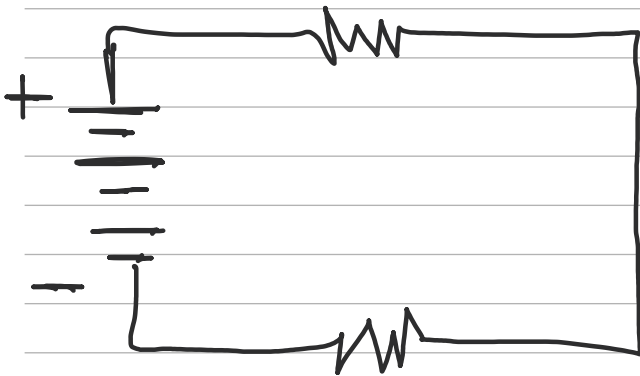


clo2, part 3, DC circuit

Page 6.1 to 6.13

Nouf Albedwawi

Series circuit



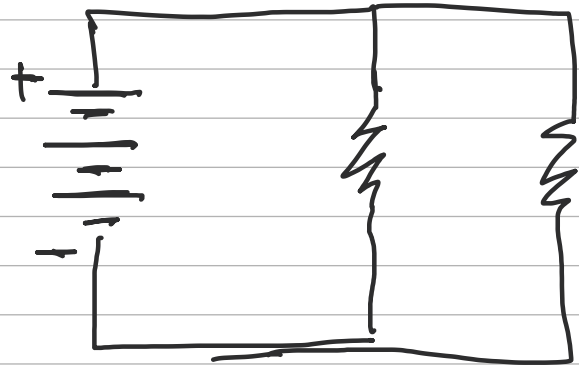
$$I_t = I_1 = I_2 = I_3$$

$$V_t = V_1 + V_2 + V_3$$

$$R_t = R_1 + R_2 + R_3 \dots$$

single path

parallel circuit

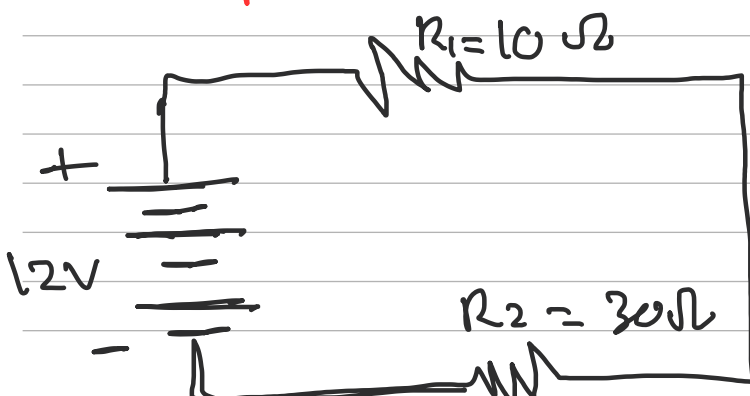


$$I_t = I_1 + I_2 + I_3$$

$$V_t = V_1 = V_2 = V_3$$

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \text{ or } \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)^{-1}$$

Example 1. series circuit.



$$V = 12V$$

$$\boxed{1} R_t = ??$$

$$\boxed{2} I_t = ??$$

$$R_t = ??$$

$$R_t = R_1 + R_2$$

$$R_t = 40\Omega$$

$$I_t = ??$$

$$= 10 + 30$$

$$V = 12V \quad I_t = \frac{V_t}{R_t}$$

$$R_t = 40\Omega$$

$$I_t = \frac{12}{40}$$

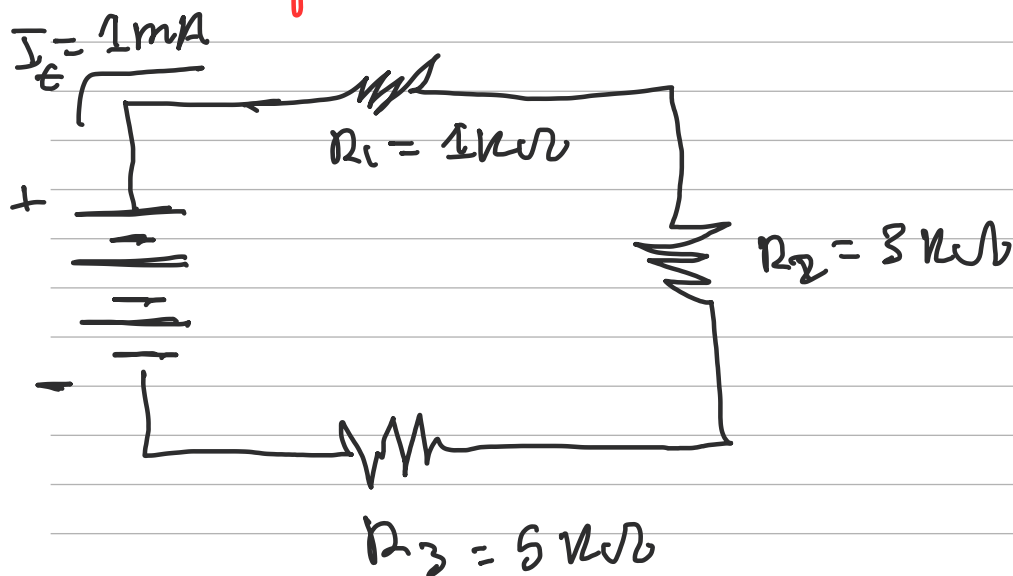
$$R_t = 40\Omega$$

$$I_t = 0.3A$$

$$V_t = 12V$$

$$\boxed{I_t = 0.3A}$$

Example 2.



$$I_t = 1mA \text{ or } 1 \times 10^{-3} \quad \boxed{1} R_t = ??$$

$$\boxed{2} V_t = ??$$

$$R_1 = 1k\Omega \text{ or } 1 \times 10^3$$

$$R_t = R_1 + R_2 + R_3$$

$$I_t = 1 \times 10^{-3}$$

$$R_2 = 3k\Omega \text{ or } 3 \times 10^3$$

$$1 \times 10^3 + 3 \times 10^3 + 5 \times 10^3$$

$$R_t = 9 \times 10^3$$

$$R_3 = 5k\Omega \text{ or } 5 \times 10^3$$

$$= 9k\Omega \text{ or } 9 \times 10^3$$

$$V_t = I_t \times R_t$$

$$V_t = ??$$

$$= 1 \times 10^{-3} \times 9 \times 10^3$$

$$V_t = 9V \Rightarrow V_1 + V_2 + V_3$$

$$\boxed{V_t = 9V}$$

$$R_t = 9 \mu\Omega \text{ or } 9 \times 10^{-3} =$$

$$I = 1 \times 10^{-3}$$

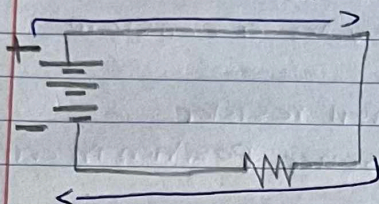
$\Downarrow$

in three R are

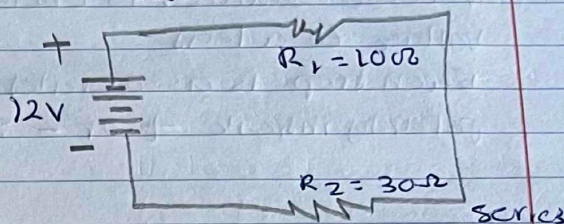
same

Part 3, DC Circuits

Simple Series Circuit



Simple DC circuit with additional resistor.



