# Current Electricity
# Lesson 2: Equivalent Resistance

1. **Equivalent Resistance in a circuit with Resistors connected in Series**
2. **Equivalent Resistance in a circuit with Resistors connected in Parallel**
3. **Equivalent Resistance in a circuit with Resistors connected both in Series and Parallel**

## YOUR TASKS: 6 Problems to be solved

**Task 1: Follow Slides 2 to 4 and Solve Problem on Slide 5**

**Task 2: Follow Slides 6 and 7 and Solve Problem on Slide 8**

**Task 3: Follow Slides 9 and 11 and Solve Problem on Slide 12**

**Task 4: Follow Slide 13 and Solve Problem on Slide 14**

**Task 5: Follow Slide 15 and give solution for the Problem given on Slide 16 on Slide 17**

**Task 6: Follow Slide 18 and give solution for the Problem given on Slide 19 on Slide 20**

# Equivalent Resistance in a Circuit

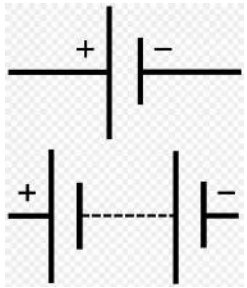
When several resistors are connected in a circuit, the net or the total resistance of all the resistors in that circuit is called the Equivalent Resistance.

In Circuit, if you see a component, with the following design, then it is a resistor

Ohm, is the unit of resistance; ohm has the following symbol

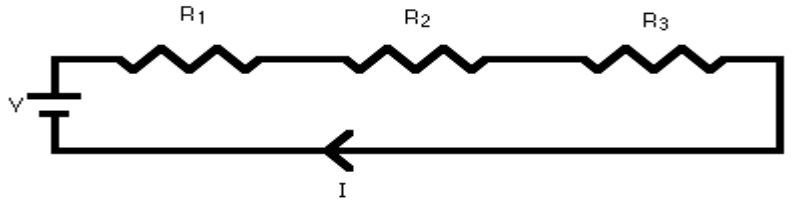
Ω

In Circuit, a battery or a power source is represented by the design on the right.
The top is for a single battery; the bottom is for two batteries.



# Resistors Connected in Series in a Circuit:
# GUIDED PRACTICE 1

Series means one after the other in the same row. An example of a circuit with three resistors connected in a series is shown below:




The Equivalent Resistance of a circuit with multiple resistors in series is the sum of resistance values of the connected resistors.

For the above circuit, the Equivalent Resistance is given by:

$R_{series} = R_1 + R_2 + R_3$

Let us assign values for $R_1$ $R_2$ $R_3$

$R_1$ = 5 ohm

$R_2$ = 8 ohm

$R_3$ = 12 ohm

The equivalent resistance of this circuit is:

$R_{series} = R_1 + R_2 + R_3$

$R_{series} = 5 + 8 + 12 = 25$ ohm

# Resistors Connected in Series in a Circuit: Guided Practice 1

A circuit has four resistors connected in a series with resistances of 0.5 ohm, 300 mohm (milliohm), 60,000 µohm (microohm), and 75cohm (centiohm); find the equivalent resistance of the circuit.

Solution

Process: Convert all resistance values into ohms (use metric ladder) and then add them up

$R_{series} = R_1 + R_2 + R_3 + R_4$

$R_1 = 0.5$ ohm

$R_2 = 300/1000 = 0.3$ ohm

$R_3 = 60{,}000/1000000 = 0.06$ ohm

$R_4 = 75/100 = 0.75$ ohm

$R_{series} = R_1 + R_2 + R_3 + R_4$

$= 0.5 + 0.3 + 0.06 + 0.75 = 1.61$ ohm

**METRIC LADDER is on my Website under the Task for April 20, 2020**

# Resistors Connected in Series in a Circuit: Independent Practice 1

A circuit has four resistors connected in a series with resistances of 0.35 ohm, 0.3 centiohm (centiohm), 48,200 µohm (microohm), and 75 daohm (decaohm); find the equivalent resistance of the circuit.

