Ministry of Higher Education
and Scientific Research
Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering

Subject: Fundamentals of Electrical Engineering

First Class

Lecture 3

.(Kirchhoff's law & their use in network

By

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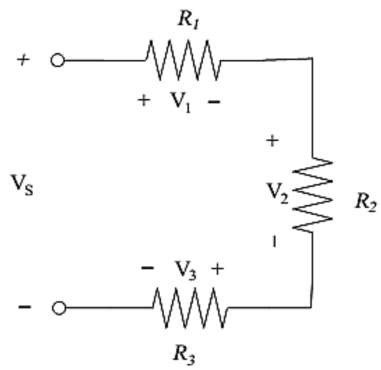
(Kirchhoff's Voltage Law (KVL)) قانون كيرشوف للجهود

ينص كريشوف على **" في اي مسار مغلق يكون المجموع الجبري للجهود مساوياً صفراً"**



$$V_s = V_1 + V_2 + V_3$$

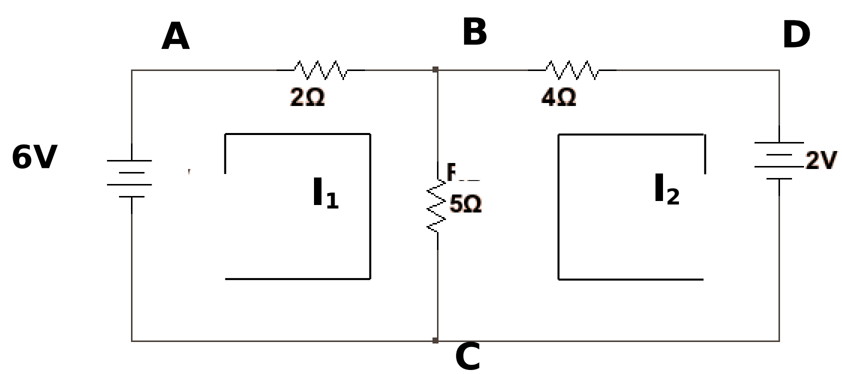
$$V_s - V_1 - V_2 - V_3 = 0$$

خطوات الحل بطريقة كير شوف:-

1- نفرض اتجاه التيار في كل فرع (مسار مغلق)

2- كتابة معادلة الجهد لكل مسار مغلق

Example 1: In the following circuit, calculate the current in each element of the circuit using Kirchhoff's Law



Sol:

In the first loop I_1:

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

In the second loop I_2:

$$2 = 4 \times I_2 + 5 \times (I_1 + I_2)$$

Solving the two equations

$$30 = 35 \times I_1 + 25 \times I_2$$
$$-14 = -35 \times I_2 - 63 \times I_2$$

$$16 = 0 - 38\ I_2$$

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

Sub. The value of I_2 in the second equation we get:

$$2 = 5\times I_1 - 9 \times 0.421$$

$$I_1 = \frac{5.789}{5} = 1.16\ A$$

So the current flow in R_{BC} is:

$$I_3 = I_1 + I_2$$

$$=1.16 + (-0.421) = 0.739\ A$$

قانون تقسيم الجهد (Voltage divider Rule)

بما ان التيار المار في مقاومات موصلة على التوالي يكون متساوياً فان هذا يؤدي الى ان هبوط الجهد على مقاومة حسب قانون اوم يعتمد على قيمة المقاومة.

فمن هذا البيان يتضح لنا, ان الجهد المطبق في الدائرة الموصلة على التوالي سوف يتسم على المقاومات حسب قيمة كل منها, فالاكبر يكون هبوط الجهد عليها كبيراً وهكذا.

ولحساب قيمة الجهد على مقاومة في الدائرة فاننا نطبق العلاقة التالية:

$$V_x = \left(\frac{R_x}{R_T}\right) V_s$$

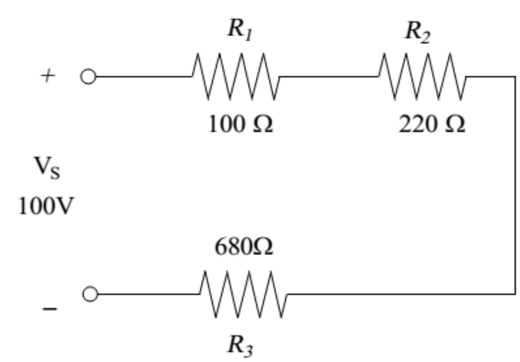
حيث:

V_x: هبوط الجهد المجهول على المقاومة R_x.

