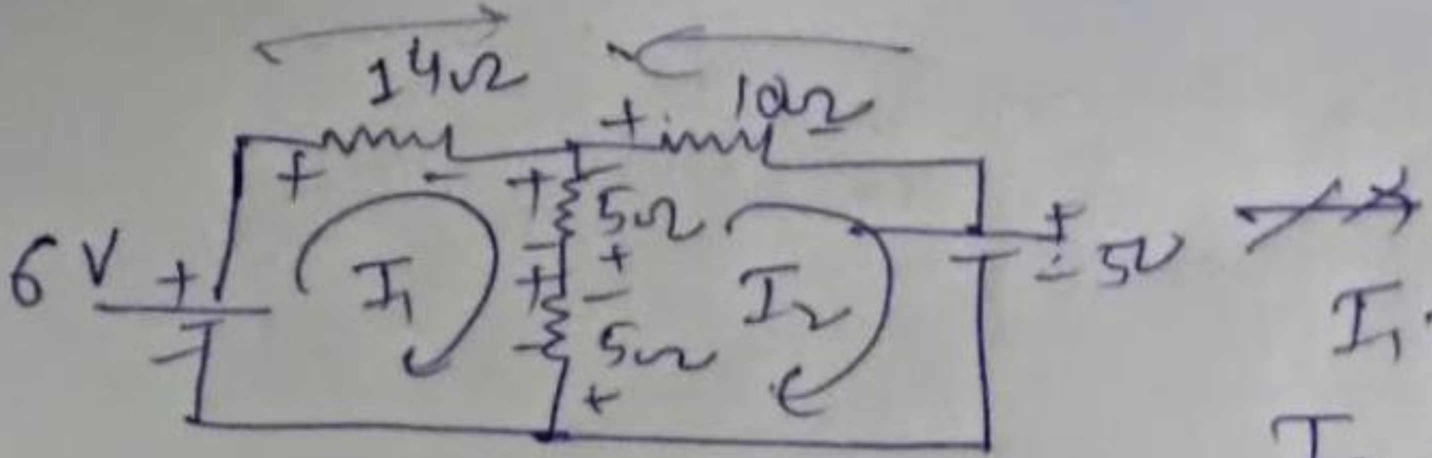
$i_1 = 2.11$ A

$i_2 = 0.192$ A

Mesh Analysis



Mesh Analysis



$$+6 - 14I_1 - 5(I_1 - I_2) - 5(I_1 - I_2) = 0$$

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

$I_1 = 184.2\text{ mA}$

$I_2 = -157.89\text{ mA}$

$I_2 = 157.89\text{ mA} \leftarrow$

$I_1 + I_2 \Rightarrow 341.79\text{ mA}$

Mesh Analysis

$6 - 14I_1 - 5I_1 + 5I_2 - 5I_1 + 5I_2 = 0$

$6 - 24I_1 + 10I_2 = 0$

$-24I_1 + 10I_2 = -6 \Rightarrow \boxed{24I_1 - 10I_2 = 6}$

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

$-20I_2 + 10I_1 = 5$

$\boxed{-4I_2 + 2I_1 = 1}$

$12 \times \boxed{2I_1 - 4I_2 = 1}$

$24I_1 - 48I_2 = 12$ — 1

$24I_1 - 10I_2 = 6$

$-38I_2 = \cancel{18}\ 6$

$\boxed{I_2 = \frac{-6}{38}} \Rightarrow -0.1578A$

