



UNIVERSITY OF HILLA
College of Engineering Technologies
Department of Medical Devices Technologies

Fundamental of Electrical Engineering(DC)
Kirchoff's Law

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First Stage

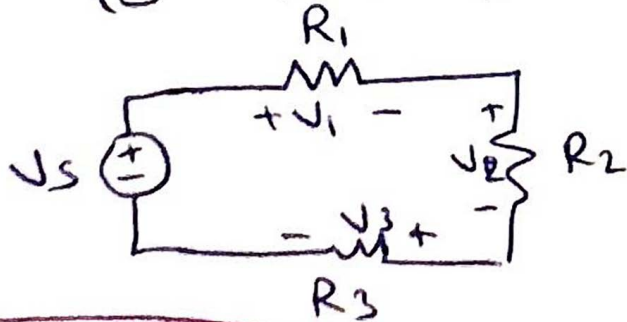
Lecture3

قانون كيرشوف

Kirchoff's law

Kirchoff's Voltage law
(KVL)

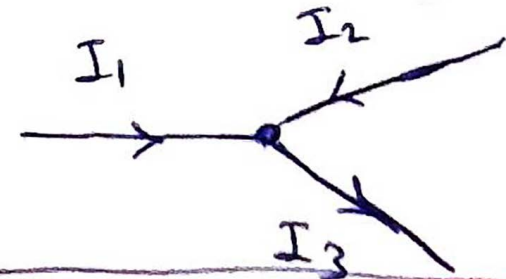
ينص قانون كيرشوف على أن في
أي مسار مغلق يكون
المجموع الجبري للجهد
يأدي (صفر)



$$V_s - V_1 - V_2 - V_3 = 0$$

Kirchoff's Current law
(KCL)

ينص قانون كيرشوف أن مجموع
التيارات الداخلة إلى النقطة و
الخارجة من النقطة تأدي
(صفر)



$$I_3 - I_1 - I_2 = 0$$

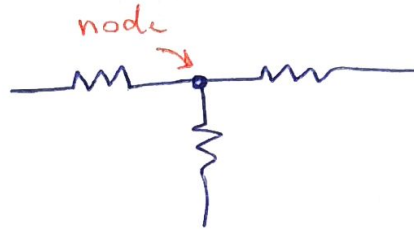


NOTE :

Branch : Represents a single element such as a voltage source $\oplus$ or a resistance $\sim$

نقطة

Node : is the point of connection between two or more branches.



حلقة

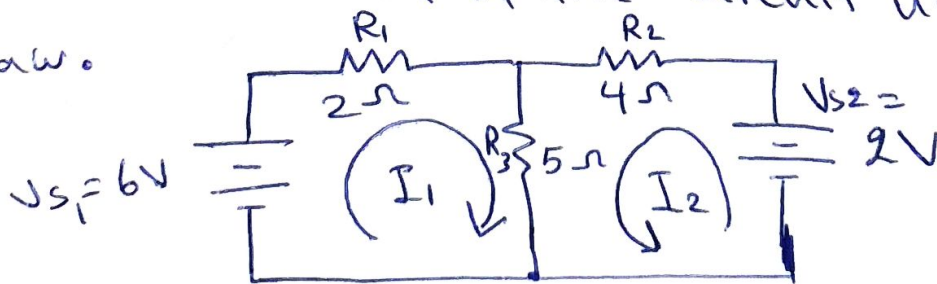
Loop :- is any closed path in a circuit.

1- Kirchhoff's Voltage law (KVL) :

خطوات اكل :-

- 1- تقرض اتجاه السيار في كل فرع (مار مقلقة)
- 2- كتابة معادلة الجهد (الفولطية) لكل مار مقلقة.

Ex:- in the following circuit, Calculate the current I in each element of the circuit using Kirchhoff's law.



