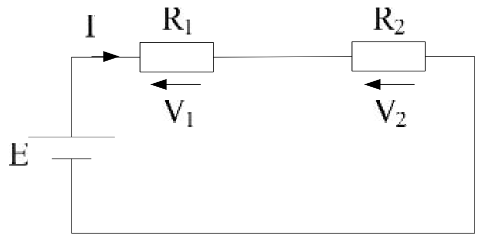
Voltage divider Rule :-



$R_T = R_1 + R_2$

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

$$V_1 = I.R_1 = \left(\frac{E}{R_T}\right).R_1 = \frac{E.R_1}{R_T}$$

$$V_2 = I.R_2 = \left(\frac{E}{R_2}\right).R_2 = \frac{E.R_2}{R_T}$$

$$\boxed{V_n = \frac{ER_n}{R_T}}$$ Voltage divider rule

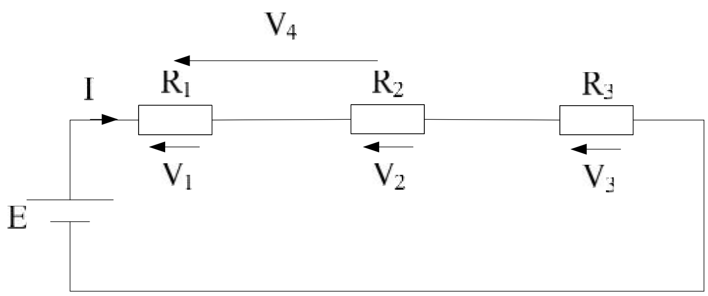
V_n = Voltage across R_n

E = The (emf) voltage across the series elements .

R_T = The total resistance of the series circuits .

Example :- Using voltage divider rule , determine the voltage V_1 , V_2 , V_3 and V_4 for the series circuit in figure below , given that ; $R_1 = 2K\Omega$, $R_2 = 5K\Omega$, $R_3 = 8K\Omega$, $E = 45$ V ?

Solution :-



$$V_1 = \frac{R_1E}{R_T} = \frac{2*10^3*45}{15*10^3} = 6V$$

$$V_2 = \frac{R_2 E}{R_T} = \frac{5*10^3*45}{15*10^3} = 15V$$

$$V_3 = \frac{R_3 E}{R_T} = \frac{8*10^3*45}{15*10^3} = 24V$$

$$V_4 = \frac{(R_1 + R_2)E}{R_T} = \frac{7*10^3*45}{15*10^3} = 21V \qquad \text{or } V_4 = V_1 + V_2 = 21V$$

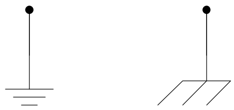
To check: $E - V_1 - V_2 - V_3 = 0$

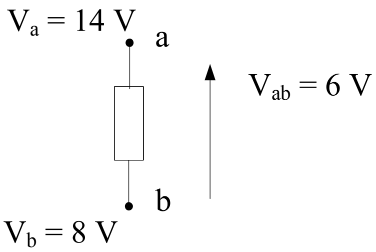
$$E = V_1 + V_2 + V_3 \Rightarrow 45 = 6 + 15 + 24$$

$$45 = 45$$

Active Potential :-

رموز الارضي





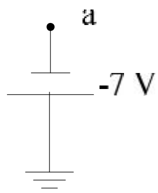
V_{ab} is the voltage difference between the point a and point b