$I_2 \Rightarrow -.15789A$

$24I_1 - 10 \times \frac{-6}{38} = 6$

$24I_1 = 6 + \frac{60}{38}$

$24I_1 = 6 - 1.578$

$I_1 = 0.1842A$

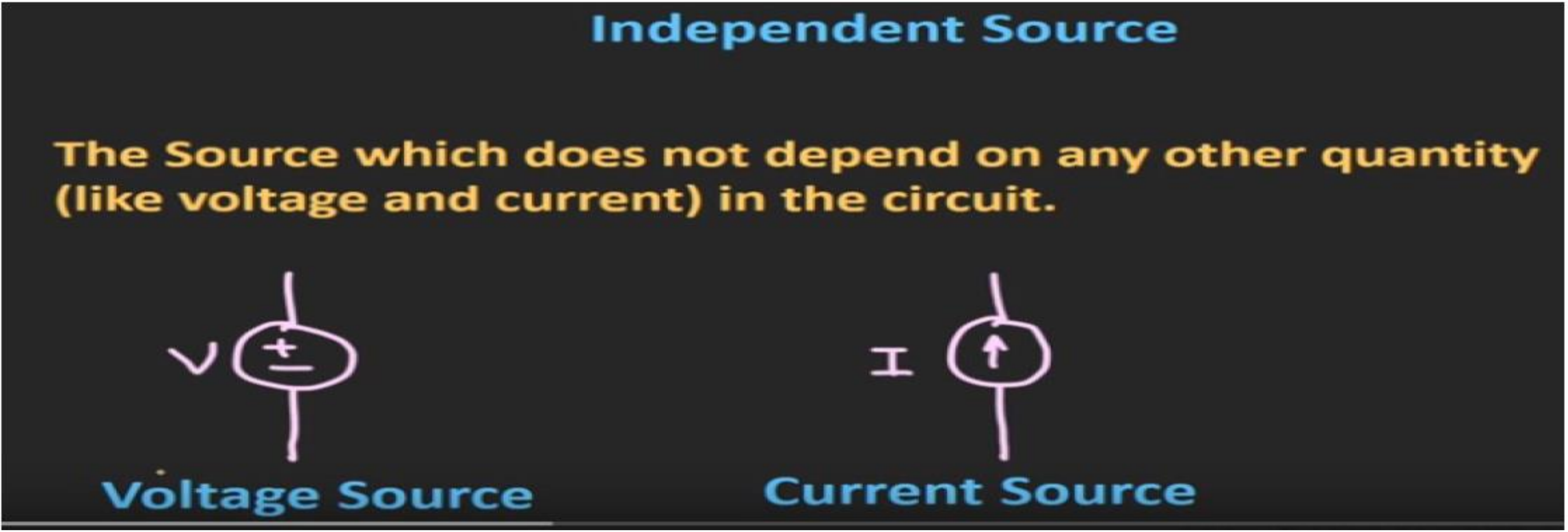
$I_1 = 184.2mA$

$I_2 = -157.89mA$

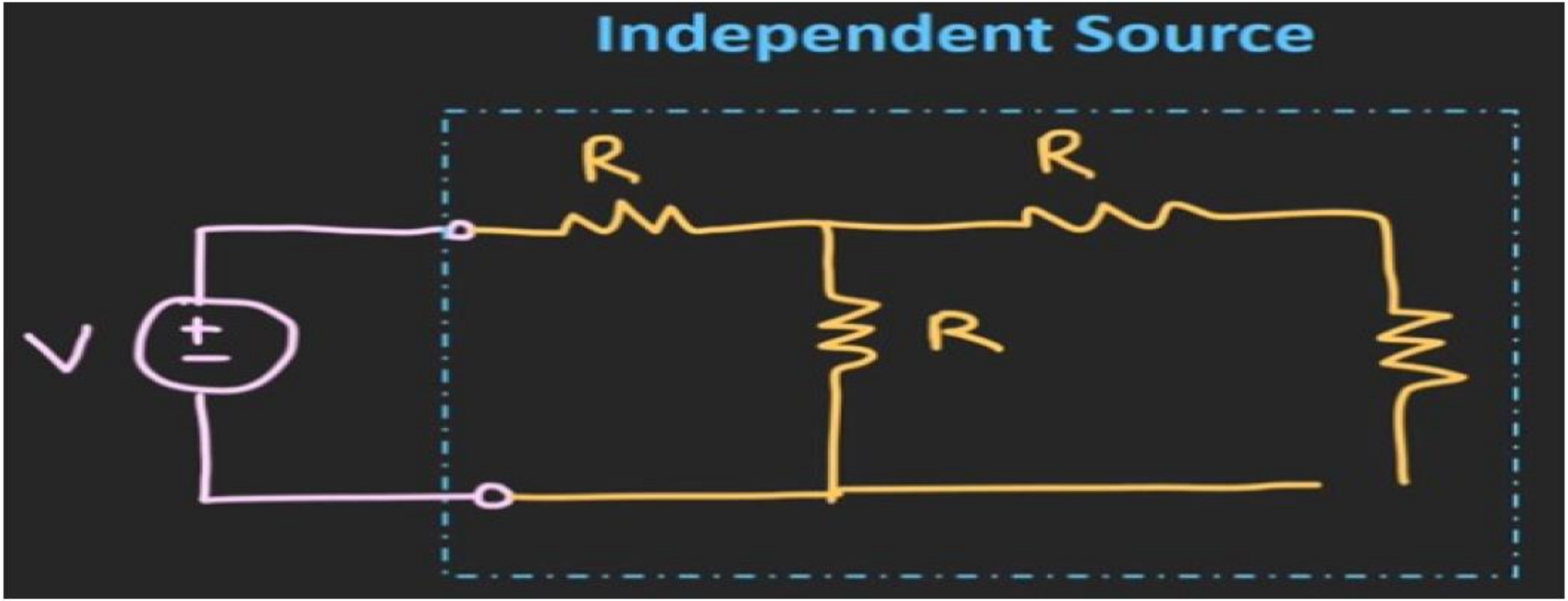
$I_2 = 157.89mA$

$I_1 + I_2 \Rightarrow 341.79mA$

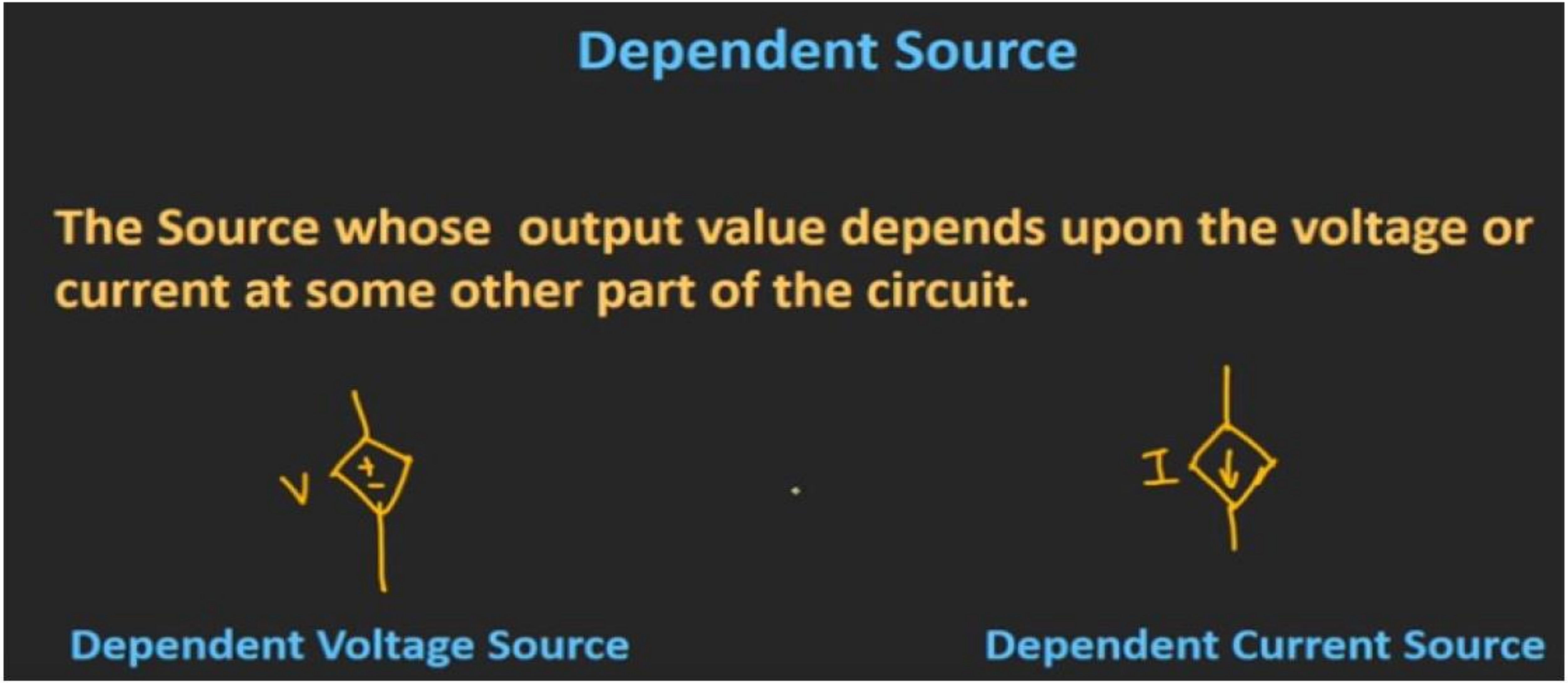
Independent Source



Independent Source

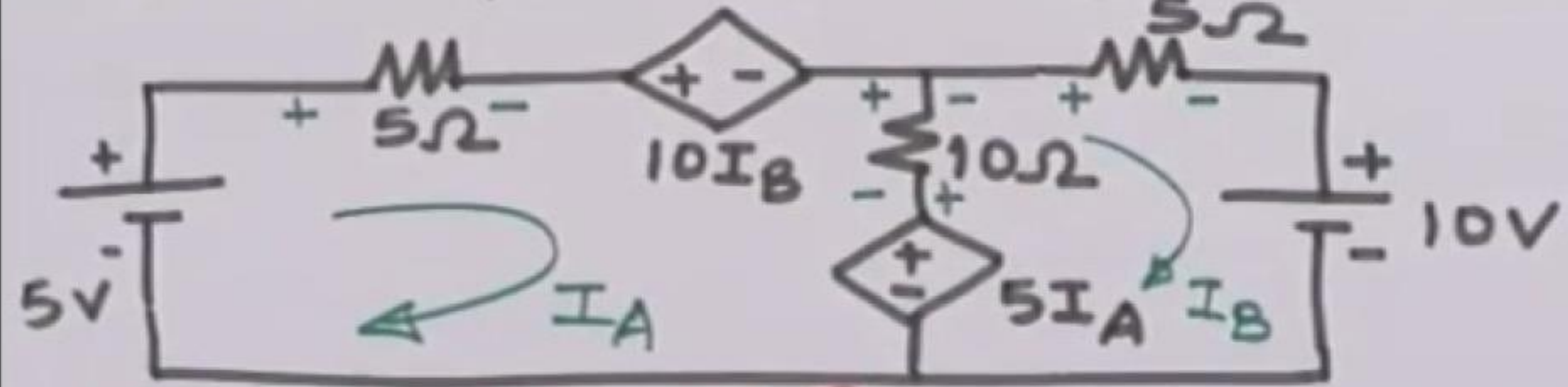


Dependent Source



Discussions

Obtain I_A and I_B using Mesh Analysis



Apply KVL to mesh ①

$$5-5I_A-\cancel{10I_B}-10I_A+\cancel{10I_B}-5I_A=0$$

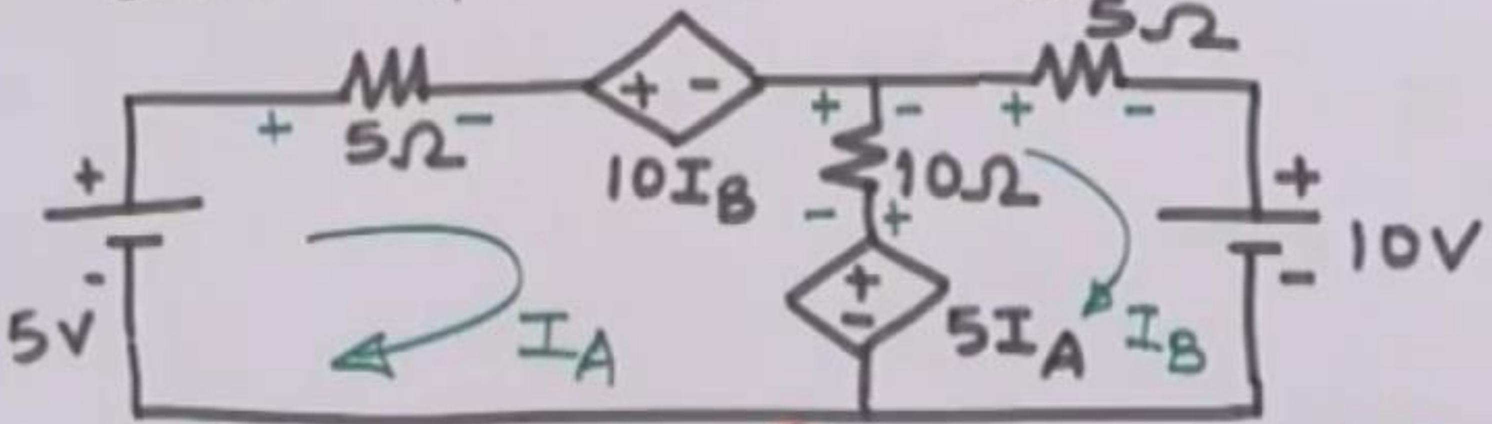
$$5-20I_A=0$$

$$5=20I_A$$

$$\boxed{I_A=0.25A}$$

Discussions

Obtain I_A and I_B using Mesh Analysis.



