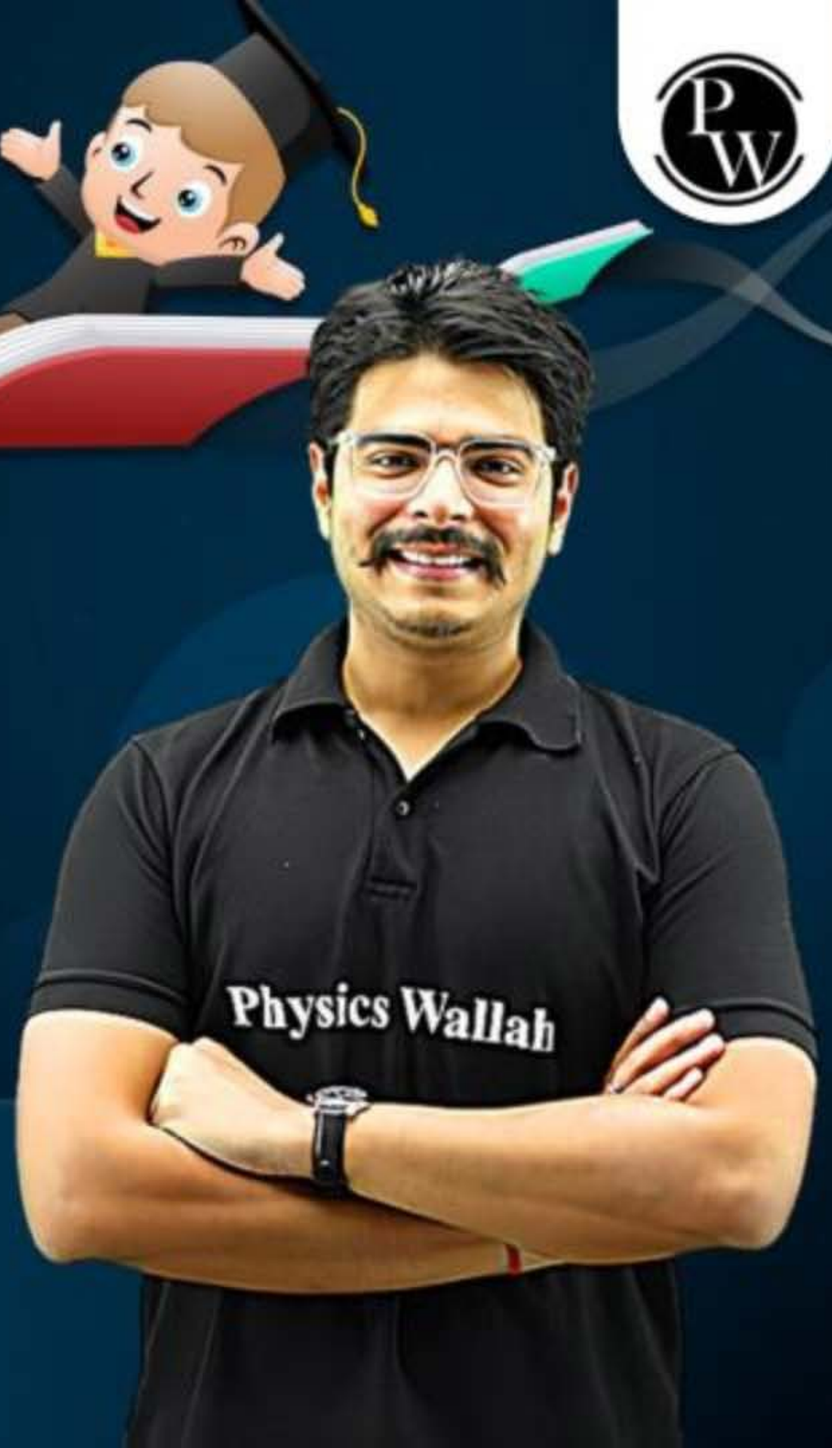
UDAAN

2025

ELECTRICITY

PHYSICS | Lecture - 05

By - ER. RAKSHAK SIR



Topics to be covered

1. SERIES CIRCUIT
2. PARALLEL CIRCUIT

} Derivation

3. COMBINATION OF RESISTORS
4. RESISTANCE OF AMMETER AND VOLTMETER
5. WORKING OF RHEOSTAT

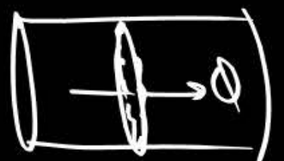
* Revision (OP)