We will use Ohm's Law

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

$$V = 12V \quad I = \frac{12}{40}$$

$$R = 40$$

$$I = 0.3A$$

$$I_t = ??$$

$$R_t = ??$$

$$R_t = R_1 + R_2 + R_3$$

$$R_t = R_1 + R_2 = 10 + 30$$

$$R_t = 40\Omega$$

$$I_t = I_1 = I_2 = I_3$$

Ohm's Law :-

* describe the relationship between the variables of V , I and R . but is linear.

$R_t =$ doubled

effect of $I_t = ??$

$$R_t = 40 \times 2 = 80\Omega$$

$$I = \frac{12}{80}$$

$$I = 0.15A$$

We conclude that

we $R \uparrow$, $I \downarrow$

When R double, I reduce by half

* if R_t Reduced to half

$$R_t = 40 \div 2 = 20\Omega$$

$$I = \frac{12}{20}$$

$$I = 0.6A$$

$R \downarrow$ $I \uparrow$

Voltage Drop and Further Application Ohm's law

Voltage Drop :-



→ refers to the loss in electrical pressure or

→ EMF caused by forcing electrons through resistor.

amount of electrical pressure required to force given number of electron through resistor $\propto$ to the size of resistor.

$$V_{R3} = 4 \times 10^{-3} \times 5 \times 10^3$$

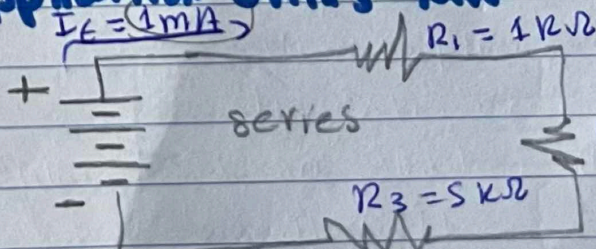
$$V_{R3} = 20V$$

$$V_{R1} = 1 \times 10^{-3} \times 1 \times 10^3$$

$$V_{R1} = 1V$$

$$V_{R2} = 1 \times 10^{-3} \times 3 \times 10^3$$

$$V_{R2} = 3V$$



$$I_t = I_1 = I_2 = I_3$$

$$V_t = V_1 + V_2 + V_3$$

$$R_t = R_1 + R_2 + R_3$$

$$I_t = 1mA = 1 \times 10^{-3}$$

$$R_t = 1 + 3 + 5$$

$$R_t = 9k\Omega$$

$$V_t = ?? \text{ or } 9 \times 10^3$$

$$V_t = I \times R_t = 1 \times 10^{-3} \times 9 \times 10^3$$

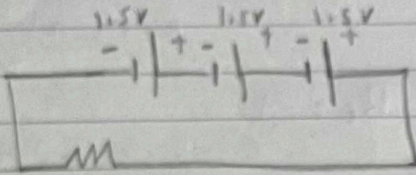
$$V_t = 9V$$

Voltage sources in series

Voltage source: is energy source that provides a constant voltage to a load

Each drop is associated with each individual resistor

polarity inherent $+$ or $-$ sign depending on source position in circuit



$$V_t = V_1 + V_2 + V_3$$

$$I_t = I_1 = I_2 = I_3$$

$$R = R_1 + R_2 + R_3$$

$$E = V_t = 1.5 + 1.5 + 1.5$$

$$E = 4.5V$$

$$E = V$$

$$V_1 = 12V$$

Kirchhoff's Voltage Law

Example 1

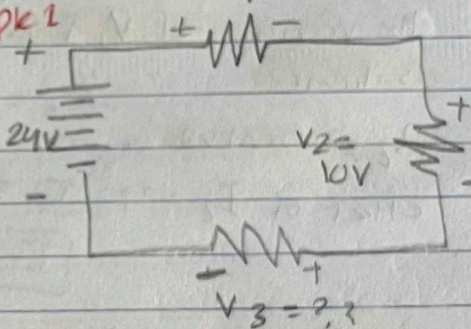
analysis of electron circuit

sum of all V around closed path

or loop is 0

sum of V drops = total source V

$$V_s = V_1 + V_2 + V_3$$



1) Series

$$V_t = V_1 + V_2 + V_3$$

step 1

2) find V_3

$$V_t = 24$$

$$V_1 = 12$$

$$V_2 = 10$$

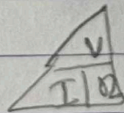
$$V_3 = ??$$

$$V_t = V_1 + V_2 + V_3$$

$$V_t - V_1 - V_2 = V_3$$

$$24 - 12 - 10 = V_3$$

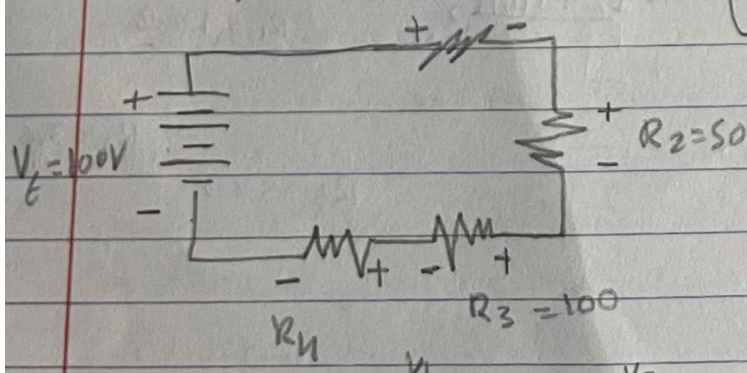
$$V_3 = 2V$$



Example 2

$$R_1 = 10$$

$$1) \text{ Series } 2) R_4 = 340\Omega \quad 3) V_t = 68V$$



$$I = 200mA \times 10^{-3}$$

$$V = 100V$$

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

$$= \frac{100}{200 \times 10^{-3}}$$

$$R_t = 500$$

$$R_4 = ??$$

$$R_t = R_1 + R_2 + R_3 + R_4$$

$$500 = 10 + 50 + 100 + R_4$$

$$500 - 100 - 50 - 10 = R_4$$

$$R_4 = 340\Omega$$

$$V_{R_1} = ??$$

$$V_1 = I \times R_1$$

$$I = 200 \times 10^{-3}$$

$$= 200 \times 10^{-3} \times 10$$

$$R_1 = 10$$

$$V_1 = 2$$

$$V_2 = 200 \times 10^{-3} \times 50$$

$$= 10V$$

$$V_3 = 10V$$

$$V_3 = 200 \times 10^{-3} \times 100$$

$$= 20V$$

$$V_t = V_1 + V_2 + V_3 + V_4$$

$$100 = 2 + 10 + 20 + V_4$$

$$100 - 20 - 10 - 2 = V_4$$

$$V_4 = 68V$$

Voltage divider

* Voltage drops are proportional to the Ohmic value of constituent resistors

* are devices that make it possible to obtain more than one V from single power source

* consist of ?

