Tishk International University
Mechatronics Engineering Department
Electrical Circuits And Network Analysis I
Lecture 3: 05 /01 /2022

Series-Parallel Circuits Analysis

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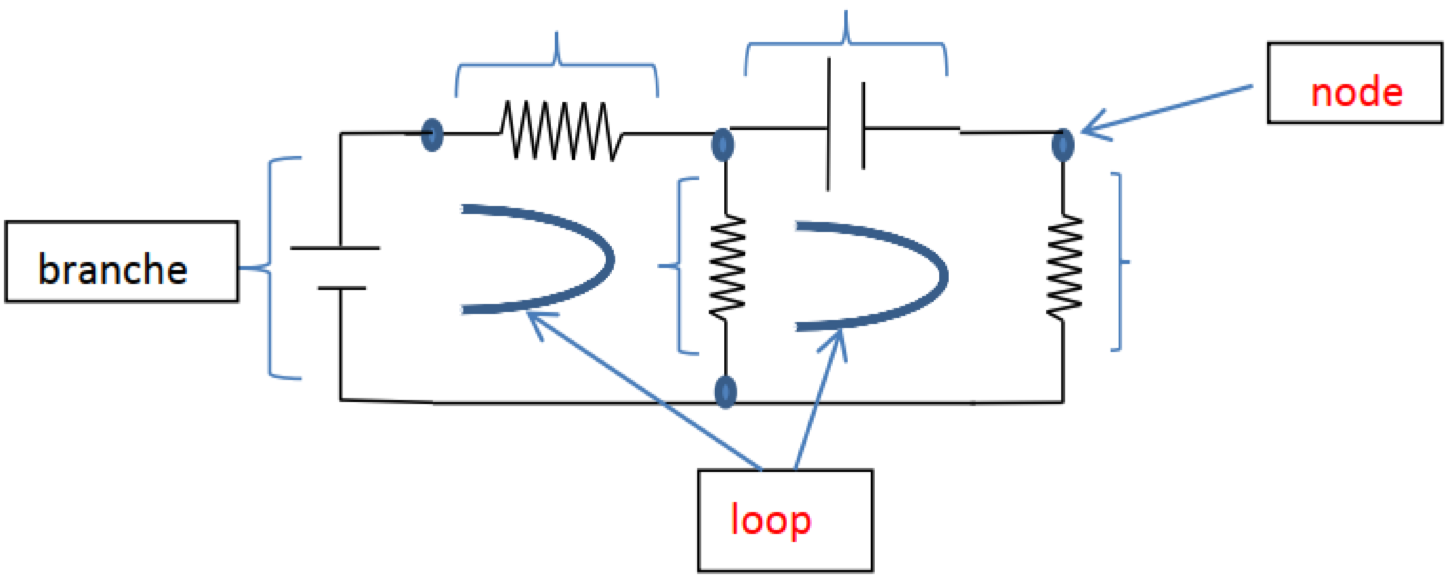
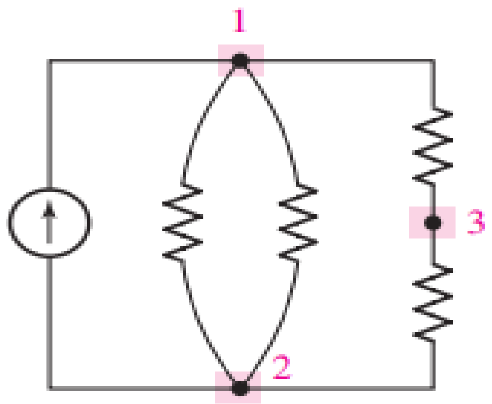
NODES, PATHS, LOOPS, AND BRANCHES

A node is a junction of connecting wires. Every point on a node is at the same potential (same voltage).

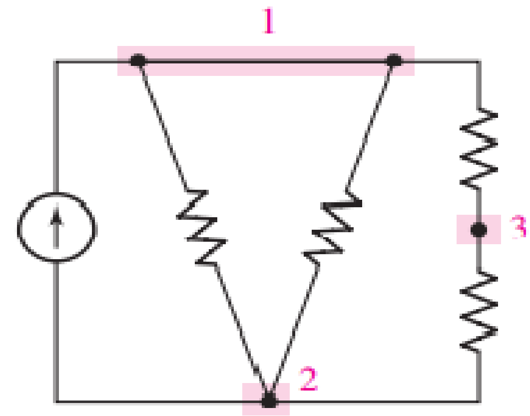
A branch is another name for any circuit element between two nodes.

