CARIBBEAN VOCATIONAL QUALIFICATION

COURSE TITLE: **Electrical Installation**

COURSE UNIT: **Foundation Theory for the following units**

- Perform related computation
- Use Electrical/Electronic Measuring Devices
- Install, Terminate and Connect Electrical Wiring
- Disconnect and Reconnect fixed wired electrical machinery, appliances and fixtures

Module Lesson: **Recognizing Series - Parallel Circuits**

LEARNING OUTCOMES:

At the end of this lesson, you are expected to do the following

- Identify Series - Parallel connected circuits
- Calculate total resistance RT in series-parallel circuits

Series-Parallel circuits are circuits that are connected with both series and parallel connected load combinations. When finding the total resistance of the connected loads it is important to recognize the series-parallel configuration. This module attempts to guide you in recognizing these configurations before problems are attempted. When calculating total resistance in series-parallel networks, we need to apply the formula for resistances in series where series connections are recognized and also to apply the formula for resistances in parallel, for parallel resistance combinations. With that being said let’s look at several series-parallel connected circuits.

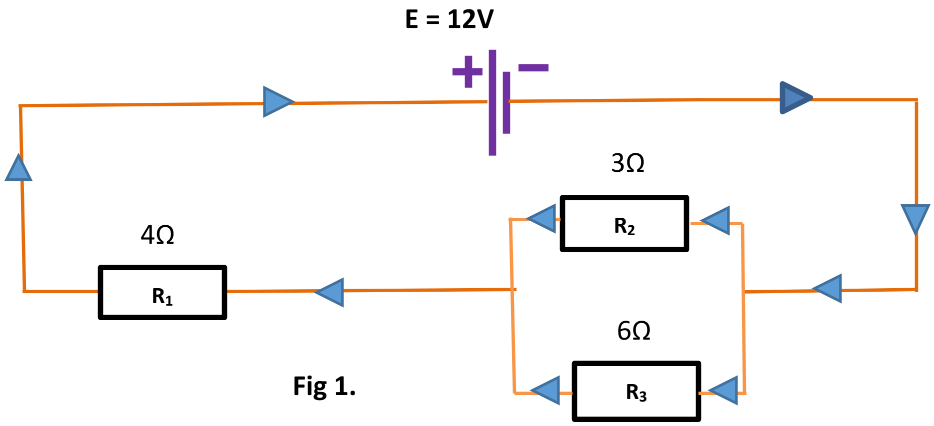

Fig 1.

If we observe the series-parallel network in fig 1, we see there is a parallel connection of $R_2||R_3$ (the *symbol ||, means in parallel*). This parallel connection is in series with the resistance, R_1.

Let's look at the circuit network in fig 2. Here we have two (2) parallel branches; each branch with two (2) resistances in series. This also is a series-parallel circuit**.**

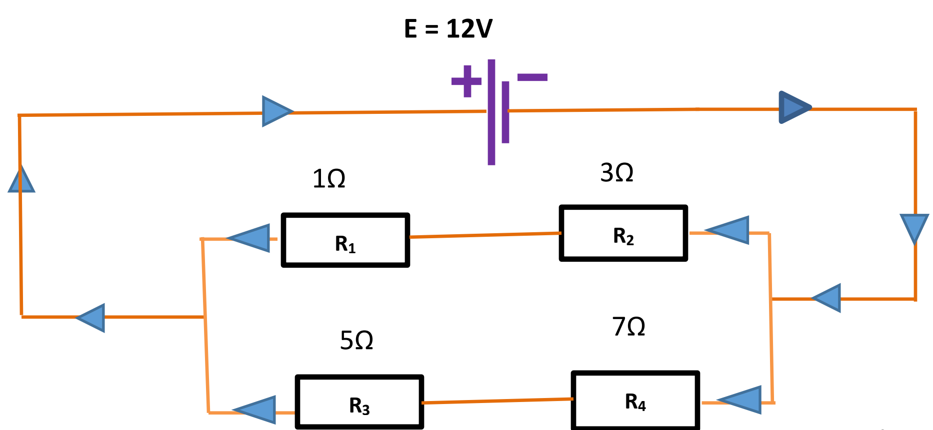

Fig 2.

TEST YOUR KNOWLEDGE 1

1.