→ resistor

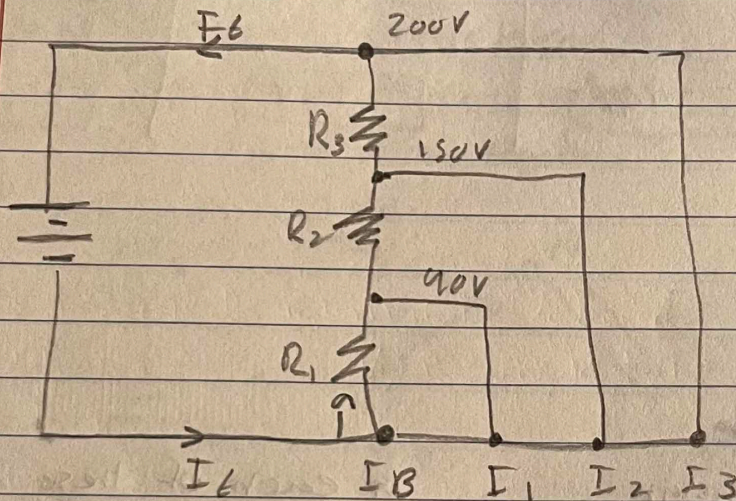
→ resistor connected in series, with fixed or movable contact and two fixed terminal contacts

* as current flows through resistors different V can be obtained between the contacts

* I not given

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

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



$$R_1 \Rightarrow I_B \quad V_{out} = \frac{R_2}{R_1 + R_2} \times V_{in}$$

$$R_2 \Rightarrow I_B + I_1$$

$$R_3 \Rightarrow I_B + I_1 + I_2$$

$$R_1 = 90$$

$$R_2 = 60$$

$$R_3 = 50$$

* Ohm's law

$$V_3 = I(R_3) \quad I = \frac{V_s}{R_E}$$

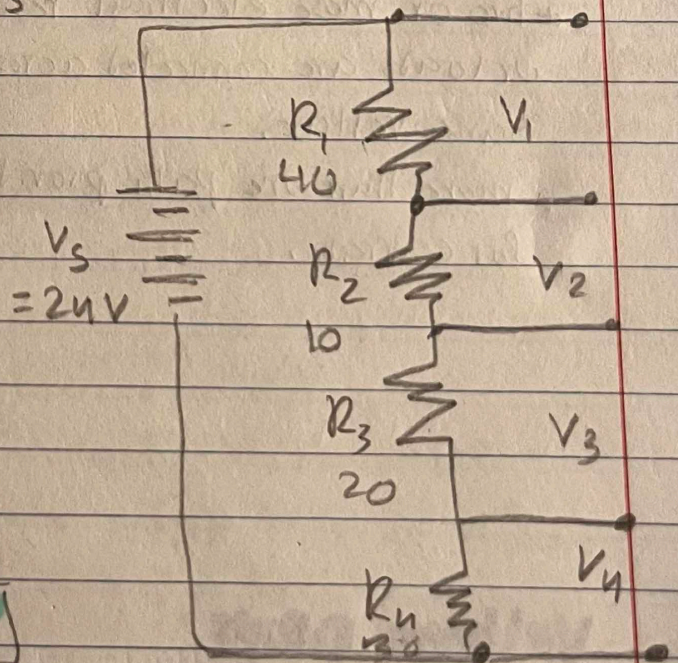
$$V_3 = \frac{R_3}{R_E} (V_s)$$

$$V_3 = \frac{R_3}{R_E} (V_3)$$

Find voltage divider ?

$$I) R_E = R_1 + R_2 + R_3 + R_n$$

$$40 + 10 + 20 + 3 = 100 \Omega$$



$$V_1 = \frac{R_1}{R_E} V_s$$

$$= \frac{40}{100} \times 24$$

$$= 9.6V$$

$$V_2 = \frac{R_2}{R_E} V_s$$

$$= \frac{10}{100} \times 24$$

$$= 2.4V$$

$$V_3 = \frac{R_3}{R_E} V_s$$

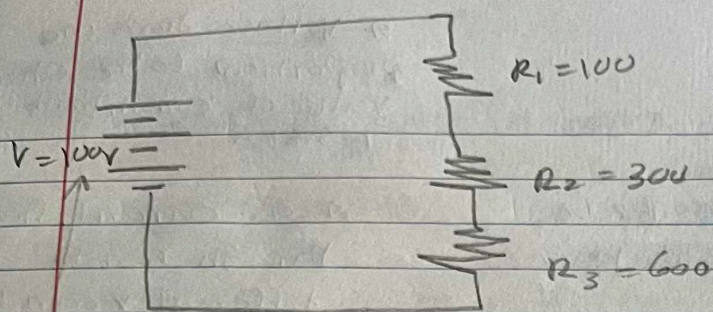
$$= \frac{20}{100} \times 24$$

$$= 4.8V$$

$$V_4 = \frac{R_n}{R_E} V_s$$

$$= \frac{30}{100} \times 24$$

$$= 7.2V$$



Voltage divider $V_x = \frac{R_x}{R_T} V_E$

$$R_T = R_1 + R_2 + R_3$$

$$= 100 + 300 + 600$$

$$= 1000 \Omega$$

$$V_1 = \frac{R_1}{R_T} V_E$$

$$= \frac{100}{1000} \times 100$$

$$= 10V$$

$$V_2 = \frac{R_2}{R_T} V_E$$

$$= \frac{300}{1000} \times 100$$

$$= 30V$$

$$V_3 = \frac{R_3}{R_T} V_E$$

$$= \frac{600}{1000} \times 100$$

$$= 60V$$

check:

$$V_1 + V_2 + V_3$$

$$= 10 + 30 + 60$$

$$= 100V$$

parallel DC circuit

- two or more electrical resistors or loads are connected across the same voltage.
- more than one path provided for current.