Apply KVL to mesh 1

$$5 - 5I_A - \cancel{10I_B} - 10I_A + \cancel{10I_B} - 5I_A = 0$$

$$5 - 20I_A = 0$$

$$5 = 20I_A$$

$$\boxed{I_A = 0.25A}$$

Apply KVL to mesh 2

$$-5I_B - 10 + 5I_A - 10I_B + 10I_A = 0$$

$$\therefore 15I_A - 15I_B = 10$$

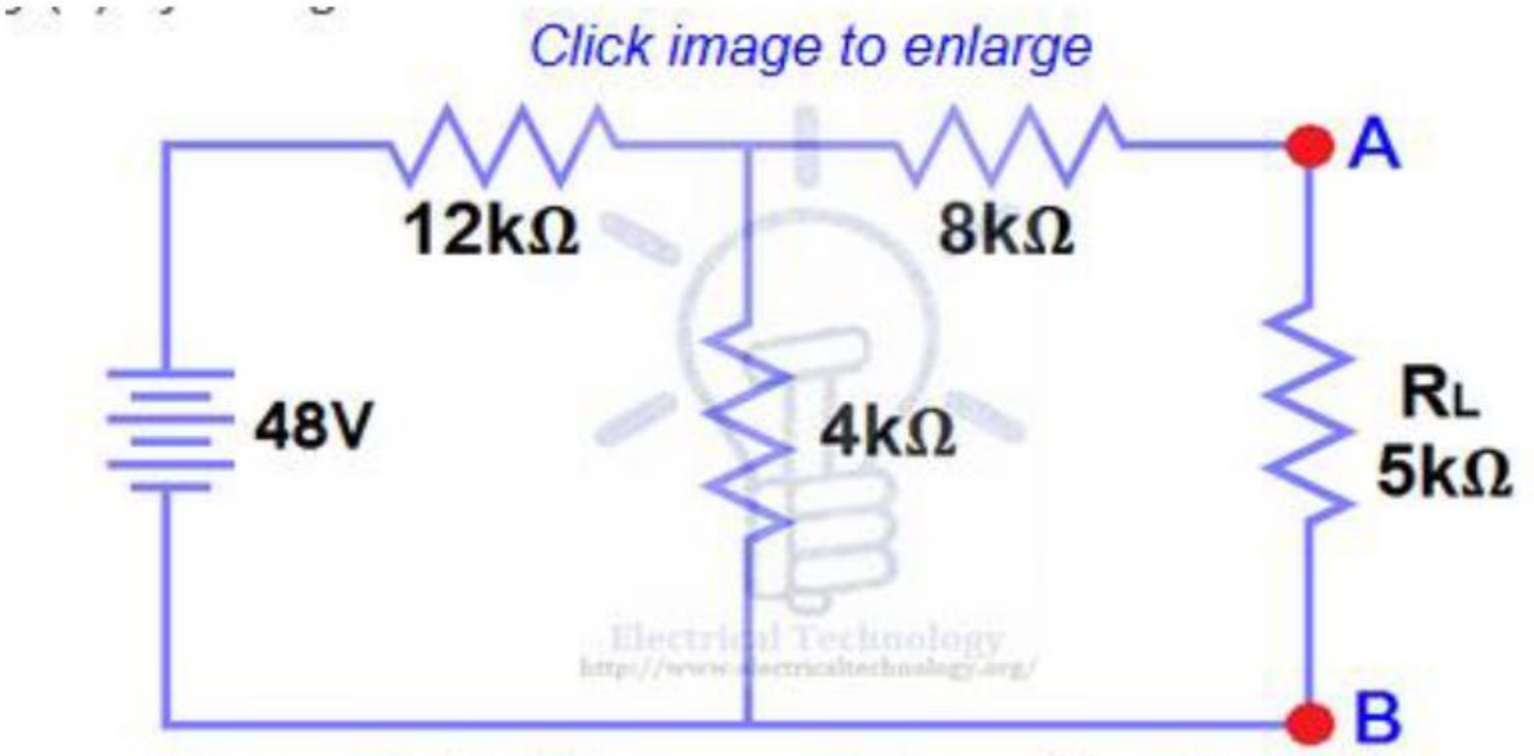
$$\therefore 15(0.25) - 15I_B = 10$$

$$3.75 - 10 = 15I_B$$

$$\therefore \boxed{I_B = -0.4167A}$$

Thevenin Theorem

Calculate current across 5Kohm using thevenin theorem



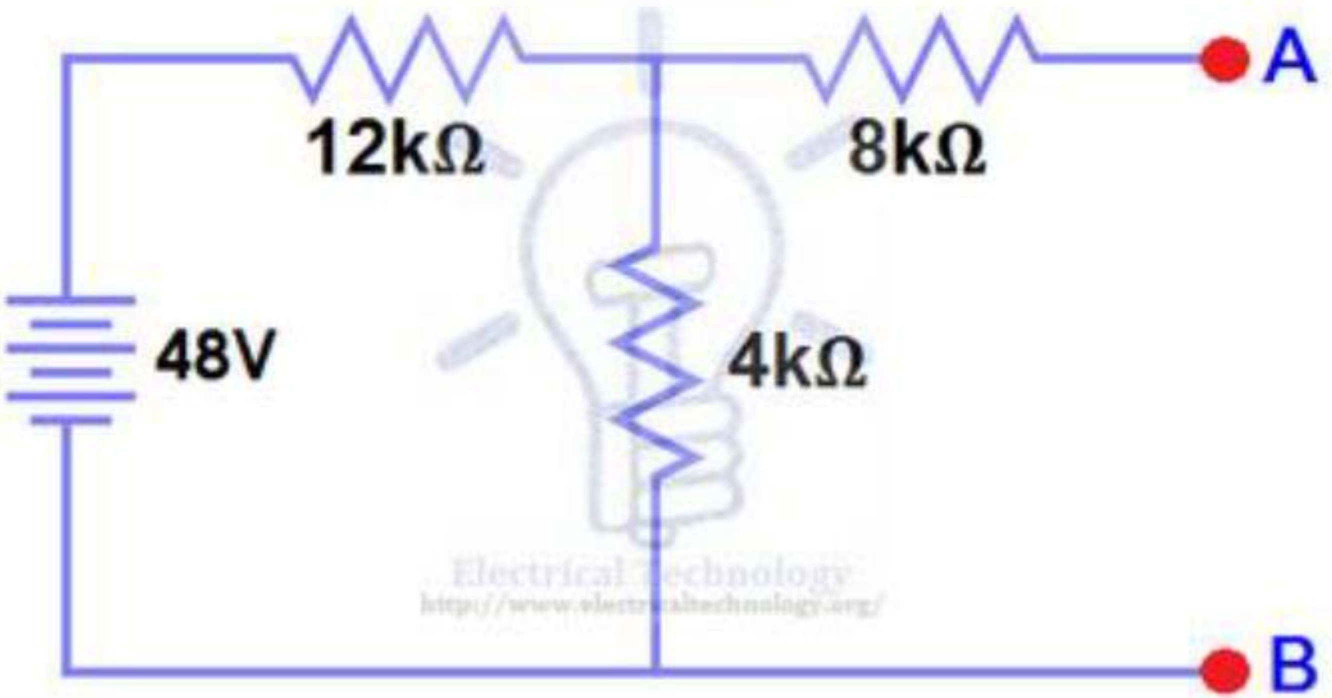
Thevenin's Theorem. Easy Step by Step Procedure with Example (Pictorial Views)

Thevenin Theorem

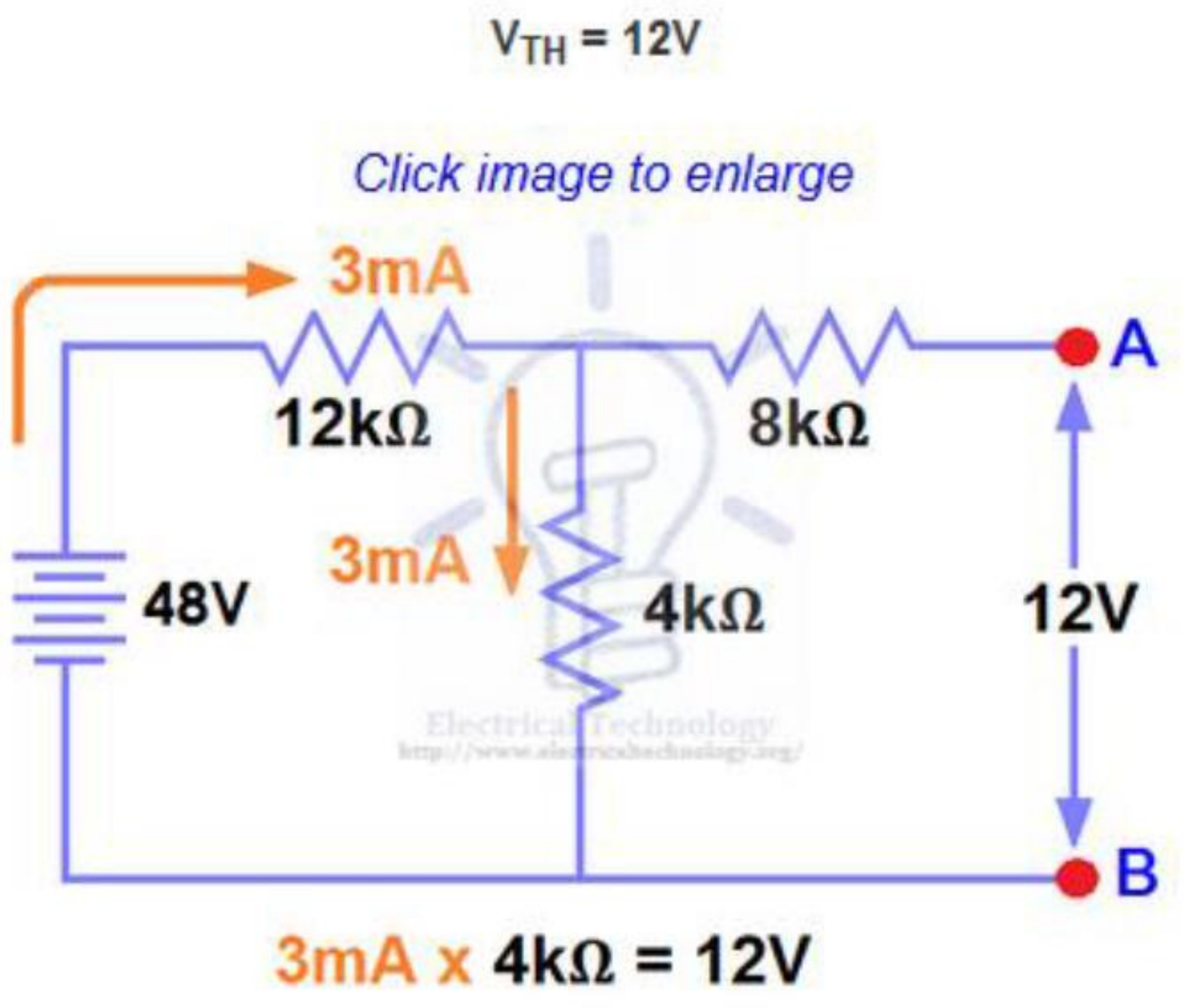
Step 1.

Open the **5kΩ load resistor** (Fig 2).

Click image to enlarge



Thevenin Theorem



Total Voltage/ Total Resistance= Total Current

***No Current flow through- 8kohm**

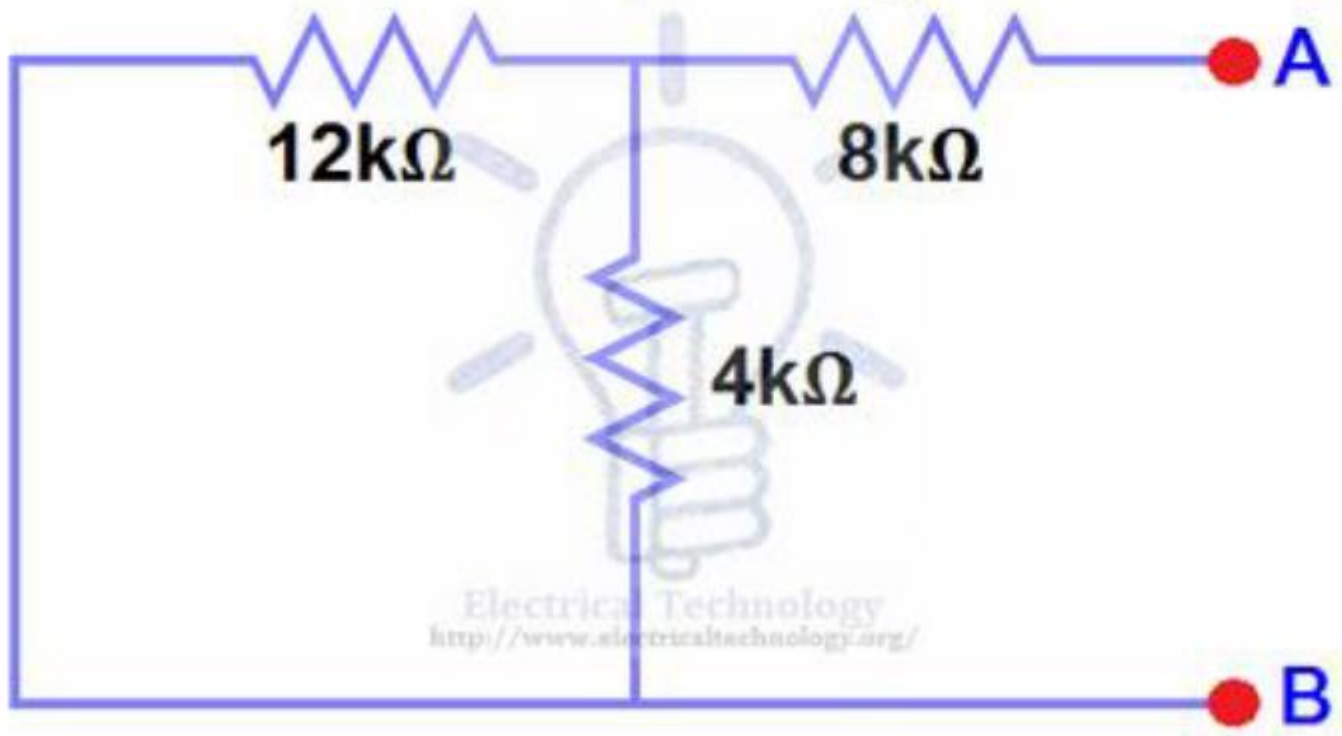
***Voltage Across 4kohm will be same- As Across A and B terminal**

