

Electric Circuit  
Al-Anbar University



**LECTURE 04**  
**SERIES AND PARALLEL CONNECTIONS**  
**EQUIVALENT RESISTANCE-CONDUCTANCE**



## Topics

- ▶ Series connection
- ▶ Parallel connection
- ▶ Equivalent resistance
- ▶ Conductance
- ▶ Power absorbed by a resistor



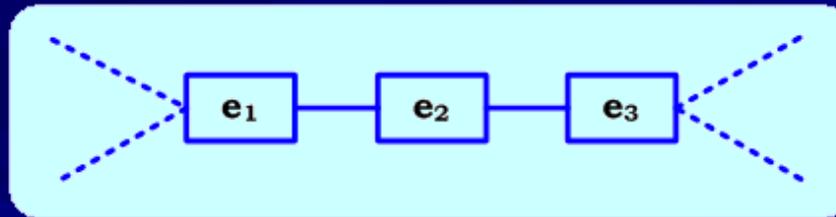
## Objectives

- ▶ Recognize series connections
- ▶ Recognize parallel connections
- ▶ Understand the meaning of series and parallel connections
- ▶ Calculate the equivalent resistance
- ▶ Relate conductance to resistance
- ▶ Understand power absorption by a resistor

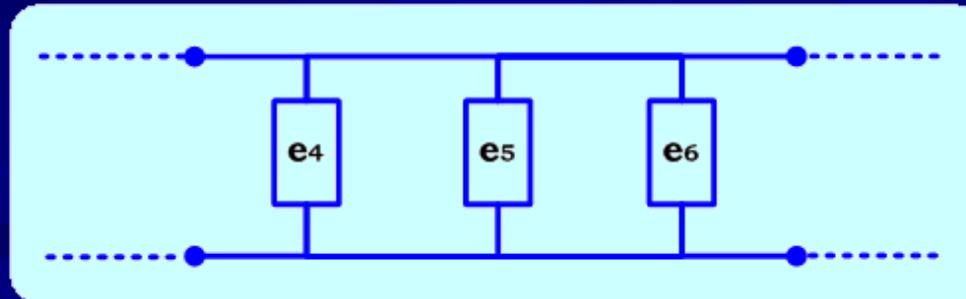


## Series and Parallel Connections

The electric elements  $e_1$ ,  $e_2$  and  $e_3$  are connected in series



The electric elements  $e_4$ ,  $e_5$  and  $e_6$  are connected in parallel

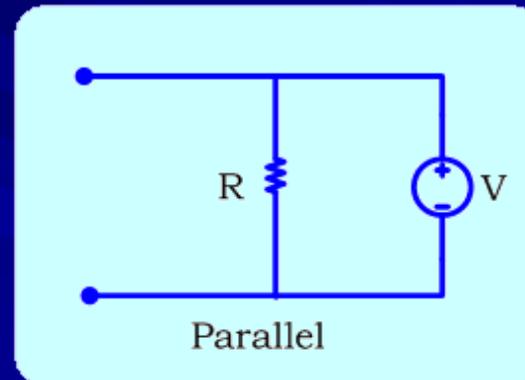
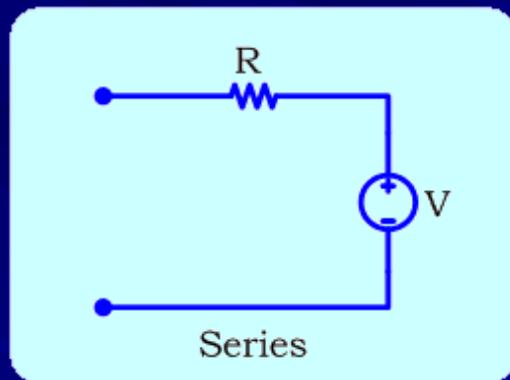




## Example

*Any two terminal* electric element can be connected in series or in parallel to *any other* element

