The resistance of a bagel toaster is 14 Ω. To prepare a bagel, the toaster is operated for one minute. How much energy is delivered to the toaster?

\[ R = 14 \, \Omega \]
\[ V = 120 \, V \]
\[ t = 60 \, s \]

\[ E_{PE} = \frac{1}{2} \, Ed \]

\[ \text{Energy} = \frac{1}{2} \, V \]

\[ I = \frac{V}{t} \]

\[ V = IR \]

\[ V = \frac{9}{t} \, R \]
The resistance of a bagel toaster is 14 Ω. To prepare a bagel, the toaster is operated for one minute from a 120 - V outlet. How much energy is delivered to the toaster?

\[ I = \frac{V}{R} \]

\[ \text{Energy} = \Delta E = V \Delta t \]

\[ \Delta E = I \Delta t \]

So...

\[ \text{Energy} = (I \Delta t) V \]

We also know

\[ V = IR \quad \text{or} \quad I = \frac{V}{R} \]

So...

\[ \text{Energy} = \left( \frac{V}{R} \right) \Delta t V = \frac{V^2}{R} \Delta t \]

\[ \text{Energy} = 6.17 \times 10^4 J \]

\[ V = IR = \frac{8}{t} R = V \quad \theta = \frac{Vt}{R} \]
The resistance and the magnitude of the current depend on the path that the current takes. The drawing vs three situations in which the current takes different paths through a piece of material. Each of the angular pieces is made from a material whose resistivity is \( \rho = 1.50 \times 10^{-2} \, \Omega \cdot \text{m} \) and the unit of length in the drawing is \( L_0 = 5.00 \, \text{cm} \). Each piece of material is connected to a 3.00-V battery. Find
(a) the resistance and
(b) the current in each case.
The resistance and the magnitude of the current depend on the path that the current takes. The drawing shows three situations in which the current takes different paths through a piece of material. Each of the rectangular pieces is made from a material whose resistivity is \( \rho = 1.50 \times 10^{-2} \, \Omega \cdot \text{m} \) and the unit of length in the drawing is \( L_0 = 5.00 \, \text{cm} \). Each piece of material is connected to a 3.00 \( - \, \text{V} \) battery. Find

(a) the resistance and

(b) the current in each case.

\[
R = \rho \frac{L}{A}
\]
The resistance and the magnitude of the current depend on the path that the current takes. The drawing shows three situations in which the current takes different paths through a piece of material. Each of the rectangular pieces is made from a material whose resistivity is \( \rho = 1.50 \times 10^{-2} \, \Omega \cdot \text{m} \). The unit of length in the drawing is \( L_0 = 5.00 \, \text{cm} \). Each piece of material is connected to a 3.00-V battery. Find (a) the resistance and
(b) the current in each case.

(a)
\[
A_i = 2L_0 \times L_0 \\
L_i = 4L_0 \\
\rho = 1.5 \times 10^{-2} \, \text{\Omega} \cdot \text{m} \\
V = 3 \, \text{V}
\]

\[ R_i = \rho \frac{4L_0}{2L_0} = \rho \frac{2}{L_0} \]

(b) 
\[
\begin{align*}
\text{ii} & \\
& A_{ii} = 2L_0 \times 4L_0 \\
L_{ii} &= L_0 \\
R_{ii} &= \rho \frac{L_0}{8L_0} = \rho \frac{1}{8L_0} \\
\text{iii} & \\
& A_{iii} = 4L_0 \times 1L_0 \\
L_{iii} &= 2L_0 \\
R_{iii} &= \rho \frac{2L_0}{4L_0} = \rho \frac{1}{2L_0}
\end{align*}
\]

\[ L_0 = 0.05 \, \text{m} \]

\[
\begin{align*}
R_i &= \left(1.5 \times 10^{-2}\right) \frac{2}{0.05} = 0.6 \, \Omega \\
R_{ii} &= \left(1.5 \times 10^{-2}\right) \frac{1}{8(0.05)} = 0.0375 \, \Omega \\
R_{iii} &= \left(1.5 \times 10^{-2}\right) \frac{1}{2(0.05)} = 0.15 \, \Omega
\end{align*}
\]
10. The resistance and the magnitude of the current depend on the path that the current takes. The drawing shows three situations in which the current takes different paths through a piece of material. Each of the rectangular pieces is made from a material whose resistivity is $\rho = 1.50 \times 10^{-2} \text{\Omega \cdot m}$ and the unit of length in the drawing is $L_0 = 5.00 \text{ cm}$. Each piece of material is connected to a $3.00 - V$ battery. Find
(a) the resistance and
(b) the current in each case.