ملاحظة :- اتجاه السيار يكون من اليمين الى اليسار

Sol/ in the first loop I_1 :-

$$V_{S1} = V_1 + V_3$$

$$V_{S1} = I_1 R_1 + (I_1 + I_2) R_3$$

$$6 = I_1 (2) + (I_1 + I_2) (5)$$

$$6 = 2I_1 + 5(I_1 + I_2) \dots \dots \textcircled{1}$$

in the second loop I_2 :-

$$V_{S2} = V_2 + V_3$$

$$V_{S2} = I_2 R_2 + (I_1 + I_2) R_3$$

$$2 = 4I_2 + 5(I_1 + I_2) \dots \textcircled{2}$$

Solving the two equations:-

$$6 = 2I_1 + 5I_1 + 5I_2 \Rightarrow (6 = 7I_1 + 5I_2 \dots \dots \textcircled{1}) \times 5$$

$$2 = 4I_2 + 5I_1 + 5I_2 \Rightarrow (2 = 5I_1 + 9I_2 \dots \dots \textcircled{2}) \times -7$$

$$\begin{array}{r} 30 = 35I_1 + 25I_2 \dots \dots \textcircled{1} \\ -14 = -35I_1 - 63I_2 \dots \dots \textcircled{2} \\ \hline \end{array}$$

$$16 = -38I_2$$

$$\therefore \boxed{I_2 = \frac{16}{-38} = -0.421 \text{ A}}$$

* عندها يكون التيار بالتيار معكس، لا تجاه ويس قيمتها بالتيار
لأن لا يوجد تيار بالتيار

$$\therefore 6 = 7I_1 + 5(-0.421)$$

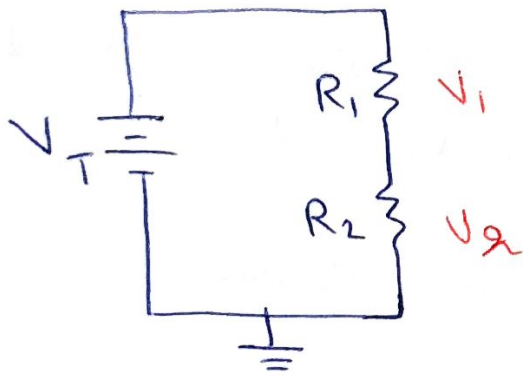
$$6 = 7I_1 - 2.105 \Rightarrow 7I_1 = 6 + 2.105$$

$$7I_1 = 8.105$$

$$I_1 = \frac{8.105}{7} = 1.157 \text{ A}$$

Voltage Divider Circuit

A Voltage Divider Rule (also called Potential divider) is a series network with a number of different voltages and derived from a single input voltage source.



according to voltage divider rule :-

$$V_1 = V_T \cdot \frac{R_1}{R_1 + R_2}$$
$$V_2 = V_T \cdot \frac{R_2}{R_1 + R_2}$$

المقاومة R₁ والمقاومة R₂ مجموع المقاومات على التوالي

Ex:- Find the values of different voltages that can be obtained from a 24 V battery with the help of (Voltage divider circuit)

Sol /

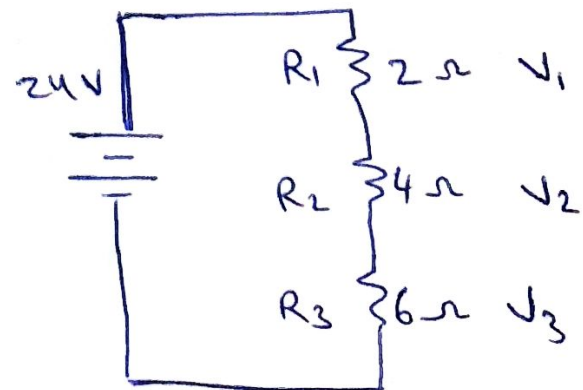
$$R_T = R_1 + R_2 + R_3 = 2 + 4 + 6 = 12 \Omega$$