$V_{ab} = V_a - V_b = 14 - 8 = 6V$

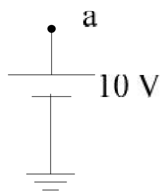
$V_{ba} = V_b - V_a = 8 - 14 = -6V$

$V_{ab} = -V_{ba}$

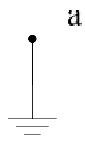
$V_a = -7\ V$



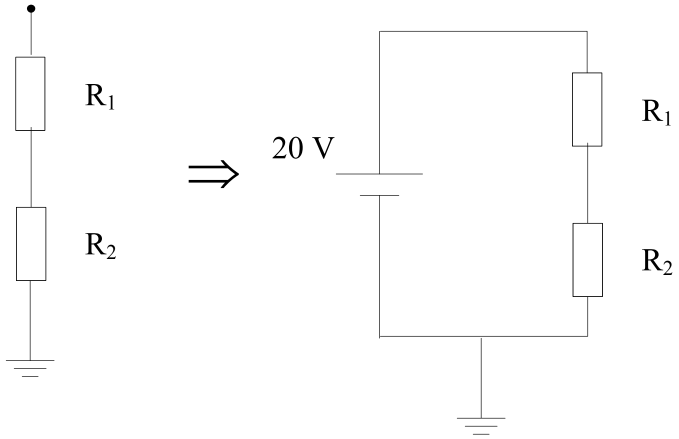
$V_a = 10\ V$



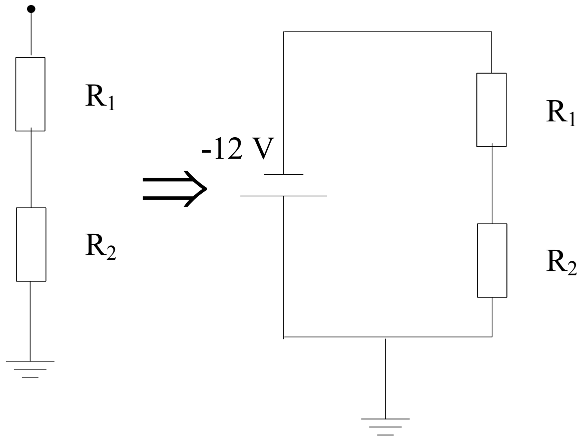
$V_a = 0\ V$

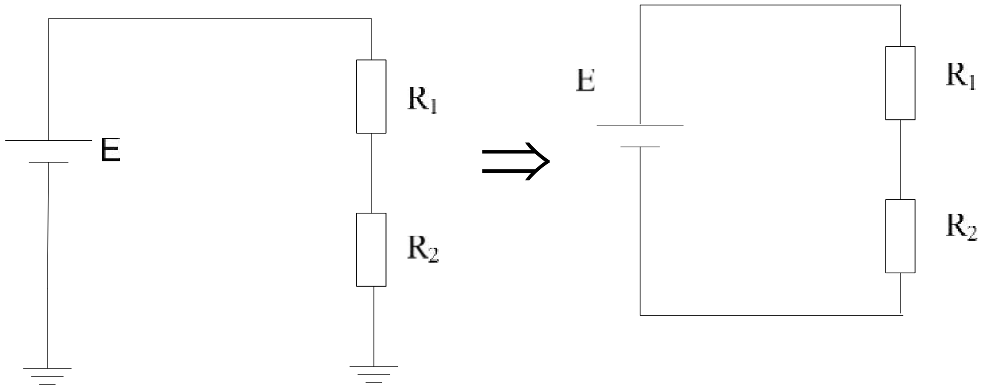


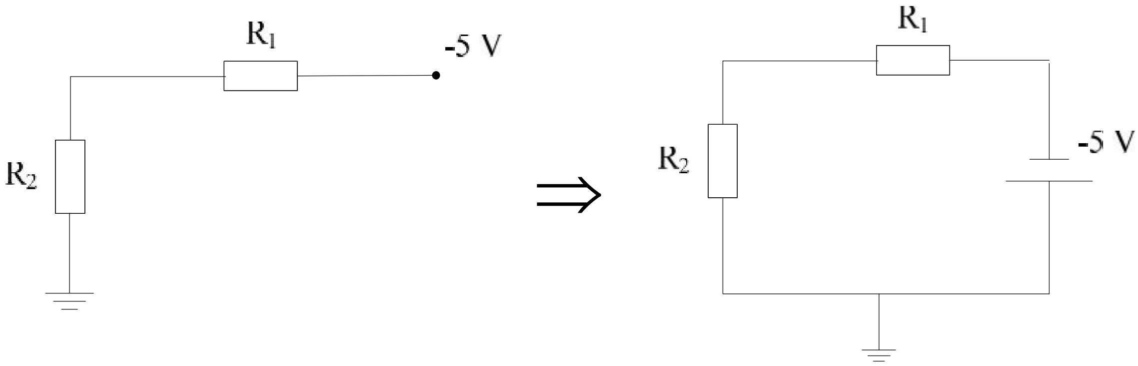
E = 20 V



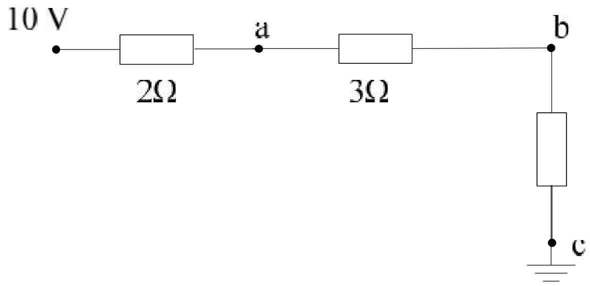
E = -12 V







Example :- Find V_a , V_b , V_c , V_{ab} , V_{ac} and V_{bc} for the following diagram .

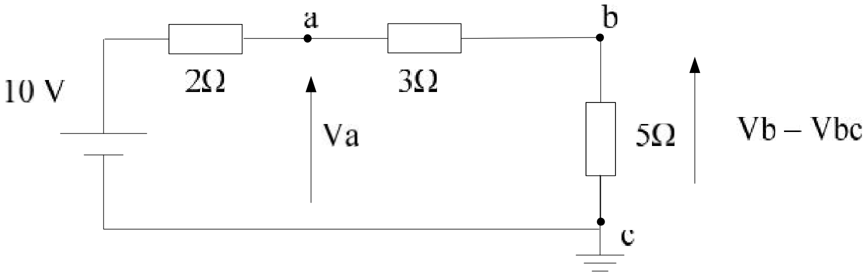


Solution :-

$R_T = R_1 + R_2 + R_3$

$= 2 + 5 + 3 = 10\ \Omega$

$I = \frac{E}{R_T} = \frac{10}{10} = 1A$



