Series Circuits

by

Nada Saab-Ismail, PhD, MAT, MEd, IB

e-mail:

saab1055@gmail.com

P4.10g Compare the currents, voltages, and power in parallel and series circuits.

P4.10h Explain how circuit breakers and fuses protect household appliances.

P4.10C Given diagrams of many different possible connections of electric circuit elements, identify complete circuits, open circuits, and short circuits and explain the reasons for the classification.

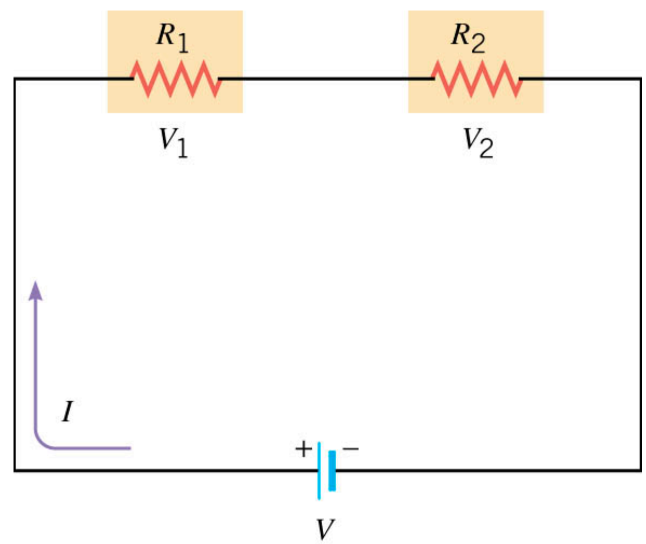
Items;

1- Series Circuits
2- Equivalent Voltage
3- Equivalent Resistor

Series Circuits

A simple way of joining several loads is to connect them in series to a source of electric potential.

Series wiring means that the devices are connected in such a way that there is the same electric current (I) through each device. The electrons have only one path to follow through the circuit. The current is exactly the same at any point is a series circuit.



Equivalent Voltage and Resistance in Series Circuit

The current is moving in a clockwise loop.

Ohm's Law: $V = I R$

According to Kirchhoff's Loop rule:

Potential rises = Potential drops

$$V = V_1 + V_2$$

$$I R_s = I R_1 + I R_2 = I (R_1 + R_2)$$

So,

$$R_s = R_1 + R_2$$

R_s is the equivalent resistance of the series circuit (Series Resistors).

Equivalent Resistance in Series Circuit
$R_s = R_1 + R_2 + R_3 + R_4 + R_5 + R_6 + \dots$

Example 1: Resistors in a Series Circuit

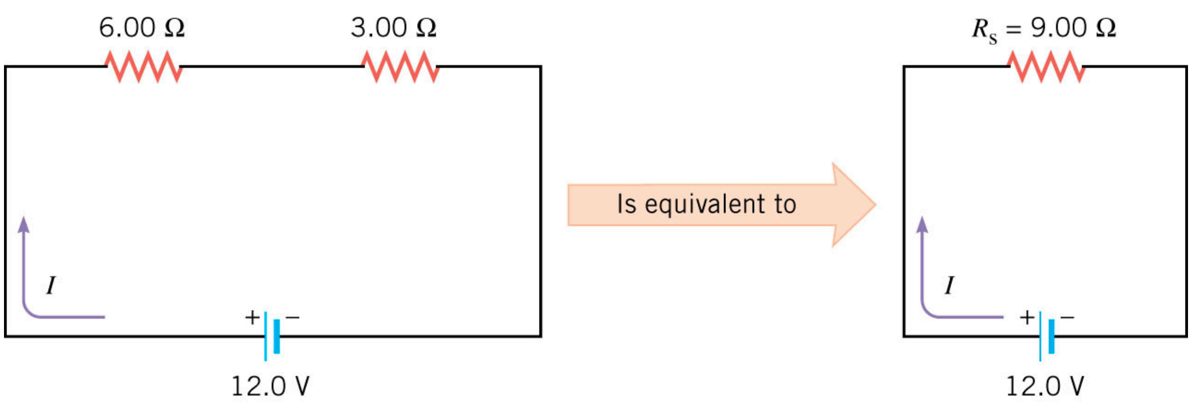
A 6.00 Ω resistor (R_1 = 6.00 Ω) and a 3.00 Ω resistor (R_2 = 3.00 Ω) are connected in series with a 12.0 V battery in the circuit C1. Assuming the battery contributes no resistance to the circuit, find:

(a) the equivalent resistance (R_s) in the circuit C2

(b) the current,

(c) the power dissipated in each resistor, and

(d) the total power delivered to the resistors by the battery.



C1 C2

Data Table							
R_1	R_2	V	R_s	I	P_{R1}	P_{R2}	P
6.00 Ω	3.00 Ω	12.0 V	?	?	?	?	?