A loop is a closed path that begins and ends at the same node.





(*a*)



(*b*)

In circuits assembled in the real world, the wires will always have finite resistance. However, this resistance is typically so small compared to other resistances in the circuit that we can neglect it without introducing significant error. In our idealized circuits, we will therefore refer to "zero resistance" wires from now on.

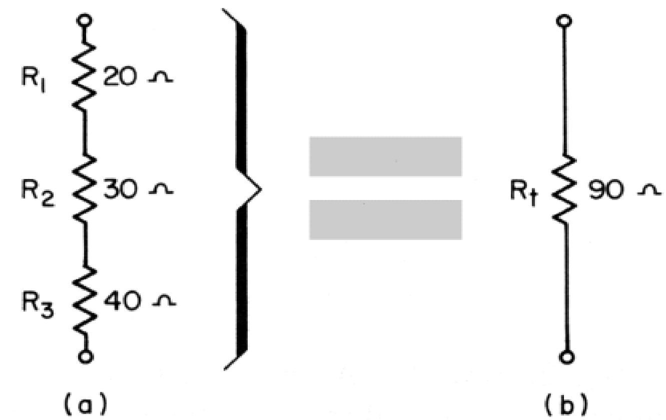
Series Circuit

- Series Circuits are the simplest to work with.
- Here we have three resistors of different resistances. They share a single connection point. When added together the total resistance is 90 **Ω**.

$$I_T = I_1 = I_2 = I_3 \ldots = I_n$$

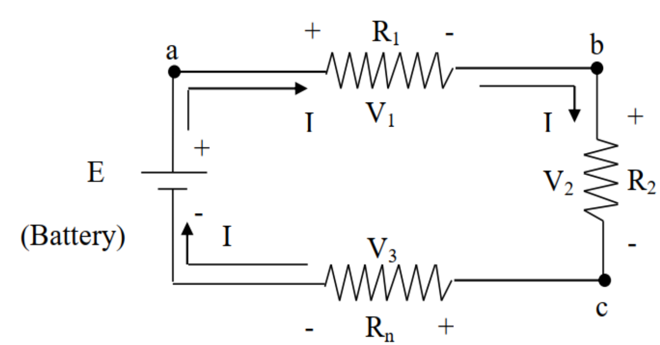
$$V_T = V_1 + V_2 + V_3 + \ldots V_n$$

$$R_T = R_1 + R_2 + R_3$$



$$R_T = 20+30+40$$

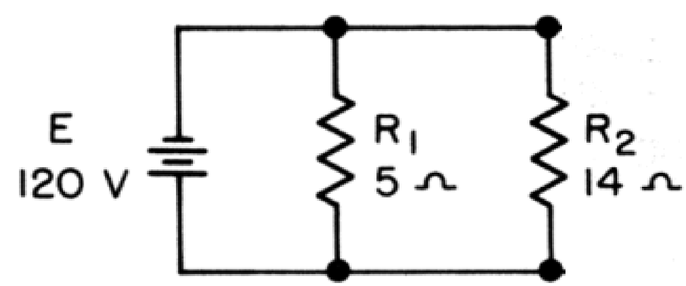
$$R_T = 90 \text{ ohm}$$



Parallel circuit

- A parallel circuit is shown here and it has TWO common connection points with another component.
- In case of TWO resistor in parallel: RT= Product Over Sum.

$$RT = \frac{(R1 * R2)}{(R1 + R2)}$$



RT = (5*14)/(5+14)