Thevenin Theorem

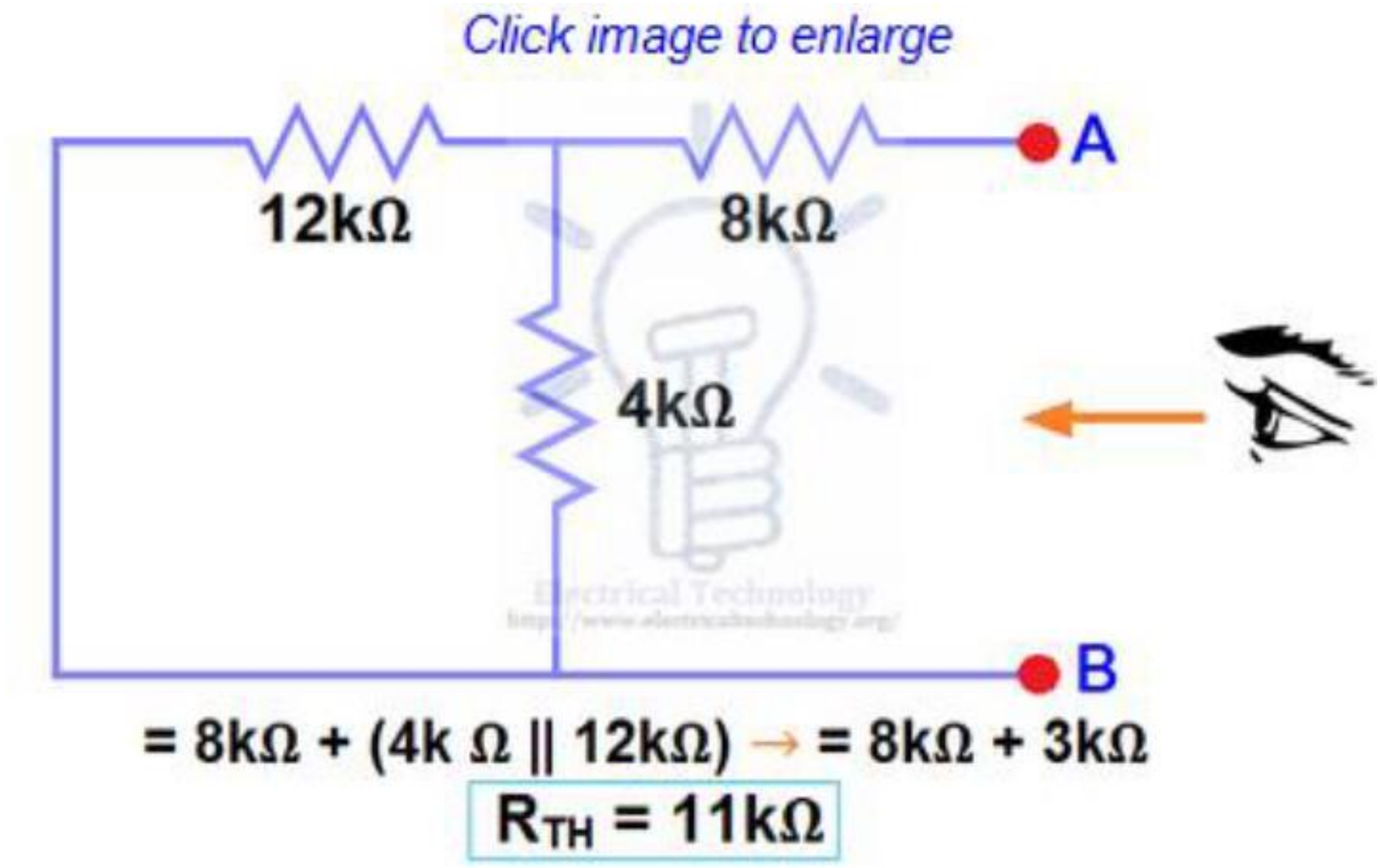
Step 3.

Open current sources and **short voltage sources** as shown below. Fig (4)

Click image to enlarge



Thevenin Theorem

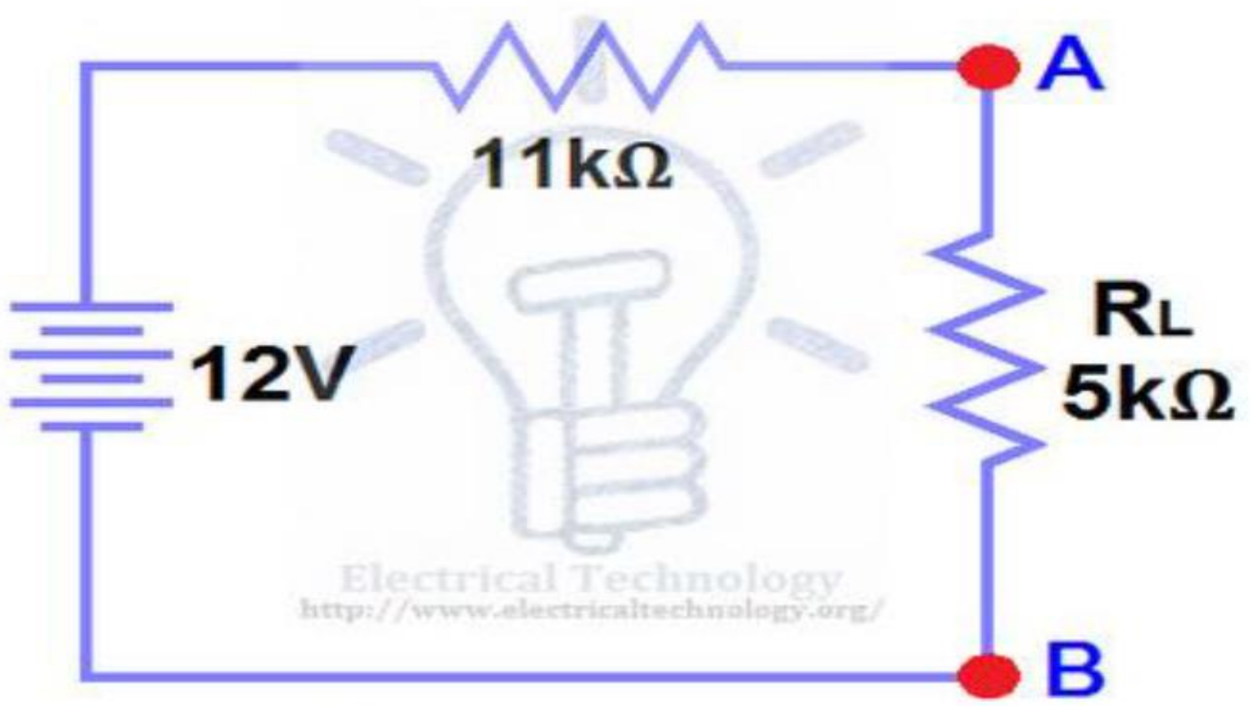


Thevenin Theorem

Step 5.

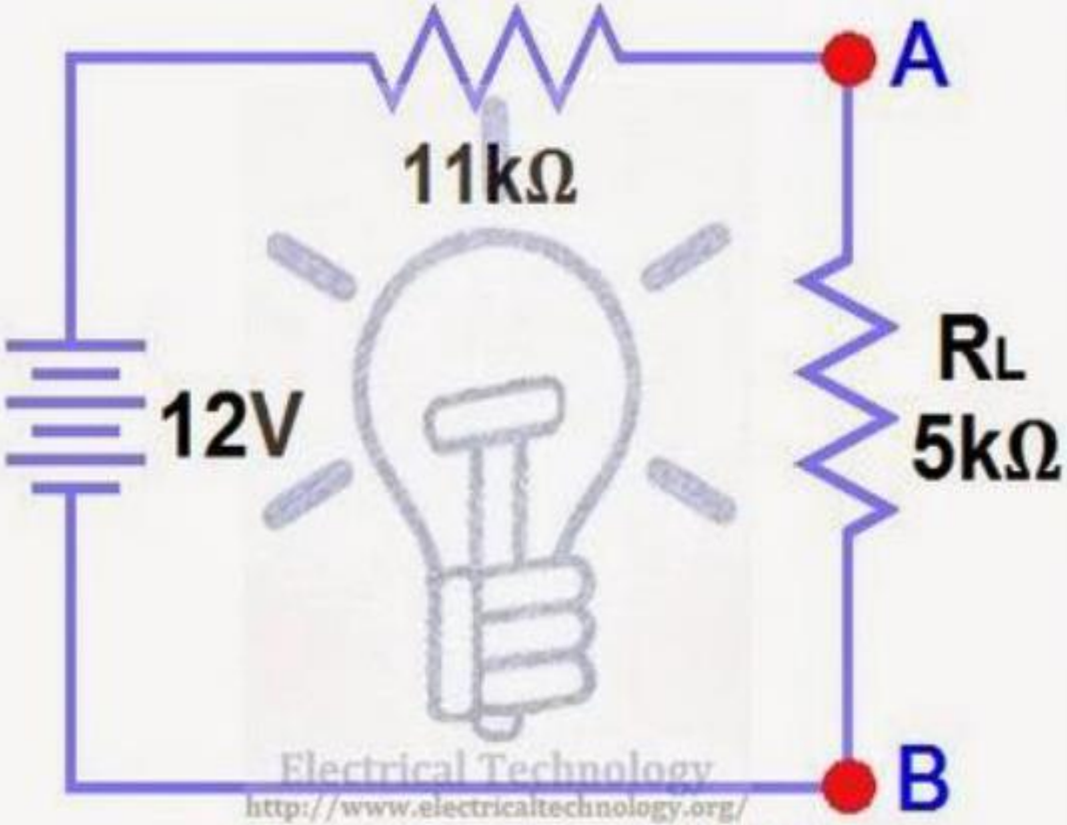
Connect the R_{TH} in series with Voltage Source V_{TH} and re-connect the load resistor. This is shown in fig (6) i.e. Thevenin circuit with load resistor. This the Thevenin's equivalent circuit