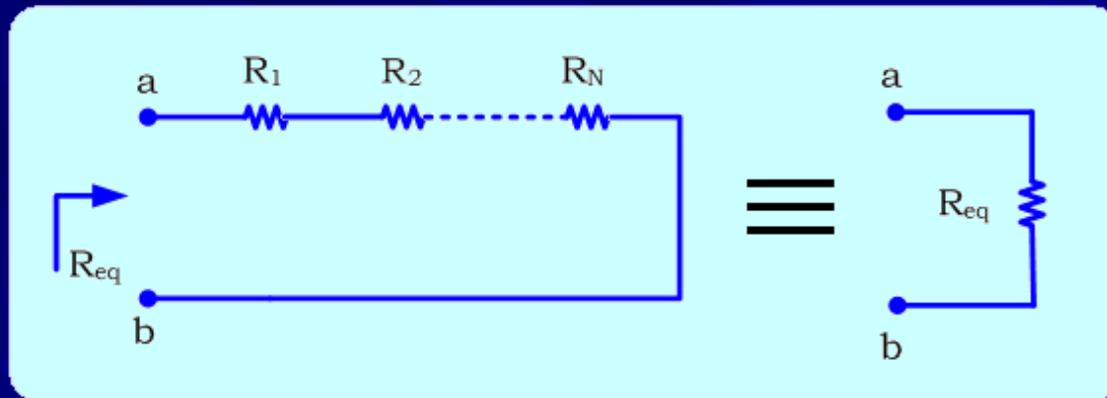
For example, a voltage source can be connected in series or in parallel to a resistor





## Equivalent Resistance of N Resistors in Series

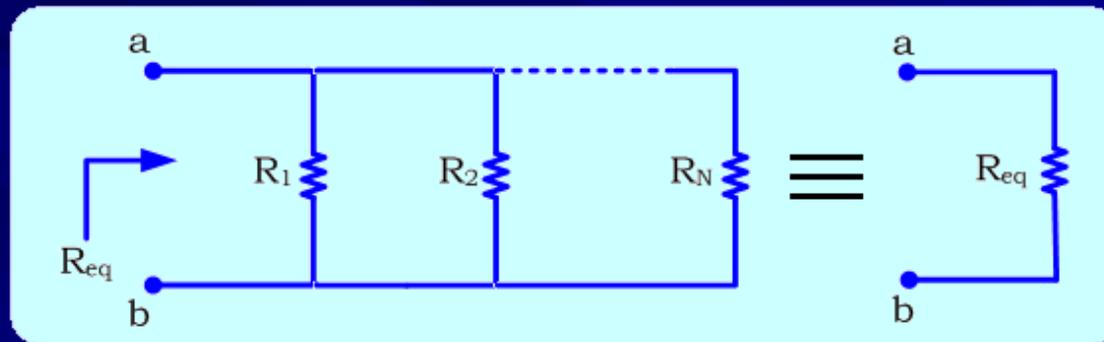
$$R_{eq} = R_1 + R_2 + \dots + R_N = \sum_{i=1}^N R_i$$





## Equivalent Resistance of N Resistors in Parallel

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_N} = \sum_{i=1}^N \frac{1}{R_i}$$



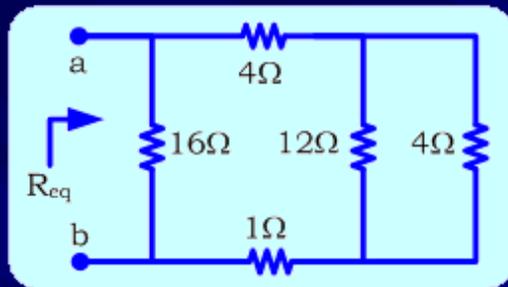
**Special Case:** If two resistors  $R_1$  and  $R_2$  are in parallel