RT= 70/19 = 3.684 ohm

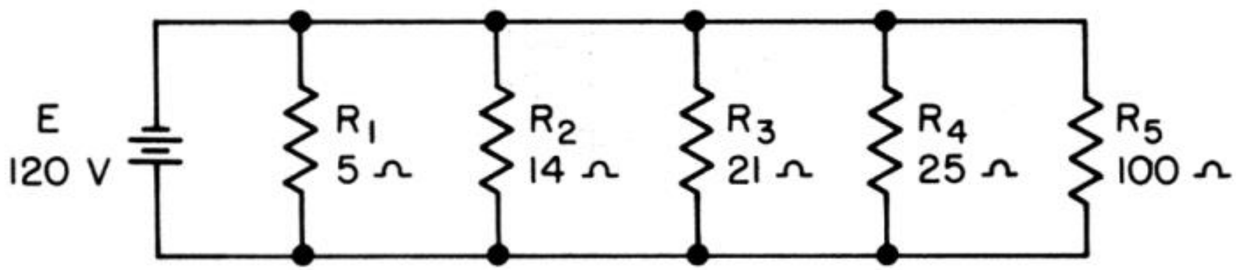
Parallel circuit

- In case of more than two resistor connected in paralle:

$$I_T = I_1 + I_2 + I_3 \dots + I_n$$

$$V_T = V_1 = V_2 = V_3 = \dots V_n$$

$$RT = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \cdots \frac{1}{Rn}$$



$$R_T = \frac{1}{5} + \frac{1}{14} + \frac{1}{21} + \frac{1}{25} + \frac{1}{100} = 2.7 \text{ ohm}$$

Series-Parallel circuit

To solve series-parallel (combination) circuits, it is important to know which components are in series with one another and which components are in parallel.

Series components must be in one current path without any branch points.

To find particular values for this type of circuit, Reduce and combine the components using the rules for individual series and parallel circuits.

Reduce the circuit to its simplest possible form.

Then solve for the needed values using Ohm's Law.

Series-Parallel circuit

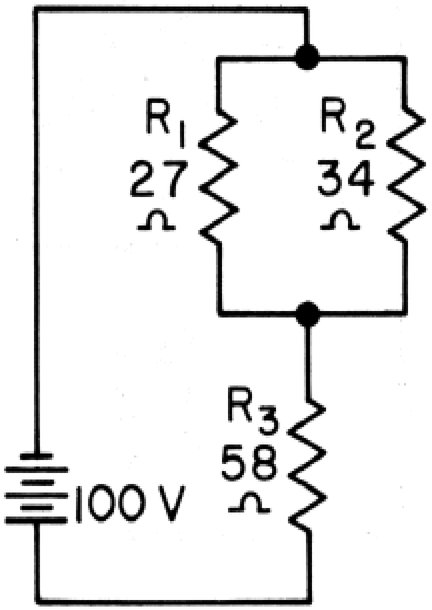
- If we combined a series circuit with a parallel circuit we produce a Series-Parallel circuit.
- R1 and R2 are in parallel and
- R3 is in series with R1 ‖ R2.
- The double lines between R1

  and R2 is a symbol for parallel.
- We need to calculate R1 ‖ R2,

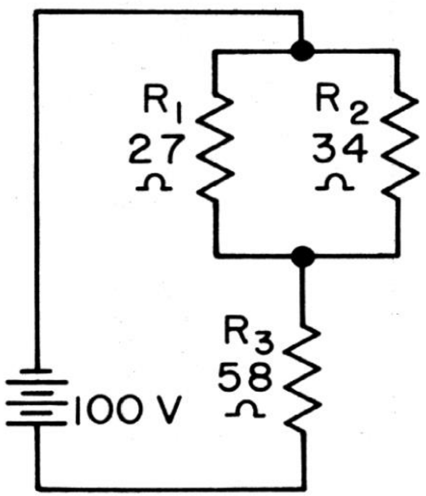
  Here we can use the shorter

  Product Over Sum equation as we only have two

  parallel resistors.
- first before adding R3.



Series-Parallel circuit



- $R1||2 = \frac{(R1*R2)}{(R1+R2)} = \frac{27*34}{27+34} = \frac{918}{61}$
- $R1||2 =$ 15.049Ω + R3 = RT
- RT = 15.049 + 58 = 73.049Ω
- RT = 73Ω

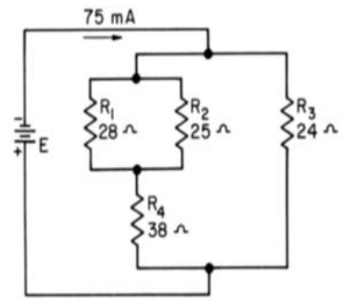
Now that we have our circuit resistance of RT we can calculate circuit current by using Ohm's Law.

