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 2

Symbols and abbreviation , Units, Electric circuit and its element.

By

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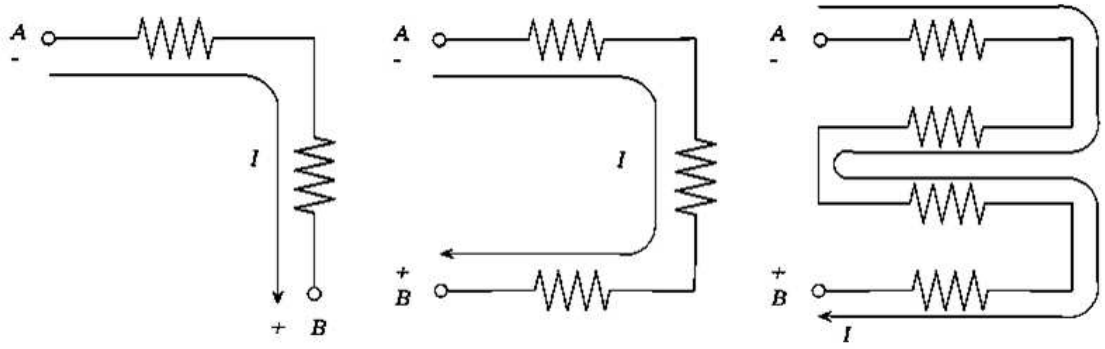
دوائر التيار المستمر المحتوية على مقاومات

(Resistors in DC Circuits)

1- دوائر المقاومات على التوالي (Series Resistors Circuits)

في اي دائرة كهربائية, تعتبر مقاومتين او اكثر موصلتان بالتوالي إذا كان نفس التيار يمر بكل مقاومة, اي ان للتيار مسار واحد فقط للمرور خلال المقاومات الموصلات بين نقطتين في الدائرة الكهربائية يتضح لنا هذا في الشكل التالي:



في جميع الدوائر السابقة نلاحظ ان التيار I المار بين نقطتين A و B هو نفسه المار في جميع المقاومات وبالتالي فان المقاومات موصلة على التوالي.

ويتم حساب قيمة المقاومة الكلية في الدائرة للمقاومات الموصله على التوالي بجمع قيم المقاومات واعتبارها مقاومة واحدة تسمى R_T

$$R_T=R_1+R_2+R_3+\ldots.+R_n$$

حيث R_n ترمز لعدد المقاومات الموصلة على التوالي.

وبمعرفة قيمة المقاومة (R) والجهد (V) يمكن ايجاد التيار (I) المار في الدائرة التالية حيث

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

وكذلك يمكن حساب جهود المقاومة كل على حده

$V_1=I\,R_1$, $V2 = I\,R_2$, $V_3 = I\,R_3$

وبالتالي فان القدرة المولد من المصدر (P_s)

$$P_s= V\,I$$

والقدرة المستهلكة في المقاومات

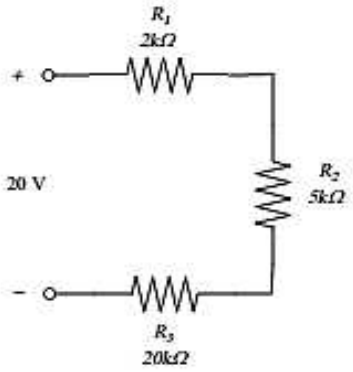
$$\mathbf{P_1 = I_1\,V_1 = I_1^2\,R = \frac{V_1^2}{R_1}}$$

$$\mathbf{P_2 = I_2\,V_2 = I_2^2\,R = \frac{V_2^2}{R_2}}$$

$$\mathbf{P_3 = I_3\,V_3 = I_3^2\,R = \frac{V_3^2}{R_3}}$$

ملاحظة مهمه: التيار المار في دائرة التوالي ثابت, اي ان $\mathbf{I = I_1=I_2=I_3}$ اما الجهد فهو متغير

Example 1: Calculate the total resistance R_T in the following circuit, then calculate the current following in the circuit.



Sol. $R_T= R_1+ R_2+ R_3$

$$R_T = 2k\,\Omega + 5\,k\,\Omega + 20\,k\,\Omega = 27\,k\,\Omega$$

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

$$I = \frac{20\,V}{27\,k\Omega} = 0.74\,mA$$

Example 2: Three resistances are connected in series with 12 V supply, so that the current flow is (6 mA). If one of the resistance equal to (1 k Ω), while the voltage across the second resistance is (3.6V), calculate the value of the third resistance.