1) Charge

$$Q = ne$$

- Q → net charge
- n → no. of electrons
- e → electronic charge ↓ $1.6 \times 10^{-19}\ C$

2) Current = $\frac{\text{Amount of charge}}{\text{time}}$



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

3) Voltage = $\frac{\text{Workdone}}{\text{Charge}}$

$$V = \frac{W}{Q}$$

- W → Joule
- Q → Coulomb
- V → Volts

4) Ohm's Law

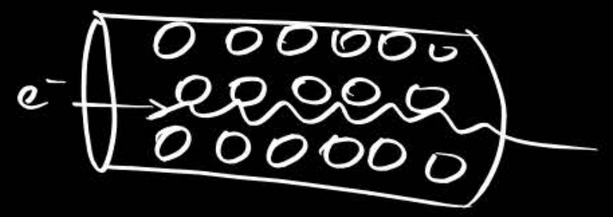
1) Conductor (ohmic)
2) T = constant

$$V \propto I$$

$$V = IR$$

- R → Const.

5) Resistance (Ω)



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

- ρ → Const. (Material)

$$R \propto l$$

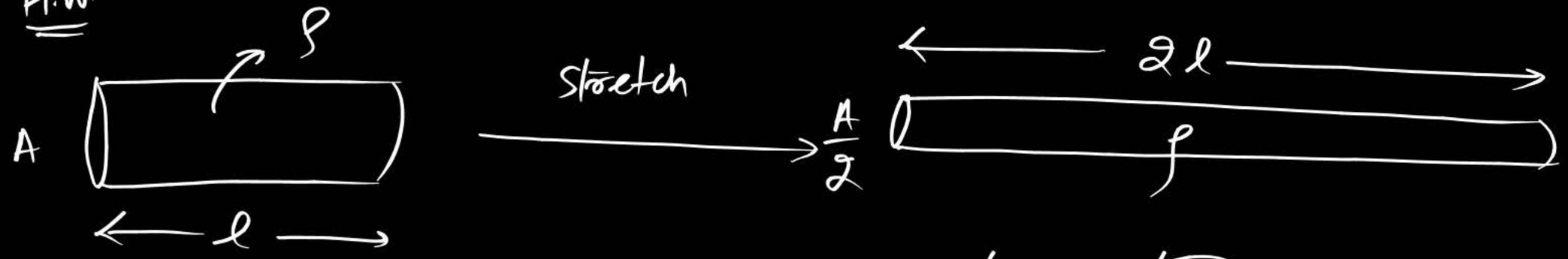
$$R \propto \frac{1}{A}$$

6) ρ

- → Material depend
- → Ohm-metre
- → $T \uparrow \rho \uparrow$

H.W.

Q)



a) $R = \rho \frac{\ell}{A}$

$$R' = \rho \frac{2\ell}{\frac{A}{2}} = 4\left(\rho \frac{\ell}{A}\right)$$

$$\boxed{R' = 4R}$$

Ans - New Resistance is 4 times the old one.