- If RT = 73Ω and E = 100V
- I = $\frac{100}{73}$ = 1.369 Amps or 1.37 A

NOTE: Put in your mind that the parallel resistors must be reduced to a single series value before being added to the series resistor.

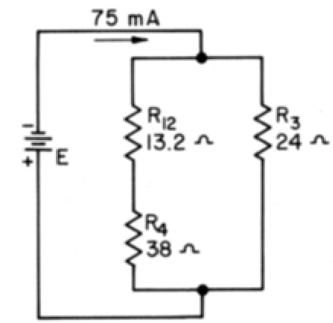
Series-Parallel circuit

- Series-Parallel circuits can be more complex as in this case:
- In circuit (a) we have the original complex circuit.



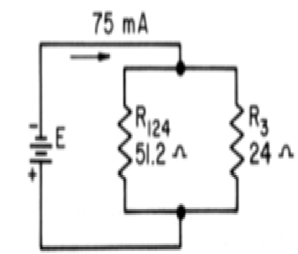
(a)

- In circuit (b) we have resistors R1 and R2 combined to get 13.2Ω.



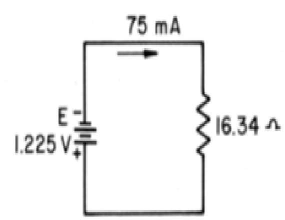
(b)

- R4 is in series with the newly combined R12 and their added value is 51.2Ω.
- And now (c) we are left with R124 in parallel with R3.



(c)

- (d) is our final circuit.

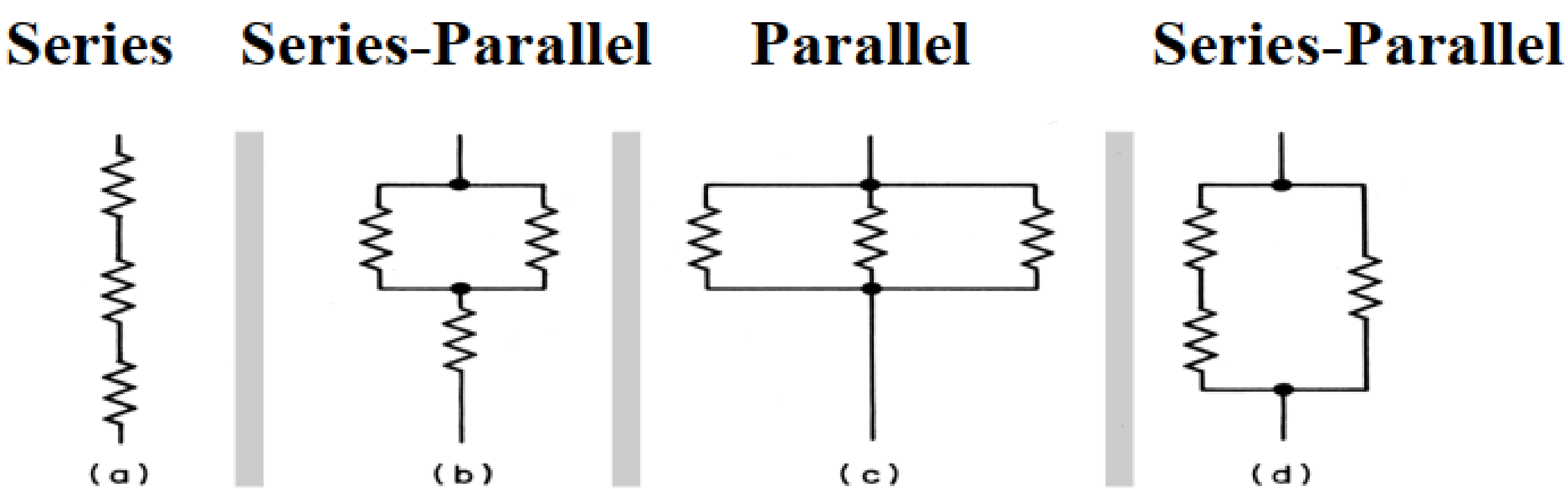


(d)