Sol.

$$R_T = \frac{V}{I} = \frac{12\,V}{6\,mA} = \frac{12}{6 * 10^{-3}} = 2000\,\Omega = 2\,k\Omega$$

If the voltage across the second resistance is (3.6 V) and the current is (6 mA) then by using ohm's law

$$R = \frac{V}{I} = \frac{3.6}{6 * 10^{-3}} = 600\,\Omega$$

$$R_T = R_1 + R_2 + R_3$$

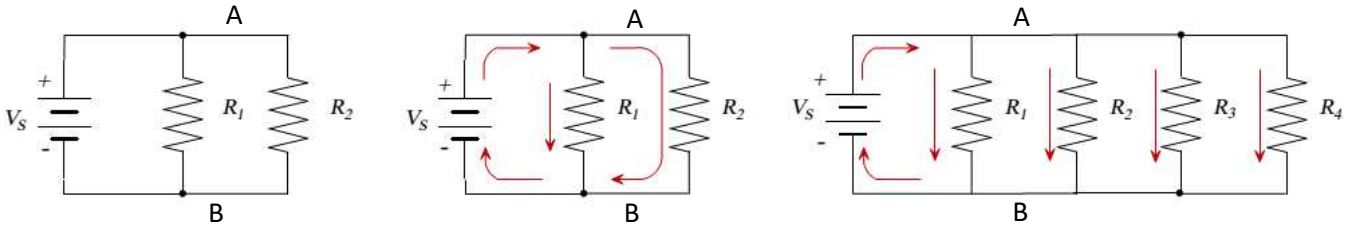
$$2000 = 1000 + 600 + R_3$$

$$2000 = 1600 + R_3$$

$$R_3 = 2000\text{-}1600 = 400\,\Omega$$

2- دوائر المقاومات على التوازي (Parallel Resistors Circuits)

تكون مقاومتان او اكثر موصلة على التوازي اذا كان اطراف المقاومتان موصلة في نقطتين مشتركتين ويتضح هذا من الشكل التالي:



حيث انه في الدوائر السابقة تكون جميع المقاومات احد اطرافها موصل بالنقطة A و الطرف الاخر موصل بالنقطة B

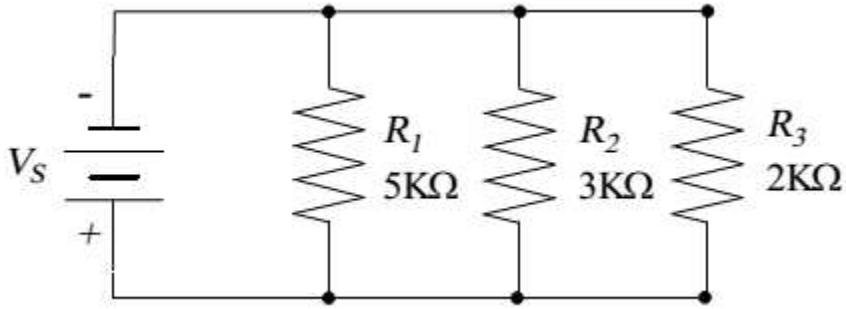
ويتم حساب المقاومة الكلية بالعلاقة التالية:

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

او

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

Example 3: calculate the total resistance of this circuit



Sol:

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

$$\frac{1}{R_T} = \frac{1}{5\ k\Omega} + \frac{1}{3\ k\Omega} + \frac{1}{2\ k\Omega}$$

$$(0.2*10^{-3})+(0.33*10^{-3})+(0.5*10^{-3})\frac{1}{R_T} =$$

$$(1.03*10^{-3})\frac{1}{R_T} =$$

$$R_T = 971\ \Omega$$

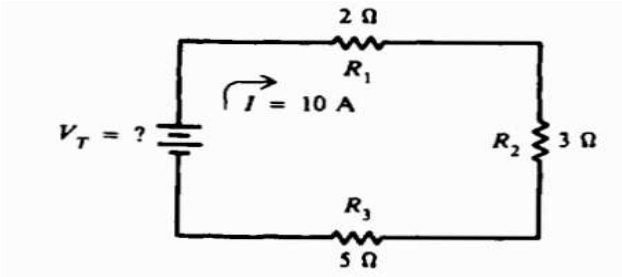
ويمكن بشكل عام اذا كان لدينا مقاومتان على التوازي فان المقاومة الكلية لهما هي:

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

ملاحظة:- نستخدم العلامة // للدلالة على التوازي.