b) $\rho \Rightarrow$ No change

Q2 Resistance of a wire becomes 8 times :-

~~A)~~ $\ell \rightarrow$ double : $R \rightarrow$ double

~~B)~~ $\ell \rightarrow$ triple : $R \rightarrow$ triple

C) $\ell \rightarrow$ double, $r \rightarrow$ half

$R \rightarrow$ double

$A \rightarrow \frac{1}{4}^{th}$

$R' = \rho \frac{2\ell}{\frac{1}{4}A}$

$R' = 8\left(\rho \frac{\ell}{A}\right)$

$R' = 8R$

D) $\ell \rightarrow$ half, $r \rightarrow$ double

$R \rightarrow$ half

$A \rightarrow 4$ times

$R' = \rho \frac{\frac{1}{2}}{4A}$

$= \frac{\rho\ell}{8A} = \frac{1}{8}\left(\frac{\rho\ell}{A}\right)$

$R' = \frac{R}{8}$

hint :-

$\ell \rightarrow 3\ell$

$A \rightarrow 9A$

$A = \pi r^2$

$r \rightarrow 2r$

$A \rightarrow 4A$

$r \rightarrow \frac{1}{2}r$

$A \rightarrow \frac{1}{4}A$

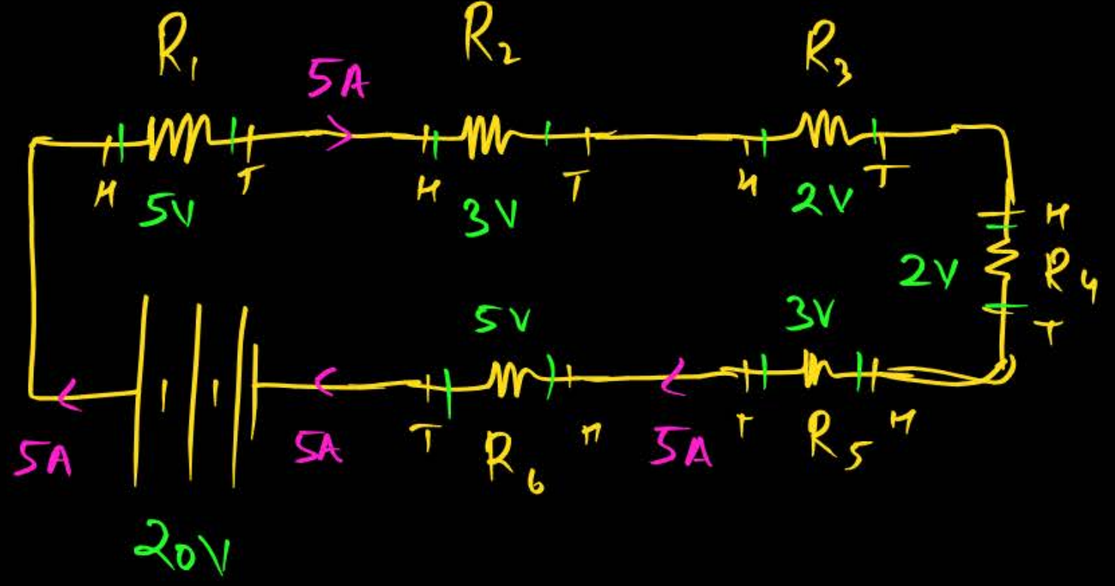
Series

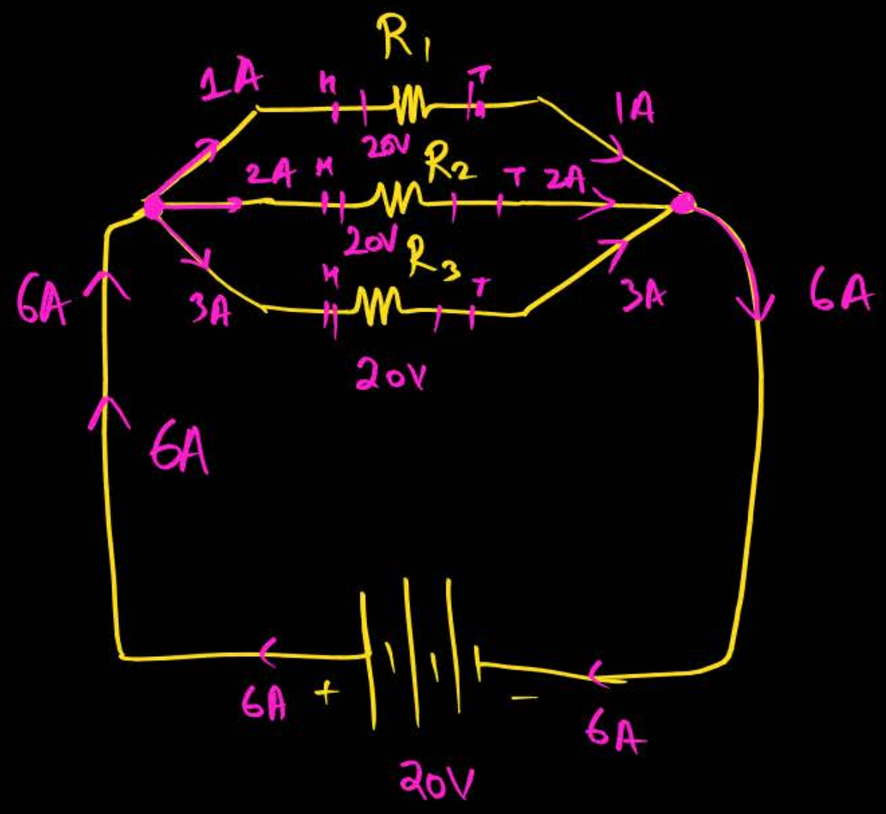
→ Head - tail connection

→ only one branch (wire) Ka Connection

→ Kyuki Path same Toh **Current Bhi Same**

→ **Voltage divides** in a series circuit.