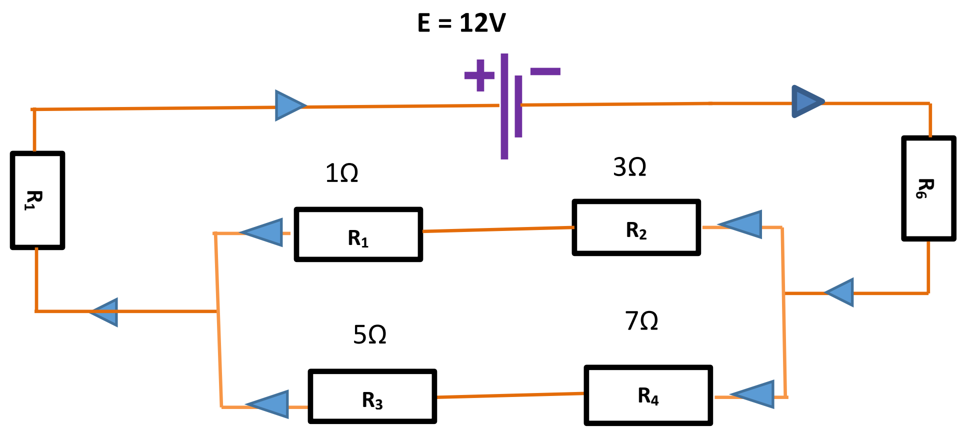

Fig 3 (a)

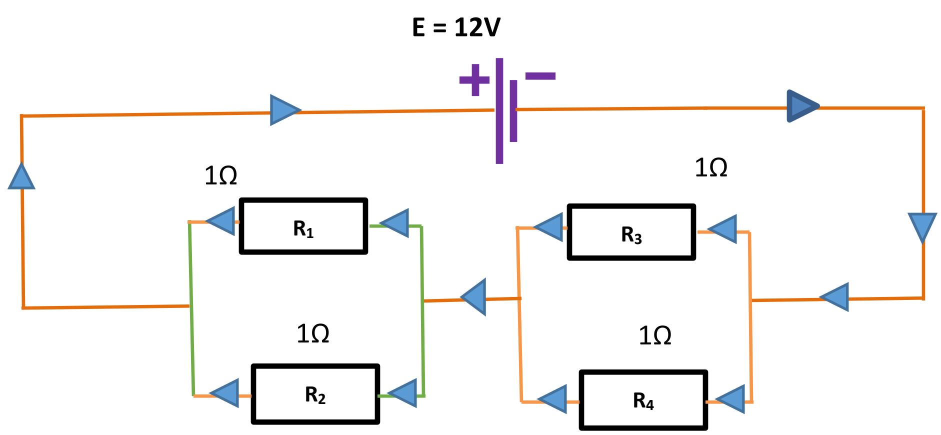

Fig 3 (b)

Explain the series-parallel combination in Fig 3 (a) and (b)

SOLUTION

1 (a)

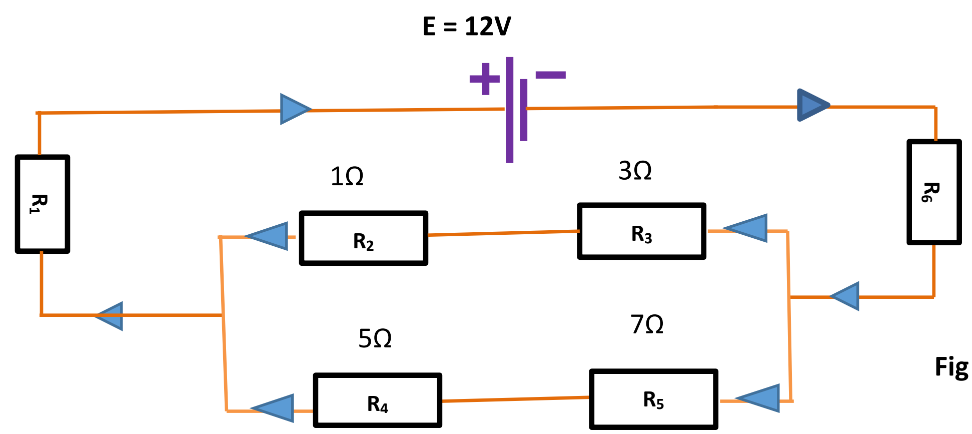

Fig 3 (a)

Fig 3(a) consist of two (2) parallel branches in which R2 & R3 are in series with each other and R_4 & R_5 are in series with each other. The two (2) parallel branches are in series with resistances R_1 &R_6.