- each of these parallel paths called branch
- minimum requirement for parallel circuit are:
 - power source
 - conductors
 - resistance or load for each current path
 - two or more paths for current flow

Voltage Drops

- voltage across any branch = voltage across all of other branches

Total Parallel R

- $R_T \downarrow$ when connected to parallel
- $R_T <$ smallest R in circuit
- I has several resistors
- $I = I_1 + I_2 + I_3$

formula of R: reciprocal

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots}$$

Current source :-

is an energy source that provide constant value of I to load even when load changes in resistive value

general rule :-

$\rightarrow I_t$ produced by current source in parallel = $I_1 + I_2 + I_3$
 $I_t = I_1 + I_2 + I_3$

Kirchhoff current law

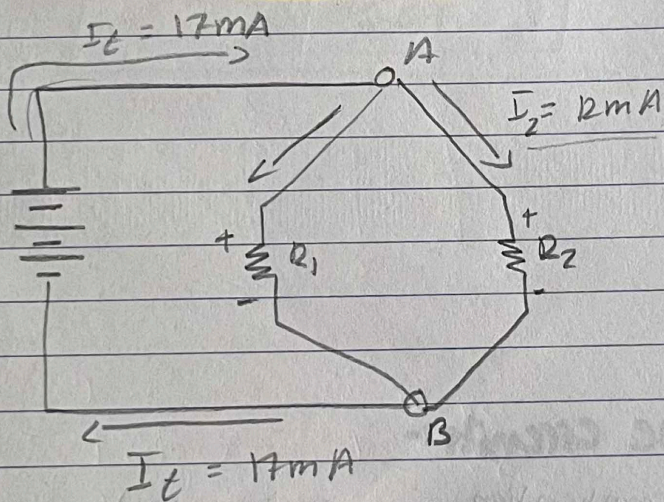
sum of I into junction or node = sum of current flowing out that junction or node

A junction can be defined as point in circuit where two or more circuit path comes together

it is the point in circuit where the minimum branches join

$$I_t = I_1 + I_2 + I_3$$

current going in = current going out
 $I_{in} = I_{out}$

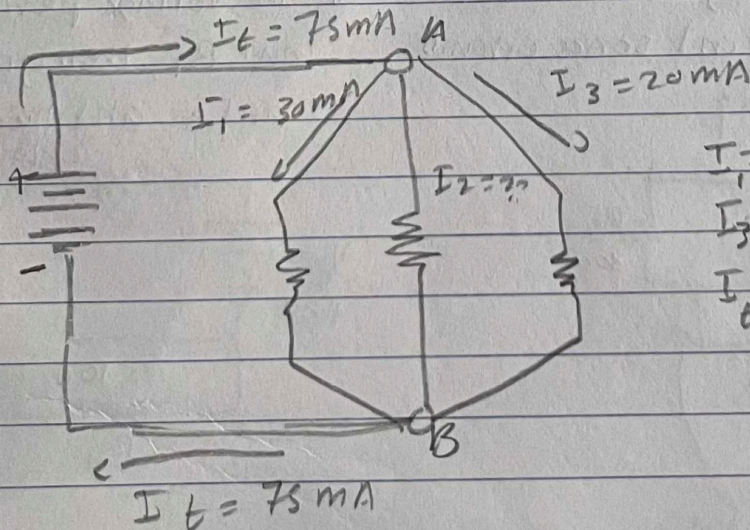


$$I_t = I_1 + I_2$$

$$I_t = 17 \text{ mA} \quad 17 - 12$$

$$I_1 = 5 \text{ mA}$$

$$I_t = 5 \text{ mA} + 12 \text{ mA} = 17 \text{ mA}$$



$$I_t = I_1 + I_2 + I_3$$

$$I_t = 75 \text{ mA} \quad 75 - 30 - 20$$

$$I_2 = 25 \text{ mA}$$

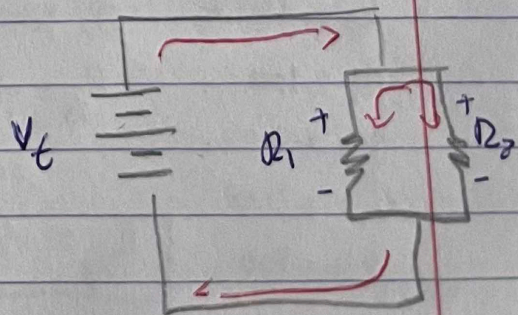
Current divider :-

parallel circuit is current divider

there is current through each resistor

V are same across both resistor.

'I inversely proportional' to the ohmic value of R



Branches
 higher R have less I than those with lower R

Ohm's Law

$$I_D = \frac{V_E}{R_D}$$

$$V_E = I_E (R_E)$$

$$I_D = \frac{R_E}{R_D} I_E$$

current divider

final answer

$$R_E = 9.2 \Omega$$

$$I_E = 1.3 \text{ A}$$

$$I_1 = 0.6 \text{ A}, I_2 = 0.4 \text{ A}$$

$$I_3 = 0.3 \text{ A}$$

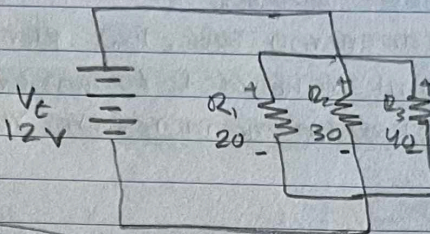
check:

$$I_E = 0.6 + 0.4 + 0.3$$

$$I_E = 1.3 \text{ A}$$

Example:

Determine I_1, I_2, I_3 ??



[1] find R_E

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

$$= \frac{1}{\frac{1}{20} + \frac{1}{30} + \frac{1}{40}}$$

$$R_E = 9.2 \Omega$$

[2] $I_E = ??$

$$I_E = \frac{V_E}{R_E}$$

$$= \frac{12}{9.2}$$

$$I_E = 1.3 \text{ A}$$

[3] $I_1 = \frac{R_E}{R_1} \times I_E$

$$= \frac{9.2}{20} \times 1.3$$

$$I_1 = 0.6 \text{ A}$$

$$I_2 = \frac{R_E}{R_2} \times I_E$$

$$= \frac{9.2}{30} \times 1.3$$

$$I_2 = 0.4 \text{ A}$$

$$I_3 = \frac{R_E}{R_3} \times I_E$$

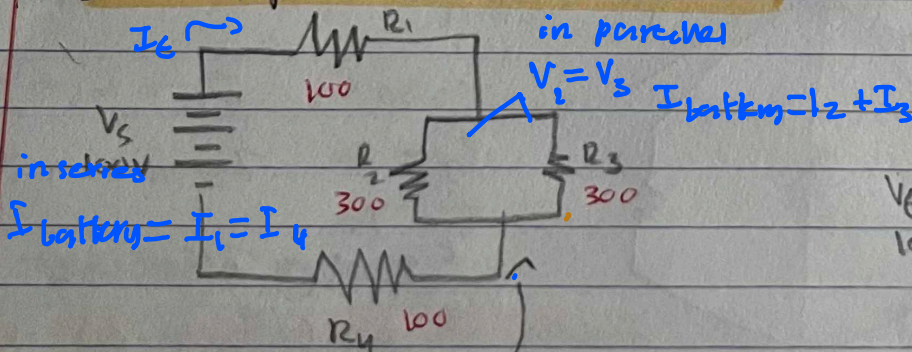
$$= \frac{9.2}{40} \times 1.3$$

$$I_3 = 0.3 \text{ A}$$

Series parallel DC circuits:-

circuits are usually combination of both, parallel and series circuits

the voltage provide current out R_1 , then group of R_2 and 3 and then R_4 .