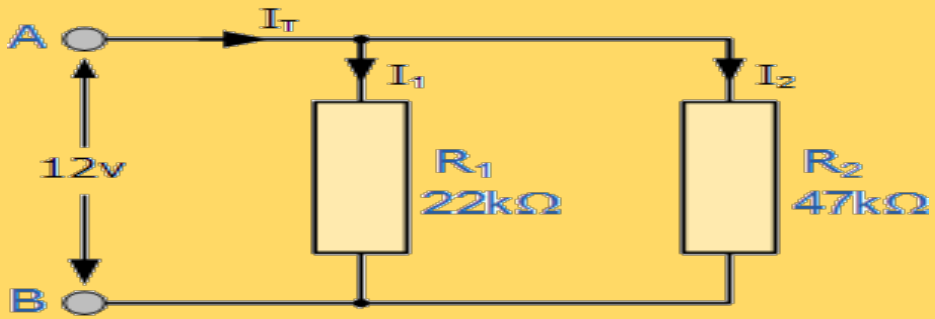
Solution

**METRIC LADDER is on my Website under the Task for April 20, 2020**

# TWO Resistors Connected in Parallel in a Circuit

**GUIDED PRACTICE – INVERSING THE SUM OF RATIOS METHOD**

**Parallel means side by side as separate rows. An example of a circuit with two resistors connected in parallel is given is shown below: Ω is the symbol for ohm.**




**The Equivalent Resistance of a circuit with two resistors in parallel is given by**

**For the above circuit, the Equivalent Resistance is given by:** $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

**Let us assign values for $R_1$ and $R_2$**

**$R_1$ = 5 ohm**

**$R_2$ = 8 ohm**

**The equivalent resistance of this circuit is:**

**$1/R_{EqParallel} = 1/R_1 + 1/R_2$**

**$1/R_{Eqarallel} = 1/5 + 1/8$**

**$1/R_{EqParallel} = 0.2 + 0.125 = 0.325$ ohm**

**$R_{EqParallel}$ is the inverse of $1/R_{EqParallel}$**

**Therefore, $R_{EqParallel} = 1/0.325 = 3.07$ ohm**

# TWO Resistors Connected in Parallel in a Circuit
# GUIDED PRACTICE: PRODUCT BY SUM METHOD

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

Putting the right-hand side over the same common denominator,

$$\frac{1}{R} = \frac{R_2 + R_1}{R_1 R_2}$$

Inverting both sides,

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

Hence, for *two* resistors in parallel,

$$\text{combined resistance} = \frac{\text{product of resistances}}{\text{sum of resistances}}$$

It is useful to learn this formula by heart.

**Let us solve the same Problem in Slide 6 by the Product Over Sum Method**

$R_{EqParallel}$ = (5 x 8)/(5+8)
= 40/13
= 3.07

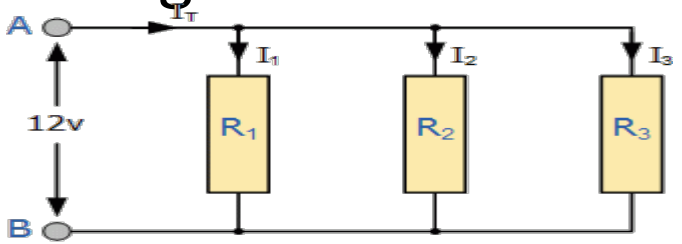
**You get the same answer in both the methods. So, you may choose to solve problems of two resistors in parallel by any one of the two methods**

# TWO Resistors Connected in Parallel in a Circuit
# INDEPENDENT PRACTICE: PRODUCT BY SUM METHOD

Two resistors of resistance values of 15 ohm and 25 ohm are connected in parallel in a circuit – find the equivalent resistance of the circuit – **you can solve by any one of the two methods shown in slides 6 and 7**