$E - V_2 - V_a = 0$

$V_a = E - V_2 = 10 - (2 * 1) = 8\ V$

$V_b = V_5 = (1 * 5) = 5\ V = V_{bc}$; $V_c = 0\ V$

or $E - V_2 - V_3 - V_b = 0 \Rightarrow V_b = E - V_2 - V_3 = 10 - 2 - 3 = 5\ V$

$V_{ab} = V_a - V_b = 8 - 5 = 3\ V$

$V_{ac} = V_a - V_c = 8 - 0 = 8\ V$

$V_{bc} = V_b - V_c = 5 - 0 = 5\ V$

<u>Equivalence of actual sources :-</u>

	Voltage Source	**Current Source**
Open Circuit	Voc = E I = 0	$V_{oc} = I_o \frac{1}{G_o}$
Short circuit	$I_{sc} = \frac{E}{R_o}$ V = 0	$I_{sc} = I_o$

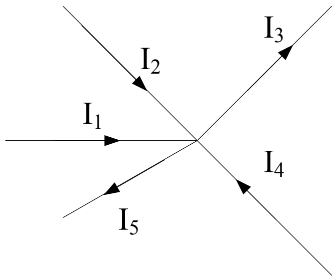
<u>Kirchoff's Current Law (K.C.L.) :-</u>

The algebraic sum of ingoing currents is equal to the out going currents at any point .