أمثلة متنوعة محلولة

Example 1: find the voltage needed so that a current of 10 A will flow through the series circuit shown below



Sol:

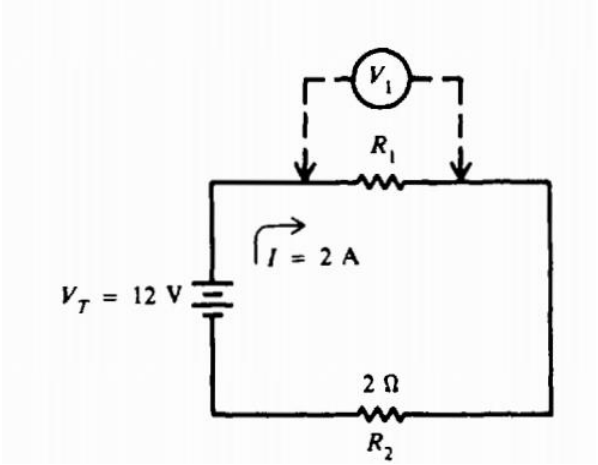
Step 1. Find total resistance.

$$R_T = R_1 + R_2 + R_3$$
$$= 2 + 3 + 5 = 10\,\Omega$$

Step 2. Find the voltage

$$V_T = IR_T$$
$$= 10(10) = 100\,\text{V}$$

Example 2:in the following circuit, a 12-V battery supplies a current of 2 A. If $R_2 = 2\Omega$, find R_1 and V_1.



Sol:

Step 1. Find R_T. By Ohm's law,

$$R_T = \frac{V_T}{I} = \frac{12}{2} = 6\,\Omega$$

Step 2. Find R_1.

$$R_T = R_1 + R_2$$

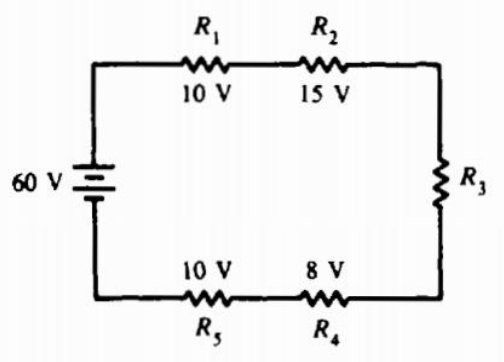
Transposing,

$$R_1 = R_T - R_2 = 6 - 2 = 4\,\Omega$$

Step 3. Find V_1.

$$V_1 = IR_1 = 2(4) = 8\,\text{V}$$

Example 3: For the circuit in Fig. below, find the voltage drop of R3.



Sol:

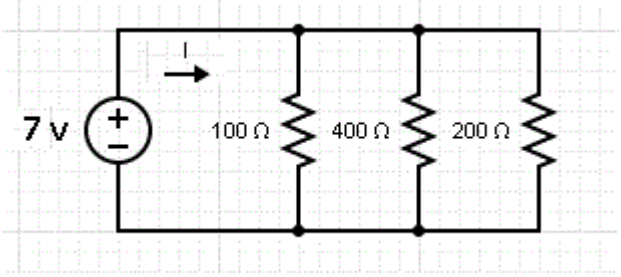
Sum of voltage drops = applied voltage

$$10 + 15 + V_3 + 8 + 10 = 60$$

$$43 + V_3 = 60$$

$$V_3 = 60 - 43 = 17\,\text{V}$$

Example 4
Find current I in the circuit below and the current passing through each of the resistors in the circuit.



