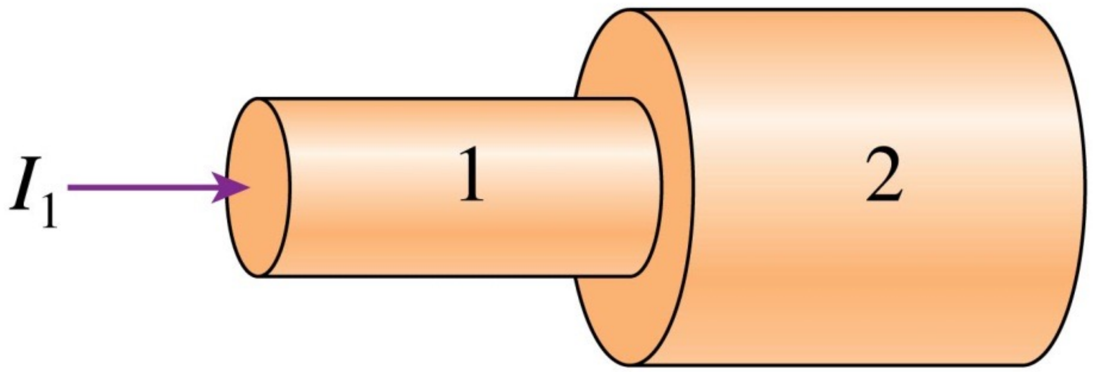

PH 220
Lance Nelson

Both segments of the wire are made of the same metal. Current I_1 flows into segment 1 from the left. How does current density J_1 in segment 1 compare to current density J_2 in segment 2?



A. $J_1 > J_2$.
B. $J_1 = J_2$.
C. $J_1 < J_2$.
D. There's not enough information to compare them.

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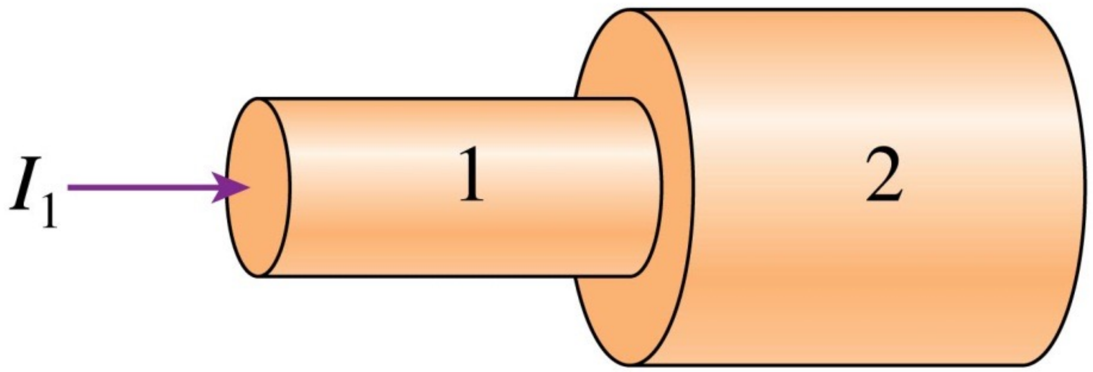


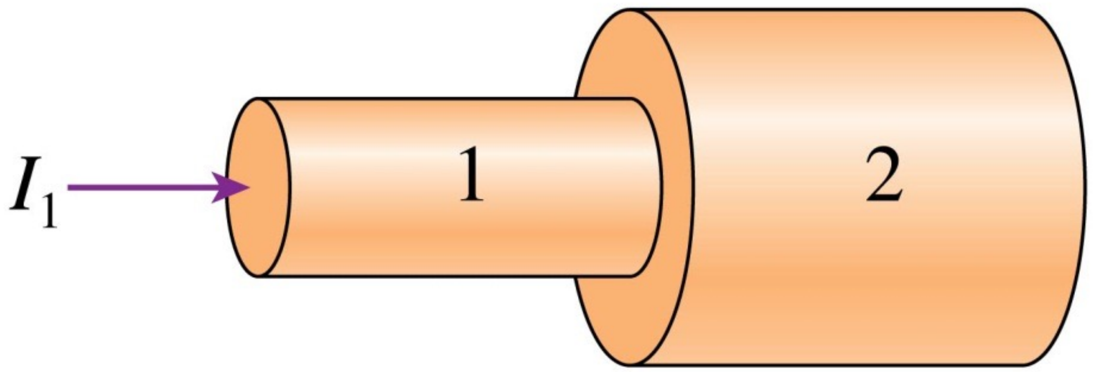
A. $J_1 > J_2$. smaller cross section

B. $J_1 = J_2$.

C. $J_1 < J_2$.

D. There's not enough information to compare them.

Both segments of the wire are made of the same metal. Current I_1 flows into segment 1 from the left. How does the electric field E_1 in segment 1 compare to the electric field E_2 in segment 2?



A. $E_1 > E_2$.

B. $E_1 = E_2$ but not zero.

C. $E_1 < E_2$.

D. Both are zero because metal is a conductor.

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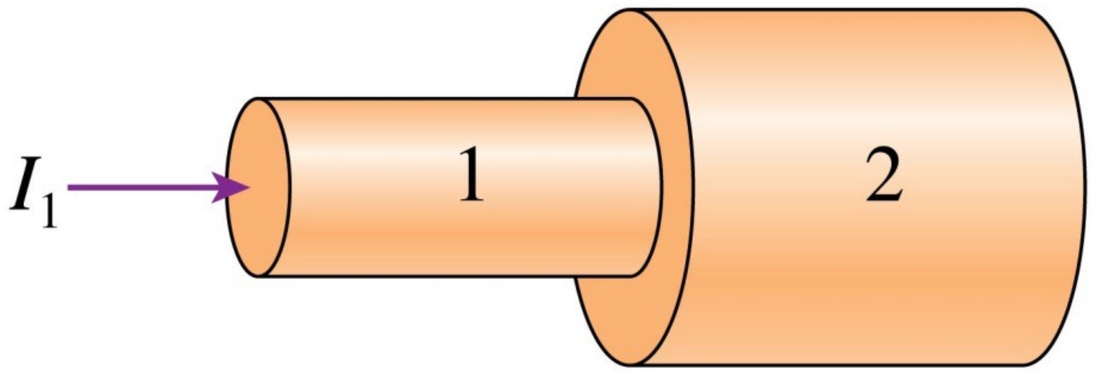