Click image to enlarge



Thevenin's equivalent circuit

Thevenin Theorem



$$I_L = \frac{V_{TH}}{R_{TH} + R_L} = \frac{12V}{11k\Omega + 5k\Omega}$$

$$\boxed{I_L = 0.75mA}$$

$$V_L = I_L \times R_L$$

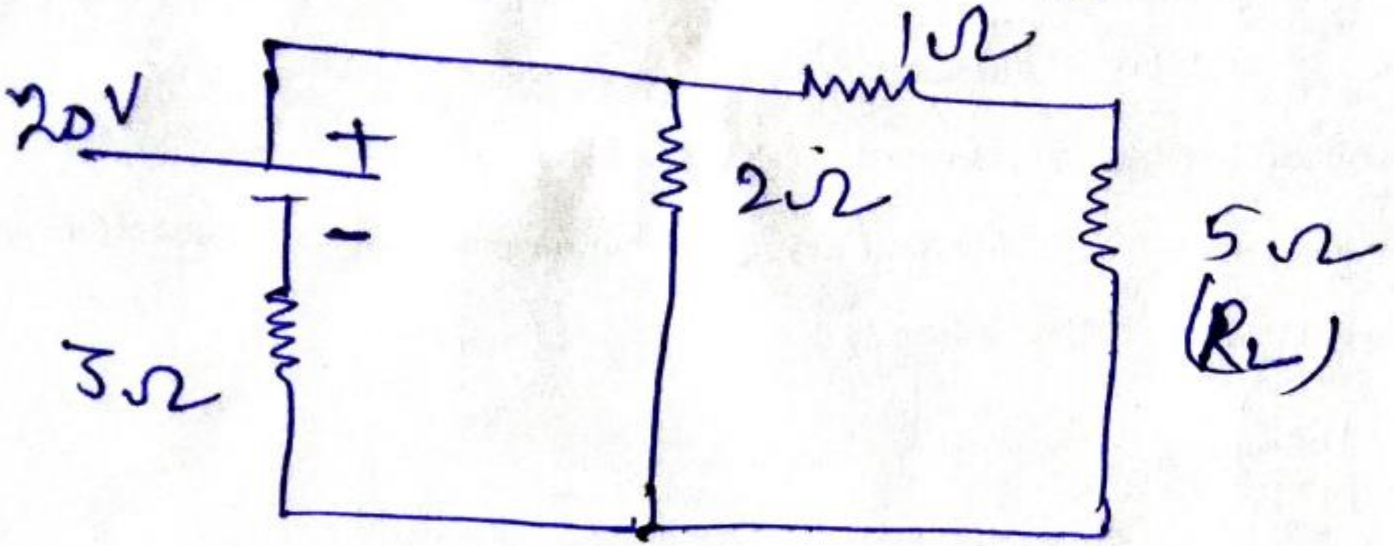
$$V_L = 0.75mA \times 5k\Omega$$

$$\boxed{V_L = 3.75V}$$

Norton Theorem

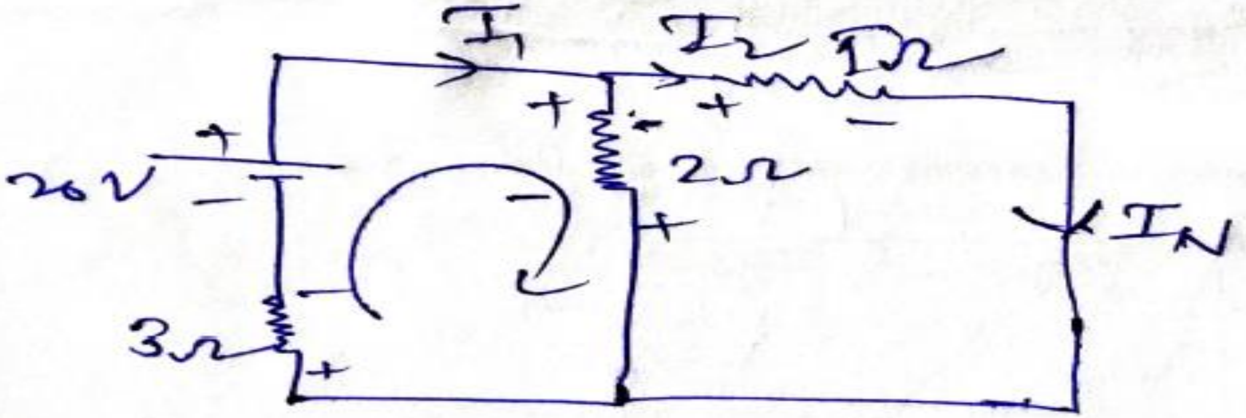
NORTON Theorem

Q: find the current through 5Ω using norton's theorem?



Norton Theorem

Soln:- Remove load resistor & short the terminal



$$+20 - 2(I_1 - I_2) - 3I_1 = 0 \longleftarrow (1)$$

$$-1 \cdot I_2 - 2(I_2 - I_1) = 0 \longrightarrow (2)$$

$$\Rightarrow -I_2 - 2I_2 + 2I_1 = 0 \Rightarrow \boxed{2I_1 = 3I_2}$$

$$I_1 = 1.5 I_2$$

put in Eq (1)

$$+20 - 2(1.5I_2 - I_2) - 3I_1 = 0$$

$$+20 - 2(0.5I_2) - 3I_1 = 0$$

$$+20 - I_2 - 3I_1 = 0 \longrightarrow +20 - I_2 - 3(1.5I_2$$

$$+20 - I_2 - 4.5I_2 = 0$$

Norton Theorem

(2)

$$+20 - I_2 - 4.5I_2 = 0$$

$$20 = 5.5I_2$$

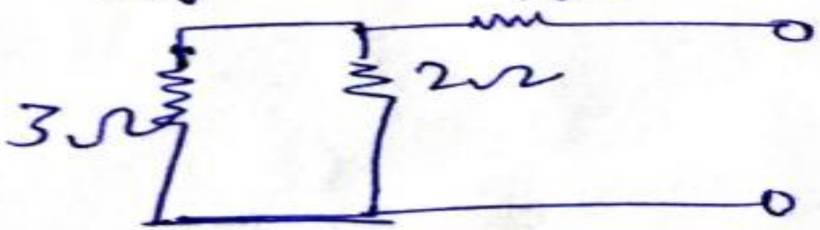
$$\boxed{\frac{20}{5.5} = I_2} \Rightarrow \boxed{3.63 = I_2}$$

$$I_1 = 1.5I_2$$

$$\boxed{I_1 \Rightarrow 1.5 \times 3.63 \Rightarrow 5.45A}$$

$$\boxed{I_N = I_2 = 3.63A}$$

R_N Remove Load

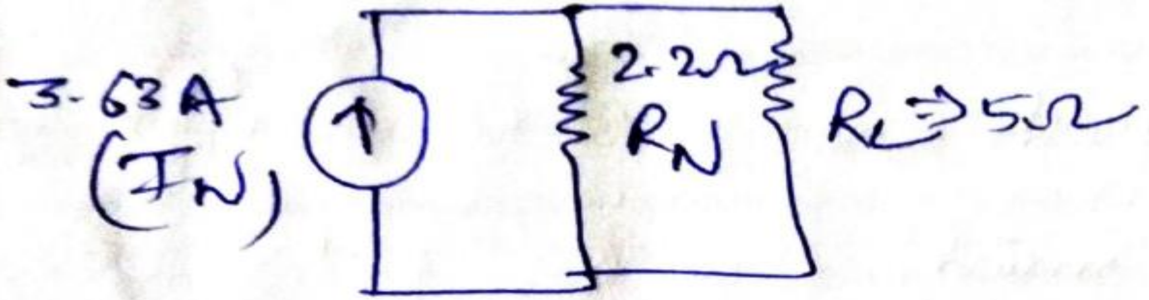


$$\Rightarrow \frac{3 \times 2}{3+2} + 1$$

$$\Rightarrow \frac{6}{5} + 1 \Rightarrow 2.2\Omega$$

Norton Theorem

3



3

$$I_{R_L} \Rightarrow \frac{I_N \cdot R_N}{R_N + R_L}$$

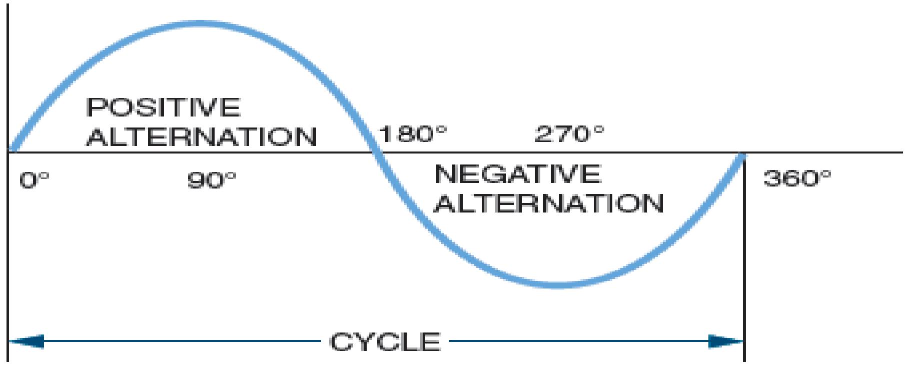
$$\Rightarrow \frac{3.63 \times 2.2}{2.2 + 5}$$

$$I_{R_L} \Rightarrow 1.109\,A$$

Fundamentals of A.C. circuits

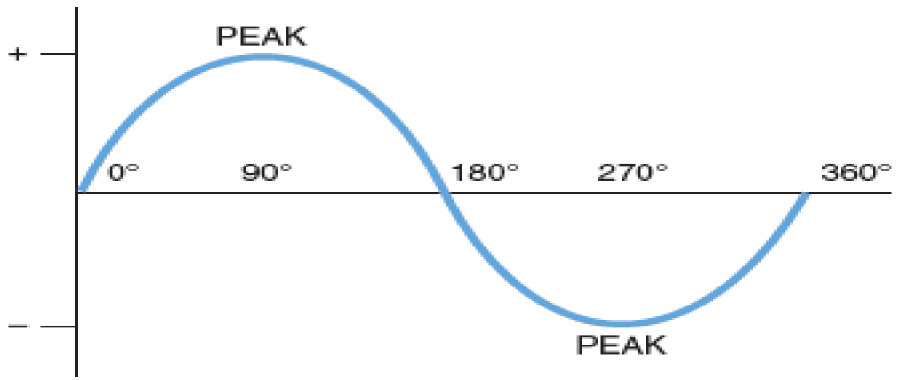
Fundamentals of A.C. circuits

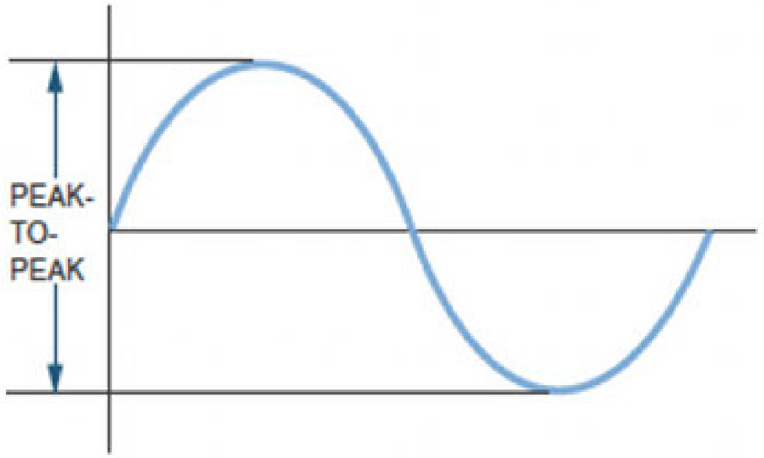
1. Each time an AC generator moves through one complete revolution, it is said to complete one cycle.
2. The two half of a cycle are referred as alternations.
3. One complete cycle per second is defined as a hertz.



AC Values

- **Peak value**: Absolute value of the point with the greatest amplitude.
- **Peak to Peak value**: Vertical distance b/w 2 peaks.
- The amplitude of an AC waveform is its height as depicted on a graph over time. An amplitude measurement can take the form of peak, peak-to-peak.