$$V_1 = V_T \cdot \frac{R_1}{R_T} = 24 \left(\frac{2}{12} \right)$$

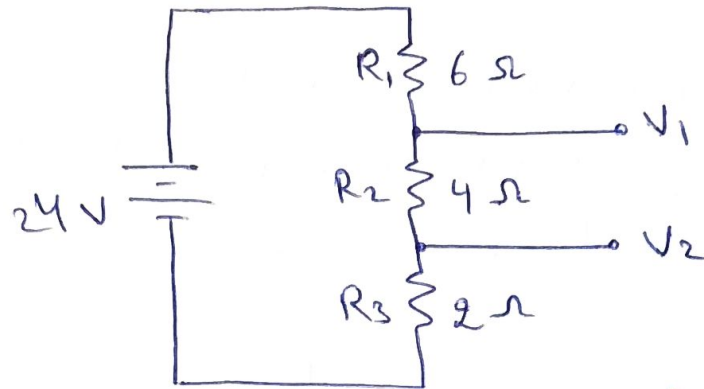
$$V_1 = 24 \left(\frac{1}{6} \right) = 4 \text{ Volt}$$

$$V_2 = V_T \cdot \frac{R_2}{R_T} = 24 \left(\frac{4}{12} \right) = 8 \text{ Volt}$$

$$V_3 = V_T \cdot \frac{R_3}{R_T} = 24 \left(\frac{6}{12} \right) = 12 \text{ Volt}$$



Ex:- what are the output voltages of the unloaded voltage divider?



ملاحظة / مرات أن تكون الفولتية على المقاومة لذلك نأخذ المقاومة خارج الفولتية المطلوبة كما موضح في المثال أدناه -

Sol/ $R_T = R_1 + R_2 + R_3 = 6 + 4 + 2 = 12\Omega$

V_1 (Drop across R_2)

$$V_1 = V_T \frac{R_2}{R_1 + R_2 + R_3}$$

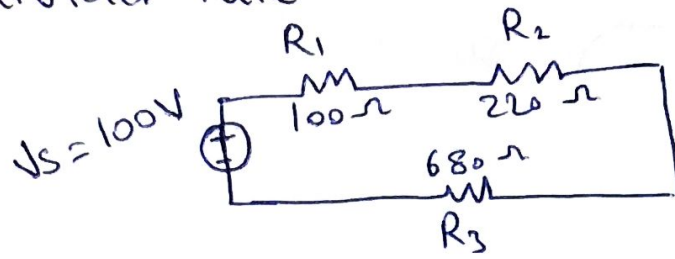
$$V_1 = 24 \frac{4}{12} = 8 \text{ Volt}$$

V_2 (Drop across R_3)

$$V_2 = V_T \frac{R_3}{R_1 + R_2 + R_3}$$

$$V_2 = 24 \frac{2}{12} = 4 \text{ Volt}$$

Ex:- in the following circuit find the value of Voltage drop through the resistance R_3 using Voltage divider rule.



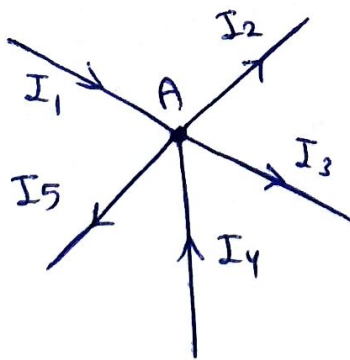
Sol/ $V_{R3} = V_s \cdot \frac{R_3}{R_1 + R_2 + R_3}$

$$V_{R3} = 100 \left(\frac{680}{100 + 220 + 680} \right)$$

$$V_{R3} = 100 \left(\frac{680}{1000} \right) = 68 \text{ Volt}$$

2- Kirchhoff's Current law (KCL) :-

- In any electrical network, the algebraic sum of the currents meeting at a Point is Zero