A. $E_1 > E_2$. how is this possible?

B. $E_1 = E_2$ but not zero.

C. $E_1 < E_2$.

D. Both are zero because metal is a conductor.

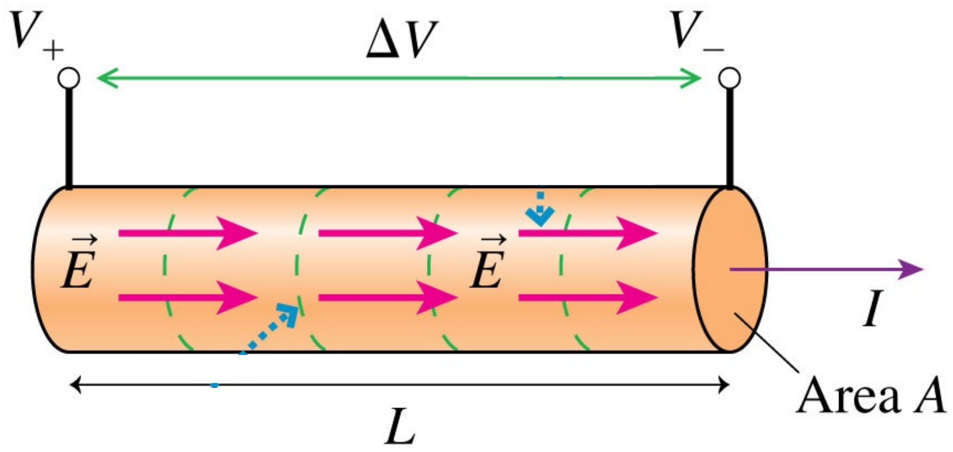
E. There's not enough information to compare them.

Ohm's Law

recall that…

$$E = \frac{\Delta V}{L}$$

$$J = \frac{I}{A} = \frac{1}{\rho} E$$



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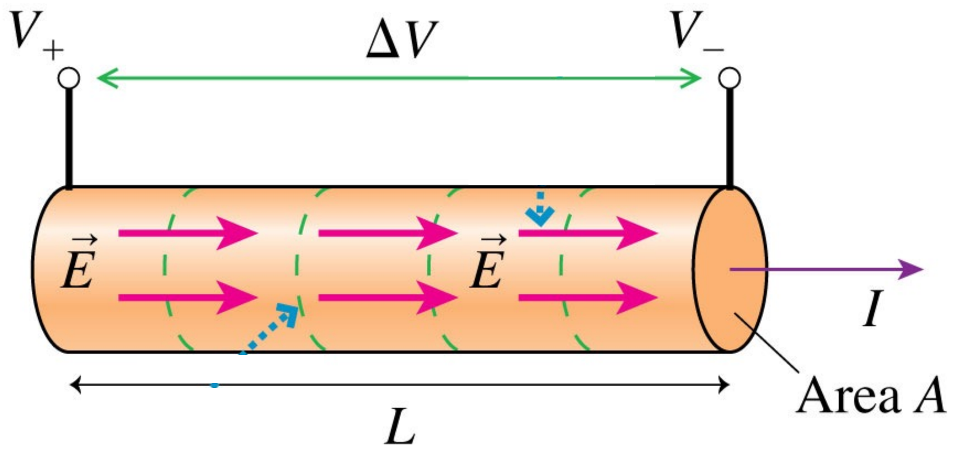

$$J = \frac{I}{A} = \frac{1}{\rho} E$$

rearrange...

$$I = JA = \frac{A}{\rho} E$$

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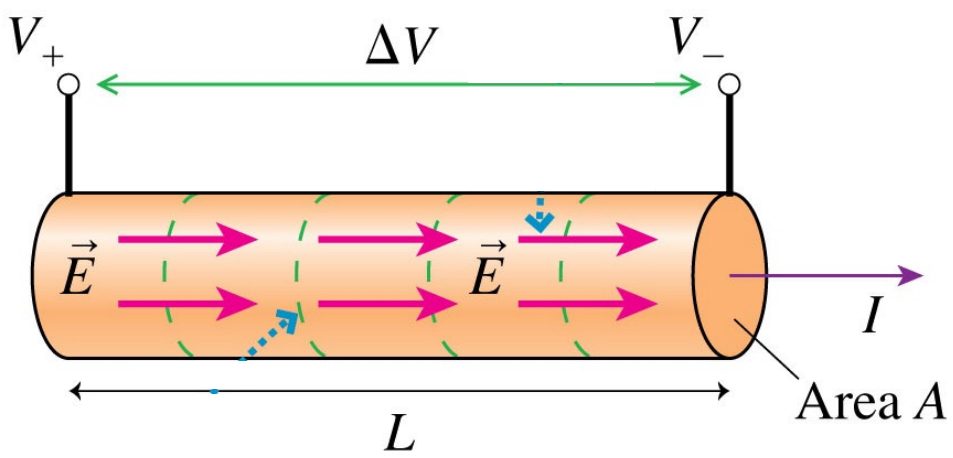

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$$I = JA = \frac{A}{\rho} E$$

$$= \frac{A \Delta V}{\rho L}$$

Ohm's Law

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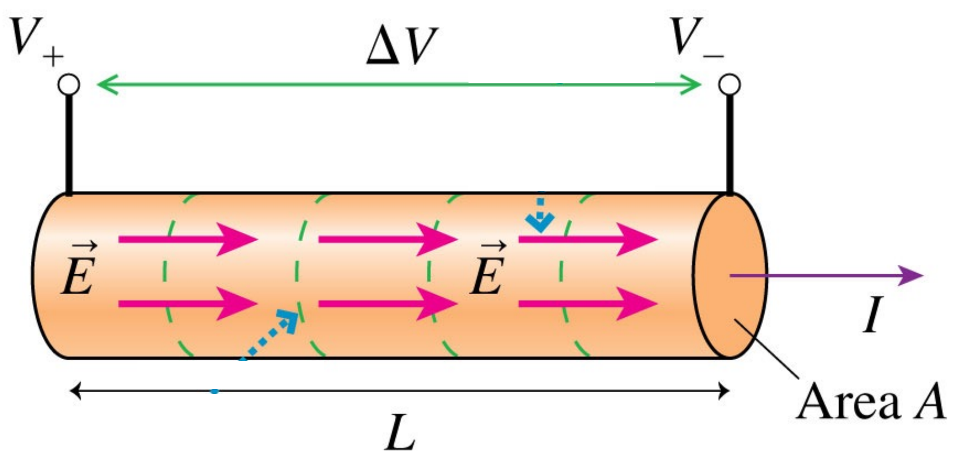

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rearrange...

$$I = JA = \frac{A}{\rho} E$$

$$= \frac{A \Delta V}{\rho L}$$

$$= \frac{\Delta V}{R}$$

Ohm's Law

recall that...