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2} \Rightarrow R_{eq} = \frac{R_1 R_2}{R_1 + R_2} \Rightarrow R_{eq} = \frac{\text{Product}}{\text{Sum}}$$



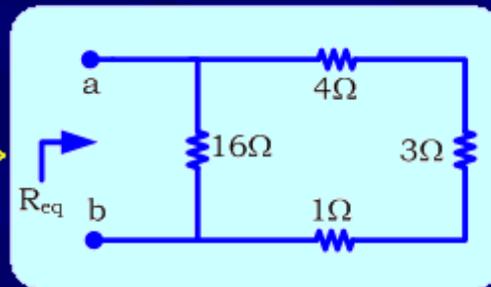
## Example 1

Calculate the equivalent resistance seen to the right of a-b



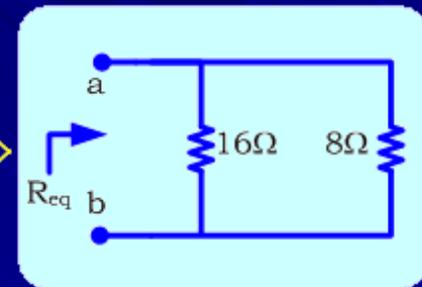
12Ω and 4Ω in parallel

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



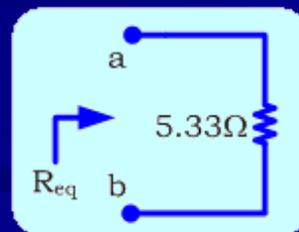
4Ω, 3Ω and 1Ω in series

$$4 + 3 + 1 = 8\Omega$$



16Ω and 8Ω in parallel

$$\frac{16 \times 8}{16 + 8} = \frac{16 \times 8}{24} = \frac{16}{3} = 5.33\Omega$$

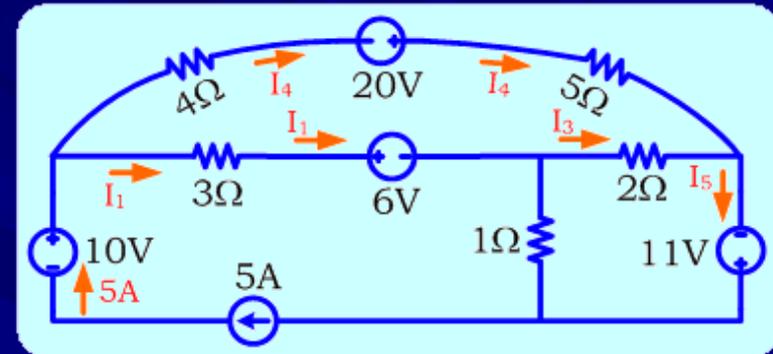


$$\therefore R_{eq} = 5.33\Omega$$

## Series and Parallel Connections

Why?

- (a)  $3\Omega$  and  $6V$  source are in series  
10V and 5A sources are in series  
 $4\Omega$ , 20V source and  $5\Omega$  are in series
- (b)  $6V$  source and  $2\Omega$  are not in series  
 $2\Omega$  and 11V source are not in series



Solution

- (a)  $3\Omega$  and  $6V$  are in series  $\Rightarrow$  the **same current**  $I_1$  passes through them  
10V and 5A sources are in series  $\Rightarrow$  the **same current** 5A passes through them  
 $4\Omega$ , 20V source and  $5\Omega$  are in series  $\Rightarrow$  the **same current**  $I_4$  passes through them
- (b)  $6V$  source and  $2\Omega$  are not in series  $\Rightarrow$  **different** currents  $I_1$  and  $I_3$  passes through them  
 $2\Omega$  and 11V source are not in series  $\Rightarrow$  **different** currents  $I_3$  and  $I_5$  passes through them