Series-Parallel Circuits

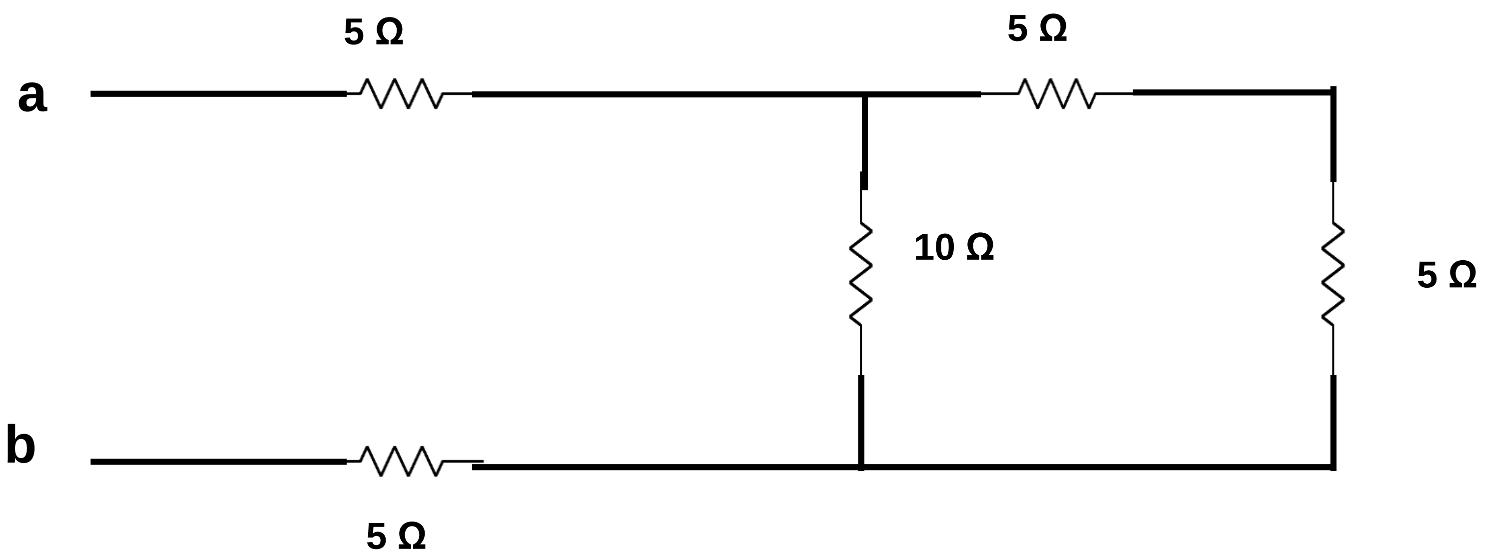
Series, Parallel and Series-Parallel circuits are the three main types of circuits and they are common in DC and AC supplied circuits.

- A series circuit has one shared connection point between components.
- A parallel circuit has two shared connection points between components.
- A series-parallel circuit can have two components sharing one connection point with a single component while they have two common connection points between them.