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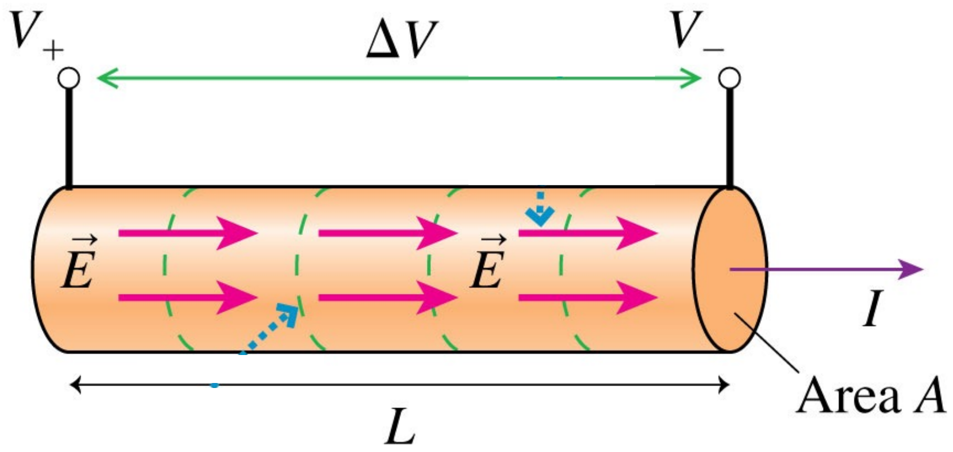

$$J = \frac{I}{A} = \frac{1}{\rho}E$$

rearrange...

$$I = JA = \frac{A}{\rho}E$$

$$= \frac{A\Delta V}{\rho L}$$

$$= \frac{\Delta V}{R}$$

$$\boxed{I = \frac{\Delta V}{R}}$$

Ohm's Law

recall that...

$$J = \frac{I}{A} = \frac{1}{\rho} E$$

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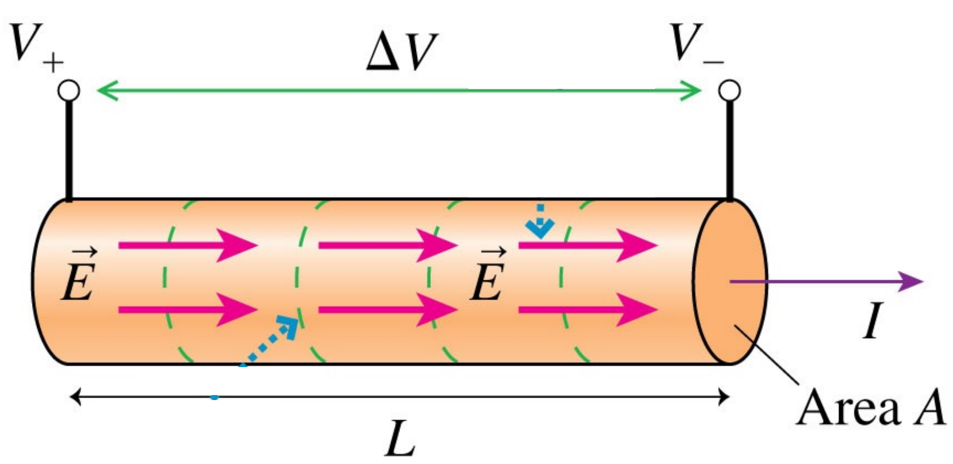
rearrange...



$$I = JA = \frac{A}{\rho} E$$

$$= \frac{A \Delta V}{\rho L}$$

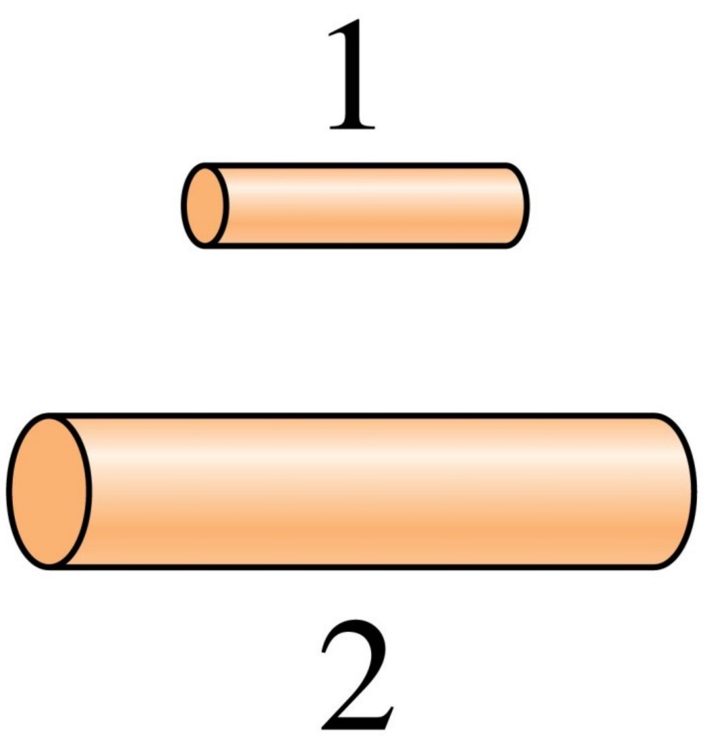
$$= \frac{\Delta V}{R}$$

$$\boxed{R = \frac{\rho L}{A}}$$

$$\boxed{I = \frac{\Delta V}{R}}$$

Question #43

Wire 2 is twice the length and twice the diameter of wire 1. What is the ratio R_2/R_1 of their resistances?