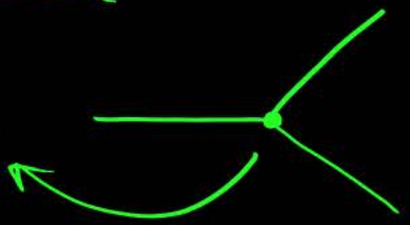




Parallel

→ Head - head or Tail - Tail connection

→ Wire joints are visible
or
Nodes / Junctions



→ Path divides

Current divides

→ Voltage same

SERIES CIRCUIT

I = Same

V = divide

* Derivation :-

$$V_t = V_1 + V_2 + V_3$$

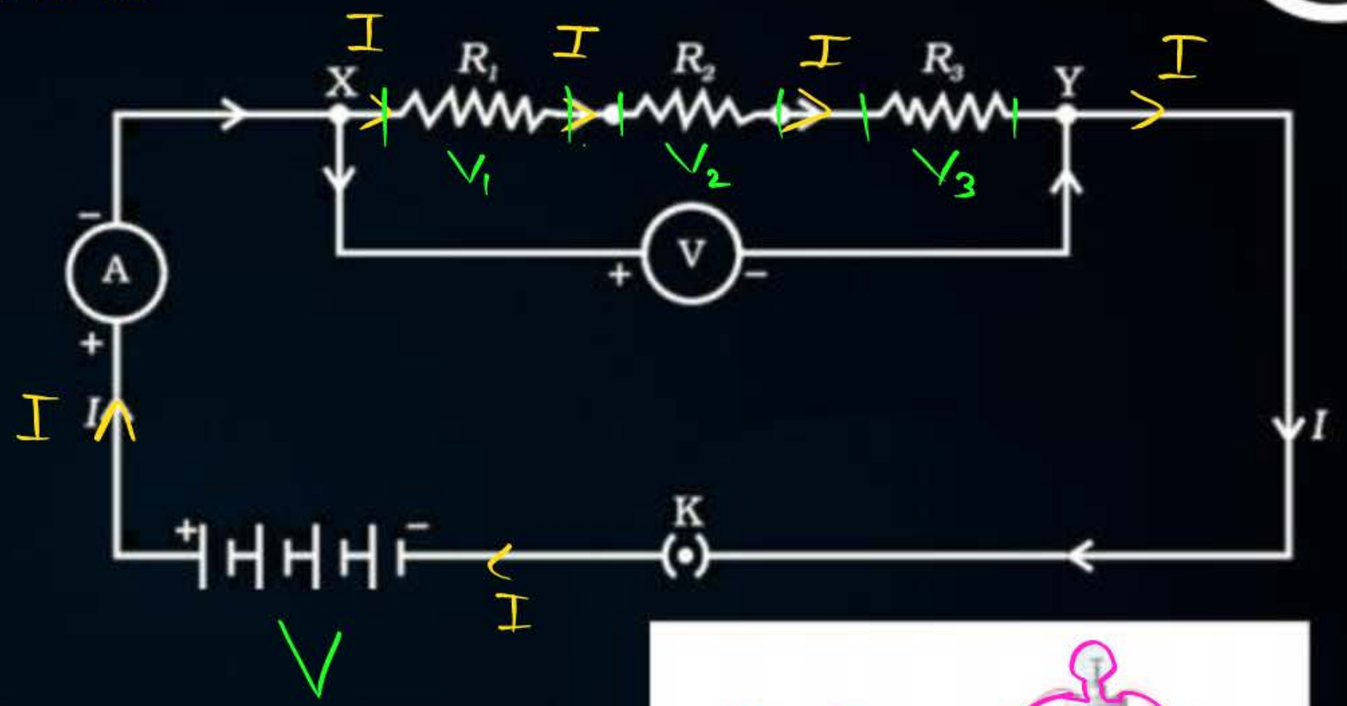
Applying ohm's law $(V = IR)$

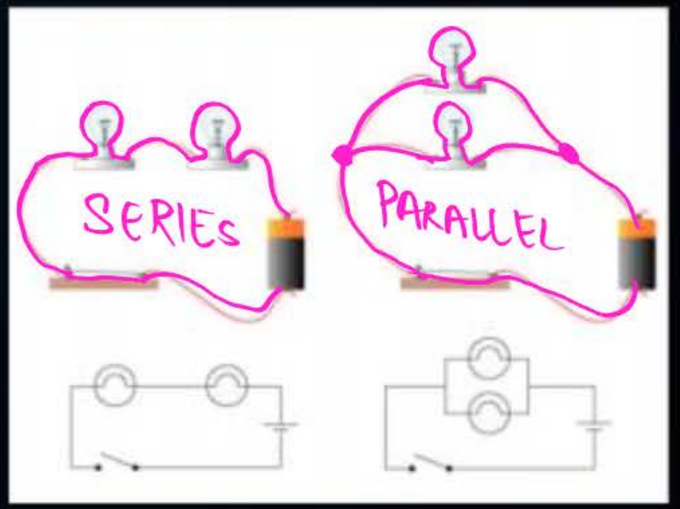
$$IR_t = IR_1 + IR_2 + IR_3$$