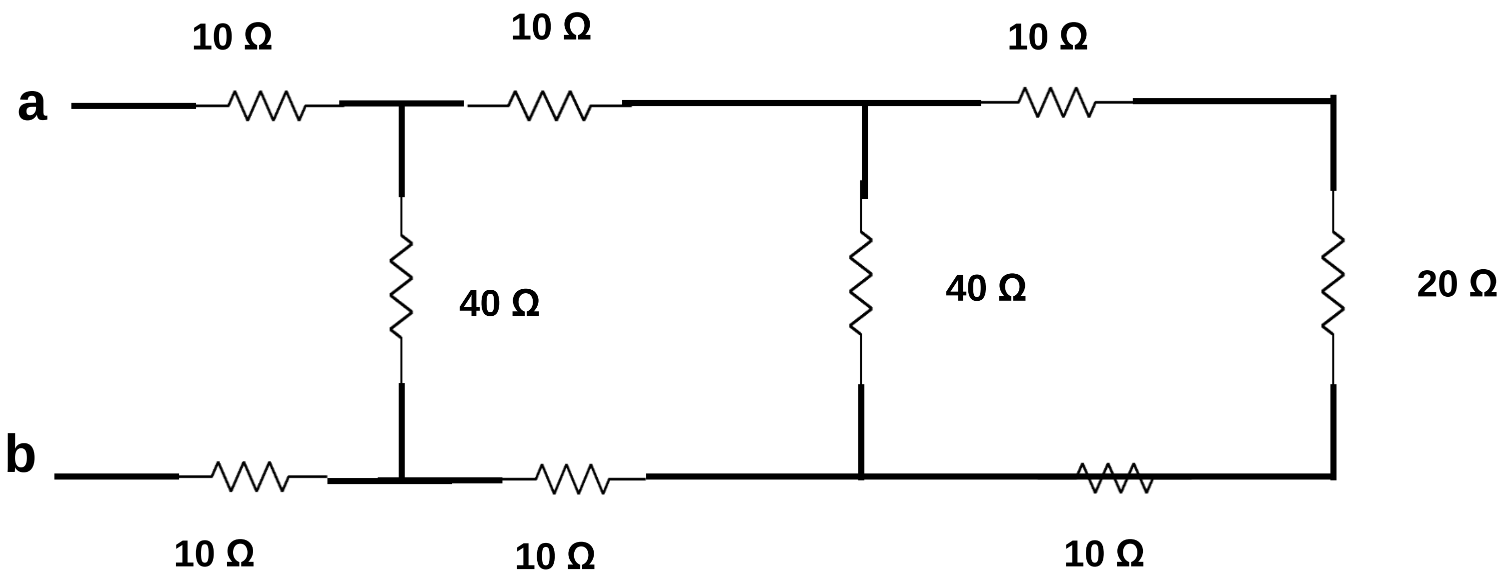
Example 1

Find the total resistance between a & b shown in the following figure.