A. 1/4.
B. 4.
C. 1.
D. 2.
E. 1/2.

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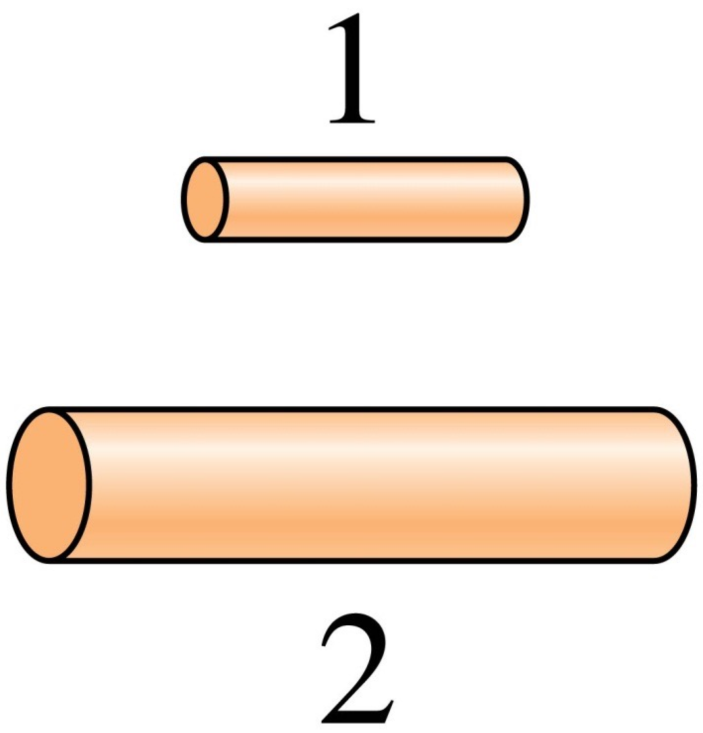
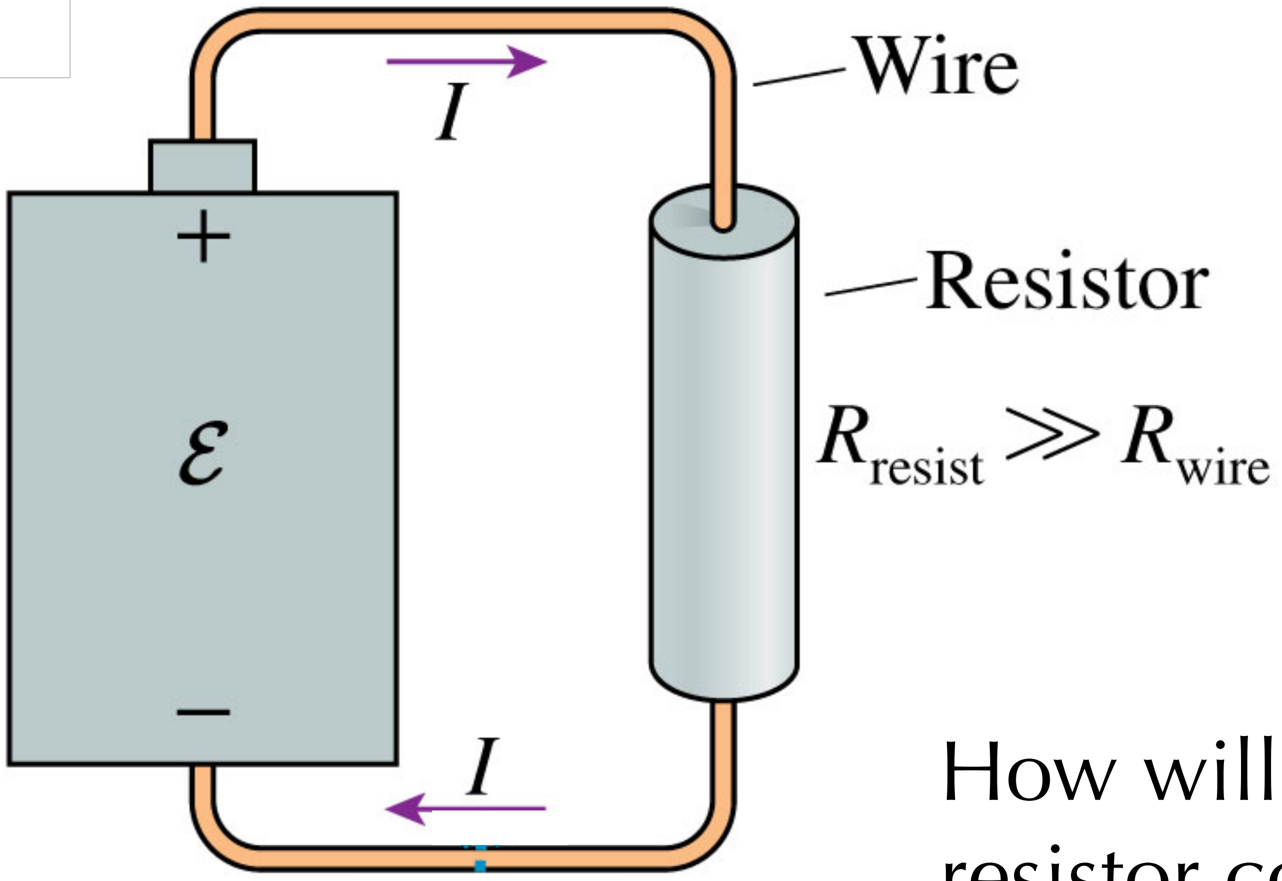