Fundamentals of A.C. circuits

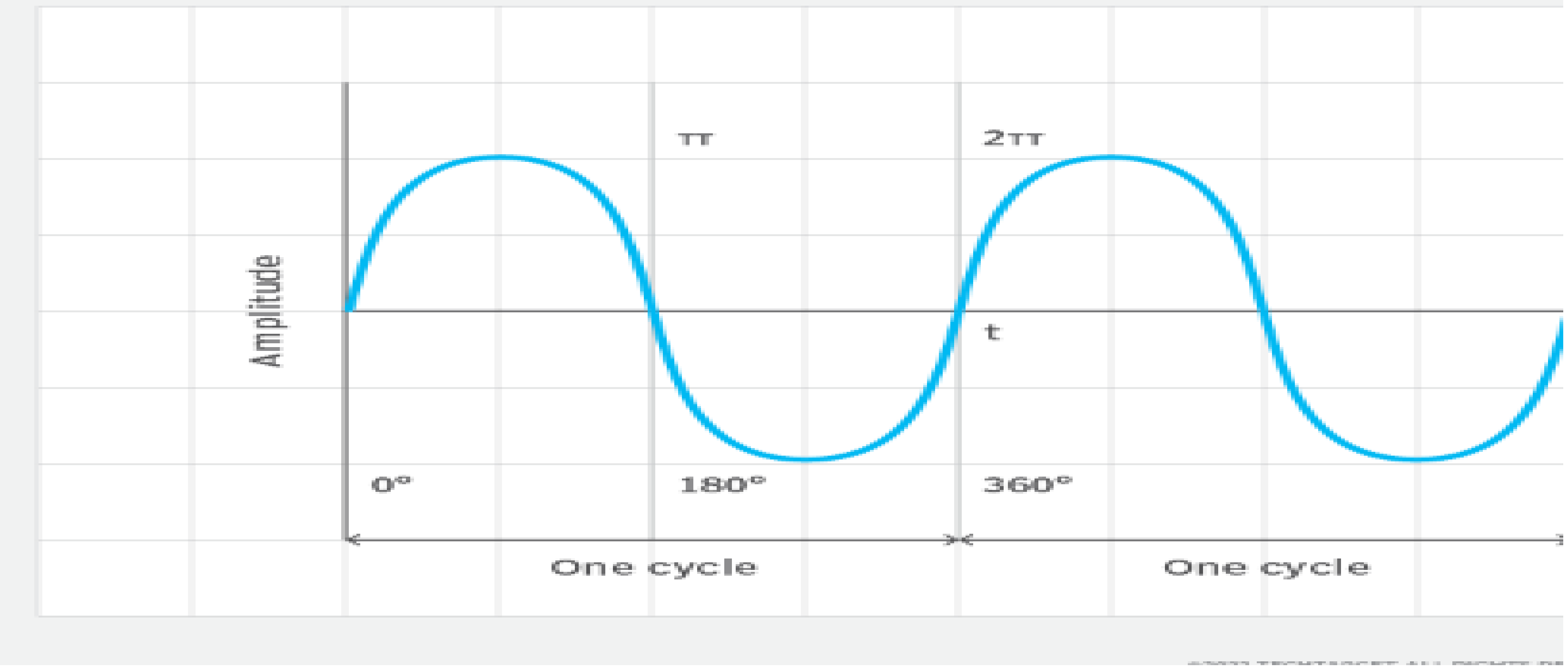
- A phase is the position of a wave at a point in time (instant) on a waveform cycle.

- It provides a measurement of exactly where the wave is positioned within its cycle, using either degrees (0-360) or radians (0-2π).

Fundamentals of A.C. circuits

- The wave starts at the 0-degree phase and has no amplitude.

- The wave reaches positive peak amplitude at the 90-degree phase.



AC Values (cont'd.)

- **Effective value of alternating current** is the amount that produces same degree of heat in a resistance as produced by direct current. It is also referred as rms value.

$$\mathbf{E_{rms} = 0.707E_p}$$

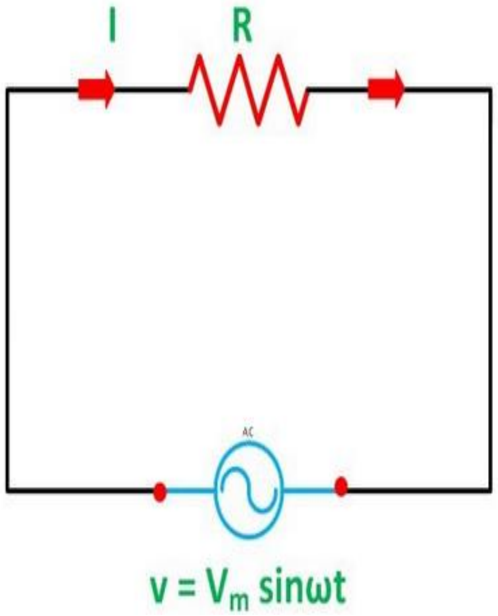
where: E_{rms} = rms or effective voltage value

Average Value of alternating current

$I_{av} = 0.637\, I_m$

The average current of a sinusoidal waveform is determined by multiplying the peak voltage value by **0.637.**

Pure Resistive AC Circuit



$$v = V_m \operatorname{Sin}\omega t \ldots\ldots\ldots\ldots\ldots(1)$$

$$i = \frac{v}{R} = \frac{V_m}{R}\sin\omega t \ldots\ldots\ldots(2)$$

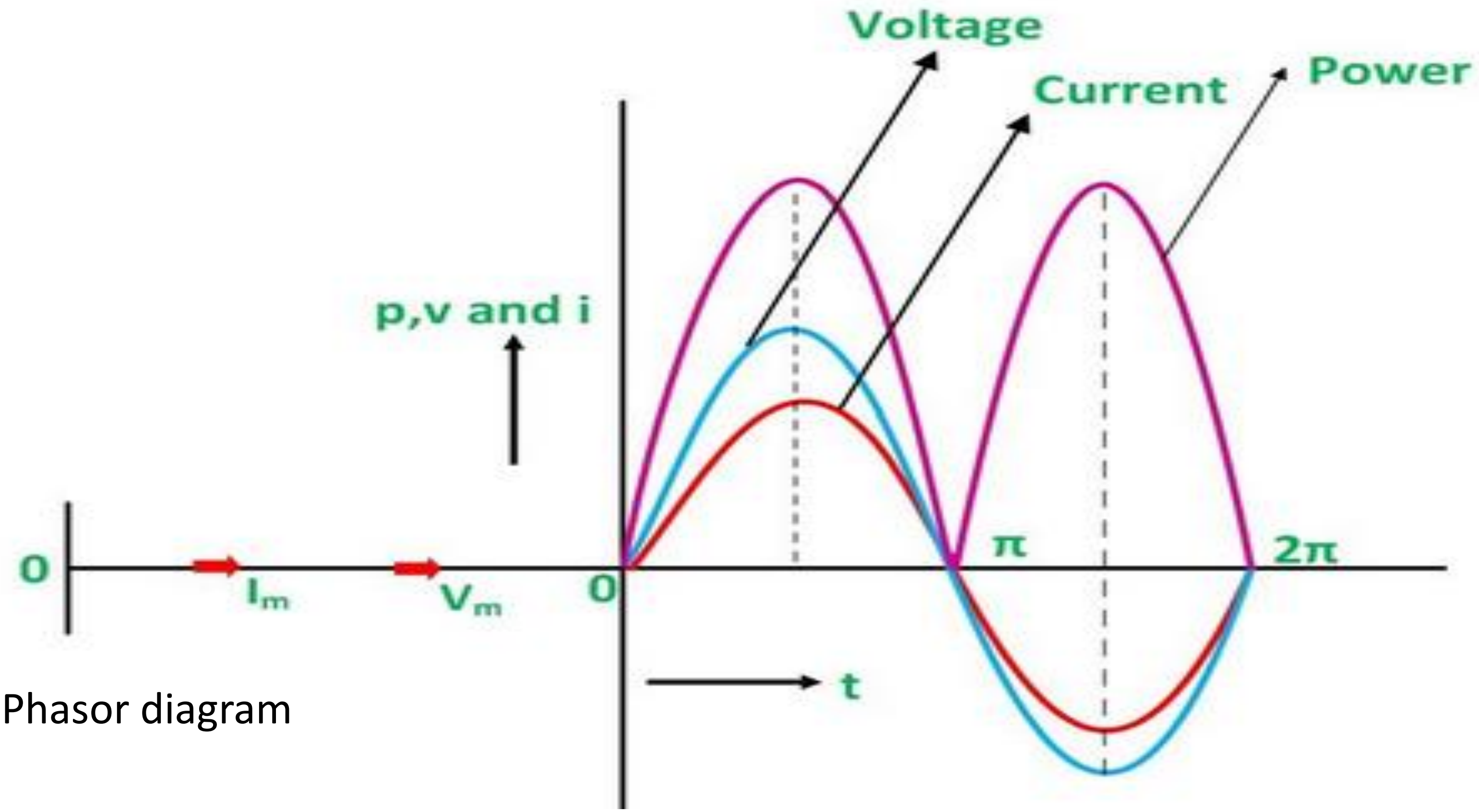
$$i = I_m \sin\omega t \ldots\ldots\ldots.(3)$$

$$v = V_m \sin\omega t \,\ldots\ldots\ldots\ldots\ldots(1)$$

$$i = I_m \sin\omega t \ldots \ldots \ldots . (3)$$

Instantaneous power, p= vi

$$p = (V_m \sin\omega t)(I_m \sin\omega t)$$



Phasor diagram

Waveform

PN Junction Diode

- **Semiconductor:** A semiconductor material has an electrical conductivity value falling between that of a conductor, such as metallic copper, and an insulator, such as glass.