R_T: المقاومة الكلية

V_s: جهد المصدر

Example 2: In the following circuit find the value of voltage drop through the resistance R_3



:Sol

$$V_{R3} = V_S\left(\frac{R_X}{R_T}\right)$$

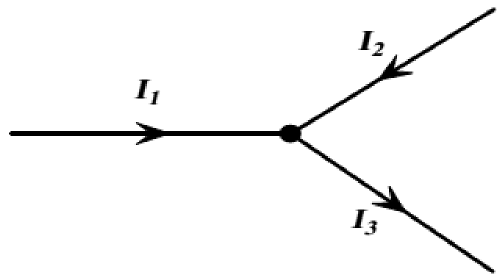
$$R_T = R_1 + R_2 + R_3$$

$$R_T = 100\Omega + 220\Omega + 680\Omega = 1K\Omega$$

$$\frac{100 * 680}{1000} = 68\,V$$

قانون كيرشوف للتيار ((Kirchhoff's Current Law (KCL)

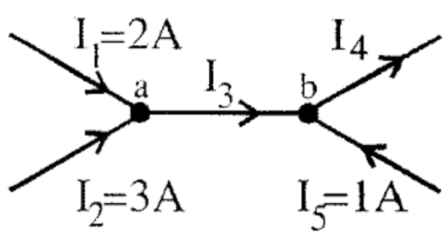
في اي نقطة في الدائرة فان المجموع الجبري للتيـارات يسـاوي الصـفر. اي ان مجمـوع التيارات الداخلة الى النقطة والخارجة من النقطة تساوي الصفر. ويتضح هذا من الشكل التالي:



ويمكن اعتبار ان اشارة التيار الداخل الي النقطة تكون سالبة واشارة التيـار الخـارج مـن النقطة تكون موجبة و بالتالي:

$$I_3 - I_2 - I_1 = 0$$

Example 3: Find the value I_3 and I_4 using Kirchhoff's Current Law (KCL).



Sol:

At node (a)

$$I_3 = I_1 + I_2$$

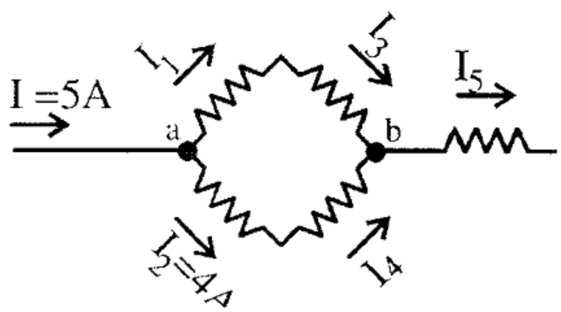
$I_3 = 2A + 3A = 5A$

At node (b)

$$I_4 = I_3 + I_5$$

$I_4 = 5A + 1A = 6A$

Example 4: From the figure below find the value of I_1, I_3, I_4, and I_5



Sol: at node (a)

$I = I_1 + I_2$

$5A = I_1 + 4A$

$I_1 = 1A$

At node (b)

$I_3 + I_4 = I_5$

Since I_1 is not divide so its equal to I_3

$I_3 = I_1 = 1A$

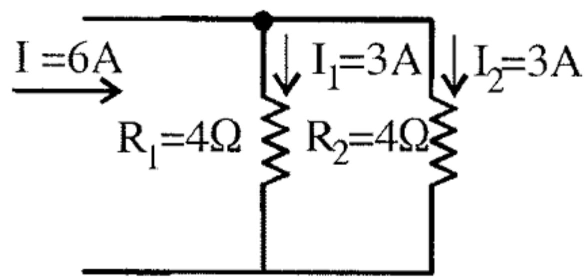
So that for $I_4 = I_2$

$I4 = I_2 = 4A$

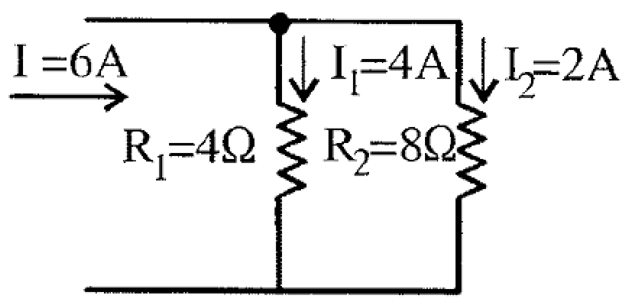
$I_5 = I_3 + I_4 = 1A + 4A = 5A$

قانون تجزئة التيار (Current Divider Rule(CDR))