# TWO Resistors Connected in Parallel in a Circuit
# GUIDED PRACTICE: PRODUCT BY SUM METHOD

Parallel means side by side as separate rows. An example of a circuit with three resistors connected in parallel is given is shown below:




The Equivalent Resistance of a circuit with multiple resistors in parallel is given by

For the above circuit, the Equivalent Resistance is given $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Let us assign values for $R_1$ $R_2$

$R_1$ = 5 ohm

$R_2$ = 8 ohm

$R_3$ = 12 ohm

The equivalent resistance of this circuit is:

$1/R_{Parallel} = 1/R_1 + 1/R_2 + 1/R_3$

$1/R_{Parallel} = 1/5 + 1/8 + 1/12$

$1/R_{Parallel} = 0.2 + 0.125 + 0.083 = 0.408$ ohm

$R_{parallel}$ is the inverse of $1/R_{Parallel}$

Therefore, $R_{parallel}$ = 1/0.408 = 2.451 ohm = 2.5 ohm

NOTE: PRODUCT BY SUM METHOD GETS COMPEX IF YOU HAVE MORE THAN TWO RESISTORS IN A CIRCUIT.

THIS IS SHOWN IN NEXT SLIDE

# THREE Resistors Connected in Parallel in a Circuit
# GUIDED PRACTICE: PRODUCT BY SUM METHOD

**In the Product by Sum Method for THREE Resistors,**

**Can be simplified** $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

**$R_{eq}$ = $(R_1 * R_2 * R_3)/ (R_2 * R_3) + (R_1 * R_3) + (R_1 * R_2)$**

**You get the same answer in both the methods. So, you may choose to solve problems of two resistors in parallel by any one of the two methods**

Let us now work with the values of resistance given in slide 9 for $R_1$ $R_2$ $R_3$

$R_1$ = 5 ohm

$R_2$ = 8 ohm

$R_3$ = 12 ohm

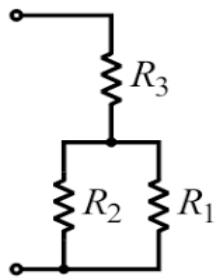
**$R_{eq}$ = $(R_1 * R_2 * R_3) /(R_2 * R_3) + (R_1 * R_3) + (R_1 * R_2)$**
**= (5x8x12) / (8x12) + (5 x12) + (5x8)**
**= 480 (96 + 60 + 40)**
**= 480/196**
**= 2.449 = 2.5 ohm**

# THREE Resistors Connected in Parallel in a Circuit
# INDEPENDENT PRACTICE: PRODUCT BY SUM METHOD

Three resistors of resistance values of 8.5 ohm, 12.3 ohm and 2.5 ohm are connected in parallel in a circuit – find the equivalent resistance of the circuit – **you can solve by any one of the two methods shown in slides 9 or 11**

# Resistors Connected in Series and Parallel in a Circuit Guided Practice - 1

An example of a circuit with resistors connected in series and parallel is shown below:




**In this circuit, $R_1$ and $R_2$ are in parallel and $R_3$ is in series with the combo set of $R_1$ and $R_2$**
**So, find the equivalent resistance of $R_1$ and $R_2$ and then add it to $R_3$**

Let us assign values for $R_1$ $R_2$ $R_3$

$R_1$ = 5 ohm

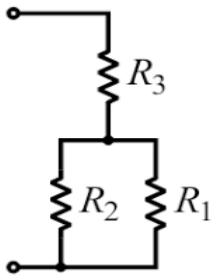
$R_2$ = 8 ohm

$R_3$ = 12 ohm

**Step 1: Equivalent resistance of $R_1$ and $R_2$ by Product Over Sum Method:**
**= (5x8)/(5+8) = 40/13 = 3.08 ohm**
**Step 2: Add Answer from Step 1 to $R_3$**
**= 3.08 + 12 = 15.08 ohm**