$$\sum I_{in} = \sum I_{out}$$

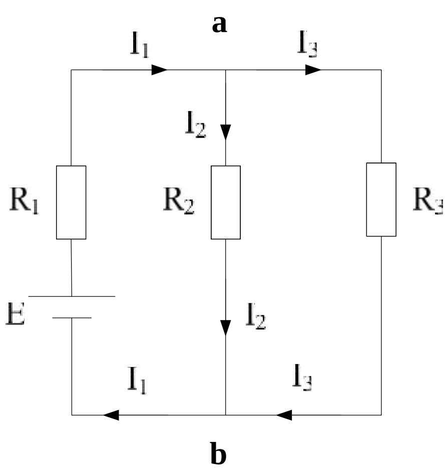
Or , At any point , the algebraic sum of entering and leaving current is zero .

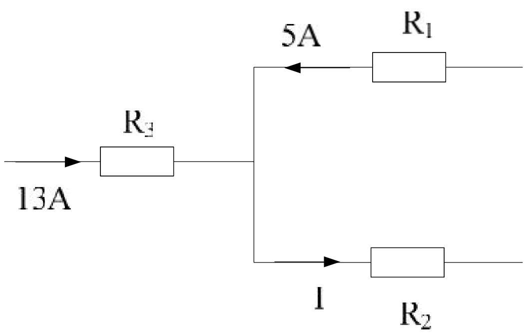
$$\sum I = 0$$



$I_1 + I_2 + I_4 = I_3 + I_5$

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





At a

$I_1 = I_2 + I_3$

Or $I_1 - I_2 - I_3 = 0$

At b

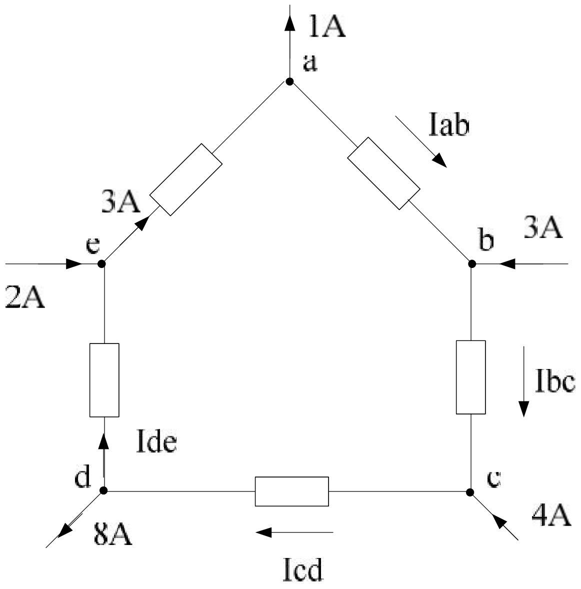
$-I_1 + I_2 + I_3 = 0$

$13 + 5 - I = 0$

$18 - I = 0$

$\therefore\ I = 18\ A$

Example :- Find the current in each section in the cct. Shown ?