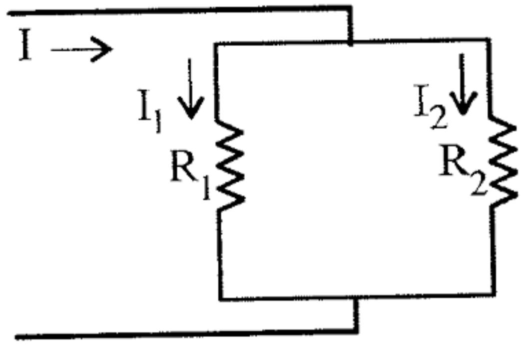
1- يتجزأ التيار المار في مقاومتين على التوازي, و يتجزأ قيمته بالتساوي على مقاومتين في حالة تساويهما في القيمة



2- اما التيار المار في مقاومتين مختلفتين فيتجزأ بيث يكون للمقاومة الاصغر تيار أكبر, ويكون للمقاومة الاكبر قيمة تيار أصغر.



في حالة مقاومتين متصلتين على التوازي



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

$$I_1 = \frac{R_T}{R_1} I$$

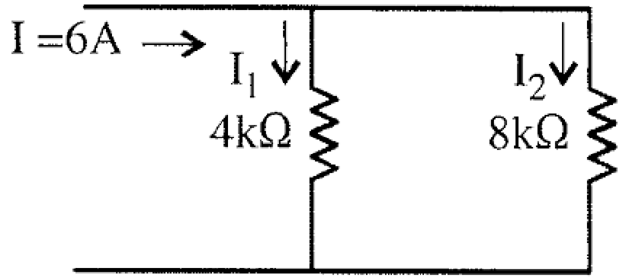
$$\therefore \quad = \frac{[(R_1 R_2)/(R_1 + R_2)]}{R_1} I$$

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

وبنفس الكيفية تكون قيمة I_2

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

Example 5: find the value of the current I_2 in the following circuit using (CDR):

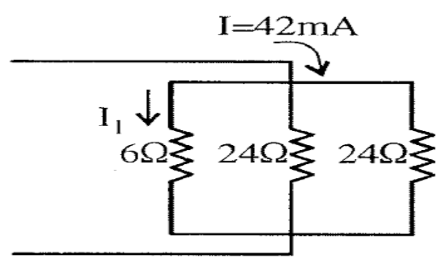


Sol:

$$I_2 = \frac{R_1}{R_1 + R_2} I = \frac{(4k\Omega)(6A)}{4k\Omega + 8k\Omega}$$

$$I_2 = \frac{24}{12} = 2A$$

Example 6: Find the value of the current I_1 in the circuit bellow.



Sol:

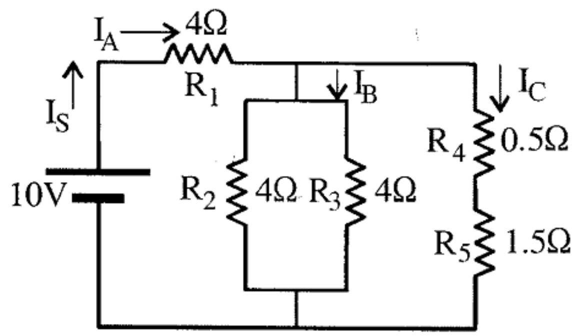
$R_T = 6\Omega \,//\, 24\Omega \,//\, 24\Omega$
$\quad = 6\Omega \,//\, 12\Omega$

$$= \frac{6\times12}{6+12} = \frac{72}{18}$$

$R_T = 4\Omega$

$$I_1 = \frac{R_T}{R_1} I \qquad I_1 = \frac{(4\Omega)(42\times10^{-3}A)}{6\Omega} = 28mA$$

Example 7: from the circuit in the following figure find the value of the current and voltage in each resistance.



Sol: by simplification the circuit we get

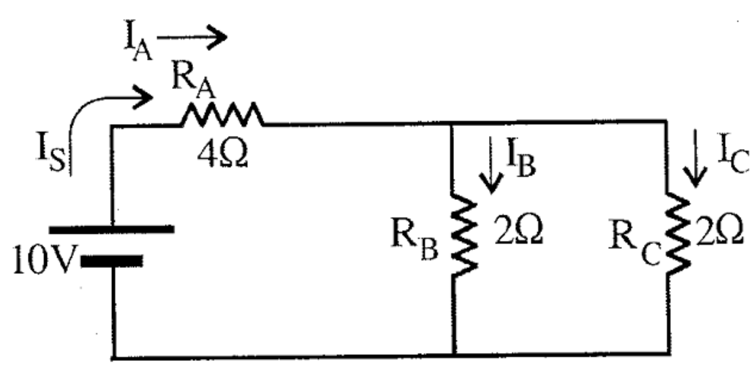
$R_A = R_1 = 4\Omega$

$R_B = R_2//R_3 = 4\Omega//4\Omega$

$R_B = 2\ \Omega$

$R_C = R_4+R_5 = 0.5+1.5$

$R_C = 2\ \Omega$



The resistance R_B and R_C are in parallel

$$\therefore \quad R_{B//C} = \frac{R}{N} = \frac{2\Omega}{2} = 1\Omega$$

The total resistance is

$$R_T = R_A + R_{B//C}$$

$$R_T = 4\Omega + 1\Omega = 5\ \Omega \longrightarrow I_S = \frac{E}{R_T} = \frac{10V}{5\Omega} = 2A$$