A. 1/4.
B. 4.
C. 1.
D. 2.
E. 1/2.

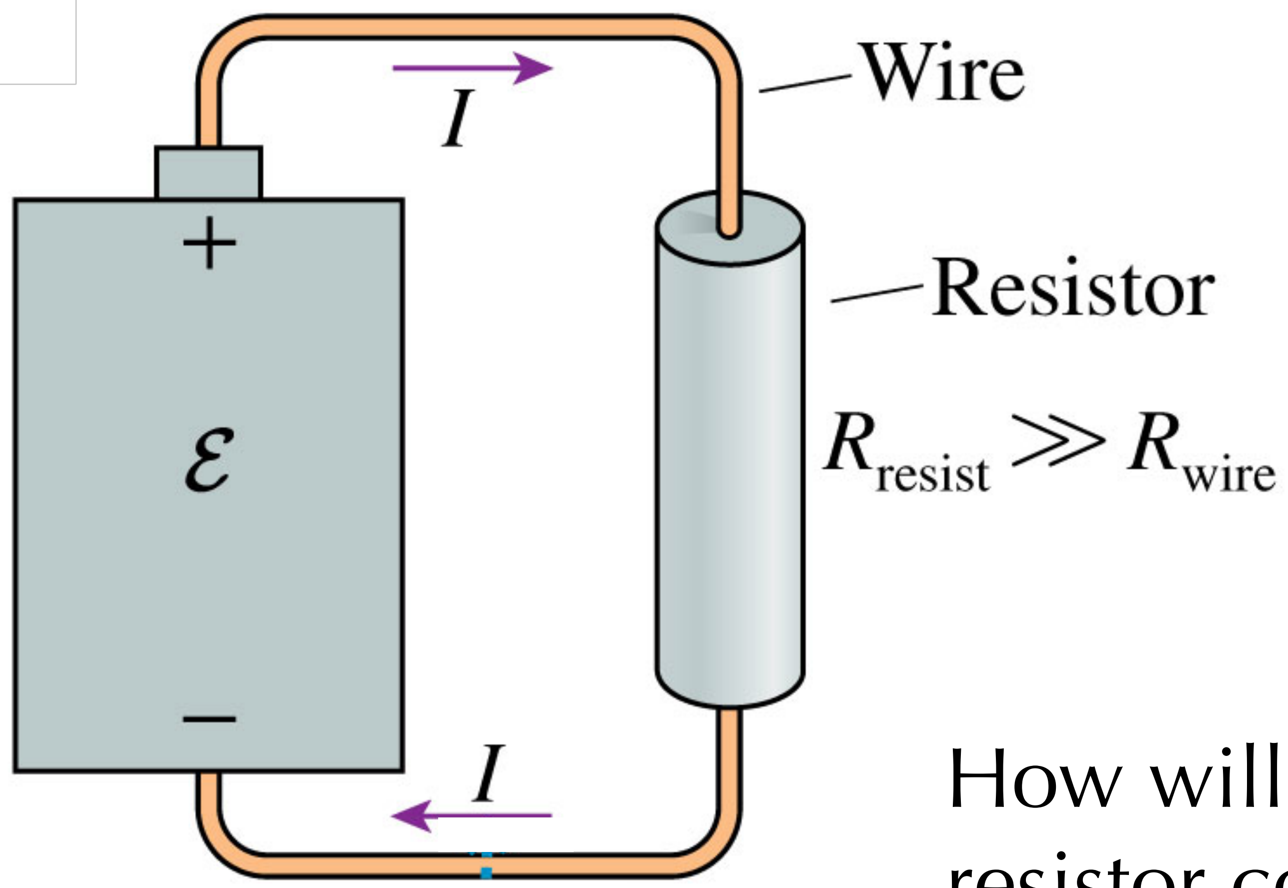
$$R = \frac{\rho L}{A}$$

Resistance is specific to the geometry of the material, not just the type of material.



How will the voltage drop across the resistor compare to the voltage drop across the wire leading to the resistor?

How is this possible?



$$I = \frac{\Delta V}{R}$$

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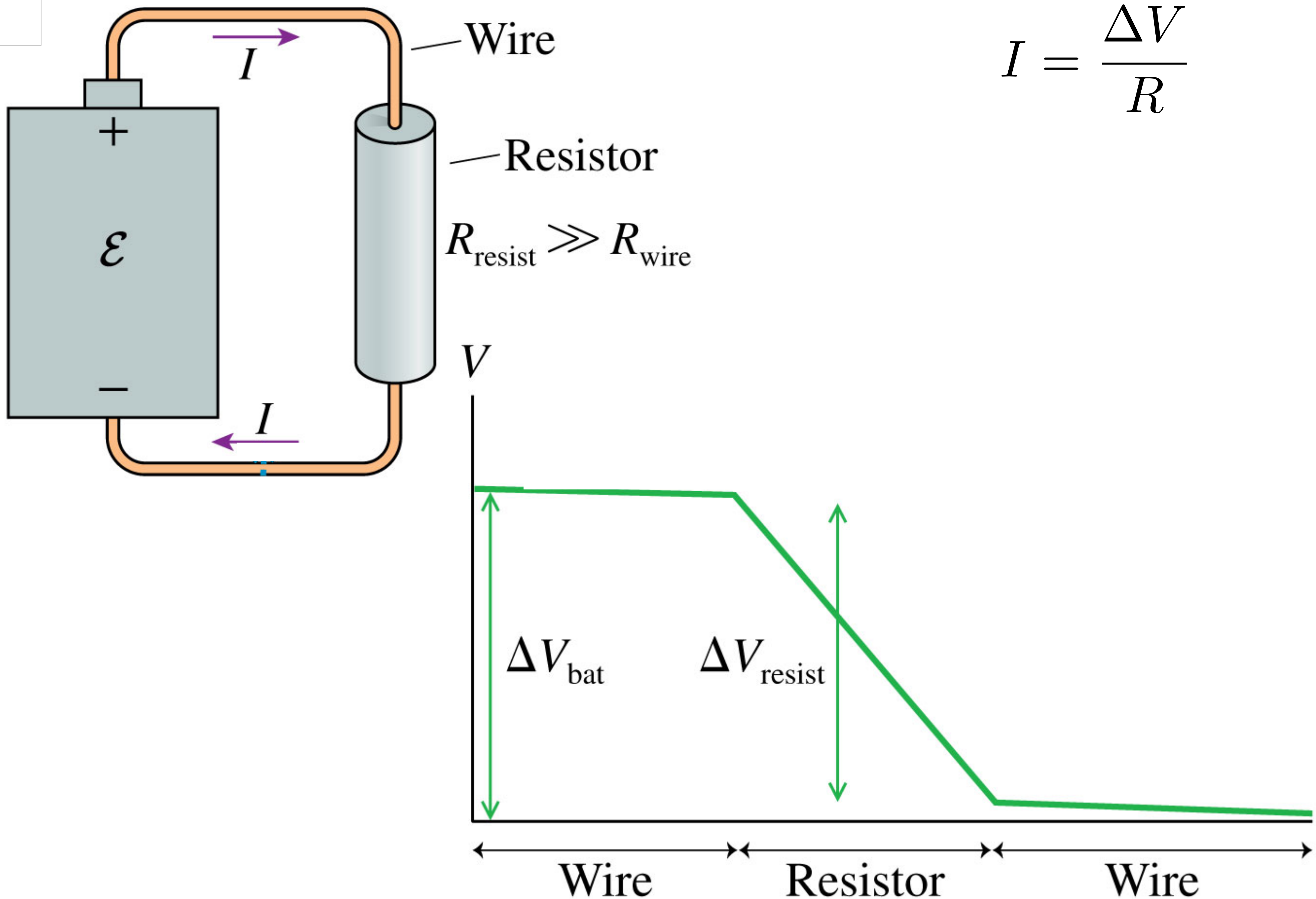