1 (b)

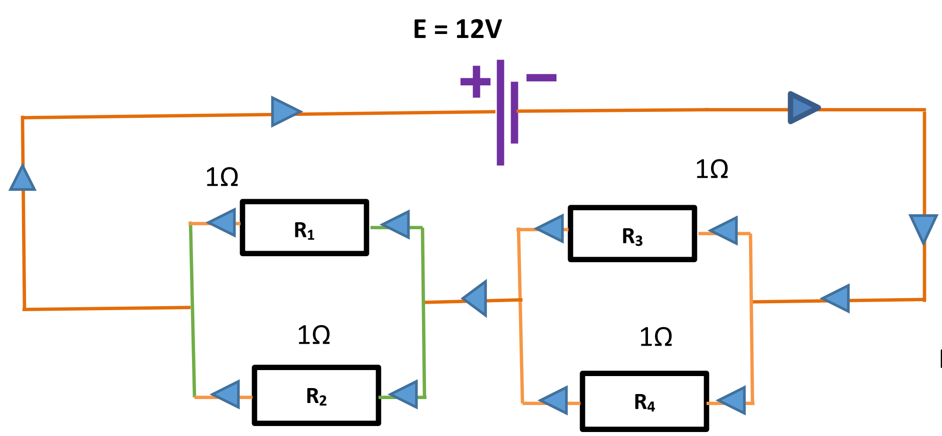

Fig 3 (b)

Fig 3(b) consist of two (2) parallel connections where R1 & R2 are in parallel and the other connection has R_3 & R_4 in parallel. The two (2) parallel connections are in series with each other.

Calculating Total Resistance of series-parallel circuits

To find the total resistance R_T of the circuit we can break the circuit down into a simple resistance as follows:

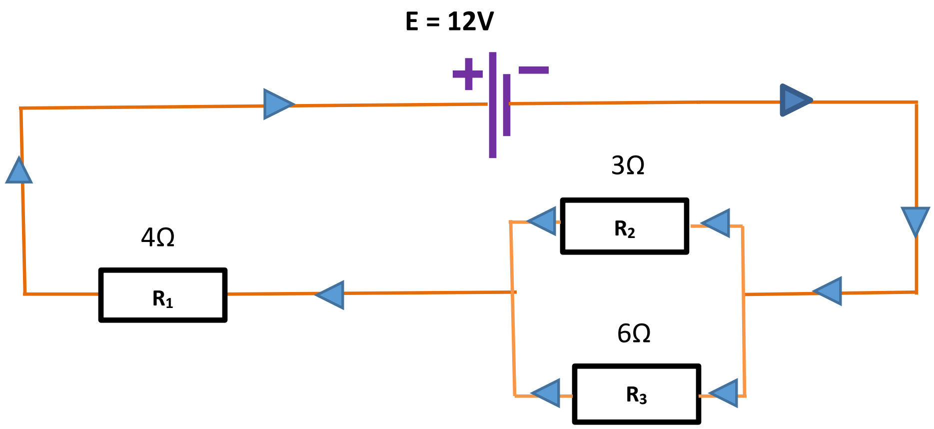

Fig 4

As we explained before, the circuit in fig 4 consist of a parallel connection of $R_2||R_3$. This parallel connection is in series with resistance, R_1.

- First we reduce the parallel connection into a single resistance. We can call this resistance, R'. To find this resistance we solve for the parallel combination:

$$\mathbf{1/R' = 1/R_2 + 1/R_3}$$

$$\mathbf{1/R' = 1/3 + 1/6}$$

$$1/R' = \frac{2+1}{6} = \frac{3}{6} = \frac{1}{2}$$

Inverting to find R'/1 = 2/1

R' = 2 Ω

This means that the combined resistances of R2 & R3 in parallel breaks down to an equivalent resistance R' = 2 Ω

The circuit can be redrawn with R' replacing the parallel combination as shown in fig 4'. This circuit we call an equivalent circuit. This circuit reveals to us that the parallel connection of $R_2||R_3$ is in series with R_1.