We can found currents in the circuit I_A , I_B, I_C

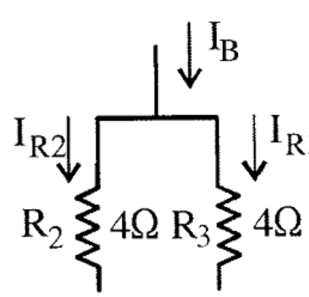
$$I_A = I_S = 2A$$

Since R_B ,R_C are equals, so the current will be divided between them

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

By return to the original shape of the circuit, we can found the current following through the resistance R_2, R_3

$$I_{R_2} = I_{R_3} = \frac{I_B}{2} = \frac{1A}{2} = 0.5A$$



The voltages V_A, V_B, V_C can be found as:

$$V_A = I_A R_A = (2A)\,(4\Omega) = 8V$$

$$V_B = I_B R_B = (1A)\,(2\Omega) = 2V$$

$$V_C = I_C R_C = (1A)\,(2\Omega) = 2V$$

By using KVL to prove the solution

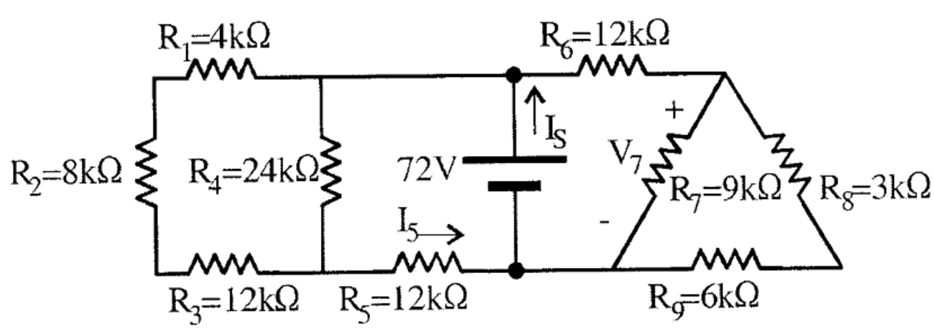
$$\sum_{\circlearrowright} V = 0$$

$$E - V_A - V_B = 0$$

$$10 - 8 - 2 = 0$$

$$10 - 10 = 0$$
$$0 = 0$$

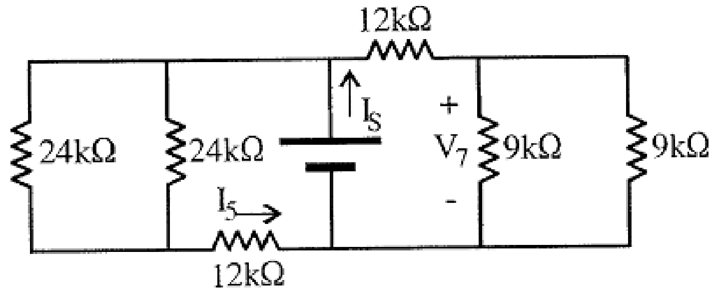
Example 8: In the following circuit find the two currents I_s and I_5 and the voltage V_7.



Sol:

The resistances R_1, R_2 and R_3 are connected in series and its equivalent 24 kΩ. The resistance R_8 and R_9 are connected in series and their equivalent is 9 kΩ.

So the circuit can be drawn as

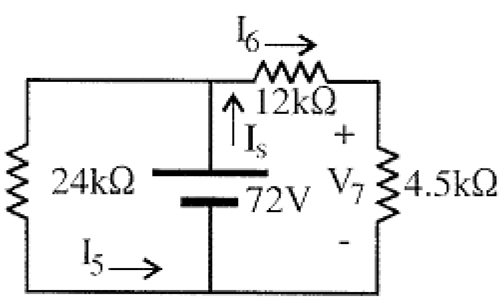


12kΩ ← 24kΩ // 24kΩ

24kΩ ← 12kΩ + 12kΩ

4.5kΩ ← 9kΩ // 9kΩ

The voltage of the 24 kΩ resistance equal to 72V in parallel with the voltage source



$$\therefore \quad I_5 = \frac{72V}{24k\Omega} = 3mA$$

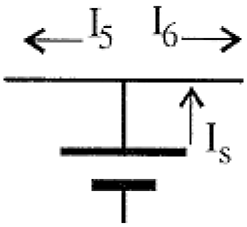
To calculate the value of V_7 we use Voltage Divided Rule

$$V_7 = \frac{(72V)(4.5k\Omega)}{4.5k\Omega + 12k\Omega} = \frac{324V}{16.5} = 19.6V$$