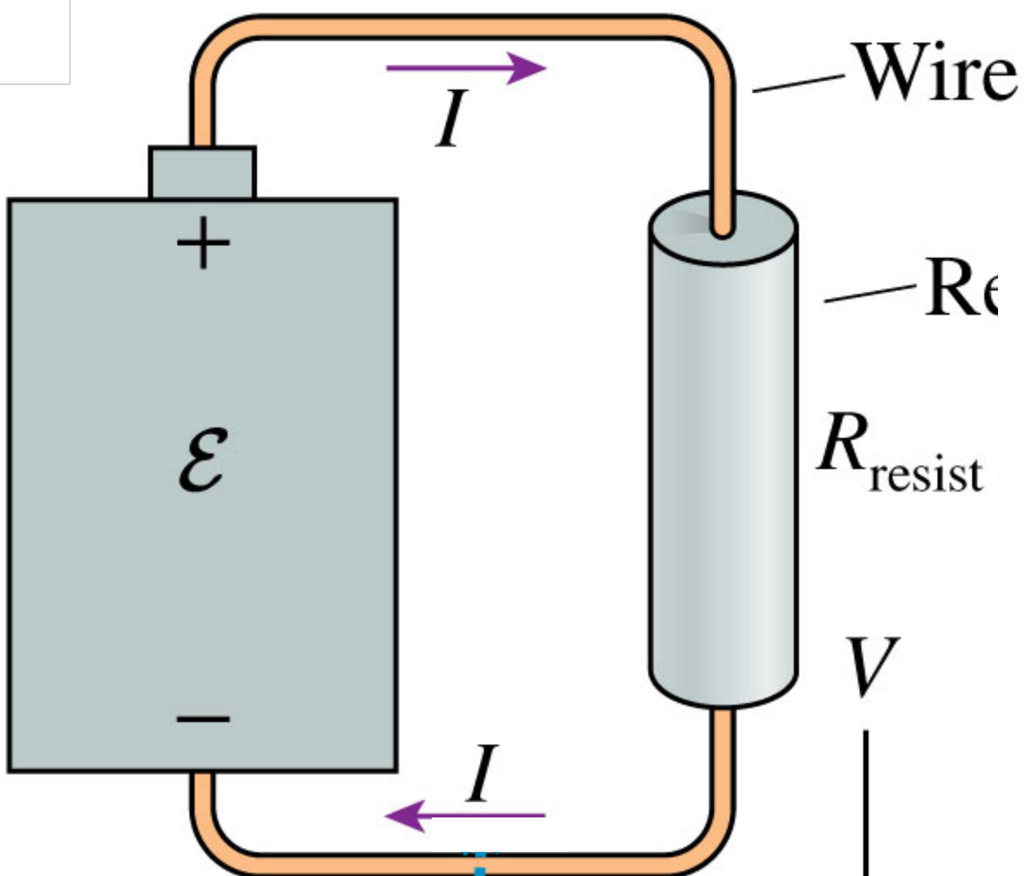

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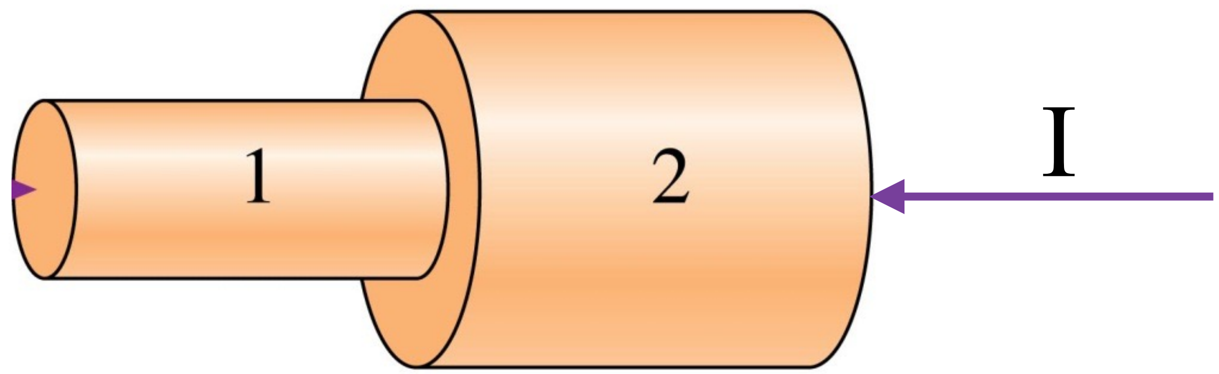