(b) $L_0 = 0.05 \text{ m}$

\[
\begin{align*}
R_i &= (1.5 \times 10^{-2}) \frac{2}{0.05} \\
R_{ii} &= (1.5 \times 10^{-2}) \frac{1}{8(0.05)} \\
R_{iii} &= (1.5 \times 10^{-2}) \frac{1}{2(0.05)}
\end{align*}
\]

\[
\begin{align*}
R_i &= 0.6 \Omega \\
R_{ii} &= 0.0375 \Omega \\
R_{iii} &= 0.15 \Omega
\end{align*}
\]

\[
I = \frac{V}{R}
\]

\[
\begin{align*}
I_i &= \frac{3}{0.6} = 5.0 \text{ A} = I_i \\
I_{ii} &= \frac{3}{0.0375} = 80.0 \text{ A} = I_{ii} \\
I_{iii} &= \frac{3}{0.15} = 20 \text{ A} = I_{iii}
\end{align*}
\]
11. Two wires are identical, except that one is aluminum and one is copper. The aluminum wire has a resistance of 0.20 $\Omega$. What is the resistance of the copper wire?
11. Two wires are identical, except that one is aluminum and one is copper. The aluminum wire has a resistance of 0.20 Ω. What is the resistance of the copper wire?

\[ R_{Al} = \rho_{Al} \frac{L}{A} \]
\[ R_{Cu} = \rho_{Cu} \frac{L}{A} \]
\[ \frac{R_{Cu}}{R_{Al}} = \frac{\rho_{Cu}}{\rho_{Al}} \]
\[ R_{Cu} = R_{Al} \left( \frac{\rho_{Cu}}{\rho_{Al}} \right) \]
\[ R_{Cu} = (0.2)(\frac{1.72 \times 10^{-8}}{2.82 \times 10^{-8}}) \]
\[ R_{Cu} = 0.12 \, \Omega \]
41. **ssm** Three resistors, 25, 45, and 75 Ω, are connected in series and a 0.51-A current passes through them. What are
(a) the equivalent resistance and
(b) the potential difference across the three resistors?

*Current: SAME...SAME!*
41. **ssm** Three resistors, 25, 45, and 75 Ω, are connected in series, and a 0.51-A current passes through them. What are
(a) the equivalent resistance and
(b) the potential difference across the three resistors?

(a) \( R_{eq} = R_1 + R_2 + R_3 \)
\[ 25 + 45 + 75 \]
\[ R_{eq} = 145 \, Ω \]

(b) \( V_T = IR_{eq} \)
Each resistor presents a Voltage drop... \( V_1, V_2, V_3 \)
\[ V_T = (0.51)(145) \]
\[ V_T = 73.95 \, V \]
The current in a series circuit is 15.0 A. When an additional 8.00 Ω resistor is inserted in series, the current drops to 12.0 A. What is the resistance in the original circuit?

Changes current... but Voltage: SAME... SAME

\[ V = I_0 R_0 = I (R + R_0) \]

\[ R_0 = ? \]
The current in a series circuit is $15.0\,\text{A}$. When an additional $8.00 - \Omega$ resistor is inserted in series, the current drops to $12.0\,\text{A}$. What is the resistance in the original circuit?