determine R_E

$$V_E = 100 \text{ V}$$

$$R_1 = 100$$

$$R_2 = 300$$

$$R_3 = 300$$

$$R_4 = 100$$

[1] parallel

$$R_{23} = \frac{1}{\frac{1}{300} + \frac{1}{300}}$$

$$R_{23} = 150 \Omega$$

[2] series

$$R_E = R_1 + R_{23} + R_4$$

$$= 100 + 150 + 100$$

$$R_E = 350 \Omega$$

[3] $I_T = ??$

$$V = 100 \text{ V} \quad I_E = \frac{V}{R} = \frac{100}{350}$$

$$R_E = 350$$

$$I_E = 0.286 \text{ A}$$

~~$$I_1 = \frac{R_{23}}{R_1} \times I_E$$~~
~~$$= \frac{150}{350} \times 0.286$$~~

~~$$I_2 = \frac{R_3}{R_2} \times I_E$$~~
~~$$= \frac{300}{300} \times 0.286$$~~

$$V_{23} = I_t \times R_{23}$$

$$= 0.286 \times 150$$

$$= 42.9$$

So the voltage
in I_2 and I_3
are 42.9V because
are parallel

$$I_2 = \frac{V_2}{R_2}$$

$$= \frac{42.9}{300}$$

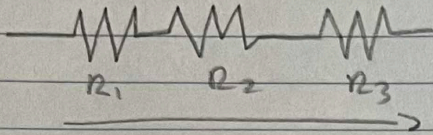
$$I_2 = 0.143$$

$$I_3 = \frac{V_3}{R_3}$$

$$= \frac{42.9}{300}$$

$$I_3 = 0.143A$$

Series resistor

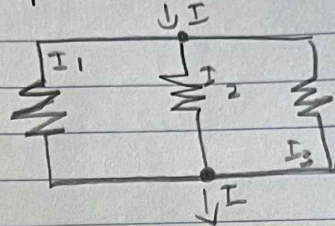


$$I_t = I_1 = I_2 = I_3$$

$$V_t = V_1 + V_2 + V_3$$

$$R_t = R_1 + R_2 + R_3$$

parallel resistor



$$I_t = I_1 + I_2 + I_3$$

$$V_t = V_1 = V_2 = V_3$$

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

Question:-

1. For resistors in series circuit, the total resistance is equal to sum of individual resistors in the circuit

2. What's Ohm's law?

one same
V = I x R → Resistor
Voltage
or
E = I x R → current

Q3. The source voltage = the sum of voltage drops in known as

Kirchhoff's Voltage Law

4. What is the primary difference between series and parallel circuit?
Series: only one path for current
parallel: more than one path for current to follow.

5. The total resistance in parallel circuit is always less than value of the smallest resistor in the circuit

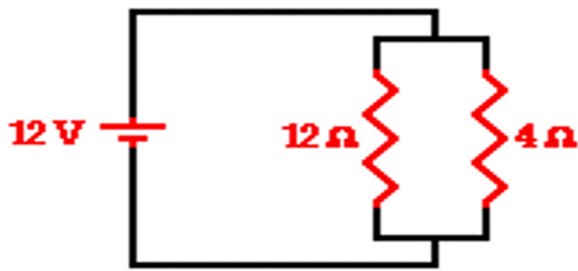
$$R_{total} < R_{smallest}$$

6. The total current produced by current sources in parallel is equal to the algebraic sum of individual source

7. A circuit that is combination of a series circuit and one or more parallel circuit is known as

series parallel circuit or combination circuit.

A 12-V battery , a 12-ohm resistor and a 4-ohm resistor are connected as shown. The voltage drop across the 12-ohm resistor is ____ that across the 4-ohm resistor.



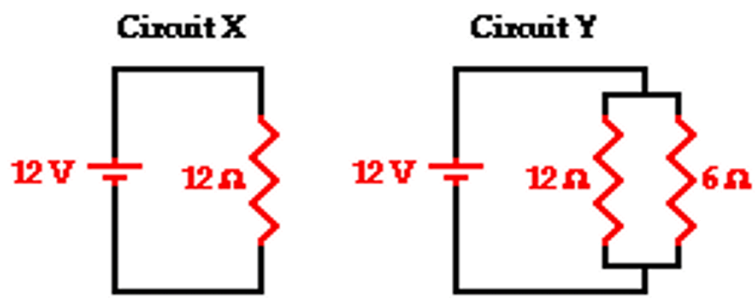
- a. 1/3
- b. 1/2
- c. 2/3
- d. the same as
- e. 1.5 times
- f. twice
- g. three times
- h. four times

Because it is voltage drops

9/27/24

A 12-V battery and a 12-ohm resistor are connected as shown in circuit. A 6-ohm resistor is added to the 12-ohm resistor to create circuit Y as shown.

The voltage drop across the 6-ohm resistor in circuit Y is ____ that across the resistor in X.



- a. larger than
- b. smaller than
- c. the same as

parallel is connected

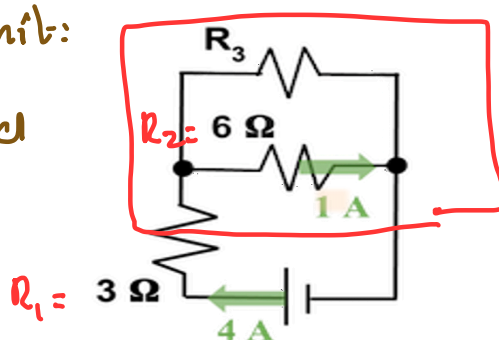
51

For the circuit shown, the current out of the battery is 4 A and the current that passes through the $6\ \Omega$ resistor is 1 A

I_{battery}

combination circuit:

series and parallel circuit



→ parallel:

$$V_{\text{battery}} = V_1 = V_2 = V_3$$

$$I_{\text{battery}} = I_1 + I_2 + I_3$$

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

What is the current that passes through R_3 ?

What is the resistance of R_3 ?

1 $I_{\text{battery}} = 4\text{ A}$

2 parallel

3 $I_{\text{battery}} = I_1 + I_3$

$$4 = \cancel{1} + I_3$$

$$\boxed{3 = I_3}$$

$$R_2 = 6\ \Omega$$

$$I_2 = 1\text{ A}$$

$$V_2 = I \times R$$

$$= 6 \times 1$$

$$\boxed{6\text{ V}}$$

$$V_2 = V_3$$

$$\text{so } \boxed{V_3 = 6\text{ V}}$$

$$R_3 = ??$$

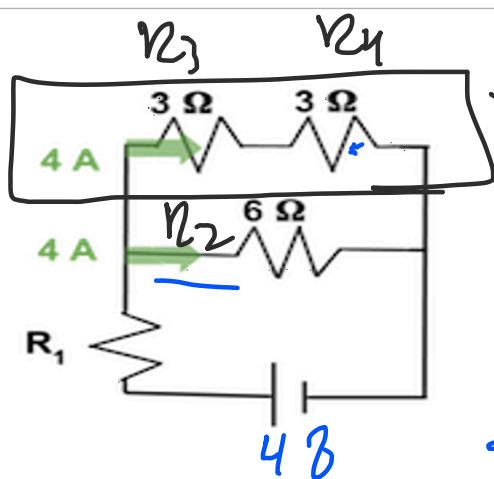
$$V_3 = 6\text{ V}$$

$$I_2 = 3$$

$$R_3 = \frac{V_3}{I_3}$$

$$= \frac{6}{3}$$

$$\boxed{R_3 = 2\ \Omega}$$



$I_{34} = 4$ so parallel
 $I_R = 4$ $I_t = 4 + 4$

$I_t = 8$



$\Rightarrow$ series
 so $I_t = I_1 = I_2 = \dots$

What is the current that passes through R_1 ?