**Solution: The Equivalent Resistance of the Given Circuit = 15.08 ohm**

# Resistors Connected in Series and Parallel in a Circuit Independent Practice - 1




Let us assign values for $R_1$ $R_2$ $R_3$

$R_1$ = 15 ohm

$R_2$ = 3 ohm

$R_3$ = 1 ohm

**Step 1: Equivalent resistance of $R_1$ and $R_2$ by Product Over Sum Method:**

**= ohm**

**Step 2: Add Answer from Step 1 to $R_3$**

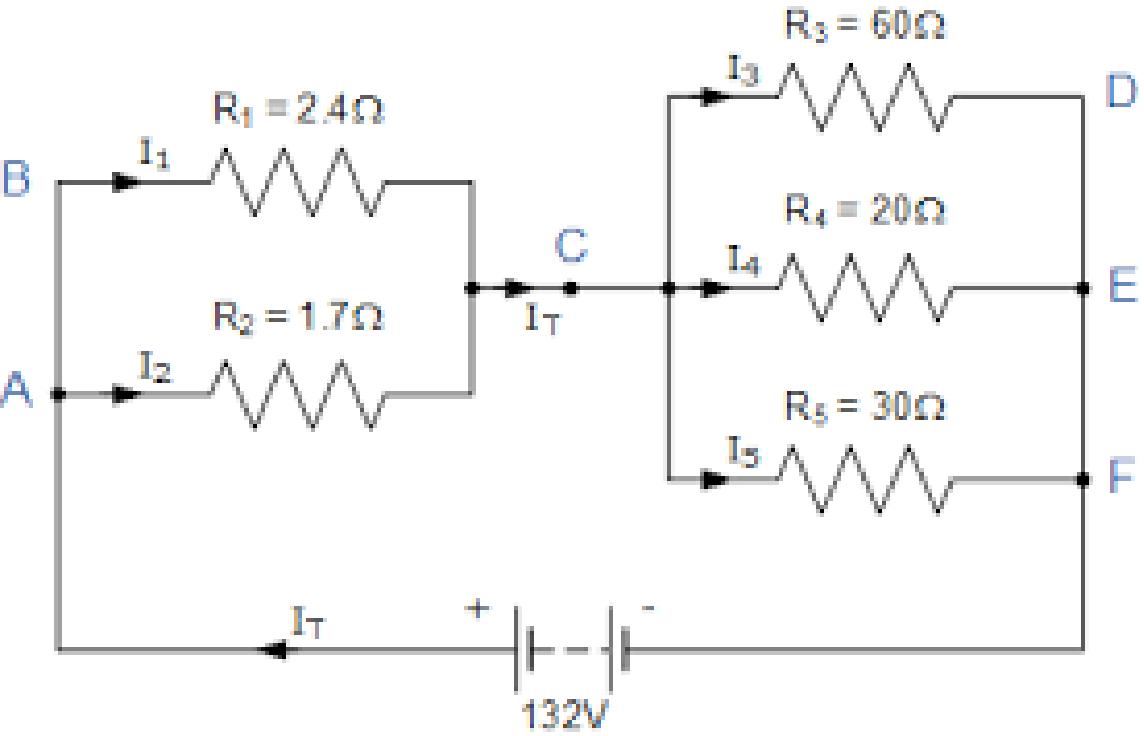
**= ohm**

**Solution: The Equivalent Resistance of the Given Circuit = ohm**

# Resistors Connected in Series and Parallel in a Circuit
# Guided Practice -2

Determine the Equivalent Resistance of the following circuit; Show complete work.
Note: Ω is the symbol for ohm.

Two sets of Parallelly connected resistors are connected in series: Find the Equivalent Resistance of the set $R_1$ and $R_2$ and then find the Equivalent Resistance of the set $R_3$ , $R_4$ and $R_5$ - Finally add both the Equivalent Resistances.