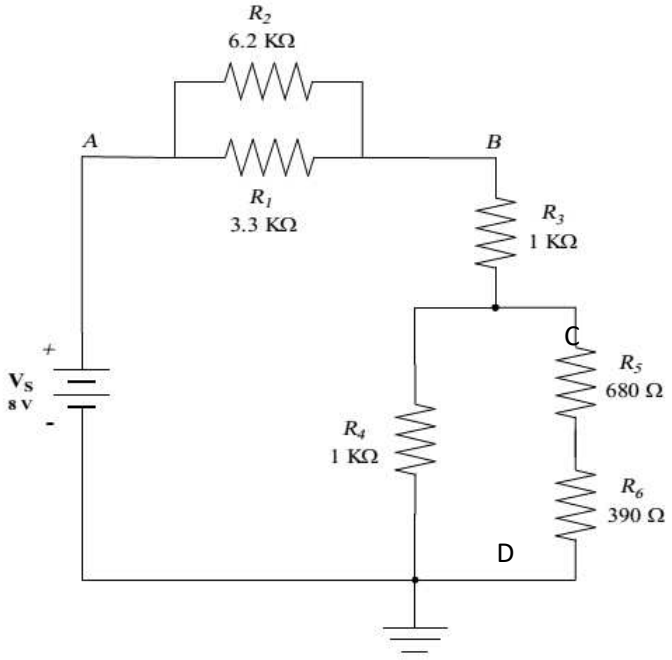
Solution to Example 4
The three resistors are in parallel and behave like a resistor with resistance Req given by
1 / Req = 1 / 100 + 1 / 400 + 1 / 200
Multiply all terms by 400 and simplify to obtain
400 / Req = 4 + 1 + 2
Solve for Req to obtain
Req = 400 / 7 Ω
The main current I is given by
I = 7 / Req = 7 / (400 / 7) = 49 / 400 A
We now use Ohm's law to find the current passing through each resistor.
The current through the resistor of 100 Ω: I1 = 7 / 100 A
The current through the resistor of 400 Ω: I2 = 7 / 400 A
The current through the resistor of 200 Ω: I3 = 7 / 200 A
As an exercise; check that the sum of the three currents above is equal to the current I = 49 / 400 A.

ـ الدوائر المركبة التوالي التوازي (Series-Parallel Circuits)

عندما يكون لدينا مقاومات في الدائرة الكهربائية موصلة على التوالي والتوازي فانه لحساب المقاومة الكلية فاننا نجري الخطوات التالية:

1. نوجد المقاومة الكلية للمقاومات الموصلة على التوالي مع ملاحظة ان نطبق عليها شروط ربط المقاومات على التوالي.
2. نوجد المقاومة الكلية للمقاومات الموصلة على التوازي مع ملاحظة ان نطبق عليها شروط ربط المقاومات على التوازي.
3. نكرر العمليات السابقة حتى نصل الى المقاومة الكلية المطلوبة.

Example 5: Calculate the total resistance in this circuit.



Sol.

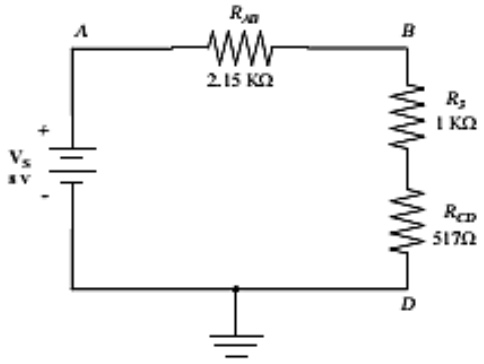
$$R_{AB} = \frac{R_1 R_2}{R_1 + R_2}$$

$$R_{AB} = \frac{(3.3\ k\Omega)(6.2\ \text{k}\Omega)}{(3.3\ k\Omega) + (6.2\ \text{k}\Omega)} = \mathbf{2.15}\ \text{k}\Omega$$

$$R_{CD} = \frac{R_4(R_5 + R_6)}{R_4 + R_5 + R_6}$$

$$R_{CD} = \frac{1k\Omega(1.07\ k\Omega)}{1k\Omega + 1.07\ k\Omega} = \mathbf{517\Omega}$$

So the circuit will be

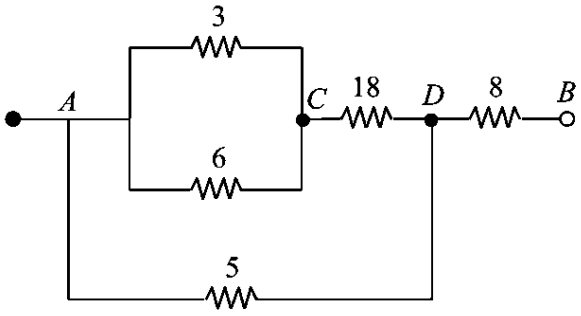


$$R_T = R_{AB} + R_3 + R_{CD}$$

$$R_T = 2.15\ k\Omega + 1\ k\Omega + 517\Omega$$

$$R_T = 3.6\ k\Omega$$

Ex 6.Calculate the effective resistance of the following combination of resistances between points A and B and the total current.