$R_o = ?$

Changes current... but Voltage: SAME... SAME

\[ I_o R_o = I (R + R_o) \]
\[ I_o R_o = IR + IR_o \]
\[ I_o R_o - IR_o = IR \]
\[ R_o (I_o - I) = IR \]
\[ R_o = \frac{IR}{I_o - I} = \frac{(12\,\text{A})(8\Omega)}{(15 - 12)\,\text{A}} \]

\[ R_o = 32\,\Omega \]
51. For the three-way bulb (50 W, 100 W, 150 W) discussed in Conceptual Example 11, find the resistance of each of the two filaments. Assume that the wattage ratings are not limited by significant figures, and ignore any heating effects on the resistances.

NOTE: Lamp would be plugged into a 120 V Source
51. For the three-way bulb (50 W, 100 W, 150 W) discussed in Conceptual Example 11, find the resistance of each of the two filaments. Assume that the wattage ratings are not limited by significant figures, and ignore any heating effects on the resistances.

\[ V = 120 \text{ V} \]

\[ R_{50} = \]
The drawing shows three different resistors in two different circuits. The battery has a voltage of $V = 24.0 \text{ V}$, and the resistors have values of $R_1 = 50.0 \, \Omega$, $R_2 = 25.0 \, \Omega$, and $R_3 = 10.0 \, \Omega$.

(a) For the circuit on the left, determine the current through and the voltage across each resistor.

(b) Repeat part (a) for the circuit on the right.
The drawing shows three different resistors in two different circuits. The battery has a voltage of $V = 24.0 \, \text{V}$. The resistors have values of $R_1 = 50.0 \, \Omega$, $R_2 = 25.0 \, \Omega$, and $R_3 = 10.0 \, \Omega$.

(a) For the circuit on the left, determine the current through and the voltage across each resistor.

(b) Repeat part (a) for the circuit on the right.

---

**Part A: Current constant across all resistors... Series**

**Part B: Voltage constant across all resistors... Parallel**
The drawing shows three different resistors in two different circuits. The battery has a voltage of $V = 24.0 \text{ V}$, and the resistors have values of $R_1 = 50.0 \, \Omega$, $R_2 = 25.0 \, \Omega$, and $R_3 = 10.0 \, \Omega$.

(a) For the circuit on the left, determine the current through and the voltage across each resistor.

(b) Repeat part (a) for the circuit on the right.
The drawing shows three different resistors in two different circuits. The battery has a voltage of $V = 24.0 \, \text{V}$, and the resistors have values of $R_1 = 50.0 \, \Omega$, $R_2 = 25.0 \, \Omega$, and $R_3 = 10.0 \, \Omega$.

(a) For the circuit on the left, determine the current through and the voltage across each resistor.

(b) Repeat part (a) for the circuit on the right.
The drawing shows two circuits, and the same battery is used in each. The two resistances $R_A$ in circuit A are the same and the two resistances $R_B$ in circuit B are the same. Knowing that the same total power is delivered in each circuit, find $\frac{1}{R_A}$ for the circuits.
The drawing shows two circuits, and the same battery is used in each. The two resistances $R_A$ in circuit A are the two resistances $R_B$ in circuit B are the same. Knowing that the same total power is delivered in each circuit, find $1/R_A$ for the circuits.

$$\frac{1}{R_B} = \frac{1}{R_B} + \frac{1}{R_B}$$

$P = \frac{1}{2} R_B$

$P = \frac{V^2}{\frac{1}{2} R_B}$

Therefore

$\frac{1}{2} R_B = 2 R_A$

$\frac{R_B}{R_A} = 2/2 = 1$  

Then...

$R_s = R_A + R$

$R_s = 2R$

$P = \frac{V^2}{2 R_A}$

If Power is same same and Voltage i. same same and $P = \frac{V^2}{R_{eq}}$
A $\Omega$ resistor is connected in parallel with a $120 \Omega$ resistor. This parallel group is connected in series with a $40 \Omega$ resistor. The total combination is connected across a $15 \text{ V}$ battery. Find

(a) the current and
(b) the power delivered to the $120 \Omega$ resistor.

\[ I = \frac{V}{R} = \frac{15}{60} = 0.25 \text{ A} \]

\[ V_{20} = I R_{20} = (0.25)(20) = 5 \text{ V} \]

\[ V_{40} = I R_{40} = (0.25)(40) = 10 \text{ V} \]

Notice that the voltage drop from A to B is $10 \text{ V}$. That same drop is across both the $60 \Omega$ and $120 \Omega$ resistor (as they are in parallel).

