# ELECTRICAL AND ELECTRONIC TECHNOLOGY

Syllabus Section 1: **Electrical Principles and Measurements**

Module Lesson: **Type of Circuits 1: Series and Parallel Circuits**

## LEARNING OUTCOMES:

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

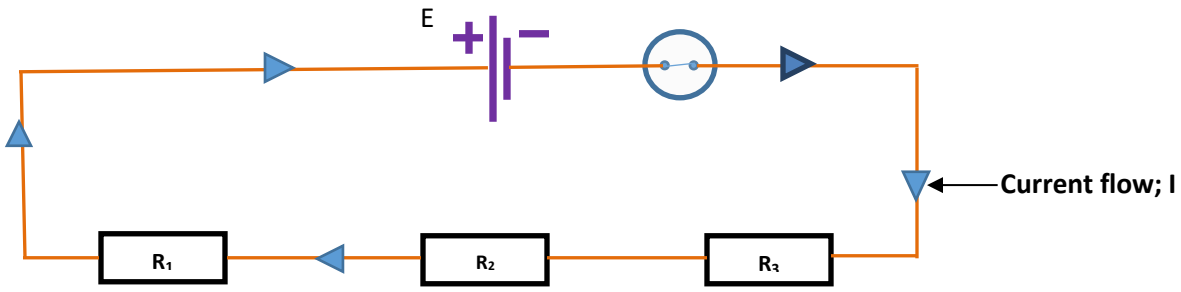
- Identify Series and Parallel connected circuits
- Apply series and parallel circuit rules to solve circuit problem exercises

When connecting loads or devices to electrical circuits, there are basically three main network connections that can be employed. These circuit connections are as follows:

(i) Series circuits
(ii) Parallel circuits
(iii) Series-Parallel circuits

# SERIES CIRCUITS

A series circuit is one which provides a single current path. The power source, electrical devices; e.g. switches), and loads are connected along the single path. Illustration of a series circuit is shown in fig 1.




**SERIES CIRCUIT**

**Fig 1.**

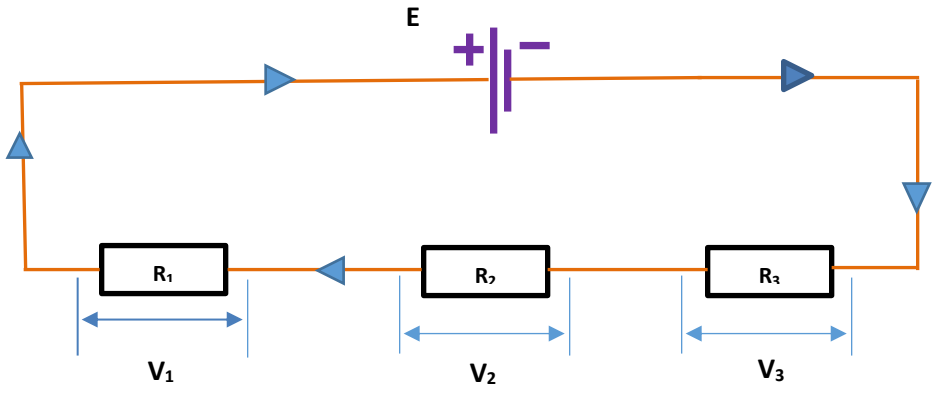
**SERIES CIRCUIT RULES**

When analyzing or solving series circuit problems, the following rules must be remembered and therefore applied:

(i) The current through each load is the same value, since there is only one path provided for this current to flow.

(ii) The sum of the individual load voltages is equal to the supply(source) voltage. Therefore, in fig 2, the source voltage designated as, E, is evaluated as follows:

$E=V_1+V_2+V_3$




**Series circuit rules: $E = V_1 + V_2 + V_3$**

**Fig 2.**

Series circuit problem solving example:

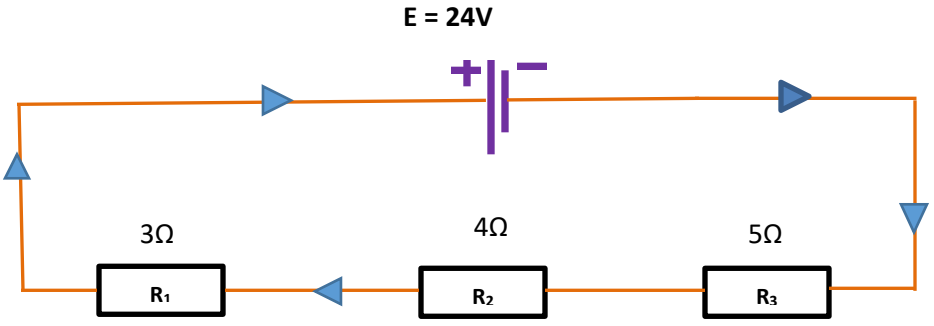



**Fig 3.**

For the circuit shown in fig3 e.g., calculate the

(a) Total resistance, $R_T$
(b) Total current, $I_T$
(c) Voltage drop across
    (i) $R_1$
    (ii) $R_2$
    (iii) $R_3$

**SOLUTION:**

(a) Total resistance, $R_T$, for the series circuit

$R_T = R_1+R_2+R_3$

Therefore: **$R_T$=3Ω+4Ω+5Ω= 12Ω**

(b) Total current flow in any circuit always depends on the power source voltage, E, and the total circuit resistance, $R_T$. Therefore, by applying Ohm's law:

$$I_T = E/R_T = 24v/12\Omega = 2A$$

(C) Since the current through each resistor is the same in this circuit (which is equal to $\mathbf{I_T}$), the individual voltages are evaluated as follows:

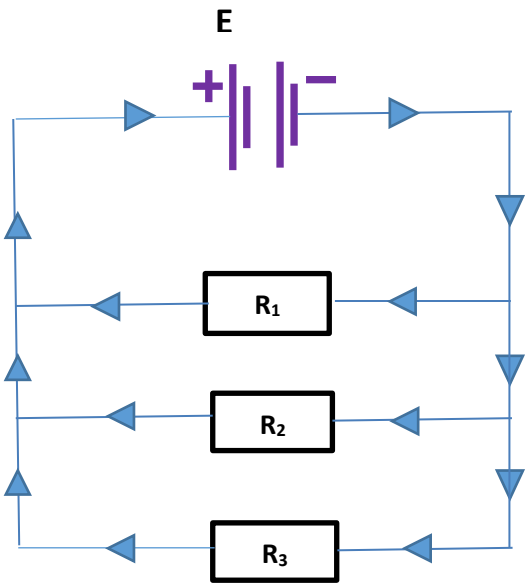
$V_1 = I_T x R_1 = 2A \times 3\Omega = 6V$
$V_2 = I_T x R_2 = 2A \times 4\Omega = 8V$
$V_3 = I_T \, X R_3 = 2A x 5\Omega = 10V$

**It should be noted here that $E = V_1 + V_2 + V_3$**

**$E = 6v + 8v + 10v = 24V.$**

## PARALLEL CIRCUITS

A pure parallel circuit is one in which the individual loads are connected directly across one another and the power source as shown in fig 4. The parallel circuit provides several pathways through which current flows. Each pathway is called a **branch**.




Parallel circuit

Fig 4

Parallel circuit rules

(1) The voltage across each load in a parallel circuit is the same value. In the case of the pure parallel circuit, the voltage across each parallel load is equal to the source voltage. This is because the loads are connected directly across the positive and the negative terminals of the power source. Each load therefore has the full source voltage across it's ends. Therefore, the voltage, V, across, $R_1$ in fig 4 is E; across $R_2$, the voltage $V_2$=E and across $V_3$, the voltage $V_3$=E.

(2) The sum of the currents through each individual branch is equal to the total current, $I_T$. Therefore, fig 5 below; $\mathbf{I_T = I_1 + I_2 + I_3}$

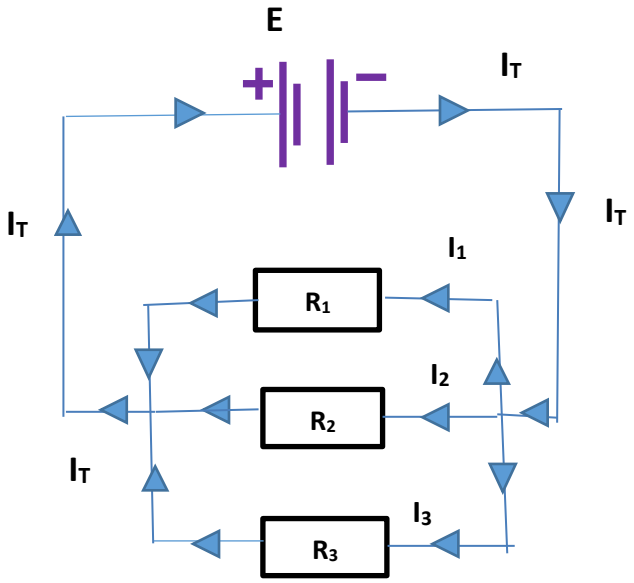



Fig 5

Parallel circuit problem solving example:

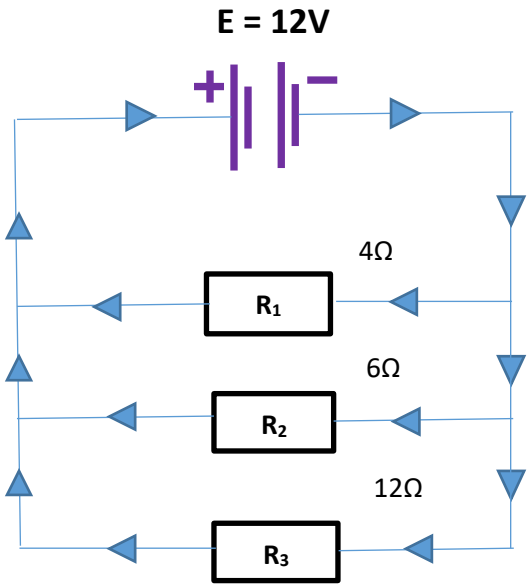



Fig 6

For the circuit shown in fig 6, calculate the

(a) Total resistance, $R_T$
(b) Total current, $I_T$
(c) Current through resistance
    (i) $R_1$
    (ii) $R_2$
    (iii) $R_3$

**Solution:**

(a) For total resistance, **$R_T$:** **$1/R_T = 1/R1 + 1/R2 + 1/R3$** Formula to derive total resistance in parallel

HENCE: **$1/R_T =$ ¼ + 1/6 + 1/12**

$$1/R_T = \frac{3 + 2 + 1}{12} = \frac{6}{12} = \frac{1}{2}$$

Inverting to find $R_{T/1} = 2/1$

**Answer $R_T$ = 2 Ω**

(b) $I_T = E/R_T = 12/ 2 = 6$ A

**$I_T$ = 6A**

(C) Current through $R_1$: $I_1 = E/R_1 = 12/4 = 3$ A

Current through $R_2$: $I_2 = E/R_2 = 12/6 = 2$ A

Current through $R_3$: $I_3 = E/R_3 = 12/12 = 1$ A

## TEST YOUR KNOWLEDGE

1. Series circuit problem:

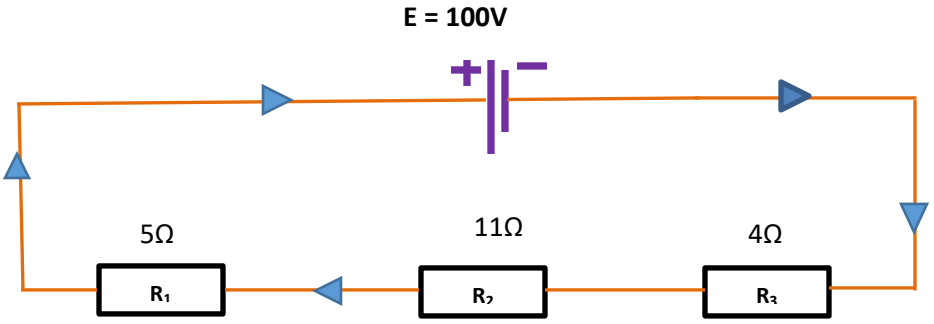



**Fig 7.**

For the circuit shown in fig3 e.g., calculate the

(d) Total resistance, $R_T$
(e) Total current, $I_T$
(f) Voltage drop across
    (i) $R_1$