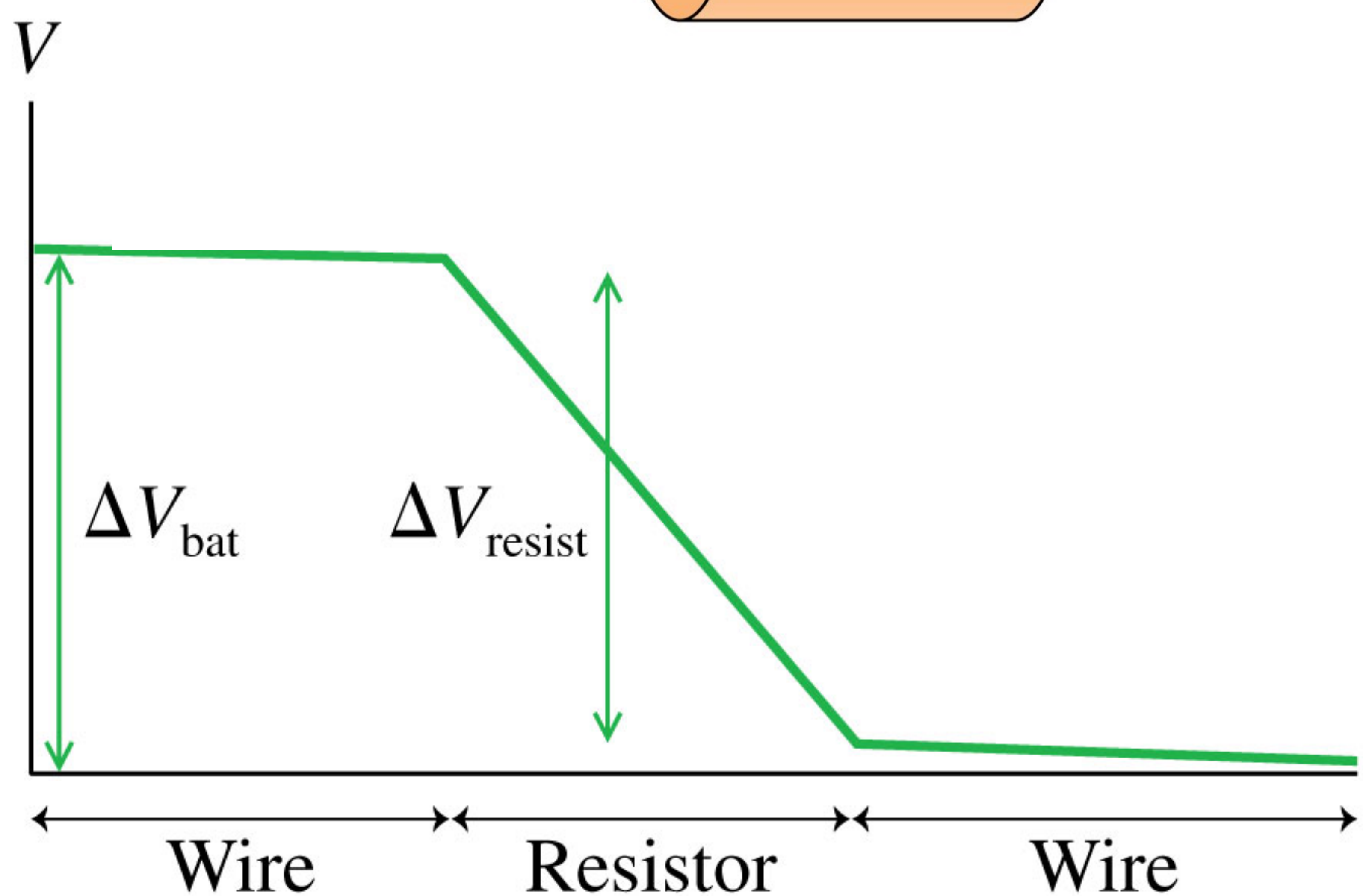

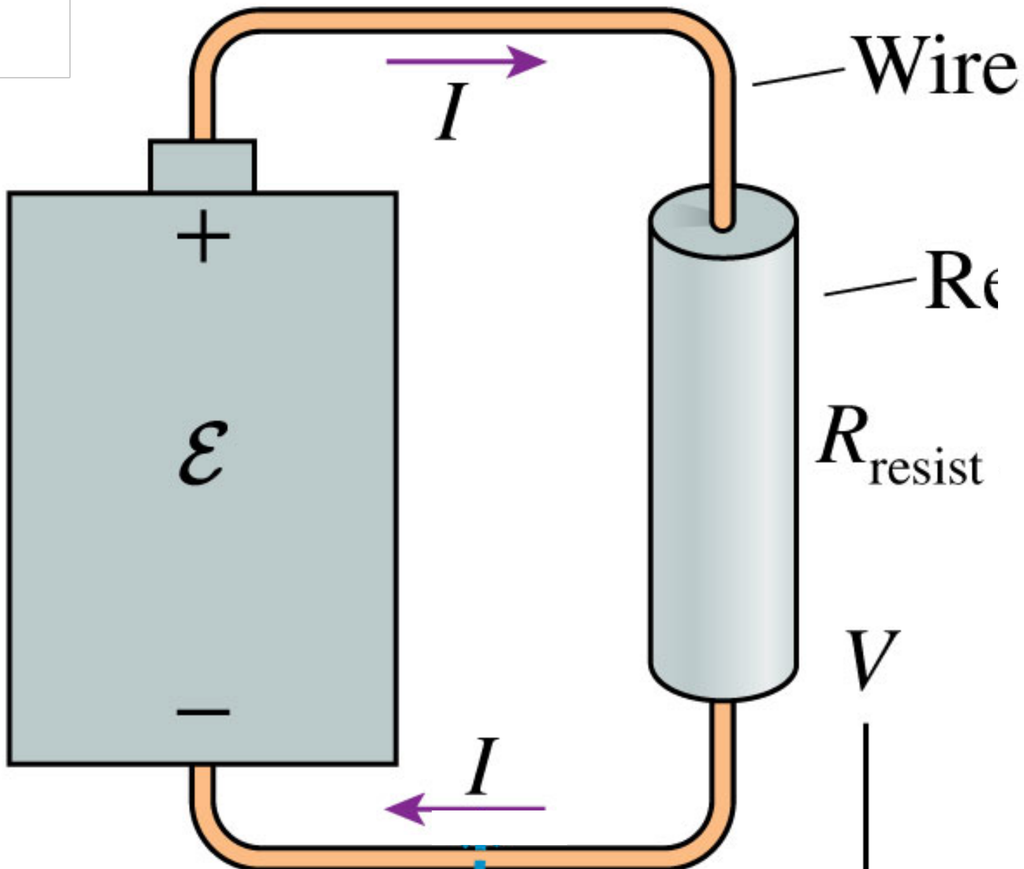

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