$$\cancel{I} R_t = \cancel{I}(R_1 + R_2 + R_3)$$

Net / Total / effective / equivalent

$$R_t = R_1 + R_2 + R_3$$





PARALLEL CIRCUIT

I = divide
V = Same

* Derivation :-

$$I_t = I_1 + I_2 + I_3$$

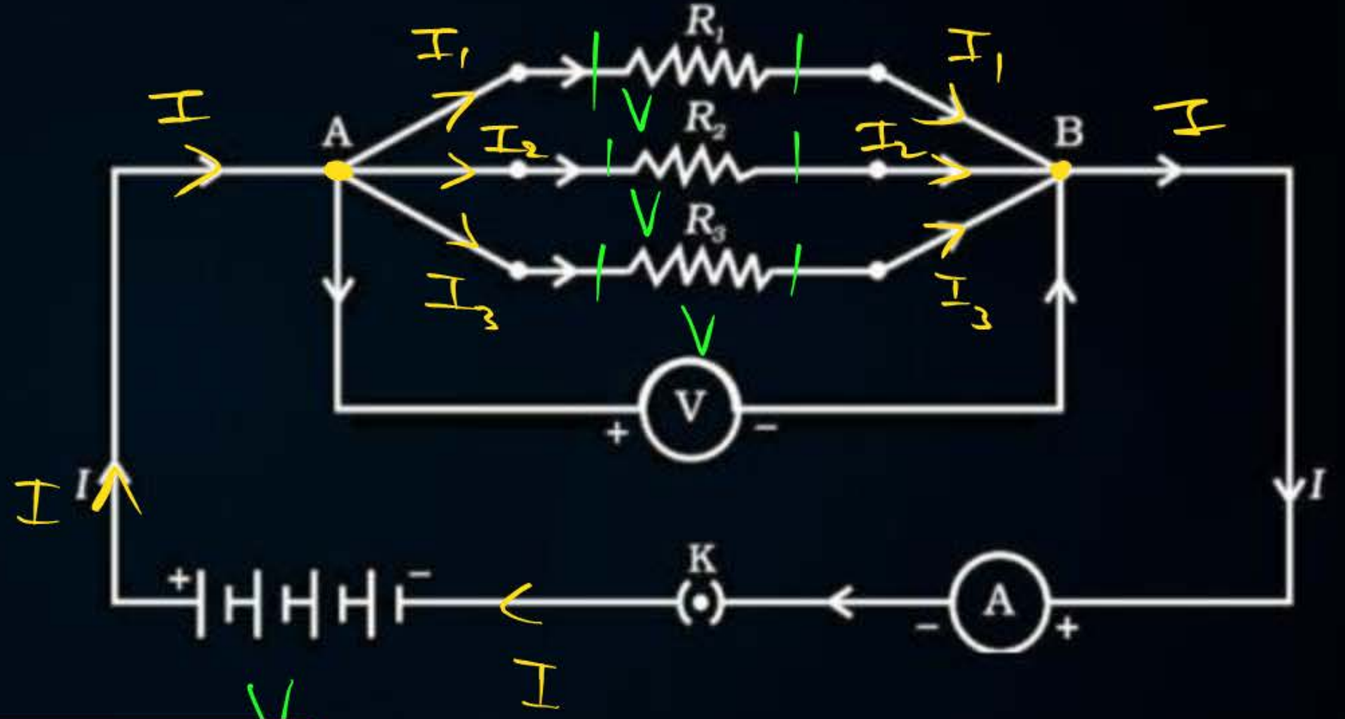
Applying ohm's law $V = IR$

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

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

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