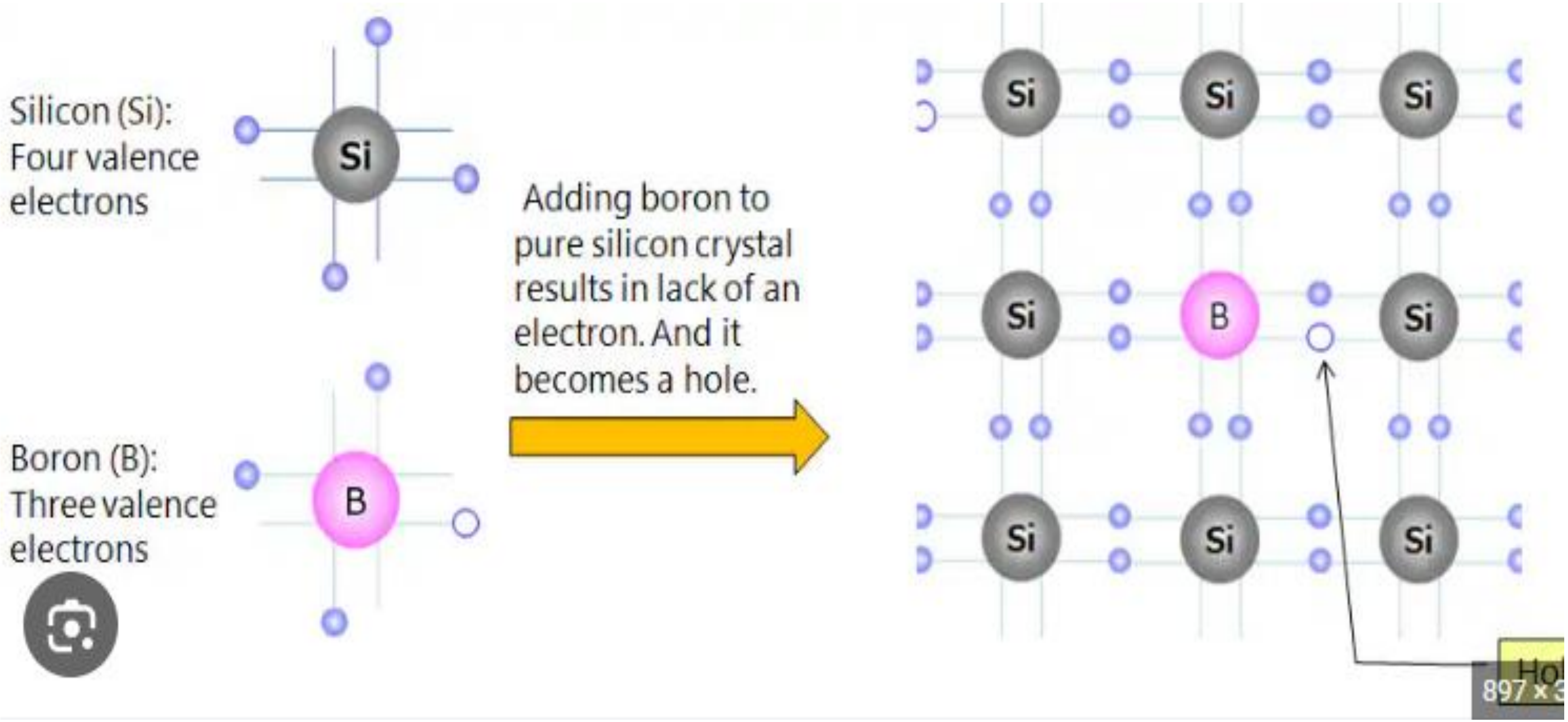
- The semiconductor in its pure form is known as **intrinsic semiconductor**.

- When a chemical impurity is added to an intrinsic semiconductor, then the resulting semiconductor is known as **extrinsic semiconductor**.

PN Junction Diode

- **P type SEMICONDUCTOR:**
- A p-type semiconductor is an intrinsic semiconductor doped with boron or indium.
- The majority of carriers in p-type semiconductors are holes.
- Electrons are minority carriers in a p-type semiconductor.
- In a p-type semiconductor, the hole density is much greater than the electron density.
- In an n-type semiconductor an intrinsic semiconductor doped with phosphorus or antimony as impurity.

PN Junction Diode



PN Junction Diode

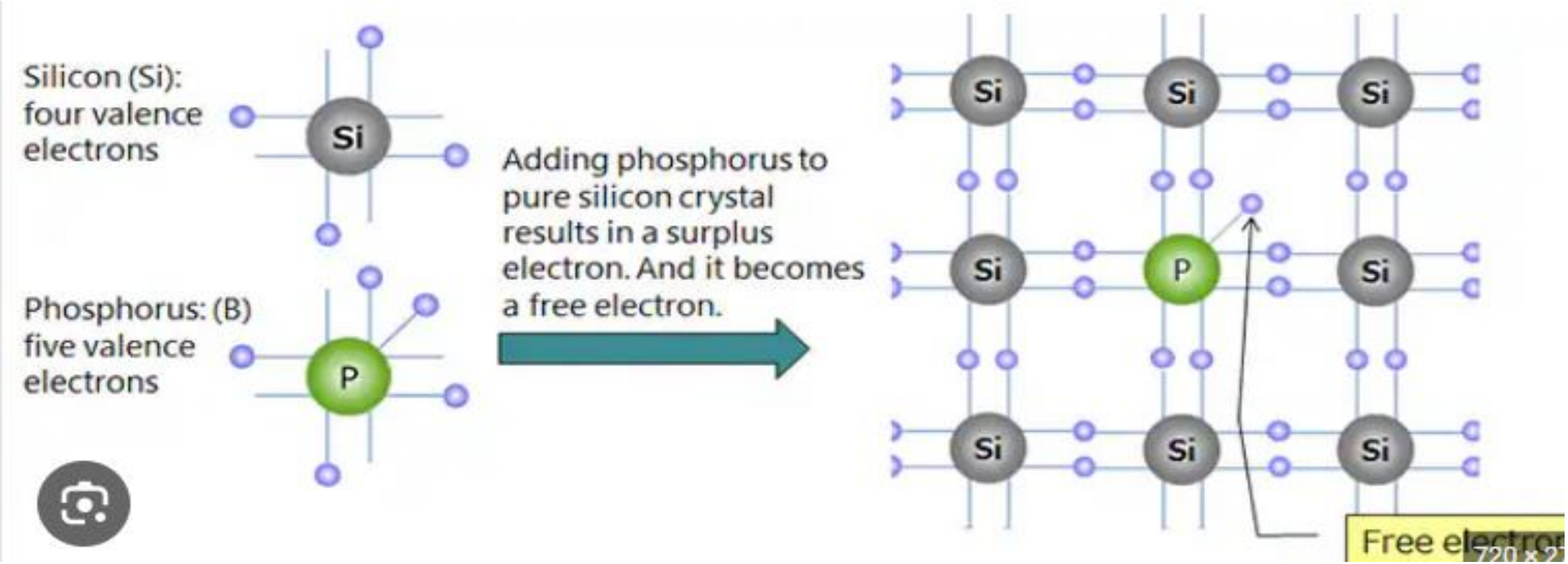
- **N TYPE SEMICONDUCTOR:**

- The majority of charge carriers in n-type semiconductors are electrons.

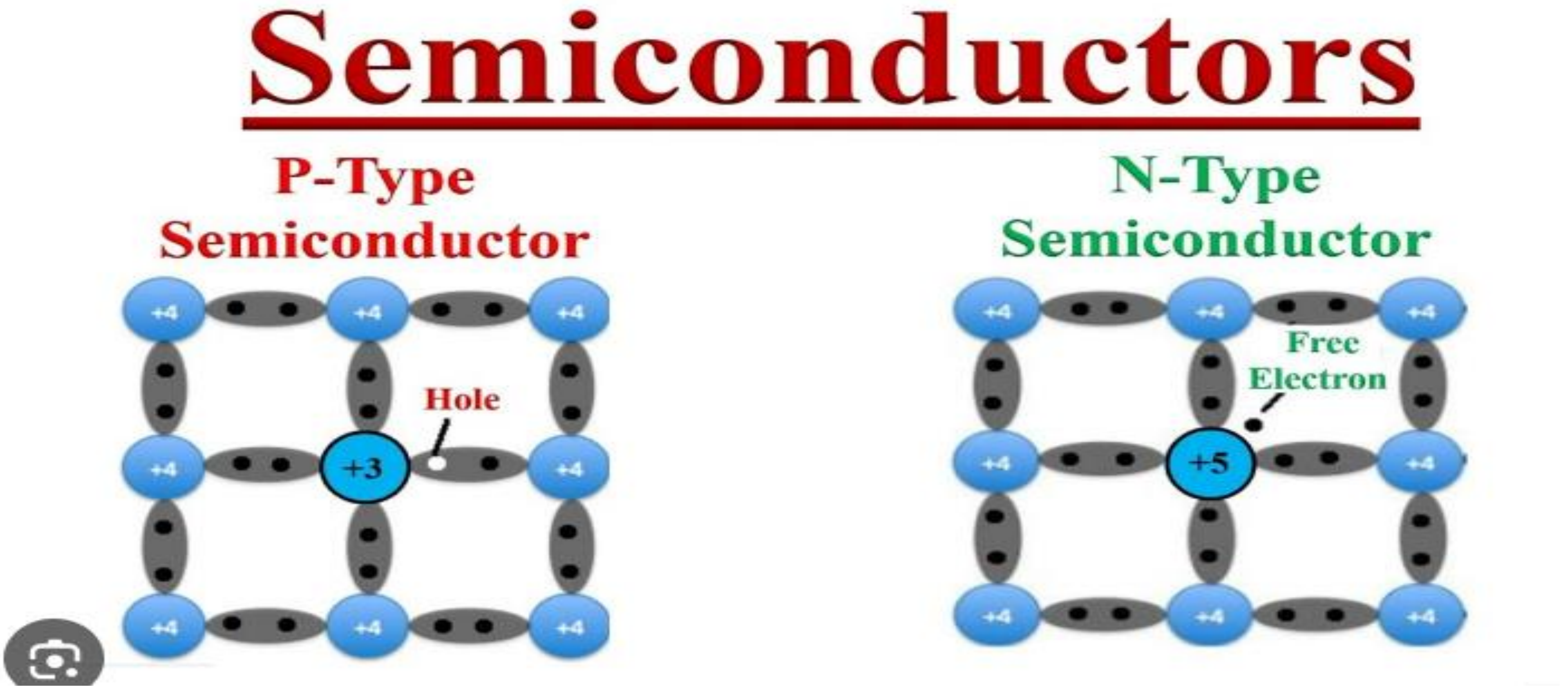
- Holes are minority carriers in a n type semiconductor.

- In the n type of semiconductor, the electron density is much greater than the hole density.

PN Junction Diode

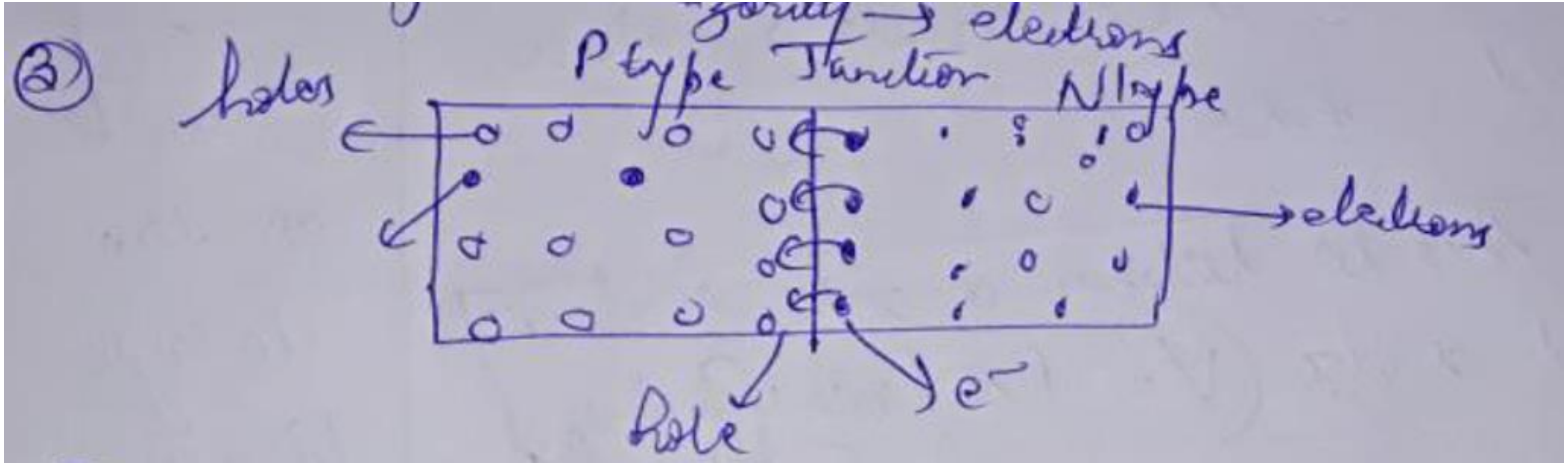


PN Junction Diode



PN Junction Diode

- Joining P type and N Type semiconductor create a device is called P-N Junction diode.
- P type-- majority- Holes
- N Type- Majority- Electrons