So... $V_{AB} = V_{60} = V_{120} = 10 \text{ V}$

\[ I_{120} = \frac{V_{120}}{R_{120}} = \frac{10\text{ V}}{120\Omega} = 0.083 \text{ A} \]

\[ P = I^2 R = (0.083)^2 (120) = 0.88 \text{ W} \]
0.0 - \( \Omega \) resistor is connected in parallel with a 120.0 - \( \Omega \) resistor. This parallel group is connected in series with another 30.0 - \( \Omega \) resistor. The total combination is connected across a 15.0 - \( V \) battery. Find

(a) the current and

(b) the power delivered to the 120.0 - \( \Omega \) resistor.
Find the magnitude and the direction of the current in the 2.0 \( \Omega \) resistor in the drawing.
Find the magnitude and the direction of the current in the 2.0 $\Omega$ resistor in the drawing.
\(I_2 = I_1 + I_3\)

\(1 - 2I_2 - 1I_1 = 0\)

\(1 = I_1 + 2I_2\)  \((\text{Solve for } I_1)\)...

\(4 + 1 - 2I_2 - 3I_3 = 0\)

\(5 = 2I_2 + 3I_3\)  \((\text{Solve for } I_3)\)...

\[I_1 = 1 - 2I_2\]

\[I_3 = \frac{5 - 2I_2}{3}\]

\[I_2 = 1 - 2I_2 + \underbrace{\frac{5 - 2I_2}{3}}_{I_3}\]

\[
I_2 = 1 - 2I_2 + \frac{5}{3} - \frac{2}{3}I_2
\]

\[I_2 + 2I_2 + \frac{2}{3}I_2 = 1 + \frac{5}{3}\]

\[3.67I_2 = 2.67\]

\[I_2 = 0.73 \text{ A}\]
Find the current in the 4.00 \text{ \Omega} resistor in the drawing. Specify the direction of the current.
Find the current in the 4.00 $\Omega$ resistor in the drawing. Specify the direction of the current.

$I_3 = ?$
\( I_2 = I_1 + I_3 \)

\( qV - 2I_1 - 4I_3 = 0 \)
\( qV = 2I_1 - 4I_3 \)
\( \cdot I_1 = 4.5 + 2I_3 \)

\( q = -8I_2 + 6 - 4I_3 \)

\( 15V - 4I_3 - 8I_2 = 0 = 15 + 4I_3 + 8I_2 \)

\( -8I_2 = 15 + 4I_3 \)
\( \cdot I_2 = -\frac{15}{8} - \frac{1}{2}I_3 \)

\[ \frac{I_2}{-\frac{15}{8} - \frac{1}{2}I_3} = \frac{I_1}{4.5 + 2I_3} + I_3 \]

\(-\frac{1}{2}I_3 - 2I_3 - I_3 = \frac{15}{8} + 4.5 \)

\(-3.5I_3 = 6.375 \)

\[ I_3 = -1.82 \text{ A} \]
When the circuit shown above is set up, the potential difference across the battery is 3.0 V. By how much will the magnitude of the potential difference across $R_2$ change when $R_3$ is removed and its branch is left open?

(A) The magnitude of the potential difference across $R_2$ does not change.
(B) The magnitude of the potential difference across $R_2$ decreases by 0.5 V.
(C) The magnitude of the potential difference across $R_2$ increases by 0.5 V.
(D) The magnitude of the potential difference across $R_2$ increases by 1.0 V.
\[
\frac{1}{R_p} = \frac{1}{100} + \frac{1}{100}
\]

\[
R_p = 50
\]

\[
R_{eq} = 100 + 50 = 150
\]

\[
I_T = \frac{V}{R} = \frac{3}{150} = 0.02 \text{ A} = I_T
\]
What is $I_2$ compared to $I_3$?
SAME ... SAME!