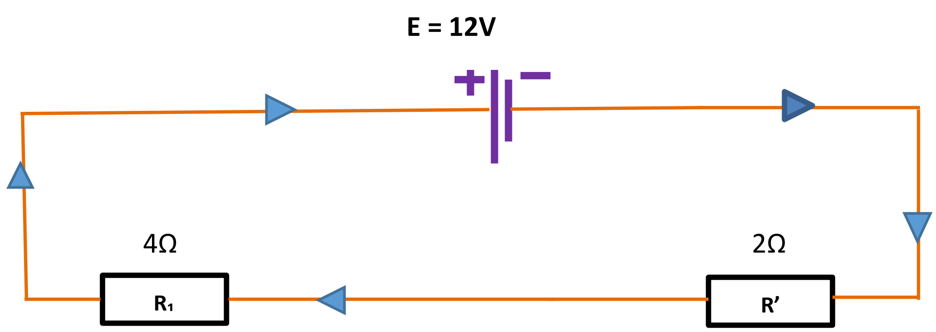

Fig 4' [equivalent cct]

We can now solve for the total resistance since we see that the equivalent resistance R' is in series with R_1. Therefore:

$R_T = R_1 + R' = 4\Omega + 2\Omega = 6\Omega$

Therefore: $\mathbf{R_T = 6\Omega}$

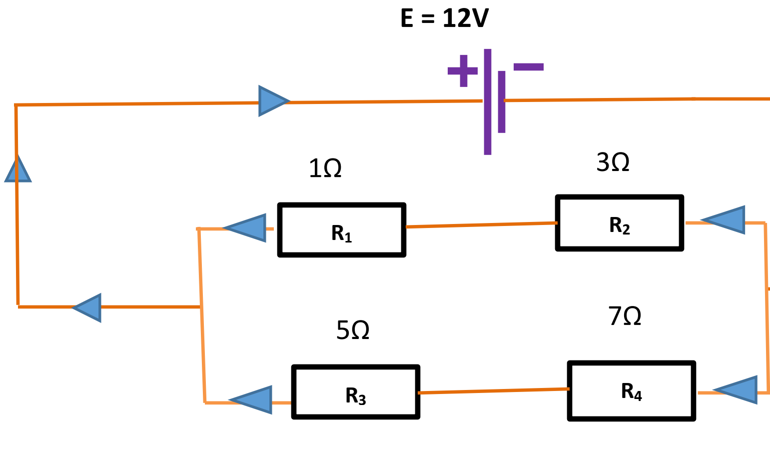

Fig 5

Fig 5 consist of two parallel branches each with resistors in series. The solution is as follows:

- Reduce the branch series resistances to a single resistance, hence

Branch 1: $R' = R_1 + R_2 = 1\Omega + 3\Omega = 4\Omega$ and

Branch 2: $R'' = R_3 + R_4 = 5\Omega + 7\Omega = 12\Omega$

- We can redraw the equivalent circuit to have a better look at the circuit composition shown in Fig 5”. Here we see the equivalent resistances are now in parallel with each other.

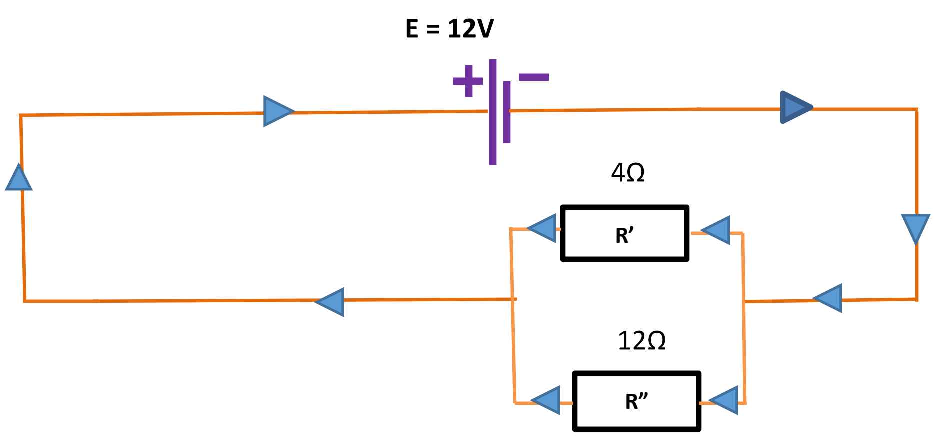

Fig 5” equivalent

Hence: Introducing a special formula to solve for two (2) resistors in parallel.