**Step 1: Equivalent Resistance of the set $R_1$ and $R_2$ by Product by Sum Method**

**= (2. 4 x 1.7)/(2.4 + 1.7) = 4.08/4.1 = 0.995 ohm**

**Step 2: Equivalent Resistance of the set $R_3$ , $R_4$ and $R_5$ by Product by Sum Method**

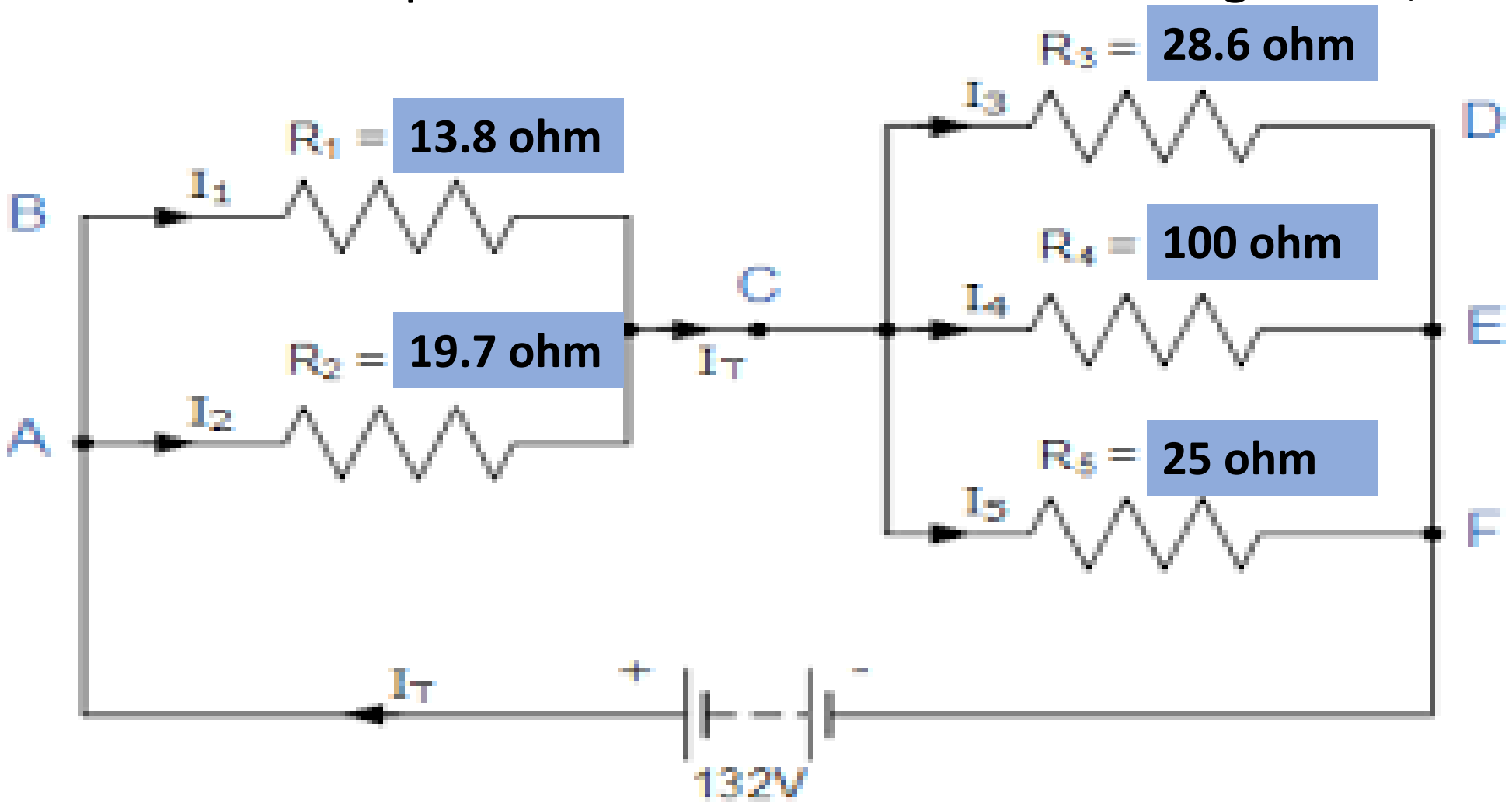
**= (60x20x30)/[(20x30)+(60x30)+(60x20) = 36,000/3,600 = 10 ohm**