So... in THIS arrangement

\[
I_2 = 0.01 \text{ A}
\]

\[
V_2 = I_2 R_2 = 0.01 \text{ A} \times 100 \Omega = 1 \text{ V}
\]

... Voltage drop across $R_2$ is 1V

in THIS arrangement.
If $R_3$ is removed...

$$I_{\text{f}} = \frac{V}{R} = \frac{3}{200} = 0.015 = I_{\text{f}}$$

$$V_2 = I_2 R_2 = (0.015)(100) = 1.5\, V$$

:: Voltage Drop across $R_2$ now is $1.5\, V$

Compare that to the IV drop across previous arrangement AND... →
When the circuit shown above is set up, the potential difference across the battery is 3.0 V. By how much will the magnitude of the potential difference across $R_2$ change when $R_3$ is removed and its branch is left open?

(A) The magnitude of the potential difference across $R_2$ does not change.

(B) The magnitude of the potential difference across $R_2$ decreases by 0.5 V.

(C) The magnitude of the potential difference across $R_2$ increases by 0.5 V.

(D) The magnitude of the potential difference across $R_2$ increases by 1.0 V.

From 1 V to 1.5 V
A researcher is analyzing data from a high-energy particle collision. The result of the analysis gives a value of $8.8 \times 10^{-19} \text{C} \pm 0.1 \times 10^{-19} \text{C}$ for the charge of one of the emitted particles. Should the researcher accept the value?

(A) Yes, it is a perfectly acceptable value.

(B) No, because the value is much bigger than the elementary charge.

(C) No, because the value is not an integer multiple of the elementary charge.

(D) No, because the uncertainty is more than 1% of the value.
A researcher is analyzing data from a high-energy particle collision. The result of the analysis gives a value of $8.8 \times 10^{-19} \text{C} \pm 0.1 \times 10^{-19} \text{C}$ for the charge of one of the emitted particles. Should the researcher accept the value?

(A) Yes, it is a perfectly acceptable value.
(B) No, because the value is much bigger than the elementary charge.
(C) No, because the value is not an integer multiple of the elementary charge.
(D) No, because the uncertainty is more than 1% of the value.
The current through the 3 Ω resistor in the circuit shown above is most nearly

(A) 1.3 A  
(B) 2.7 A  
(C) 3.0 A  
(D) 4.0 A
\[ I_3 = ? \]

\[ \frac{1}{R_p} = \frac{1}{3} + \frac{1}{6} \]

\[ R_p = 2 \, \Omega \]

\[ R_{eq} = 3 \, \Omega \]

\[ I_T = \frac{V}{R} = \frac{12}{3} \]

\[ I_T = 4 \, A \]
Concepts Folks... 4A split into $I_3$ & $I_2$ where

$I_2$ encounters twice the $R$ as $I_3$  \( (I_2 = 2I_3) \)

So... 6Ω $R$ has $\frac{1}{3}$ of $I_T$ and 3Ω $R$ has $\frac{2}{3}$ of $I_T$

\[
I_3 = 2.64 \, \text{A} \\
I_2 = 1.32 \, \text{A}
\]

'Most Nearly'
Math Folks:

\[ I_1 = I_2 + I_3 \]  

\[ 12 - I_1 - 3I_3 \]

\[ I_1 = 12 - 3I_3 \]

\[ -6I_2 + 3I_3 = 0 \]

\[ 6I_2 = 3I_3 \]

\[ I_2 = \frac{1}{2}I_3 \]

\[ I_1 = I_2 + I_3 \]

\[ 12 - 3I_3 = \frac{1}{2}I_3 + I_3 \]

\[ 12 = I_3(3 + \frac{1}{2} + 1) \]

\[ 12 = 4.5I_3 \]

\[ \frac{12}{4.5} = I_3 = 2.67\text{A} \]
The current through the 3 Ω resistor in the circuit shown above is most nearly

(A) 1.3 A
(B) 2.7 A
(C) 3.0 A
(D) 4.0 A