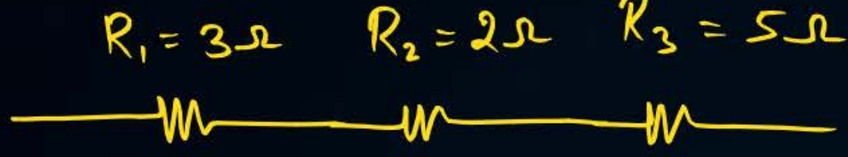
$$\boxed{\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$



COMBINATION OF RESISTORS

Series:

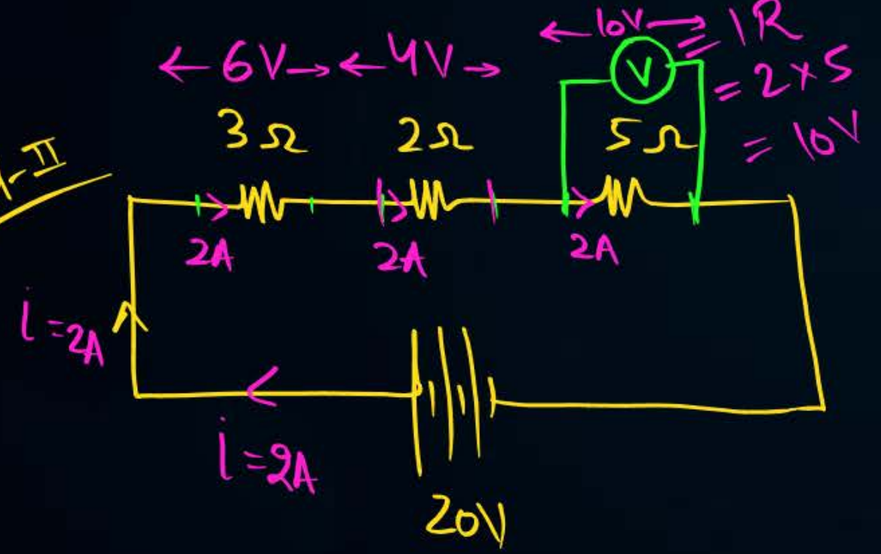
Level-I



$$\equiv \quad R_t = R_1 + R_2 + R_3 = 2 + 3 + 5 = 10\Omega$$

$$R_t = 10\Omega$$

Level-II



find the current drawn in the circuit ⇒ ?

$R_t = 10\Omega$, $V = 20V$

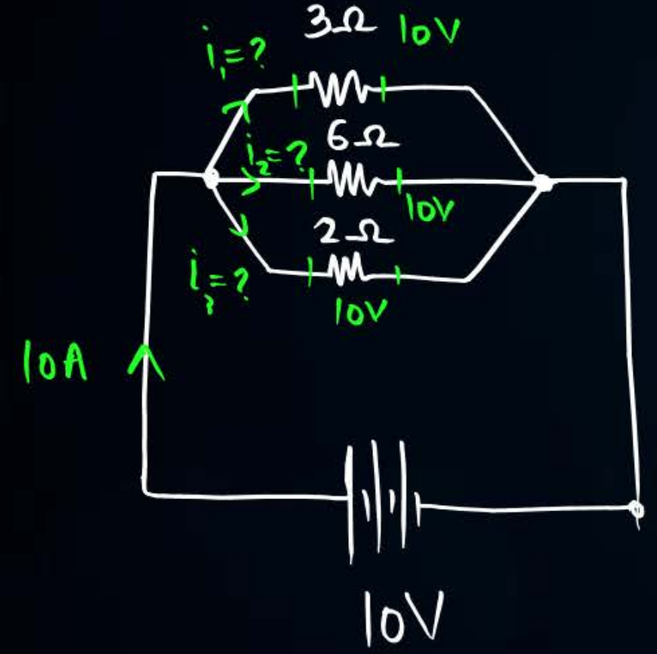
$$i = \frac{V}{R} = \frac{20}{10} = 2A$$

