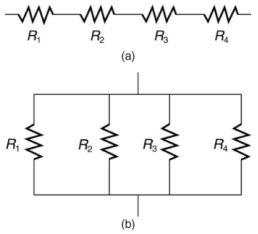
Introduction to Physical Science

Electric Circuits

Presented by Robert Wagner

Types of Circuits

- Circuits will generally have multiple components (resistors)
- Two basic combinations
  - Series
  - Parallel



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Resistors in Series

- Resistors are in series when the current must flow through each resistor in turn
- Current is the same through each resistor
  -
- The total resistance is the sum of the individual resistances
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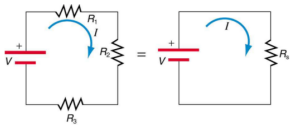

Figure 21.3 Three resistors connected in series to a battery (left) and the equivalent single or series resistance (right).

Image Credit: OpenStax College Physics - Figure 21.3 CC BY 4.0

Example

- A battery with voltage 12.0 V, is applied through three resistances (in series):

  .

  What are the total resistance, current and total power dissipated.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

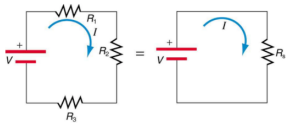

Figure 21.3 Three resistors connected in series to a battery (left) and the equivalent single or series resistance (right).

Image Credit: OpenStax College Physics - Figure 21.3 CC BY 4.0

Example

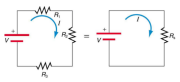

Figure 21.3 Three resistors connected in series to a battery (left) and the equivalent single or series resistance (right).

- A battery with voltage 12.0 V, is applied through three resistances (in series):

  What are the total resistance, current and total power dissipated.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$V = 12.0\ V\ ;\ R_1 = 1.00\Omega, R_2 = 6.00\Omega, R_3 = 13.0\Omega$

$R_s = R_1 + R_2 + R_3$

$R_s = 1.00\Omega + 6.00\Omega + 13.0\Omega = 20.0\Omega$

$I = \frac{V}{R_s} = \frac{12.0\ V}{20.0\ \Omega} = 0.600\ A$

$P = IV = (0.600\ A)(12.0\ V) = 7.20\ W$

Image Credit: OpenStax College Physics - Figure 21.3 CC BY 4.0

Example

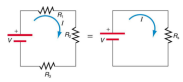

Figure 21.3 Three resistors connected in series to a battery (left) and the equivalent single or series resistance (right).

- A battery with voltage 12.0 V, is applied through three resistances (in series):

  What is the voltage drop across each resistor?
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$V = 12.0\ V\ ;\ R_1 = 1.00\Omega, R_2 = 6.00\Omega, R_3 = 13.0\Omega$

$V_1 = IR_1$

$V_1 = (0.600\ A)(1.0\ \Omega) = 0.600\ V$

$V_2 = IR_2$

$V_2 = (0.600\ A)(6.0\ \Omega) = 3.60\ V$

$V_3 = IR_3$

$V_3 = (0.600\ A)(13.0\ \Omega) = 7.80\ V$

$V_1 + V_2 + V_3 = 7.80\ V + 3.60\ V + 0.600\ V = 12.0\ V$

Image Credit: OpenStax College Physics - Figure 21.3 CC BY 4.0

Resistors in Parallel

- In a parallel circuit, the current will be split among multiple resistors.
- Total resistance is the sum of the inverse of each resistance
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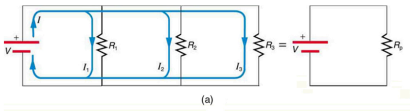
- The total resistance will be less than all of the individual resistances



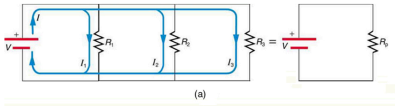
(a)

Image Credit: OpenStax College Physics - Figure 21.4a CC BY 4.0

Example

- A battery with voltage 12.0 V, is applied through three resistances (in parallel):

  What are the total resistance, current and total power dissipated.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve



(a)

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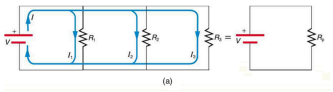
Example



- A battery with voltage 12.0 V, is applied through three resistances (in parallel):

  What are the total resistance, total current and total power dissipated.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$V = 12.0\ V;\ R_1 = 1.00\Omega, R_2 = 6.00\Omega, R_3 = 13.0\Omega$