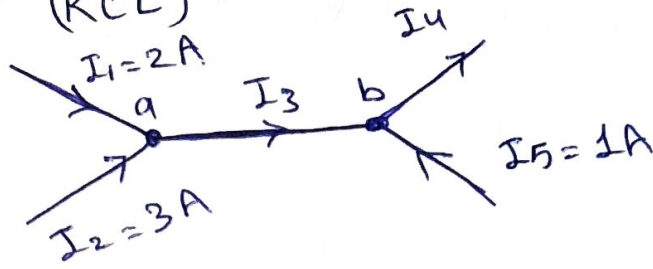


قانون التيار :-
 1- نفرض ان التيار الداخل الى نقطة ما، والى الخارج من النقطة، انهم موجبة.

2- نأخذ حاصل جمع للتيار فيكون $-I_1 + I_2 + I_3 - I_4 + I_5 = 0$

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

Ex:- Find the Value I_3 and I_4 using Kirshoff's Current law (KCL).



Sol/

at node (a) $\Rightarrow -I_1 - I_2 + I_3 = 0$

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

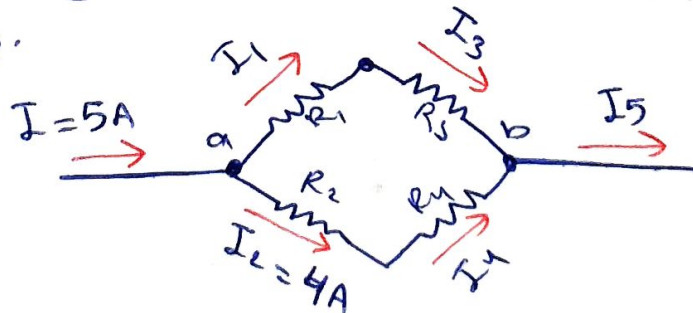
$$-5 + I_3 = 0 \Rightarrow \boxed{I_3 = 5A}$$

at node (b) $\Rightarrow -I_3 + I_4 - I_5 = 0$

$$-5 + I_4 - 1 = 0$$

$$-6 + I_4 = 0 \Rightarrow \boxed{I_4 = 6A}$$

Ex:- From the Figure below find the Value of I_1, I_3, I_4 and I_5 .



Sol/ at node (a)

$$-I + I_1 + I_2 = 0$$

$$-5 + I_1 + 4 = 0 \Rightarrow -1 + I_1 = 0 \Rightarrow \boxed{I_1 = 1A}$$

at node (b)

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

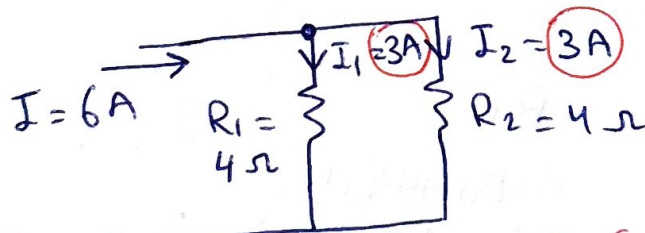
- ∴ $I_1 = I_3 = 1A$ (Because the connection between R_1 and R_3 is Series)
- ∴ $I_2 = I_4 = 4A$ (Because the connection between R_2 and R_4 is Series)
- ∴ $-I_3 - I_4 + I_5 = 0$
- $-1 - 4 + I_5 = 0 \Rightarrow -5 + I_5 = 0 \Rightarrow \therefore \boxed{I_5 = 5A}$

Current Divider Rule CDR

- To find the current through a resistor in a Parallel circuit, we use current divider rule (CDR)