Solution. Resistance between A and C

$= 6 \parallel 3 = 2\ \Omega$

Resistance of branch ACD $= 18 + 2 = 20\ \Omega$

Now, there are two parallel paths between points A and D of resistances 20 Ω and 5 Ω

Hence, resistance between A and $D = 20 \parallel 5 = 4\ \Omega$

$\therefore$Resistance between A and $B = 4 + 8 = 12\ \Omega$

Total circuit current = 60/12 = 5 A

EX 7.Find current through 4Ω resistance.

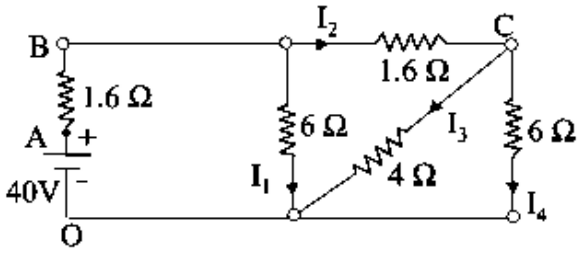


Fig. 1.26

Solution. Simplifying the series-parallel combinations, and solving the circuit, the source current is 10 amp. With respect to 0, $V_A = 40$, $V_B = 40 - 16 = 24$ volts.

I_1 = 4 amp, hence $I_2 = 6$ amp

$V_C = V_B - I_2 \times 1.6 = 24 - 9.6 = 14.4$ volts

I_3 = 14.4/4 = 3.6 amp, which is the required answer. Further $I_4 = 24$ amp.

Example 2.10. *Two resistors R_1 and R_2 are connected in parallel to a certain supply. If the current taken from the supply is 5 A, calculate the value of R_1. Given that $R_2 = 6\ \Omega$ and that current through R_1 is 2A. Also find the total power absorbed by the circuit.*

Solution. Fig. 2.13 shows the circuit arrangement.

Current through R_2, $I_2 = 5 - 2 = 3A$

Supply voltage, $V = I_2 R_2 = 3 \times 6 = 18\ V$

$\therefore \quad R_1 = V/I_1 = 18/2 = \mathbf{9\ \Omega}$

Power absorbed by the circuit

$= I_1^2 R_1 + I_2^2 R_2$

$= (2)^2 \times 9 + (3)^2 \times 6$

$= 36 + 54$

$= \mathbf{90\ watts}$

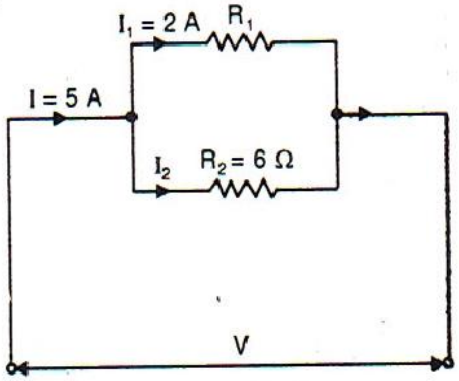


Fig. 2.13

Example 2.12. *Three resistors 4 Ω, 12 Ω and 6 Ω are connected in parallel. If the total current taken is 12 A, find the current through each resistor.*

Solution. Fig. 2.14 shows the circuit arrangement.