## Series and Parallel Connections

3A source and 4Ω are in parallel

6Ω and 8Ω are in parallel

2V source and 8Ω are not in parallel

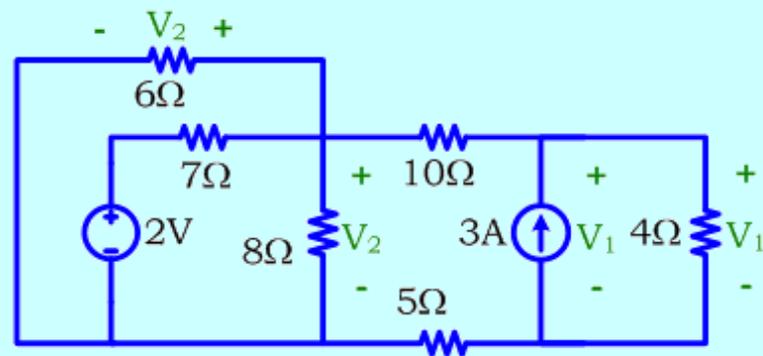
Why?

Solution

the *same voltage*  $V_1$  appears across 3A and 4Ω  $\Rightarrow$  they are in parallel

the *same voltage*  $V_2$  appears across 6Ω and 8Ω  $\Rightarrow$  they are in parallel

*different voltages* appear across 2V and 8Ω  $\Rightarrow$  they are not in parallel





## Conductance

The conductance  $G$  of a resistor is the reciprocal of the resistance  $R$

$$G = \frac{1}{R}$$

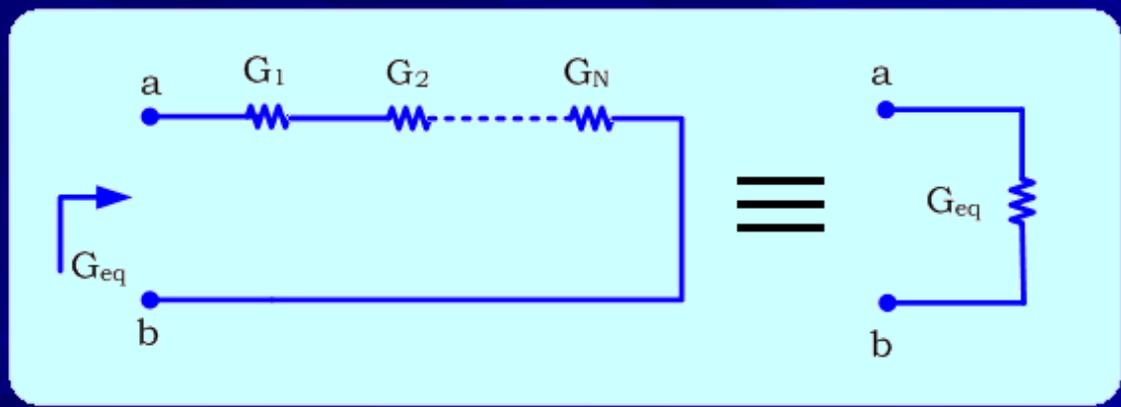
Unit of  $G$  is  $\frac{1}{\Omega}$  or *Siemens* [ $S$ ]  $\Rightarrow \frac{1}{\Omega} \equiv S$



## Conductance

N conductances in series

$$\frac{1}{G_{eq}} = \frac{1}{G_1} + \frac{1}{G_2} + \dots + \frac{1}{G_N} = \sum_{i=1}^N \frac{1}{G_i}$$