**Step 3: Sum of Answers of Step 1 and Step 2**

**= 0.995 + 10 = 10.995 ohm**

# Resistors Connected in Series and Parallel in a Circuit
# Independent Practice -2

Determine the Equivalent Resistance of the following circuit; Show complete work




Show work on next slide

# Your complete work for Problem on Slide 11

**Step 1: Equivalent Resistance of the set $R_1$ and $R_2$ by Product by Sum Method**

**= ohm**

**Step 2: Equivalent Resistance of the set $R_3$ , $R_4$ and $R_5$ by Product by Sum Method**

**= ohm**

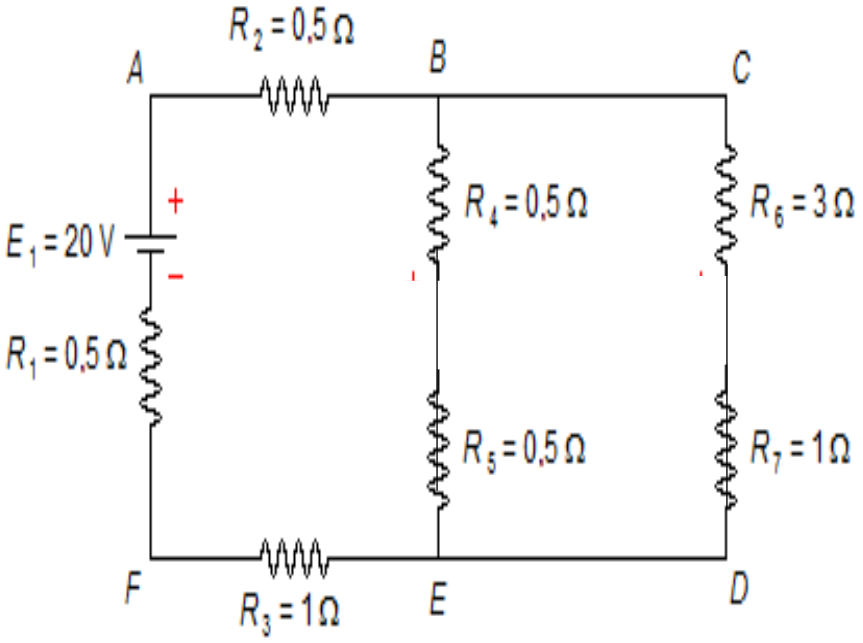
**Step 3: Sum of Answers of Step 1 and Step 2**

**= + = ohm**

# Resistors Connected in Series and Parallel in a Circuit
# Guided Practice -3

**Determine the Equivalent Resistance of the following circuit; Show complete work. Clue: Two sets of Parallelly connected resistors are connected in series with three resistors already connected in series:**

**First find the resistance of set $R_4$ and $R_5$ ; next, find the resistance of $R_6$ and $R_7$ . Then, find the Equivalent Resistance of the parallel connection between the set $R_4$ and $R_5$ and the set $R_6$ and $R_7$ - Finally add the Equivalent Resistance to the sum of $R_1 + R_2 + R_3$**