$$\frac{1}{R_P} = \frac{1}{4} + \frac{1}{12} + \frac{1}{6}$$

$$= \frac{6}{12}$$

$\therefore \quad R_P = 12/6 = 2\ \Omega$

P.D. across the parallel circuit,

$V = I R_P = 12 \times 2$

$= 24\ V$

Current through $4\ \Omega = 24/4 = \mathbf{6\ A}$

Current through $12\ \Omega = 24/12 = \mathbf{2\ A}$

Current through $6\ \Omega = 24/6 = \mathbf{4\ A}$

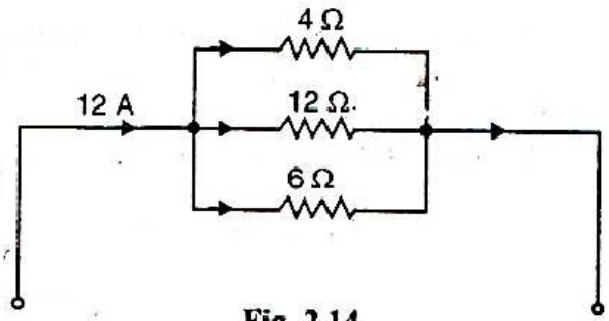
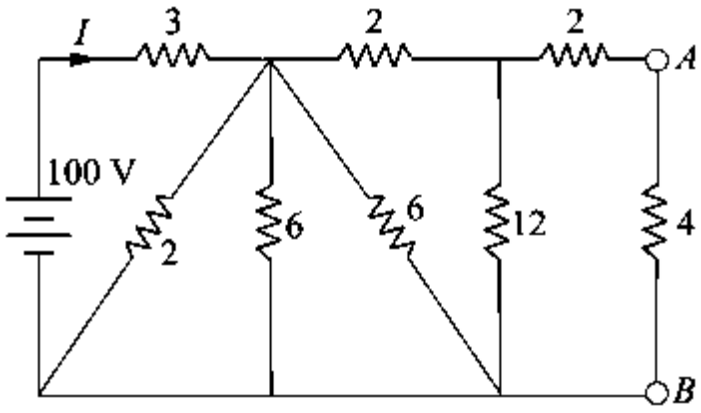


Fig. 2.14

واجب بيتي

Q1: calculate the total resistance



Rt=25ΩΩ

4. What is the drop across the 150 Ω resistor in Fig. 2.6 ? **[5.33 V]**

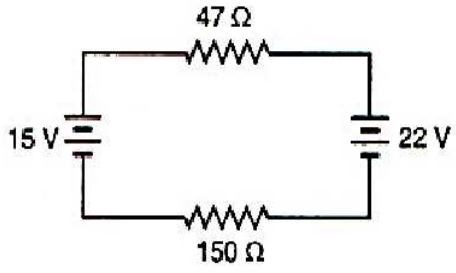


Fig. 2.6

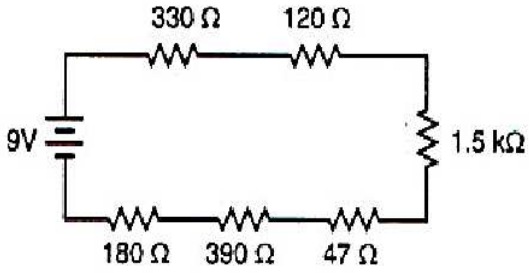
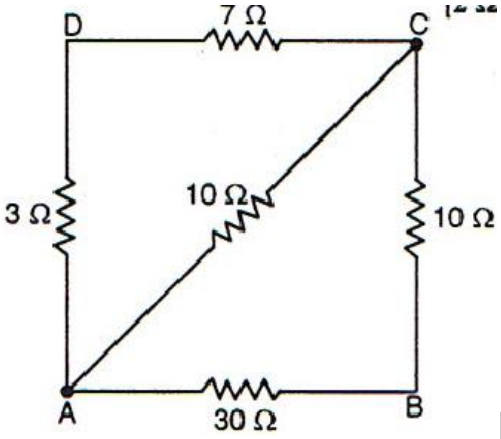


Fig. 2.7

5. Calculate the current flow for Fig. 2.7. **[3.51 mA]**

Find the equivalent resistance between points A and B in the circuit shown below



[10 Ω]

5. Find the voltage across and current through 4 kΩ resistor in the circuit shown in Fig. 2.39.

[4 V ; 1 mA]

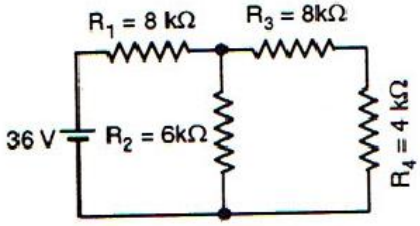


Fig. 2.39

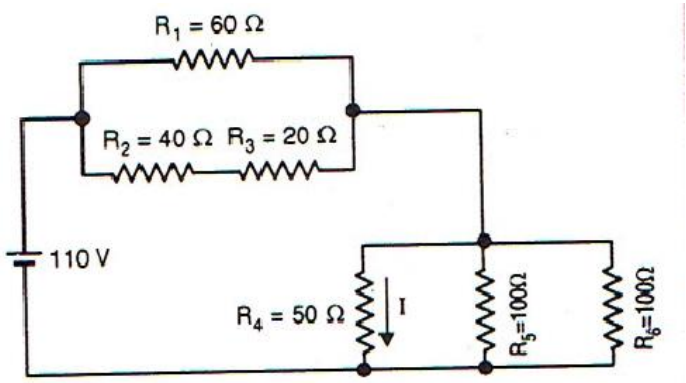


Fig. 2.40

6. Find the current *I* in the 50 Ω resistor in the circuit shown in Fig. 2.40.

[1 A]