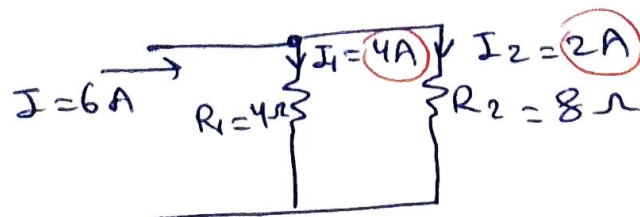
طريقة

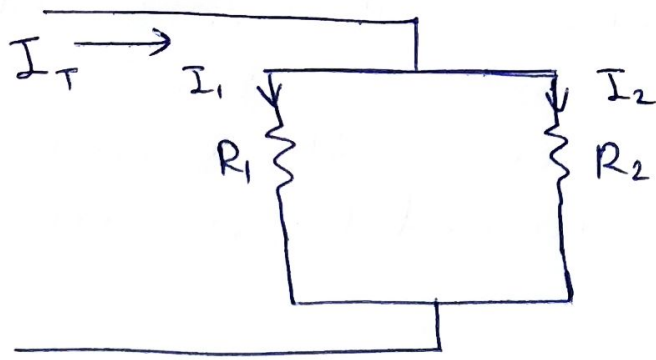
1- يُجوزُ السَّيْرُ الْمَارُ فِي مَقَاوِمٍ عَلَى تَوَازِيٍّ، وَيُحْزَرُ قِيَمَتُهُ بِالتَّوَازِيٍّ عَلَى مَقَاوِمٍ فِي حَالَةِ تَوَازِيٍّ فِيهِمَا فِي الصِّفَةِ.



2- أَمَّا السَّيْرُ الْمَارُ فِي مَقَاوِمٍ مُتَعَدِّينَ فَيُحْزَرُ بِحَيْثُ يَكُونُ لِلْمَقَاوِمِ الْأَصْغَرِ سَيْرُ أَكْبَرٍ، وَيَكُونُ لِلْمَقَاوِمِ الْأَكْبَرِ قِيَمَتُ سَيْرِ أَصْغَرٍ.

$I \propto \frac{1}{R}$ (علاقة عكسية)





Derivation
استقراء
(مفرد)

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

$$I_1 = \frac{R_T}{R_1} \cdot I_T$$

في حالة وجود
أكثر من مقاومتين

$$I_1 = \frac{\left(\frac{R_1 R_2}{R_1 + R_2} \right)}{R_1} \cdot I_T$$

$$I_1 = \frac{\cancel{R_1} R_2}{\cancel{R_T} (R_1 + R_2)} \cdot I_T$$

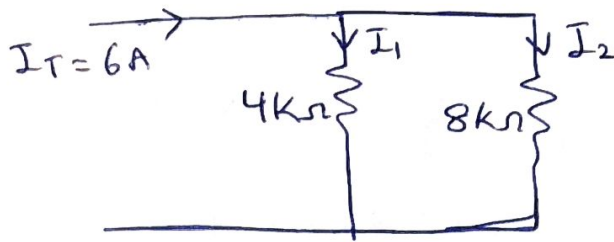
$$I_1 = \left(\frac{R_2}{R_1 + R_2} \right) I_T$$

بنفس الطريقة تكون قيمة I_2

$$I_2 = \frac{R_1}{R_1 + R_2} \cdot I_T$$

في حالة
وجود مقاومتين
فقط

Ex:- Find the value of the current I_2 in the following circuit using (CDR)



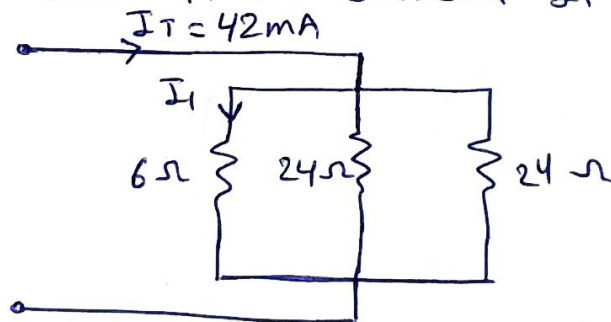
Sol

$$I_2 = \frac{R_1}{R_1 + R_2} \cdot I_T$$

$$I_2 = \left(\frac{4K}{4K + 8K} \right) \cdot (6A)$$

$$I_2 = \frac{4 \cancel{K} \Omega}{12 \cancel{K} \Omega} \times 6A = 2A$$

Ex:- Find the value of the current I_1 in the circuit below:-



Sol/ $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{6} + \frac{1}{24} + \frac{1}{24}$