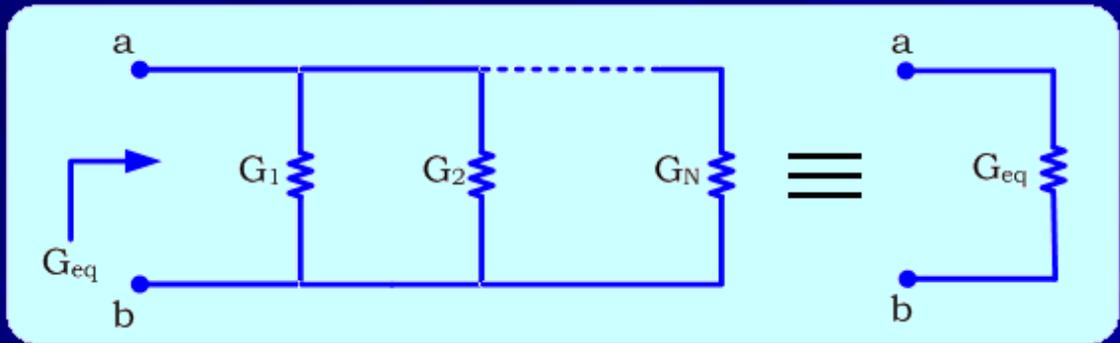




## Conductance

N conductances in parallel

$$G_{eq} = G_1 + G_2 + \dots + G_N = \sum_{i=1}^N G_i$$





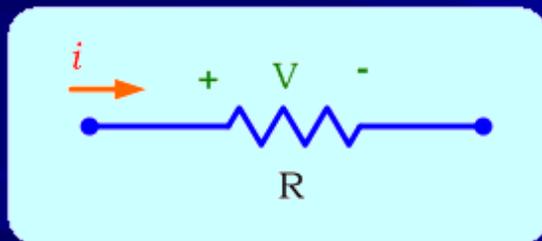
## Power Absorbed by a Resistor

Using circuit (a)  $p_R = +iv = +i(iR) = i^2R = \frac{v^2}{R}$

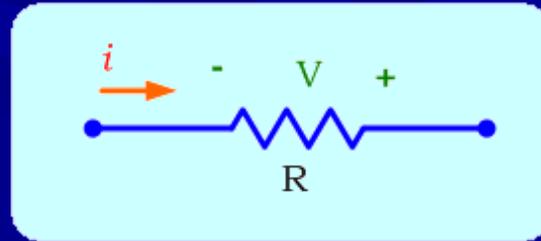
Using circuit (b)  $p_R = -iv = -i(-iR) = i^2R = \frac{v^2}{R}$

$$\therefore p_R = \frac{v^2}{R} = i^2R \quad (\text{regardless of the direction of } i \text{ and polarity of } v)$$

$\therefore p_R \geq 0 \Rightarrow$  a resistor does not generate electric power, it always absorbs it



(a)

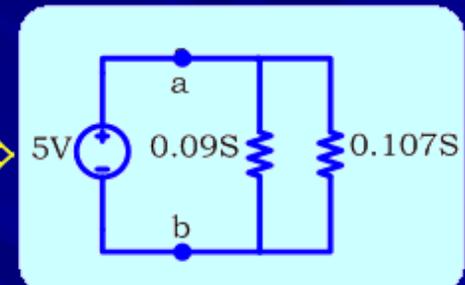
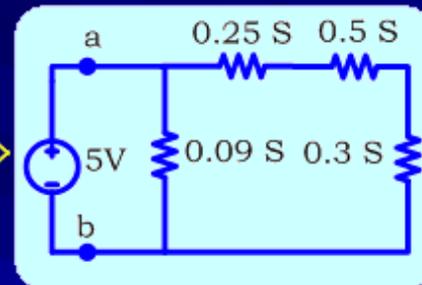
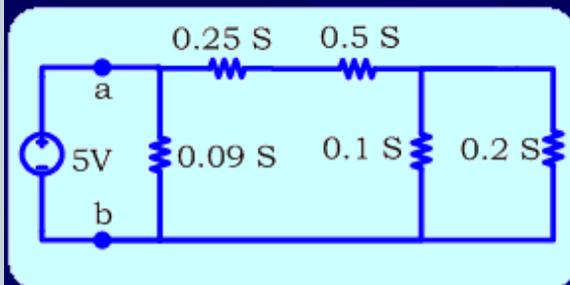