Solution :-

At node a

$3 - 1 - I_{ab} = 0$

$2 - I_{ab} = 0 \Rightarrow I_{ab} = 2$ A

At node b

$I_{ab} + 3 - I_{bc} = 0$

$2 + 3 - I_{bc} = 0 \Rightarrow I_{bc} = 5$ A

At node c

$I_{bc} + 4 - I_{cd} = 0$

$5 + 4 - I_{cd} = 0 \Rightarrow I_{cb} = 9$ A

At node d

$I_{cd} - 8 - I_{de} = 0$

$9 - 8 - I_{de} = 0 \Rightarrow I_{de} = 1$ A

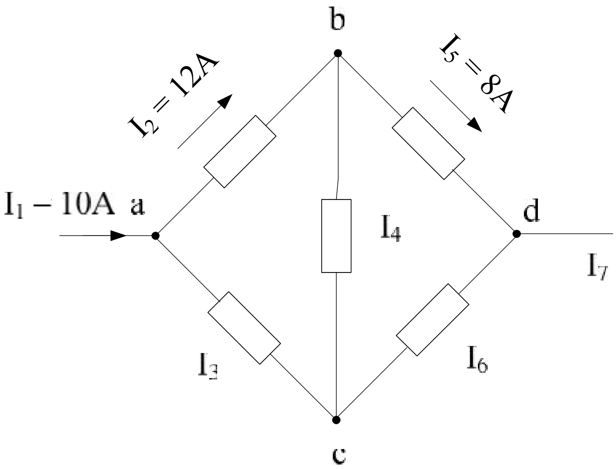
At node e

$2 - 3 + I_{de} = 0$

$2 - 3 + 1 = 0$

$0 = 0$ check .

Example :- Find the magnitude and direction of the currents I_3 , I_4 , I_6 , I_7 in the following cct. Diagram?



Solution :-

$$\sum I_{enter} = \sum I_{leave}$$

$\therefore$ $I_1 = I_7 = 10$ A

At node a ; suppose I_3 is entering

$I_1 + I_3 - I_2 = 0$

$10 + I_3 - 1_2 = 0 \Rightarrow I_3 = 2$ A

At node b;

I_2 enter , I_5 leave , $\therefore$ I_4 must be leaving

$I_2 = I_5 + I_4$

$12 = 8 + I_4 \Rightarrow I_4 = 12 - 8 = 4$ A

At node c;

I_4 enter , I_3 leave , $\therefore$ I_6 leave

$I_4 = I_3 + I_6$

$4 = 2 + I_6 \Rightarrow I_6 = 2$ A

At node d;

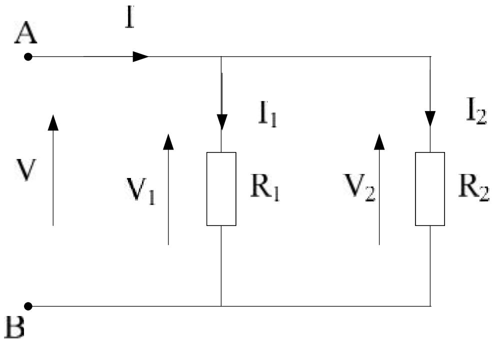
I_5 and I_6 enter , I_7 leave

$I_7 = I5 + I_6$

$10 = 8 + 2$

$10 = 10$ Ok.

Resisters in Parallel :-



From K.V.L. $V = V_1 = V_2$

From K.C.L. $I = I_1 + I_2$

From Ω.L. $I = \frac{V_1}{R_1} + \frac{V_2}{R_2}$

$= V_1G_1 + V_2G_2$

$= V_1 (G_1 + G_2)$

or $I = V (G_1 + G_2)$

$I = VG_T$

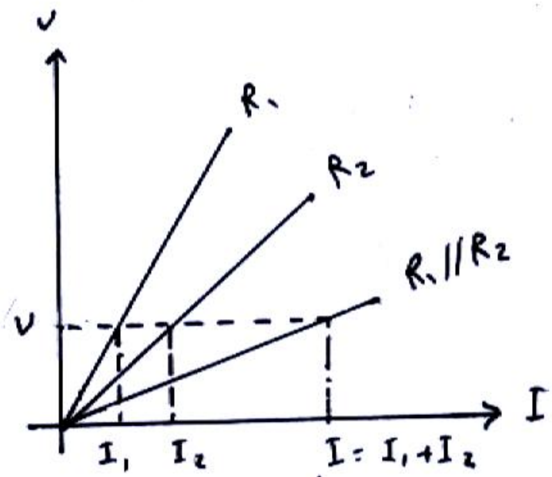
Where $G_T = G_1 + G_2$

Hence $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1.R_2}$

or $\boxed{R_T = \frac{R_1.R_2}{R_1 + R_2}}$

In the same minner , if we have three resistors in parallel , then:

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



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

$$R_T = \frac{R_1.R_2.R_3}{R_2.R_3 + R_1.R_3 + R_1.R_2}$$

And , if we have N of parallel resistance , then

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

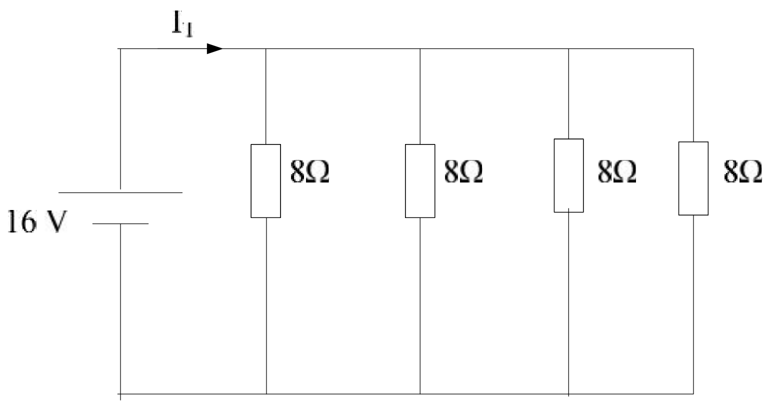
Also

$P_T = P_1 + P_2 + P_3$

$$P_1 = V_1 I_1 = I_1^2 R_1 = \frac{V_1^2}{R_1}$$

Source power $P_s = EI_T = I_T^2 R_T = \dfrac{E_T^2}{R_T}$

Example :- For the following cct. Find R_T , P_T , I_T , I_b?



Solution :-

$$R_T = \frac{R}{N} = \frac{8}{4} = 2\Omega$$ في حالة كون قيم المقاومات متساوية

$$I_T = \frac{E}{R_T} = \frac{16}{2} = 8A$$

$$I_{branch} = \frac{E}{R_1} = \frac{16}{8} = 2A$$

$$P_T = I_T^2 R_T = (8)^2.(2) = 128W$$

or $\quad P_T = E.I_T = 16 * 8 = 128W$

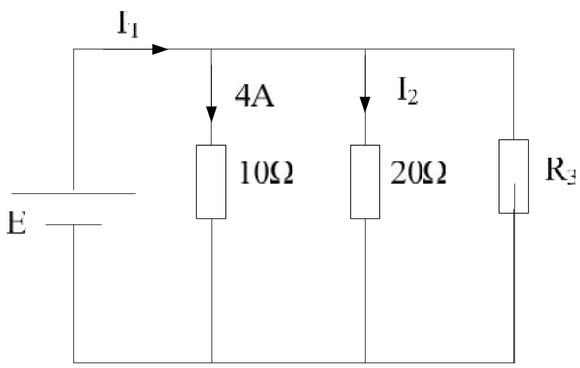
or $\quad P_T = P_1 + P_2 + P_3 + P_4$

$$= (2)^2 * 8 + (2)^2 * 8 + (2)^2 * 8 + (2)^2 * 8$$

$$= 32 + 32 + 32 + 32 = 128W$$

Example :- For the parallel network in fig. below , find :-

a) R_3 , b) E , c) I_T , I_2 , d) P_2 ; given that $R_T = 4\ \Omega$?



Solution :-

a)