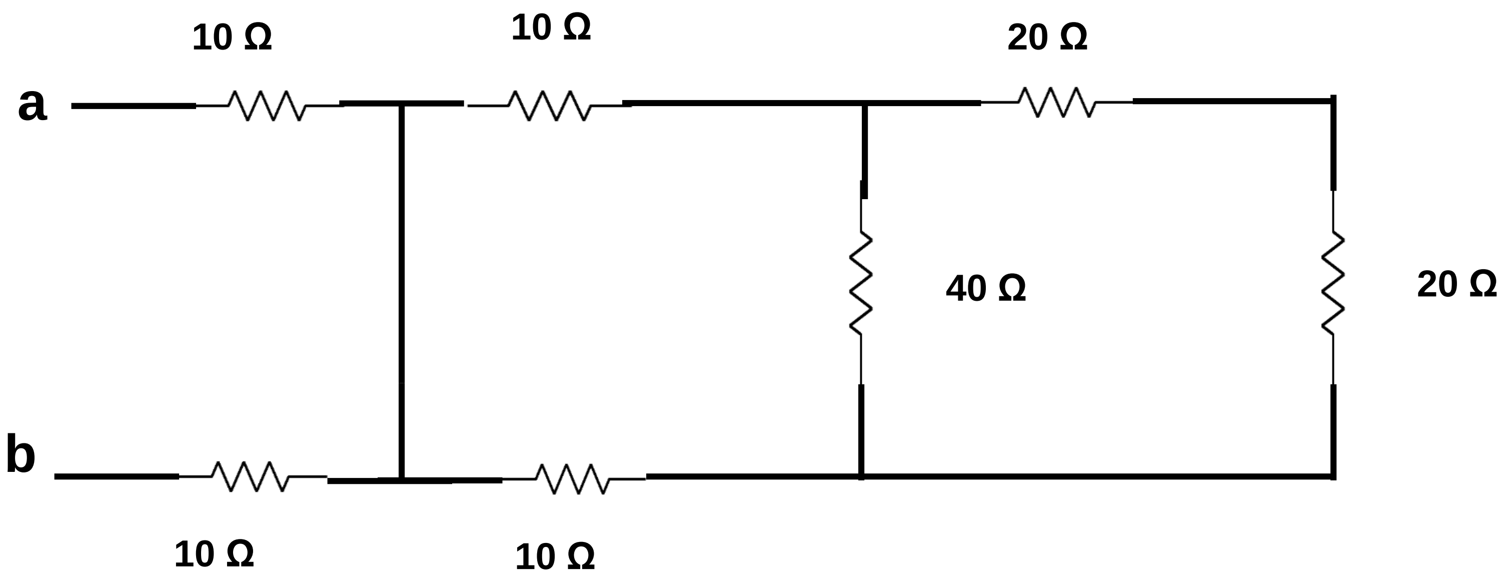
Class Activity

Find the total resistance between a & b shown in the following figure.



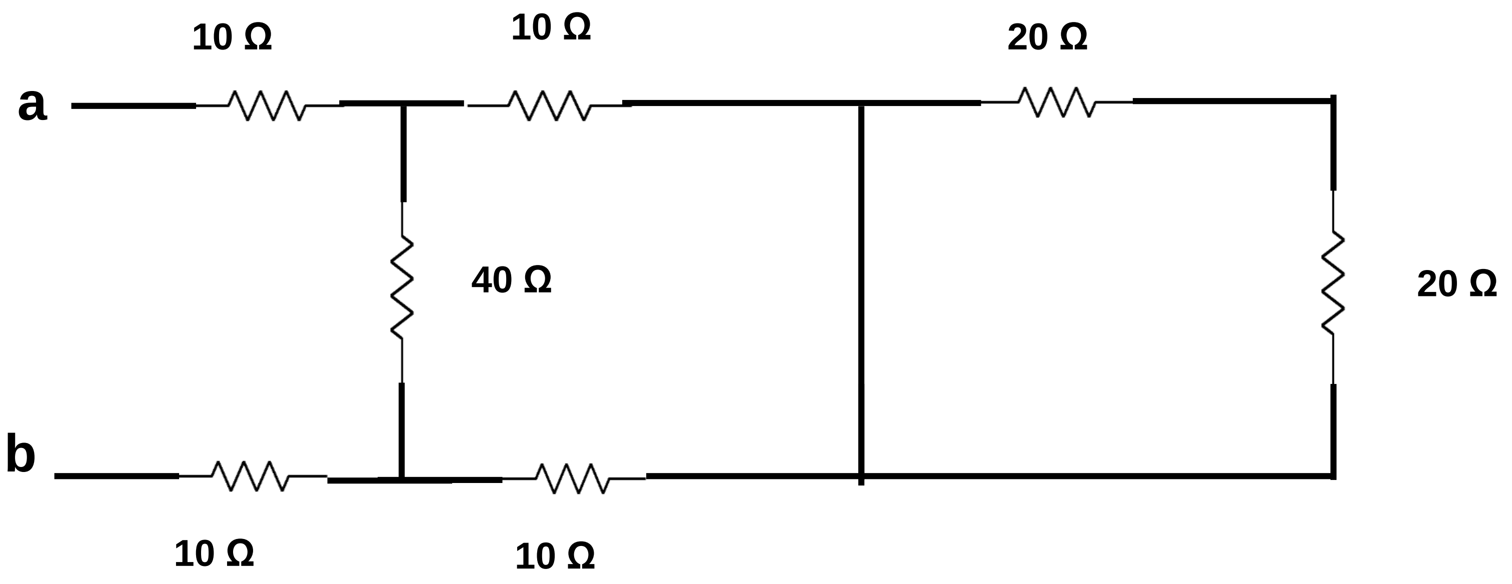
Example 2

Find the total resistance between a & b shown in the following figure.



Home Work

Find the total resistance between a & b shown in the following figure.



References For Electrical Circuits And Network Analysis I

- **Engineering Circuit Analysis 8th Edition,** by William Hayt (Author), Jack Kemmerly (Author), Steven Durbin (Author) **Website**: Engineering Circuit Analysis: Hayt, William, Kemmerly, Jack, Durbin, Steven: 9780073529578: Amazon.com: Books