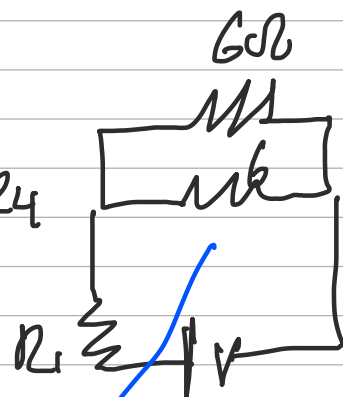
If the battery voltage is 48 V, what is resistance of R_1 ?

1 $R_1 = ??$

$R_{34} = R_3 + R_4$

$= 3 + 3$

$R_{34} = 6\Omega$



I_R is also 8

because I_{342} is 8 so I_1 also

$I_1 = 8A$

2

parallel so R_{342}

$R_{342} = \frac{1}{\frac{1}{6} + \frac{1}{6}}$
 $R_1 = 3\Omega$

4 $V_{R1} = 24$

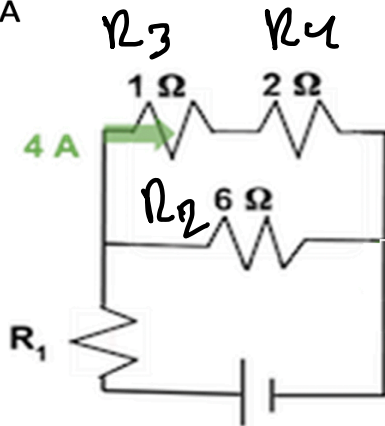
$R_1 = ??$ $R_1 = \frac{24}{8}$

$I = 8$

$= 3$

$V_{R342} = 3 \times 8 = 24 \Rightarrow V_t = 48 \quad 48 - 24 = 24$
 $R_{342} = 3$
 $I = 8$
 $V_{R342} = 24$

For the circuit shown, the current through the branch with the 1Ω and 2Ω resistors is 4 A , and the current out of the node is 6 A



$I = 4$
 $R_{34} = 3$
 $V_{34} = 12$
 V_{R2}

What is the current that passes through the 6Ω resistor?

If the battery voltage is 24 V , what is resistance of R_1 ?



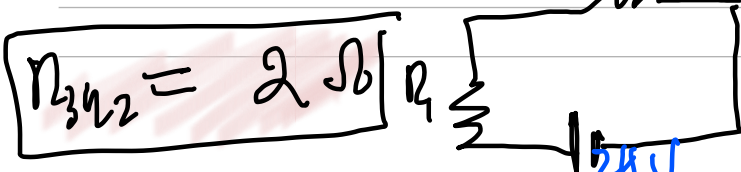
$R_3 = 1\Omega$
 $R_4 = 2\Omega$
 $R_{34} = R_3 + R_4$
 $= 1 + 2$
 $R_{34} = 3\Omega$