(b)

## Example 2

In the given circuit calculate

- (a)  $G_{eq}$  seen by the voltage source  
(b)  $R_{eq}$  (c) the power absorbed by the load



(a) 0.1 S and 0.2 S in parallel

$$0.1 + 0.2 = 0.3 \text{ S}$$

0.25 S, 0.5 S, 0.3 S in series

$$\frac{1}{0.25} + \frac{1}{0.5} + \frac{1}{0.3} = 4 + 2 + 3.33 = 9.33$$

$$\Rightarrow \frac{1}{9.33} = 0.107 \text{ S}$$

0.107 & 0.09 in parallel

$$0.107 + 0.09 = 0.197 \text{ S}$$

$$\therefore G_{eq} = 0.197 \text{ S}$$

$$(b) R_{eq} = \frac{1}{G_{eq}} = \frac{1}{0.197} = 5.08 \Omega$$

$$(c) P_{5.08 \Omega} = \frac{v^2}{R} = \frac{(5)^2}{5.08} = 4.97 \text{ W}$$



### Example 3

Calculate

- (a) the power absorbed by the  $3\Omega$  resistor
- (b) the equivalent resistance seen by the  $10\text{V}$  source

(a) KVL  $\Rightarrow -10 + v_1 + v_2 = 0$

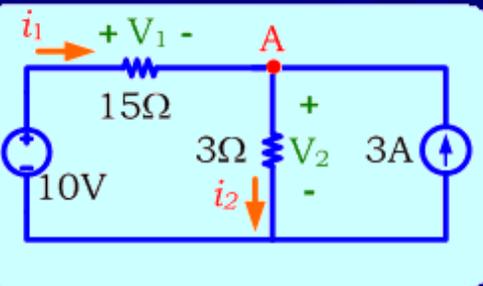
Ohm's Law  $\Rightarrow -10 + 15i_1 + 3i_2 = 0 \dots \dots (1)$

KCL  $\Rightarrow i_1 + 3 = i_2 \dots \dots \dots (2)$

Solving (1)  $\Rightarrow -10 + 15(i_2 - 3) + 3i_2 = 0$   
and (2)  $\Rightarrow 18i_2 = 55 \Rightarrow i_2 = \frac{55}{18} = 3.056\text{A}$

$\therefore p_{3\Omega} = 3i_2^2 = 3(3.056)^2 = 28.02\text{W}$

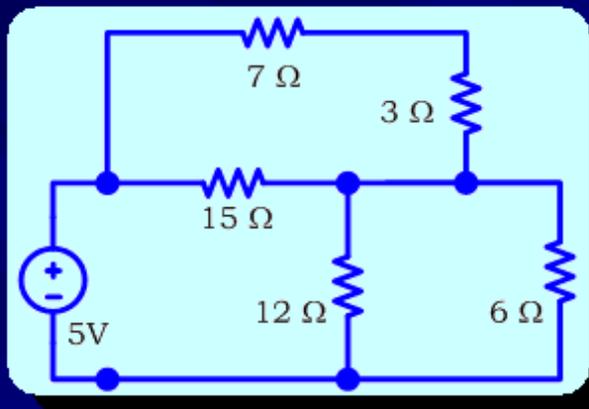
(b) Using (2)  $\Rightarrow i_1 = i_2 - 3 = 3.056 - 3 = 0.056\text{A}$



$\therefore R_{eq} = +\frac{v}{i_1} = +\frac{10}{0.056} = 178.57\Omega$

## Self Test

Calculate the equivalent resistance seen by the 5V source



- A  $R_{eq} = 12.00\Omega$
- B  $R_{eq} = 4.00\Omega$
- C  $R_{eq} = 27.00\Omega$
- D  $R_{eq} = 10.00\Omega$
- E  $R_{eq} = 10.05\Omega$