(a) Equivalent Resistor in a Series Circuit is $R_s = R_1 + R_2$

$$R_S = 6.00\ \Omega + 3.00\ \Omega = 9.00\ \Omega$$

(b)

$$I = \frac{V}{R_S} = \frac{12.0\ \text{V}}{9.00\ \Omega} = 1.33\ \text{A}$$

(c)

For $R = 6.00\ \Omega$: $P = I^2R = (1.33\ \text{A})^2(6.00\ \Omega) = 10.6\ \text{W}$

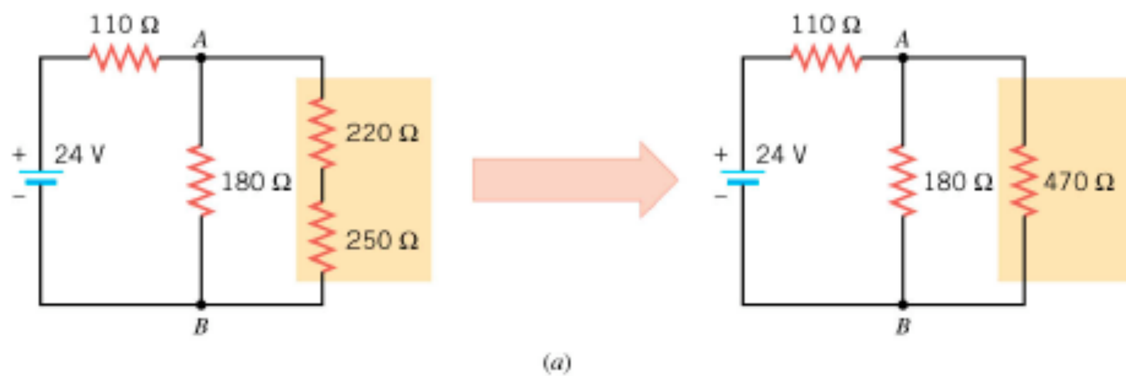
For $R = 3.00\ \Omega$: $P = I^2R = (1.33\ \text{A})^2(3.00\ \Omega) = 5.31\ \text{W}$

(d)

Total power dissipated: $P = 10.6\ \text{W} + 5.31\ \text{W} = 15.9\ \text{W}$

Example 2: Resistors in a Series Circuit

The figure shows a circuit C1 composed of a 24-V battery and four resistors, whose resistances are 110, 180, 220 and 250 Ω. The equivalent circuit C2 has three resistors 110, 180 and 470 Ω .



C1 C2

The two series resistors 220 and 250 Ω in C1 can be replaced by an equivalent resistor of 470 Ω in C2.

$$R_s = R_1 + R_2 = 220 + 250 = 470\ \Omega$$

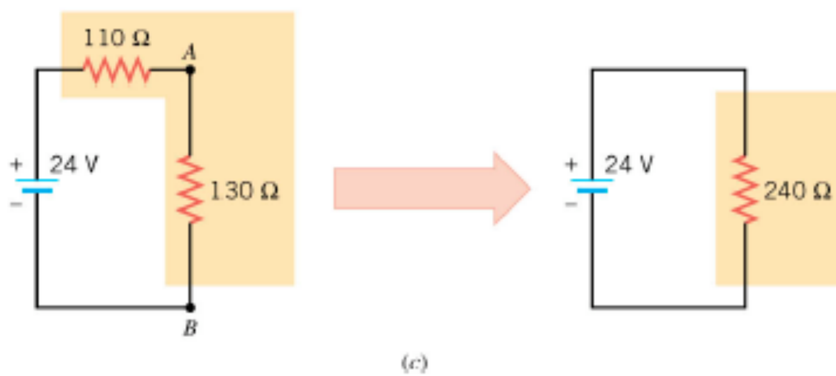
Example 3: Resistors in a Series Circuit

The figure shows a circuit (C1) composed of a 24-V battery and two resistors, whose resistances are 110 and 130 Ω, and its equivalent circuit C2 with one resistor of 240 Ω .

(a) Explain how the 240 Ω was calculated.

(b) Find the total current supplied by the battery.

(c) Find the voltage between points A and B in the circuit.



C1 C2

Data Table					
R_1	$R_2 = R_{AB}$	V	R_s	I	V_{AB}
110 Ω	130 Ω	24 V	?	?	?

a) The two series resistors 110 and 130 Ω in C1 can be replaced by an equivalent resistor of 240 Ω.

$$R_s = R_1 + R_2 = 110 + 130 = 240\ \Omega$$

b) Total current (I) supplied by the battery;

Ohm's Law: $V = I R_s$

$$I = V / R_s = 24 / 240 = 0.10\ A$$

c) The current (I) is the same at any point. Voltage between points A and B (V_{AB});

Ohm's Law: $V_{AB} = I R_{AB} = 0.10 \times 130 = 13\ V$

References:

1) Humanic. (2013). www.physics.ohio-state.edu/~humanic/. In Thomas Humanic Brochure Page.

Physics 1200 Lecture Slides: Dr. Thomas Humanic, Professor of Physics, Ohio State University, *2013-2014 and Current.* *www.physics.ohio-state.edu/~humanic/*

2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department: "We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"

3) Martindale, D. G. & Heath, R. W. & Konrad, W. W. & Macnaughton, R. R. & Carle, M. A. (1992). *Heath Physics.* Lexington: D.C. Heath and Company

4) Zitzewitz, P. W. (1999). *Glencoe Physics Principles and Problems*. New York: McGraw-Hill Companies, Inc.

5) Schnick, W.J. (n.d.). *Calculus-based physics, A Free Physics Textbook*. Retrieved from http://www.anselm.edu/internet/physics/cbphysics/index.html

6) Nada H. Saab (Saab-Ismail), (2010-2013) Westwood Cyber High School, Physics, Detroit, Michigan, U.S.A.

7) Nada H. Saab (Saab-Ismail), (2009- 2014) Wayne RESA, Bilingual Department, Detroit, Michigan, U.S.A.