To find the current I_6

$$I_6 = \frac{19.6V}{4.5k\Omega} = 4.35mA$$

To calculate the current I_S we use Kirchhoff's Voltage Law(KVL)



$I_S = I_5 + I_6$

$= 3mA + 4.35\ mA = 7.35mA$

Example 2.19. *A circuit consists of two parallel resistors, having resistance of 20 Ω and 30 Ω respectively, connected in series with 15 Ω. If current through 15 Ω resistor is 3 A, find (i) the current through 20 Ω and 30 Ω resistors (ii) the voltage across the whole circuit and (iii) total power.*

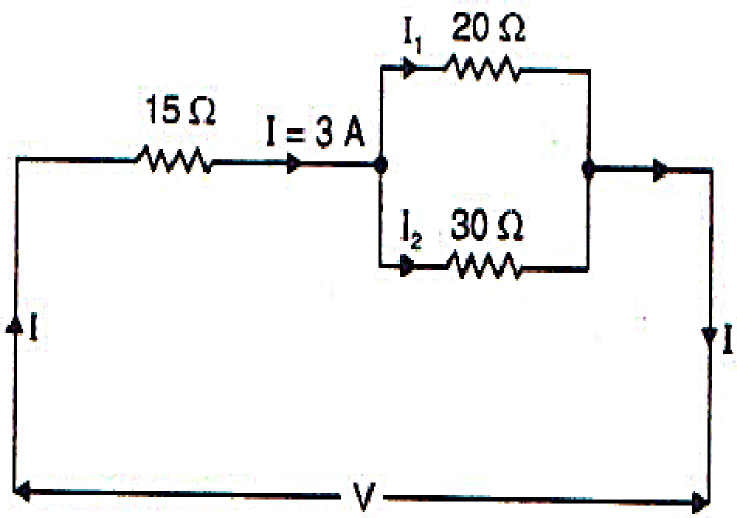


Fig. 2.25

Solution. Fig. 2.25 shows the circuit arrangement.

(*i*) The total current of 3A will divide between 20 Ω and 30 Ω as under :

Current through 20 Ω,

$$I_1 = 3 \times \frac{30}{20+30} = \mathbf{1 \cdot 8\ A}$$

Current through 30 Ω, $I_2 = 3 \times \frac{20}{20+30} = 1{\cdot}2$ **A**

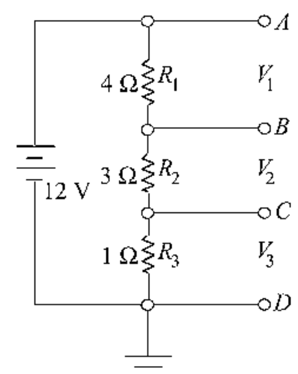
(*ii*) For parallel circuit, $R_P = \frac{20 \times 30}{20+30} = 12\ \Omega$

Total circuit resistance $= 15 + 12 = 27\ \Omega$

∴ Supply voltage, $V = 3 \times 27 = $ **81 V**

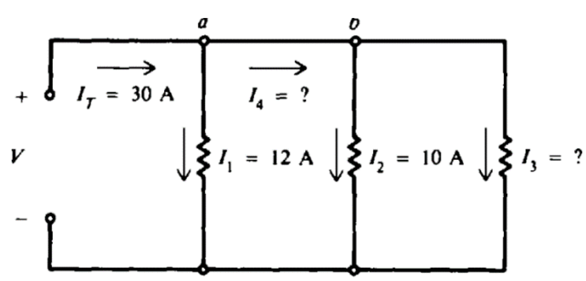
(*iii*) Total power $= VI = 81 \times 3 = $ **243 watts**

Q1: find the value of different voltages that can be obtained from a 12-V battery (V_{AB} , V_{BC} , V_{CD} ,V_{AC} ,V_{AD}) with the help of voltage divider circuit shown below



Ans.[6 V, 4.5 V, 1.5 V, 10.5 V, 12 V]

Q2: Find the value of I_3 and I_4 using KCL



Ans.[8 A, 18 A]