$$R_T = \frac{R' \times R''}{R' + R''}$$

Note: This formula can only be used to find the single resistance of **only** two (2) resistors in parallel. If you chose, you could have applied the normal formula for resistances in parallel. Please try it if you have some time.

$$R_T = \frac{4 \times 12}{4+12} = \frac{48}{16} = 3\Omega$$

$$\mathbf{R_T = 3\Omega}$$

TEST YOUR KNOWLEDGE 1

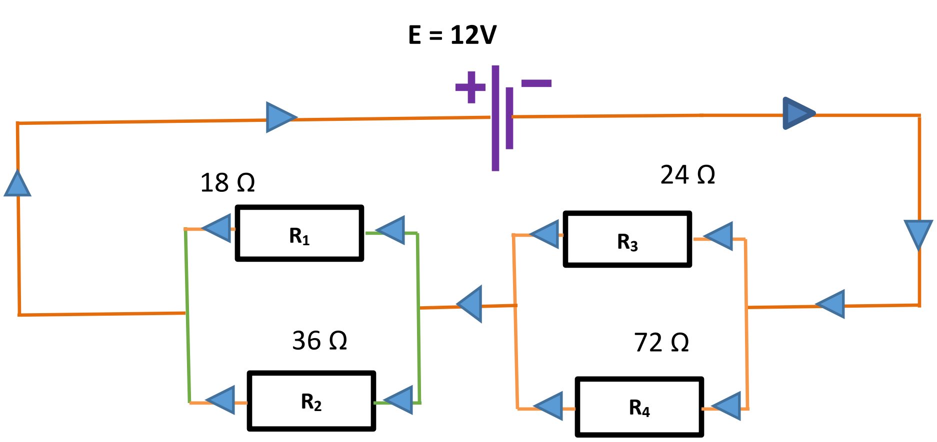

Fig 6.

1. For the circuit above in Fig 6, calculate the total resistance, R_T.

SOLUTION

1. The circuit above consist of two (2) parallel connections where R_1 & R_2 are in parallel and the other connection has R_3 & R_4 in parallel. The two (2) parallel connections are in series with each other.

The total resistance R_T is solved as follows:

Branch 1 [R_1 || R_2] : $R' = \frac{R1 \times R2}{R1 + R2}$

Hence: $R' = \frac{18 \times 36}{18+36} = \frac{648}{54} = 12\ \Omega$

R' = 12 Ω

Branch 2 [R_3 || R_4]: $R'' = \frac{R1 \times R2}{R1 + R2}$

Hence: $R'' = \frac{24 \times 72}{24+72} = \frac{1728}{96} = 18\ \Omega$

Redrawing the equivalent circuit, we get Fig 6'

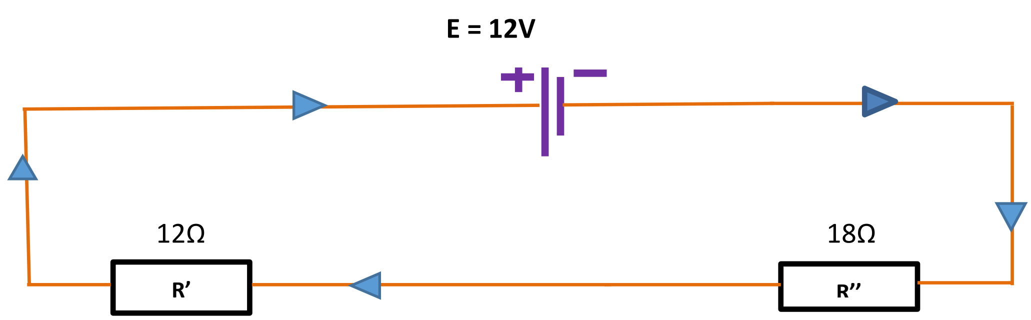

Fig 6' equiv

$R_T = R_1 + R' = 12\ \Omega + 18\ \Omega = 30\ \Omega$

Therefore: $\mathbf{R_T = 30\ \Omega}$