Level-III

find $V_{\text{at } 5\Omega} = IR = 2 \times 5 = 10V$

COMBINATION OF RESISTORS

Parallel: I = divide, V = Same



level - I find R_t = ?

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_t} = \frac{1}{3} + \frac{1}{6} + \frac{1}{2} = \frac{4+2+6}{12}$$

$$= \frac{12}{12} = 1$$

$R_t = 1\Omega$ ✓

Level-2 find I = ?

$V = IR$

$10 = I \times 1$

$I = 10A$ ✓

level - 3 find

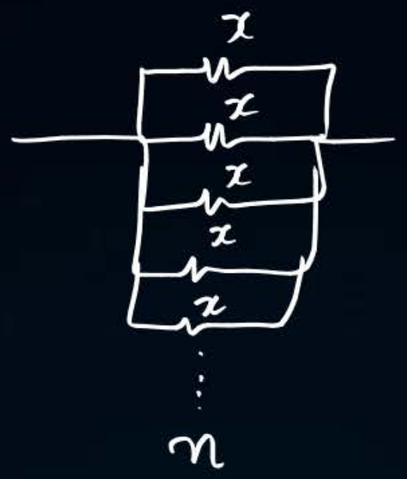
$$i_1 = \frac{V}{R_1} = \frac{10}{3} = 3.33\,A$$

$$i_2 = \frac{V}{R_2} = \frac{10}{6} = \frac{5}{3} = 1.66\,A$$

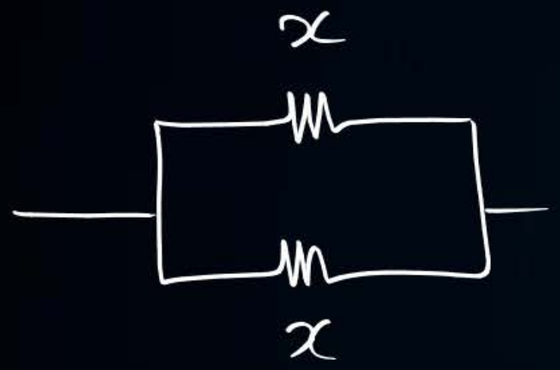
$$i_3 = \frac{V}{R_3} = \frac{10}{2} = 5A$$

PRACTICE PROBLEMS 1 :

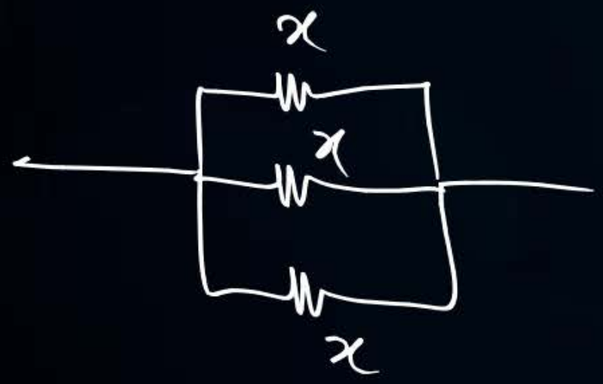
TRICKS (for MCQ or Answer Jhatka Verify)