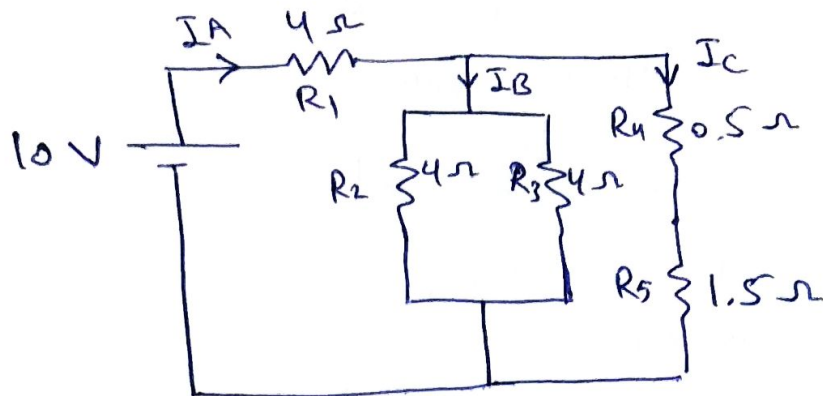
$$\frac{1}{R_T} = \frac{4 + 1 + 1}{24} = \frac{6}{24} = \frac{1}{4}$$

$$\therefore \boxed{R_T = 4\Omega}$$

$$I_1 = \frac{R_T}{R_1} \cdot I_T$$

$$\boxed{I_1} = \frac{4 \cancel{\Omega}}{6 \cancel{\Omega}} (42 \times 10^{-3} A) = \boxed{28mA}$$

Ex:- From the circuit in the following figure, find the value of the current and voltage in each resistance.

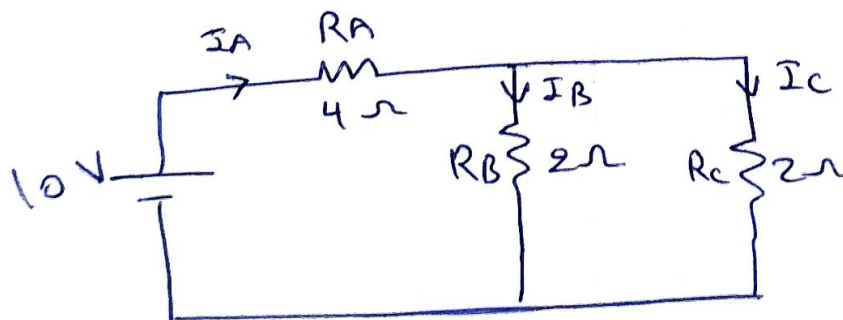


Sol/ $R_A = R_1 = 4\ \Omega$

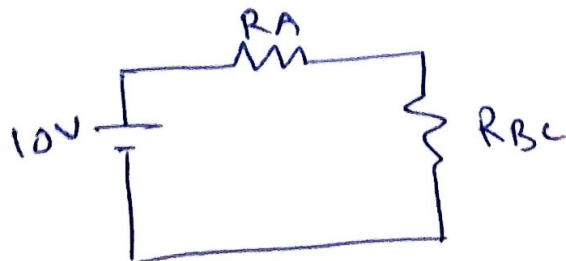
اولاً، نحدد المقاومة

$$R_B = \frac{R_2 R_3}{R_2 + R_3} = \frac{4 \times 4}{4 + 4} = \frac{16}{8} = 2\ \Omega$$

$$R_C = R_4 + R_5 = 0.5 + 1.5 = 2\ \Omega$$



$$R_{BC} = \frac{R_B R_C}{R_B + R_C} = \frac{2 \times 2}{2 + 2} = \frac{4}{4} = 1\ \Omega$$



$$R_T = R_A + R_{BC} = 4 + 1 = 5\ \Omega$$

$$I_T = \frac{V_T}{R_T} = \frac{10V}{5} = 2A$$

$$I_T = I_A = 2A$$

∵ R_B, R_C are equals, So the current will be divided between them.