$R_2 = 6\Omega$
 $V_2 = 12$
 $I_2 = \frac{12}{6}$

$I_2 = 2\text{ A}$

parallel so R_{342}

$R_{342} = \frac{1}{\frac{1}{3} + \frac{1}{6}}$
 2Ω



8) $I_{342} = ??$

$R_{342} = 2\Omega$

$V_{342} = 12$

$I_{342} = \frac{V}{R}$
 $= \frac{12}{2}$

$I_{342} = 6A$

So if I_{342} is 6 also
 $I_{R1} = 6$
because it's series

$R_1 = 2\Omega$

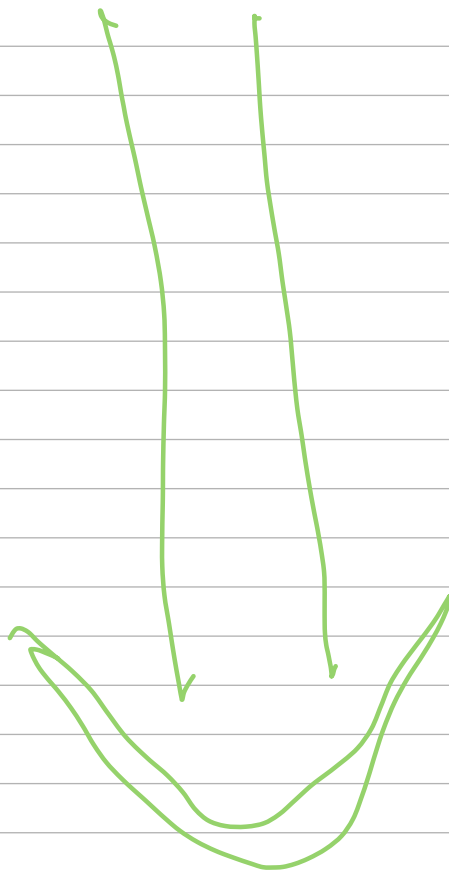
$V_1 = 12$

$I_1 = 6$

$R_1 = \frac{V_1}{I_1}$
 $= \frac{12}{6}$

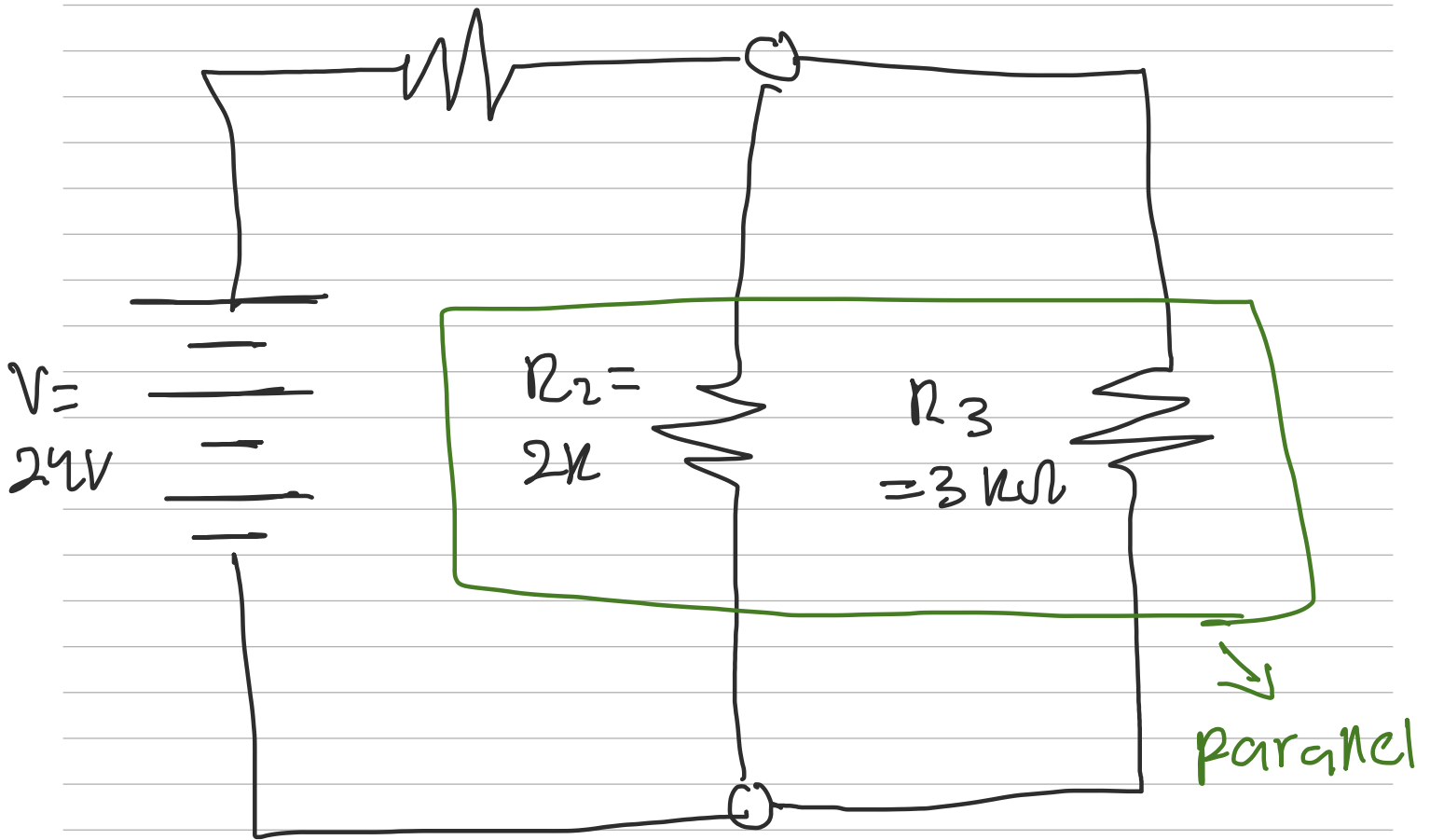
$R_1 = 2\Omega$

Extra examples



$$R_1 = 1\text{ k}\Omega$$

Find I_2 and I_3



1) Combination circuit

2) $R_{23} = ??$

$$R_{23} = \frac{1}{\frac{1}{2 \times 10^3} + \frac{1}{3 \times 10^3}}$$

$$R_{23} = 1200\Omega$$

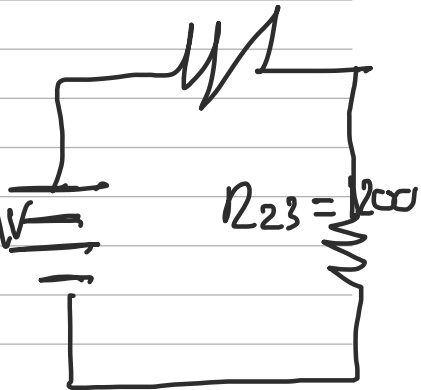
3) $R_t =$

$$R_t = R_1 + R_{23}$$

$$= 1 \times 10^3 + 1200$$

$$R_t = 2200\Omega$$

$$R_1 = 1\text{ k}\Omega$$



4) $I_t = ??$

$$V_s = 24$$

5) $V_{R_{23}} = ??$

$$V_{R_{23}} = I_t \times R_{23}$$

$$R_t = 2200$$

$$I_t = \frac{24}{2200}$$

$$= 0.011 \text{ A}$$

$$= 0.01 \times 1200$$

$$V_{R_3} = 12 \text{ V}$$

so $V_{R_2} = 12$ and

$$V_{R_3} = 12 \text{ V}$$

Q I_2 and $I_3 = ??$

$$I_2 = \frac{V_2}{R_2}$$

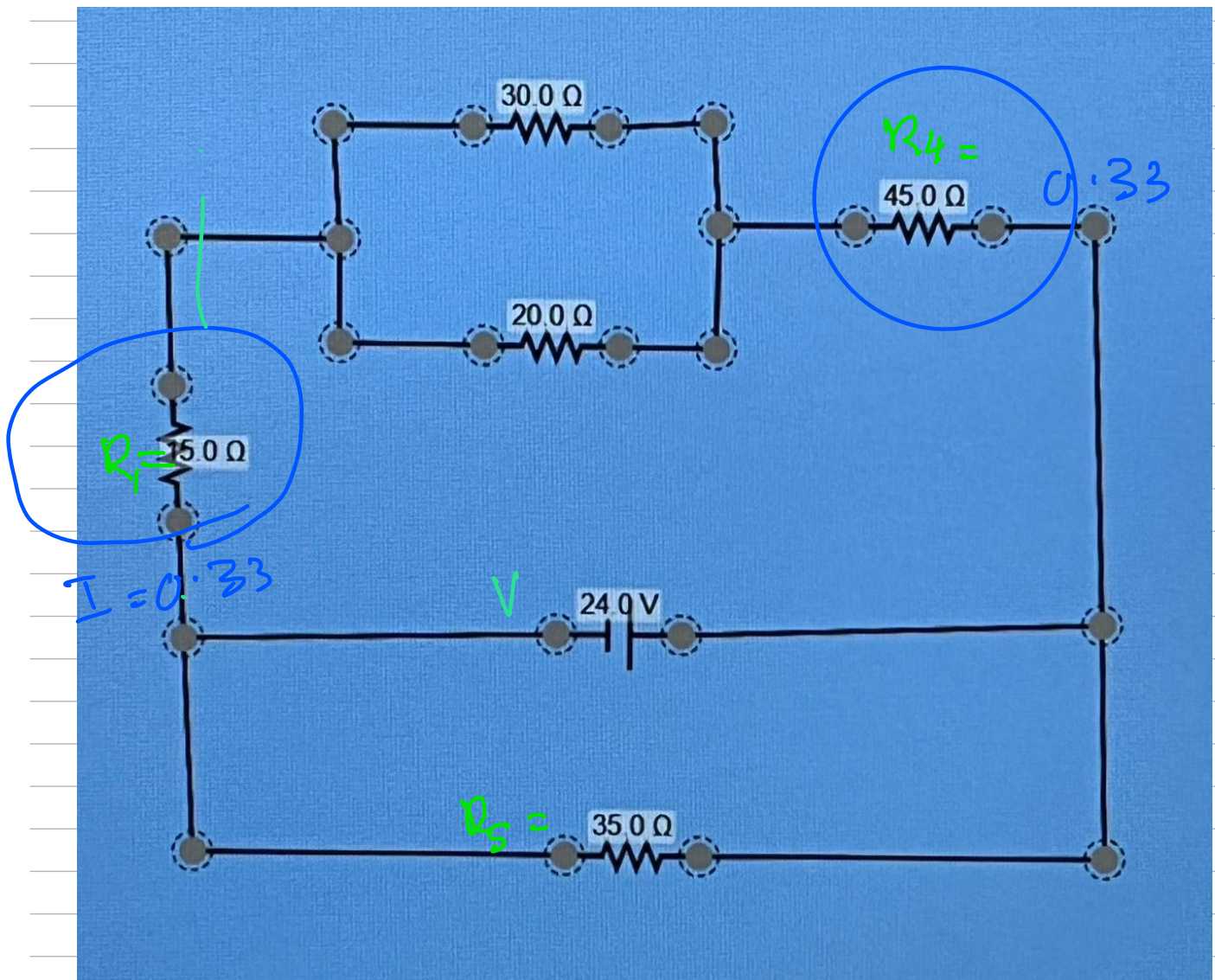
$$= \frac{12}{2 \times 10^3}$$

$$= 6 \times 10^{-3} \text{ A}$$

$$I_3 = \frac{V_3}{R_3}$$

$$= \frac{12}{3 \times 10^3}$$

$$= 4 \times 10^{-3} \text{ A}$$



:Questions

- .Calculate the total resistance of the circuit R_t .1 ✓
- .Find the total current supplied by the battery I_t .2 ✓