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

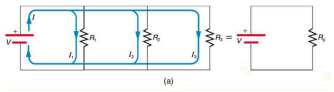
$$\frac{1}{R_p} = \frac{1}{1.00\Omega} + \frac{1}{6.00\Omega} + \frac{1}{13.0\Omega}$$

$$\frac{1}{R_p} = (1 + 0.167 + 0.0769)\frac{1}{\Omega}$$

$$\frac{1}{R_p} = 1.2439\frac{1}{\Omega}\ or,\ R_p = 0.804\ \Omega$$

Image Credit: OpenStax College Physics - Figure 21.4a CC BY 4.0

Example



- A battery with voltage 12.0 V, is applied through three resistances (in parallel):

  What are the total resistance, total current and total power dissipated.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$V = 12.0\ V;\ R_1 = 1.00\Omega, R_2 = 6.00\Omega, R_3 = 13.0\Omega$

$R_p = 0.804\ \Omega$

$$I = \frac{V}{R_p} = \frac{12.0\ V}{0.804\ \Omega} = 14.9\ A$$

$$P = IV = (14.9\ A)(12.0\ V) = 179\ W$$

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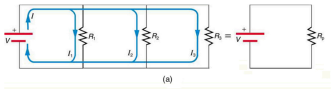
Example



- A battery with voltage 12.0 V, is applied through three resistances (in parallel):

  What is the current through each resistor?
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$V = 12.0\ V;\ R_1 = 1.00\Omega, R_2 = 6.00\Omega, R_3 = 13.0\Omega$

$$I_1 = \frac{V}{R_1} = \frac{12.0\ V}{1.00\ \Omega} = 12.0\ A$$

$$I_2 = \frac{V}{R_2} = \frac{12.0\ V}{6.00\ \Omega} = 2.0\ A$$

$$I_3 = \frac{V}{R_3} = \frac{12.0\ V}{13.00\ \Omega} = 0.92\ A$$

$$I_1 + I_2 + I_3 = 12.0\ A + 2.0\ A + 0.92\ A$$

$$I_1 + I_2 + I_3 = 14.92\ A$$

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Combination Circuits

- We often have more complex circuits involving both series and parallel components.
- We can reduce these to a single equivalent resistance

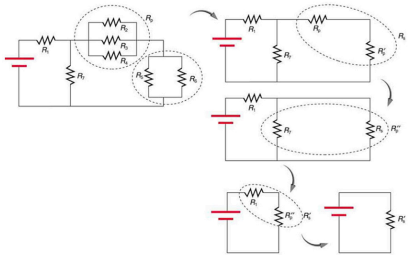
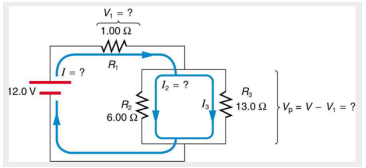


Image Credit: OpenStax College Physics - Figure 21.5 CC BY 4.0

Example

- For the circuit shown, find the total resistance, voltage drop across R_1, current through R_2, and power dissipated by R_2.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve



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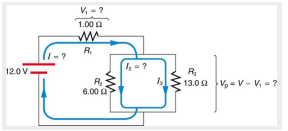
Example



- For the circuit shown, find the total resistance, voltage drop across R_1, current through R_2, and power dissipated by R_2.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$$\frac{1}{R_p} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{6.00\ \Omega} + \frac{1}{13.0\ \Omega}$$

$$\frac{1}{R_p} = 0.2436\frac{1}{\Omega}$$

$$R_p = 4.11\ \Omega$$

$$R_{tot} = R_1 + R_p = 1.00\ \Omega + 4.11\ \Omega = 5.11\ \Omega$$

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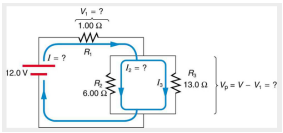
Example



- For the circuit shown, find the total resistance, voltage drop across R_1, current through R_2, and power dissipated by R_2.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$$I = \frac{V}{R_{tot}} = \frac{12.0\ V}{5.11\ \Omega} = 2.35\ A$$

$$V_1 = IR_1$$

$$V_1 = (2.35\ A)(1.00\ \Omega) = 2.35\ V$$

$$V_p = V - V_1 = 12.0\ V - 2.35\ V = 9.65\ V$$

$$I_2 = \frac{V_p}{R_2} = \frac{9.65\ V}{6.00\ \Omega} = 1.61\ A$$

$$P_2 = (I_2)^2 R_2 = (1.61\ A)^2(6.00\ \Omega) = 15.5\ W$$

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Problem Solving Strategies

- Draw a circuit digram - label all resistors and voltage sources - this identifies your known values
- Identify unknowns
- Determine if the resistors are in series, parallel or a combination
- Reduce the problem in to steps considering how to handle series and parallel components
- Check to make sure answers are reasonable

Summary

- Electrical Circuits can involve resistors in series, parallel, or a combination of these two
- Resistors in series add directly and resistors in parallel add inversely
- Combination circuits are more complex and include both series and parallel components