$\equiv \frac{x}{n}$

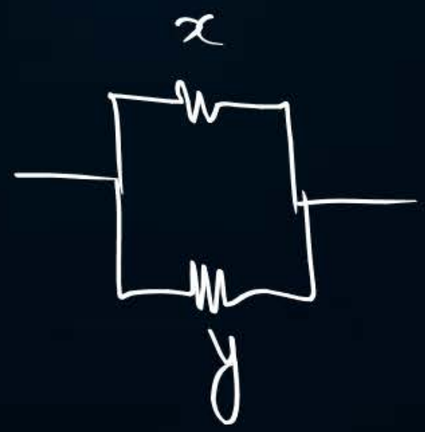


$\equiv \frac{x}{2}$

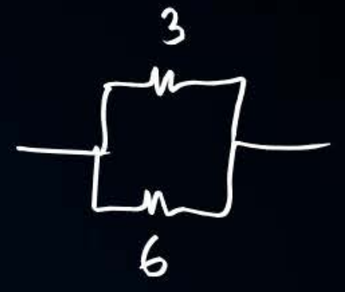


$\equiv \frac{x}{3}$

Common



$\equiv \frac{xy}{x+y}$



$\equiv \frac{3\times 6}{3+6}$

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

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

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

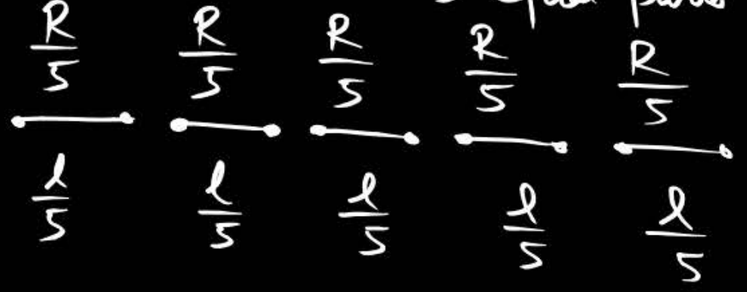
$\frac{1}{R_t} = \frac{1}{2} \Rightarrow R_t = 2\Omega$

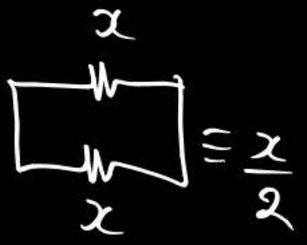
Imp. Ques

R

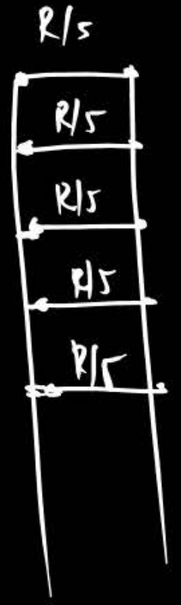
↓ divides it into 5 equal parts

$\frac{R}{5} \propto \frac{l}{5}$





$\equiv \frac{x}{2}$



$\equiv \frac{R/5}{5} = \left(\frac{R}{25}\right)$ ✓

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$$

$$\frac{1}{R_t} = \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}}$$

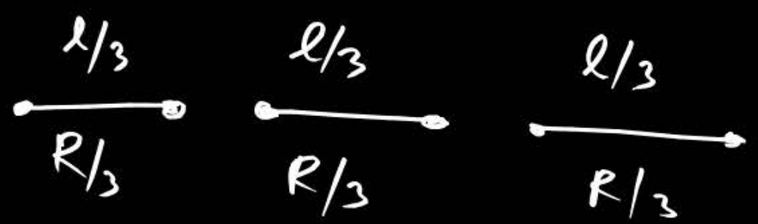
$$\frac{1}{R_t} = \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R}$$

$$\frac{1}{R_t} = \frac{25}{R}$$

$$R_t = \frac{R}{25}$$

$$\frac{R_{Pehle}}{R_{Baad}} = \frac{R}{\frac{R}{25}} = 25\,\frac{R}{R'}$$

$$R : R' = 25 : 1$$



R'

$\frac{R/3}{3} = \frac{R}{9}$

$R : R' = \frac{1}{R} : \frac{1}{R'} = 1 : \frac{1}{9} = 9 : 1$

General Jugaad (GeJu)

n Tukde

R'

$R : R' = n^2 : 1$

Pahle Baad

QUESTION

H.W.

A piece of wire of resistance R is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is R', then the ratio R/R' is:

A 1/25

B 1/5

C 5

D 25

QUESTION

H.W.

How many 176 Ω resistors (in parallel) are required to carry 5 A on a 220 V line?

THANK YOU