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

$$\frac{1}{4} = \frac{1}{10} + \frac{1}{20} + \frac{1}{R_3}$$

$$0.25 = 0.1 + 0.05 + \frac{1}{R_3}$$

$$0.25 - 0.1 - 0.05 = \frac{1}{R_3}$$

$$0.1 = \frac{1}{R_3} \Rightarrow R_3 = \frac{1}{0.1} = 10\Omega$$

b) $\quad E = V_1 = I_1 R_1 = 4 * 10 = 40\ V$

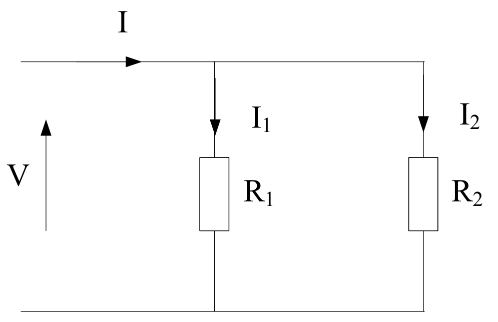
c) $$I_T = \frac{E}{R_T} = \frac{40}{4} = 10A$$

$$I_2 = \frac{V_2}{R_2} = \frac{E}{R_2} = \frac{40}{20} = 2A$$

d) $$P_2 = I_2^2 R_2 = (2)^2.(20) = 80W$$

or $P_2 = \frac{V_2^2}{R_2}$, or $P_2 = I_2V_2$

<u>Current division Rule :-</u>



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

$$I_1 = \frac{V}{R_1} = \frac{I\frac{R_1.R_2}{R_1 + R_2}}{R_1}$$

$$\therefore I_1 = I\frac{R_2}{R_1 + R_2}$$

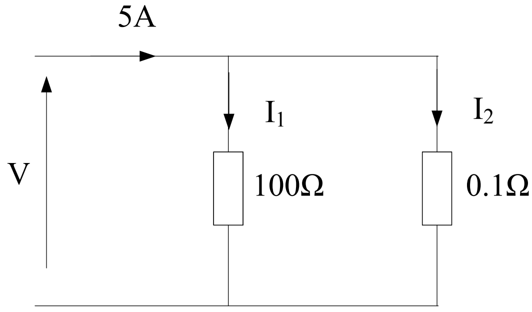
In the same miner

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

Also $$\frac{I_1}{I_2} = \frac{I\frac{R_2}{R_1 + R_2}}{I\frac{R_1}{R_1 + R_2}} = \frac{R_2}{R_1}$$

$$\therefore \frac{I_1}{I_2} = \frac{R_2}{R_1} = \frac{G_1}{G_2}$$

Example :- For the following circut. , find V , I_1 and I_2?



Solution :-

$$R_T = \frac{R_1.R_2}{R_1+R_2} = \frac{100*0.1}{100+0.1} = \frac{10}{100.1} = 0.0999\Omega$$

$V = I \,.\, R_T = 5 * 0.0999 = 0.4995$ V

$$I_1 = \frac{V}{100} = 0.004995A$$

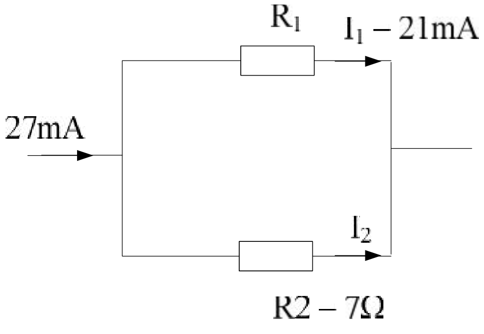
$$I_2 = \frac{V}{0.1} = 4.995A$$

To check $I = I_1 + I_2$

$5 = 0.004995 + 4.995$

$5 = 5$ Ok.

Example :- Determine the resistance R1 in the figure below?



Solution :-

$I = I_1 + I_2$

or $I_2 = I - I_1 = 27 - 21 = 6$ mA

$V_2 = I_2R_2 = 6 * 10^{-3} * 7 = 42$ mV

$V_1 = V_2 = 42$ mV

$$R_1 = \frac{V_1}{I_1} = \frac{42*10^{-3}}{21*10^{-3}} = 2\Omega$$

or

$$I_1 = I\frac{R_2}{R_1 + R_2} \Rightarrow 21*10^{-3} = \frac{27*10^{-3}*7}{R_1 + 7}$$

$$R_1 = 2\Omega$$