- .Determine the voltage across R_1 (V_{R1}) .3 ✓
- .Calculate the current through each resistor (I_2, I_3, I_4, I_5) .4

$R_1 = 15$

$R_2 = 30$

$R_3 = 20$

$R_4 = 45$

$R_5 = 35$

Battery voltage $V = 24$

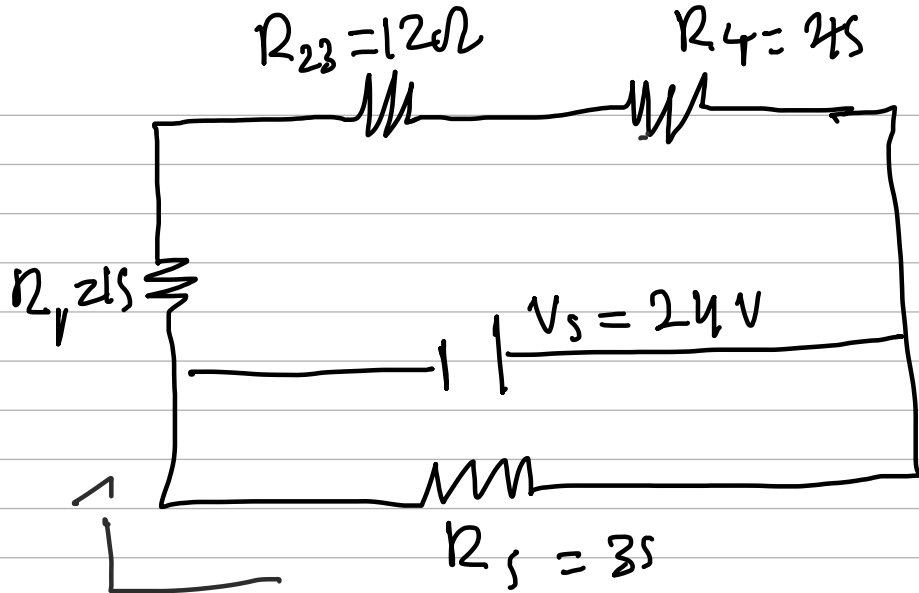
parallel

$R_2 = 30$

$R_3 = 20$

$$R_{23} = \frac{1}{\frac{1}{30} + \frac{1}{20}}$$

$R_{23} = 12 \Omega$

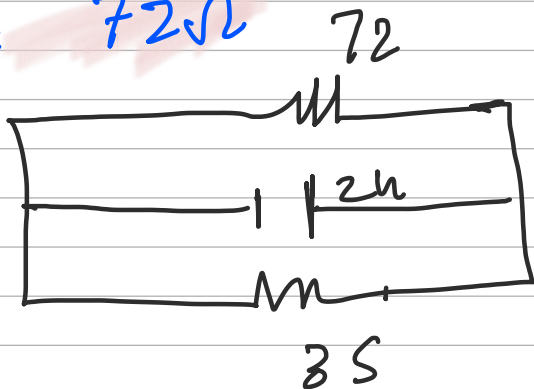


$I_t = 1.019$

[2] $R_1 + R_{23} + R_4$

$R = 1S + 12 + 4S$

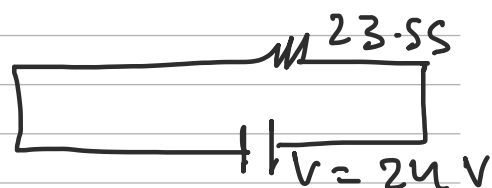
$R_{1234} = 72 \Omega$



[3] $R_t = \frac{1}{\frac{1}{R_{23u}} + \frac{1}{R_5}}$

$$= \frac{1}{\frac{1}{72} + \frac{1}{3S}}$$

$R_t = 23.55 \Omega$



[4] $I_t = ??$

$R_t = 23.55 \Omega$

$V_s = 24V$

$$I_t = \frac{V}{R} = \frac{24}{23.55}$$

$I_t = 1.019A$

[5] $R_{123u} = 72$

$V = 24$

$$I = \frac{V}{R} = \frac{24}{72}$$

$I_1 = 0.33A$

[6] $I_1 = 0.33$

$I_4 = 0.33A$

$$R_1 = 15$$

$$V_{R_1} = 4.95 \text{ V}$$

$$[7] \quad I_s = ??$$

$$R_s = 35 \quad I_s = \frac{24}{35}$$

$$V = 24$$

because its
parallel

$$I_s = 0.685$$

$$[9] \quad I_2 \text{ and } I_3$$



$$R_2 = 30$$

$$V_2 = 3.96$$

$$I_2 = \frac{V}{R} \\ = \frac{3.96}{30}$$

$$I_2 = 0.132 \text{ A}$$

$$R_3 = 20$$

$$V_3 = 3.96$$

$$I_3 = \frac{V}{R} \\ = \frac{3.96}{20}$$

$$I_3 = 0.198 \text{ A}$$

$$I_{23} = 0.33 \text{ A} \\ \text{because it's series}$$

[8]

$$R_{23} = 12$$

$$V_{23} = ??$$

$$I_{23} = 0.33$$

$$V_{23} = I_{23} \times R_{23} \\ = 0.33 \times 12$$

$$V_{23} = 3.96$$

Note if we add I_2 and I_3

$$I_{23} = 0.33 \text{ A} \Rightarrow 0.132 + 0.198$$