**Step 1: Resistance of the series set $R_4$ and $R_5$**
**= (0.5 + 0.5) = 1 ohm**

**Step 2: Resistance of the series set $R_6$ and $R_7$**
**= (3 + 1) = 4 ohm**

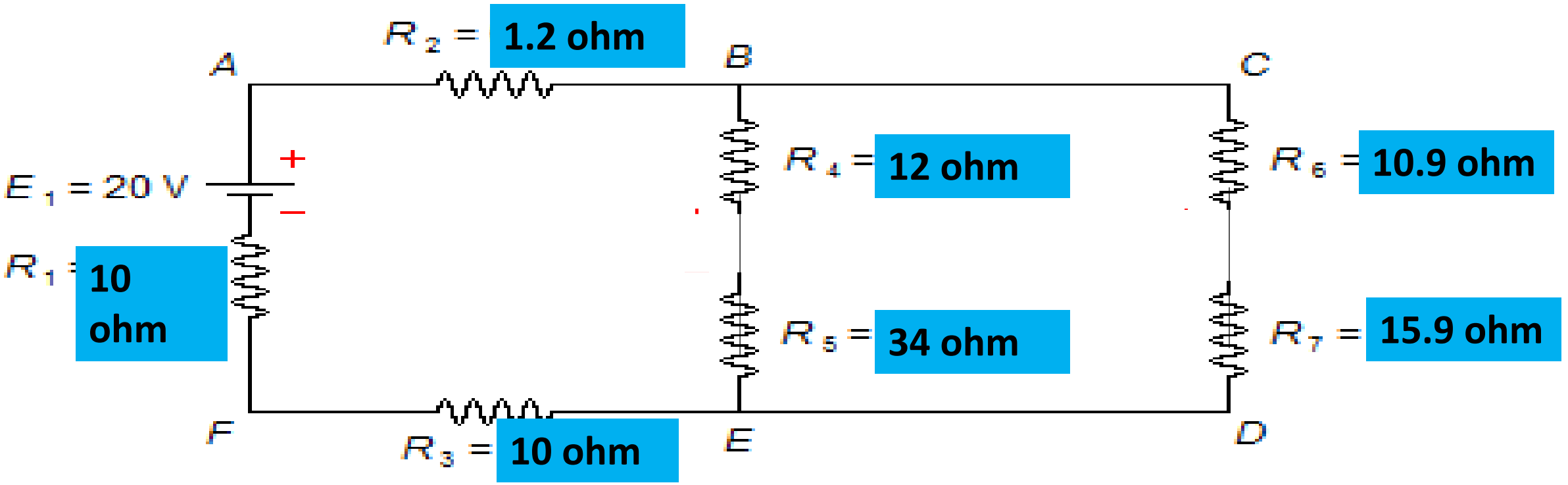
**Step 3: Equivalent Resistance of the two sets from Step 1, and Step 1 by Product by Sum Method**
**= (1x4)/(1+4) = 4/5 = 0.8 ohm**

**Step 4: Total Series Resistance of the Circuit: Add answer from Step 3 to $R_1 + R_2 + R_3$**

**= 0.8 + 0.5 + 0.5 + 1 = 2.8 ohm**

# Resistors Connected in Series and Parallel in a Circuit
# Independent Practice -3 – SHOW WORK ON NEXT SLIDE

Follow Slide 20, and determine the Equivalent Resistance of the following circuit; Show complete work on next slide.



# Resistors Connected in Series and Parallel in a Circuit
# Guided Practice -3

Follow Slide 19 and show your complete work for the solution for the Problem on Slide 20

**Step 1: Resistance of the series set $R_4$ and $R_5$**

**= ohm**

**Step 2: Resistance of the series set $R_6$ and $R_7$**

**= ohm**

**Step 3: Equivalent Resistance of the two sets from Step 1, and Step 1 by Product by Sum Method**

**= ohm**

**Step 4: : Total Series Resistance of the Circuit: Add answer from Step 3 to $R_1 + R_2 + R_3$**

**= = 2.8 ohm**