PN Junction Diode

4. Electrons Move Towards holes

5. It moves itself & Diffuse. So, it neutralise holes.

6. Electrons move so there exist some current which is called as diffusion current. {moment current}

7. This process is called as diffusion & current is known as diffusion current.

8. In P Type holes vanish/ neutralise electrons near the junction which are not present now.

PN Junction Diode

9. Electrons move due to which positive ions are created.

10. Shortage of charges in layer is called Depletion layer.{Deplete}

11. Here + to - create an electric field.

PN Junction Diode

12. Due to distance d with electric field creates V=Ed (with the help of E and d, we will have V)

13. This potential difference is known as potential barrier.

14. Due to + higher potential and - lower potential

15. Remaining electrons can not go due to large distance.

16. They need more energy to do so.

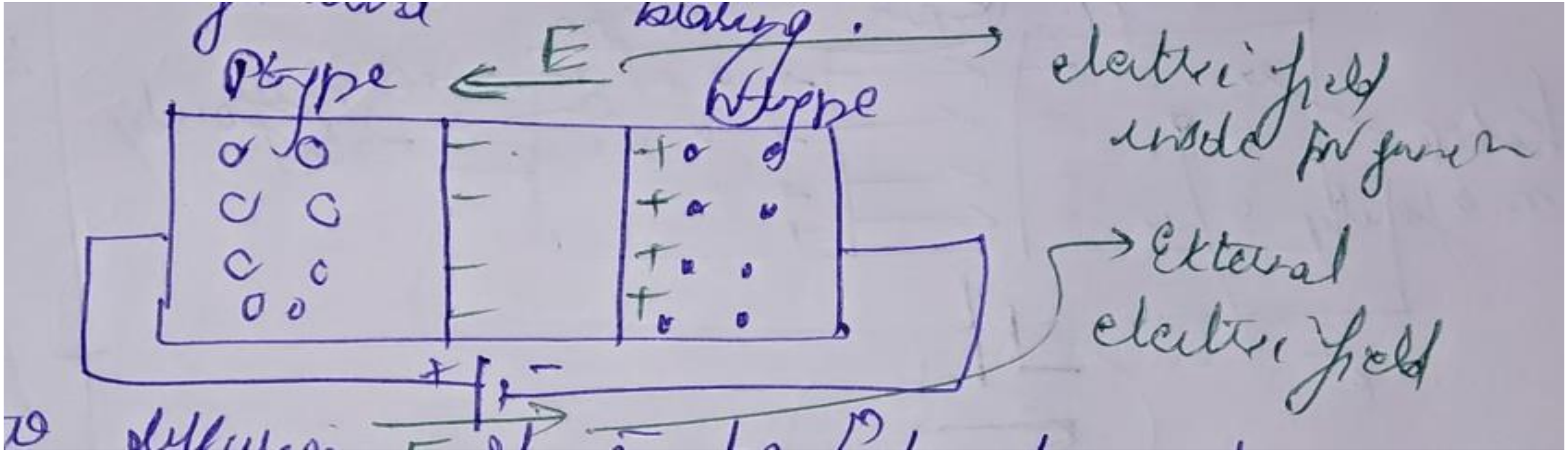
Biasing of Diode

- Whenever PN Diode is connected with battery then this situation is called as biasing.

- **Forward Biasing**

- P with positive terminal and n section is connected with negative terminal. So, this is called as forward biasing.

Biasing of Diode



Biasing of Diode

- Due to Diffusion of electrons to holes so layer of N Type have positive ions and

P Type have negative ions.

- Resultant electric field will be less because of opposite direction. So overall electric field decreases.

- Due to this potential barrier decrease & depletion layer becomes small.

- n section electrons will move easily due to battery when electrons diffuse into holes

so current start flowing.

Biasing of Diode

- **Reverse Bias**

- p type-- connected---with-- negative Terminal

- n type-- connected-- with- positive terminal

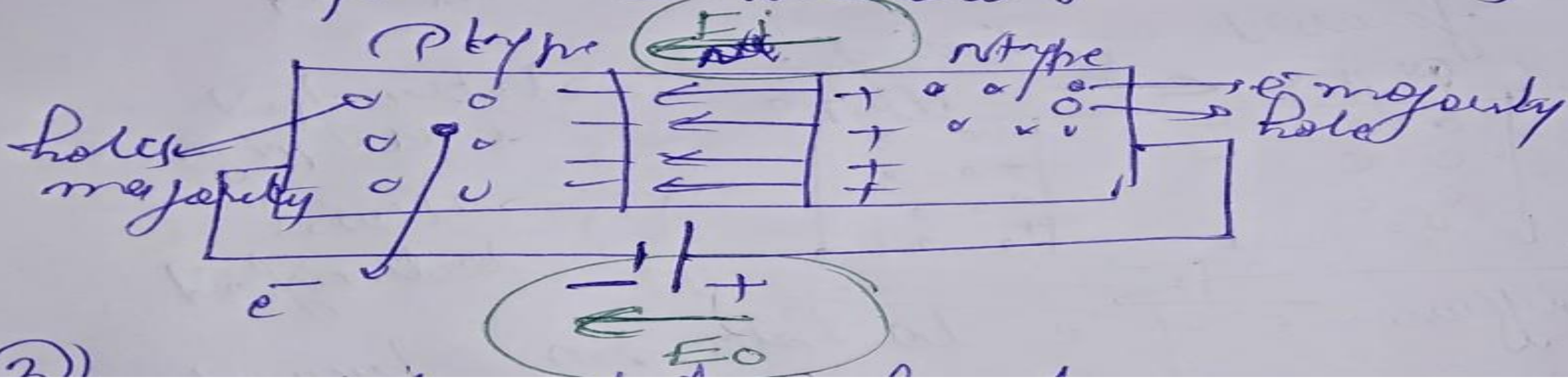
- Inside electric field and outside electric field are in same direction. So net
- electric field will increase.

- Hence, depletion layer increases

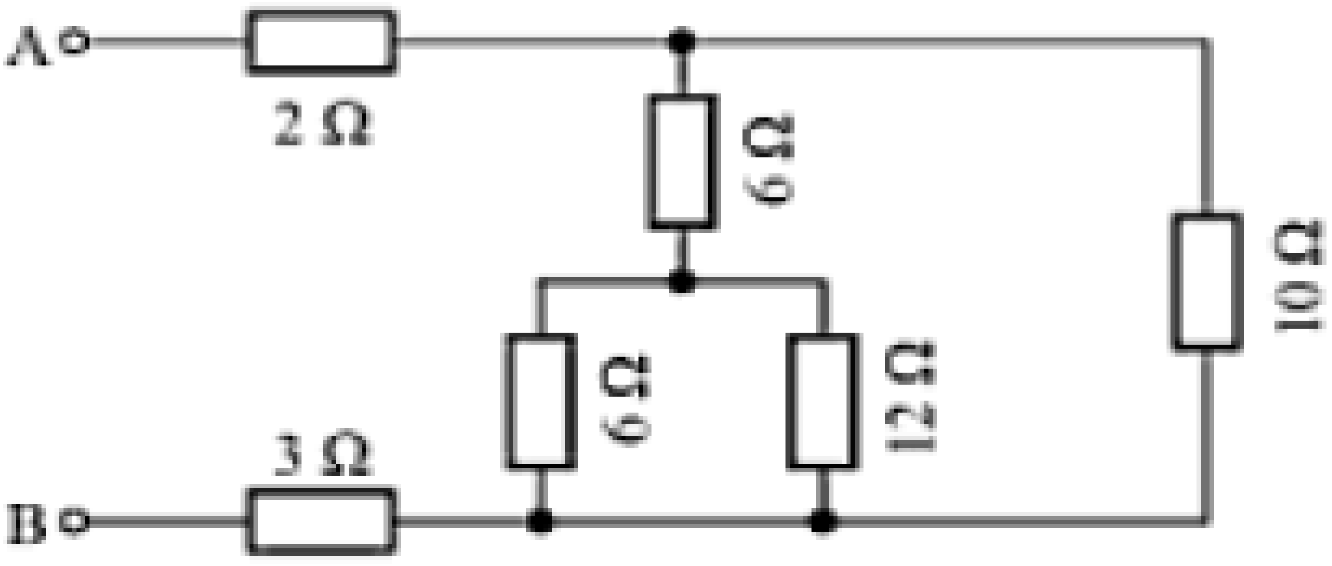
- Need more voltage to jump the electrons. So, very small amount of current will flow.

Biasing of Diode

(1) p type → (−) terminal
n type → (+) terminal } Reverse biasing



Discussions



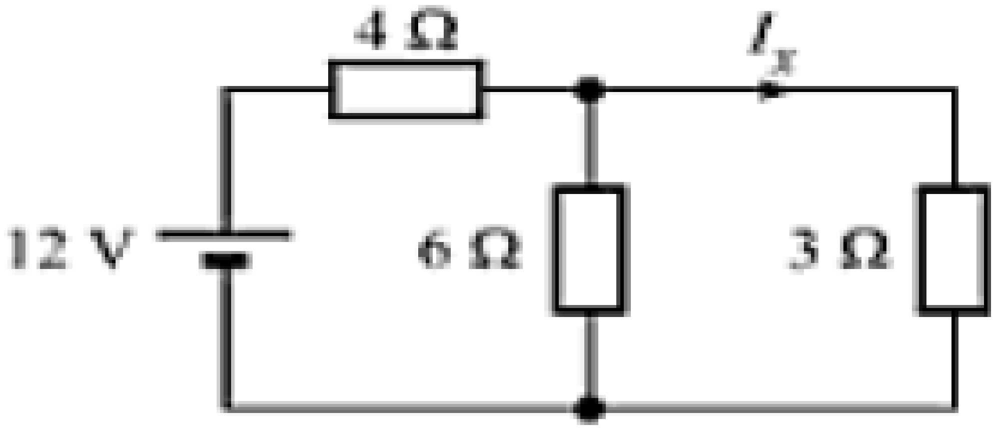
(b)

Discussions

(*b*) The resistance between terminals A and B is

$$R_{AB} = 2 + [\{6 + (6 \parallel 12)\} \parallel 10] + 3 = 2 + [\{6 + 4\} \parallel 10] + 3 = 2 + [10 \parallel 10] + 3$$
$$= 2 + 5 + 3 = 10\,\Omega$$

Discussions



Total resistance

Current across all resistors

Voltage across each resistors