$$I_B = I_C = \frac{I_A}{2} = \frac{2}{2} = 1A$$

$$I_C = I_{R4} = I_{R5} = 1A$$

$$I_{R2} = I_{R3} = \frac{I_B}{2} = \frac{1}{2} = 0.5A$$

لأن R_2, R_3 نفس

القيمة فيكون التيار

نفس القيمة أيضاً

على كل فرع

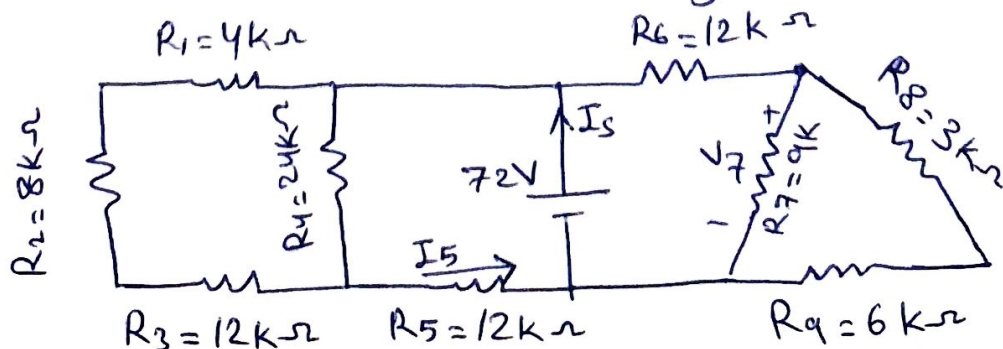
$$V_A = I_A R_A = 2(4) = 8 \text{ Volt}$$

$$V_B = I_B R_B = 2 \times 1 = 2 \text{ Volt}$$

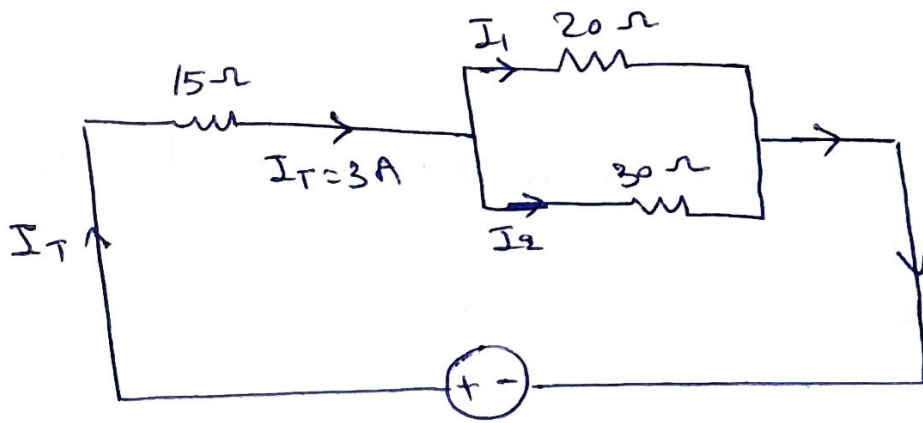
$$V_C = I_C R_C = 1 \times 2 = 2 \text{ Volt}$$

Home Work

1- in the following circuit find the two currents I_5 and I_5 and the voltage V_7 .



2-



- 1- Find the Current through $20\ \Omega$ and $30\ \Omega$ resistors.
- 2- Find the Voltage across the whole circuit.
- 3- The total Power.