    (ii)$R_2$

    (iii)$R_3$

2. Parallel circuit problem solving example:

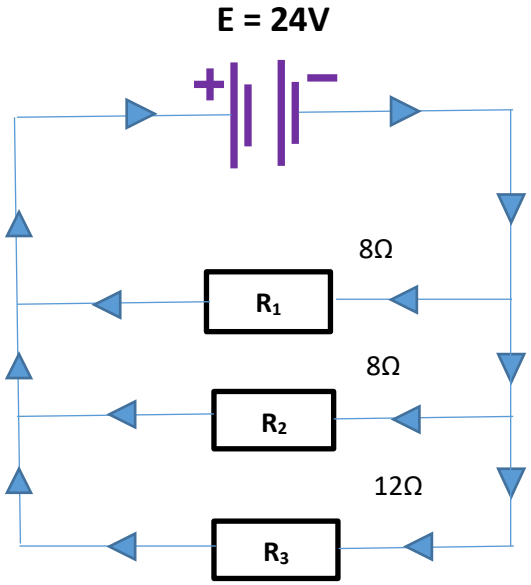



Fig 8

For the circuit shown in fig 8., calculate the

(d) Total resistance, $R_T$
(e) Total current, $I_T$
(f) Current through resistance
  (i) $R_1$
  (ii) $R_2$
  (iii) $R_3$

## SOLUTION

1.

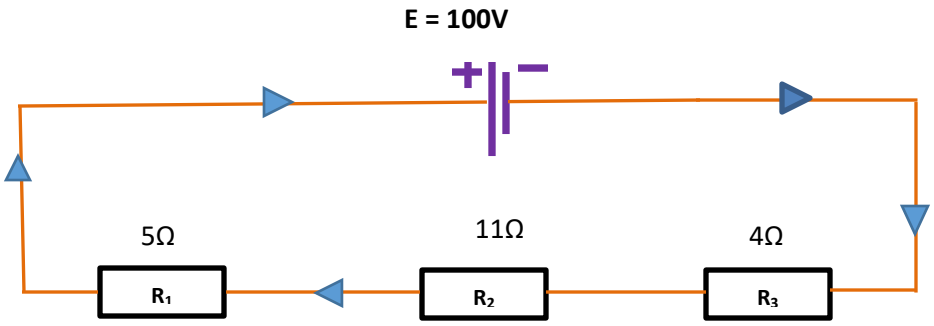



**Fig 7.**

**SOLUTION:**

(c) Total resistance, $R_T$, for the series circuit

$R_T = R_1+R_2+R_3$

Therefore: $\mathbf{R_T=5\Omega+11\Omega+4\Omega= 20\Omega}$

Total current flow in any circuit always depends on the power source voltage, E, and the total circuit resistance, $R_T$. Therefore, by applying Ohm's law:

$I_T= E/R_T = 100V/20\Omega = 5A$

(C) Since the current through each resistor is the same in this circuit (which is equal to $\mathbf{I_T}$), the individual voltages are evaluated as follows:

$V_1=I_TxR_1 = 5A \times 5\Omega= 25V$
$V_2=I_TxR_2= 5A \times 11\Omega= 55V$
$V_3=I_T\ XR_3=5Ax4\Omega= 20V$

2.

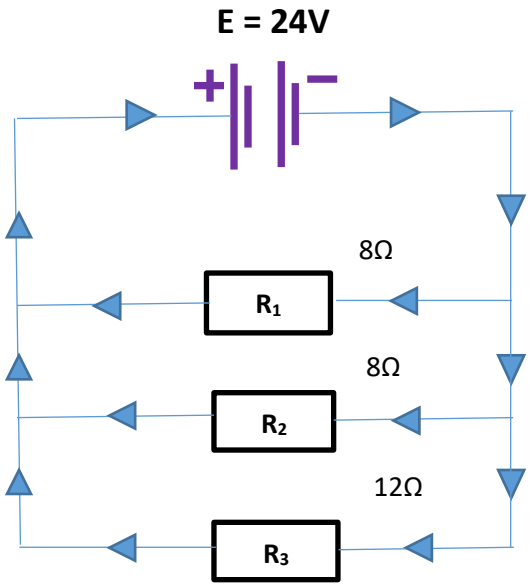



Fig 8

## Solution:

(c) For total resistance, **$R_T$:** **$1/R_T = 1/R1 + 1/R2 + 1/R3$**

HENCE: **$1/R_T =$ 1/8 + 1/8 + 1/12**

$$1/R_T = \frac{3+3+2}{24} = \frac{8}{24} = \frac{1}{3}$$

Inverting to find $R_{T/1} = 3/1$

**Answer $R_T = 3\ \Omega$**

(d) $I_T = E/R_T = 24/3 = 8$ A

**$I_T = 8A$**

(C) Current through $R_1$: $I_1 = E/R_1 = 24/8 = 3$ A

Current through $R_2$: $I_2 = E/R_2 = 24/8 = 3$ A

Current through $R_3$: $I_3 = E/R_3 = 24/12 = 2$ A