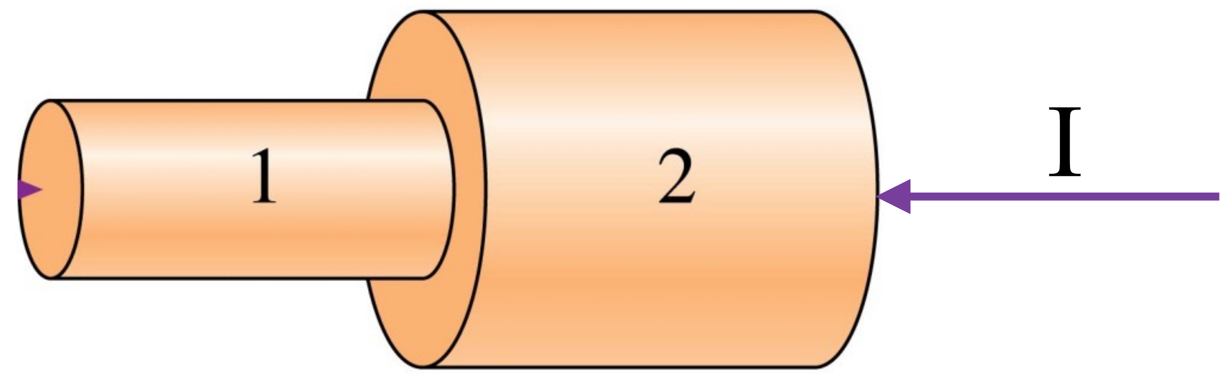
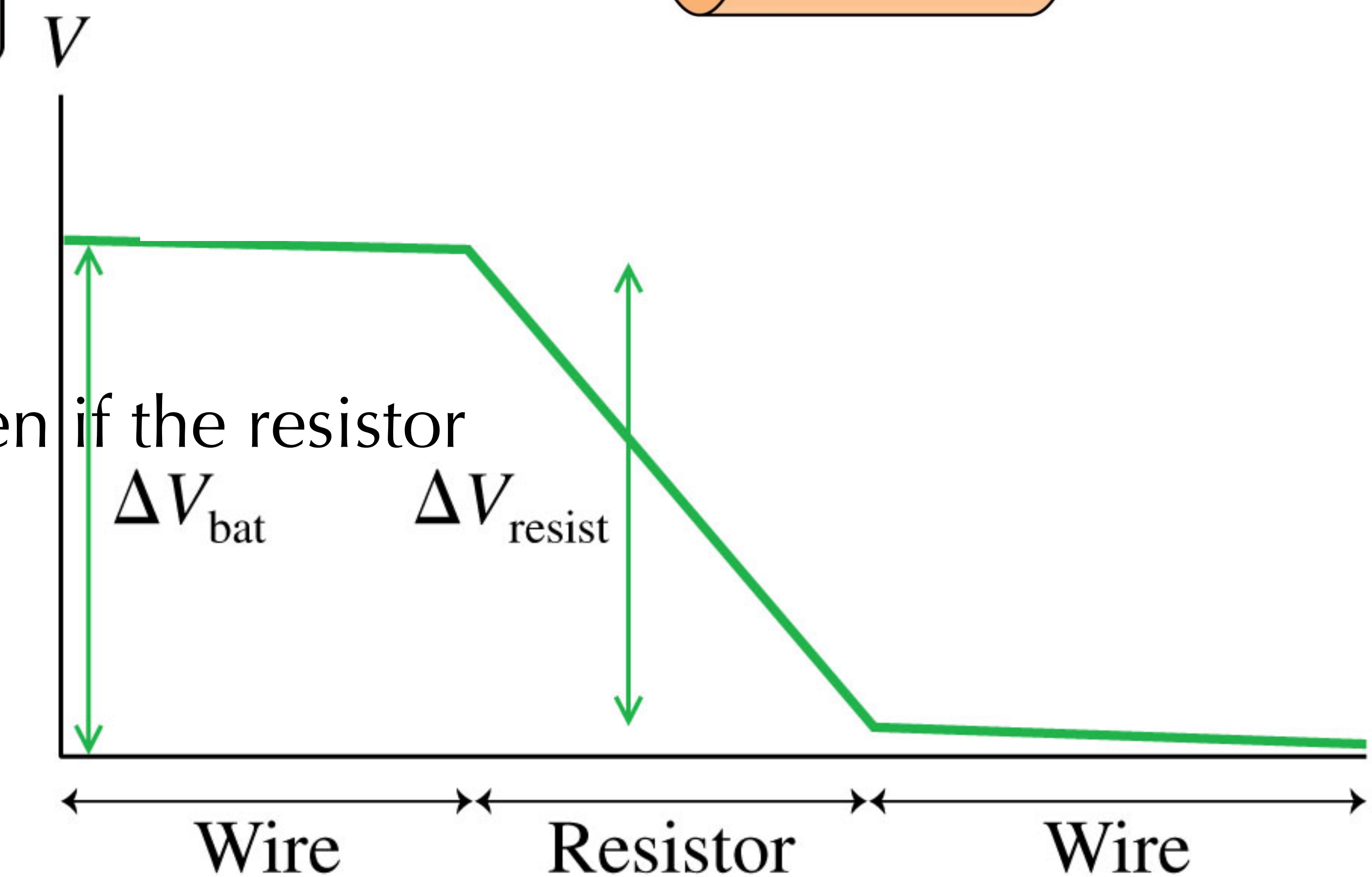
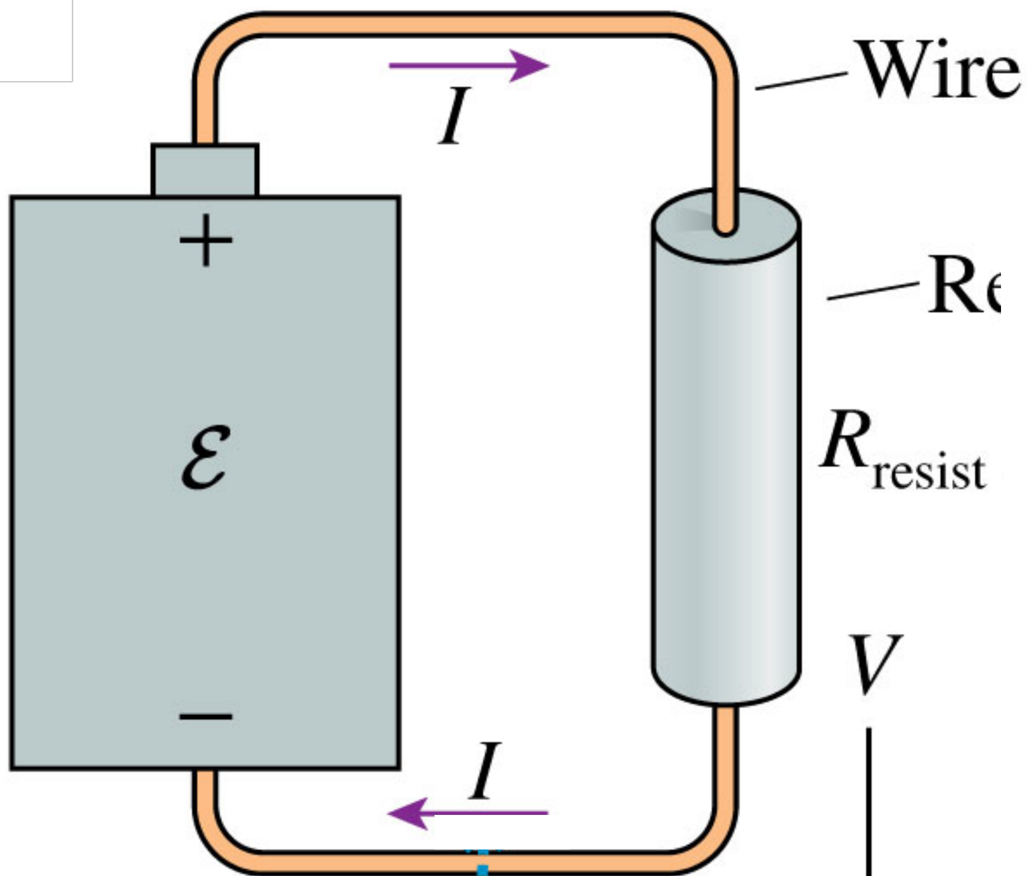
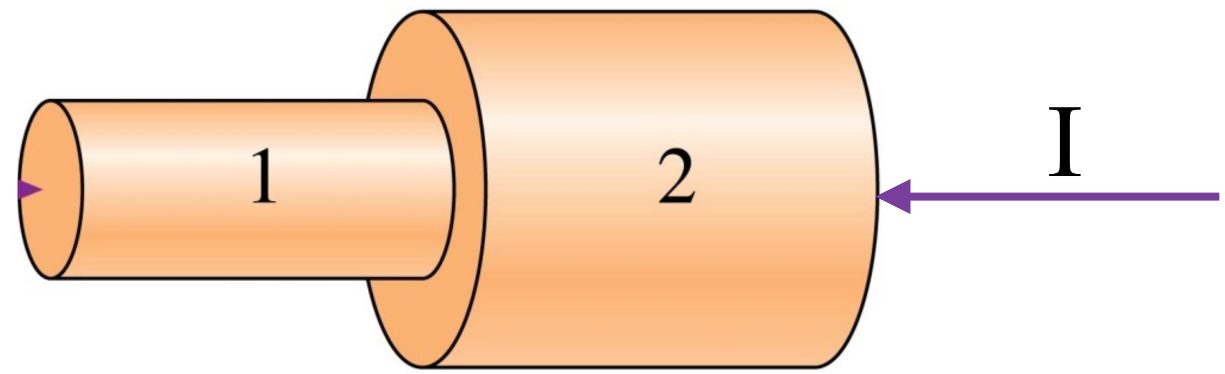


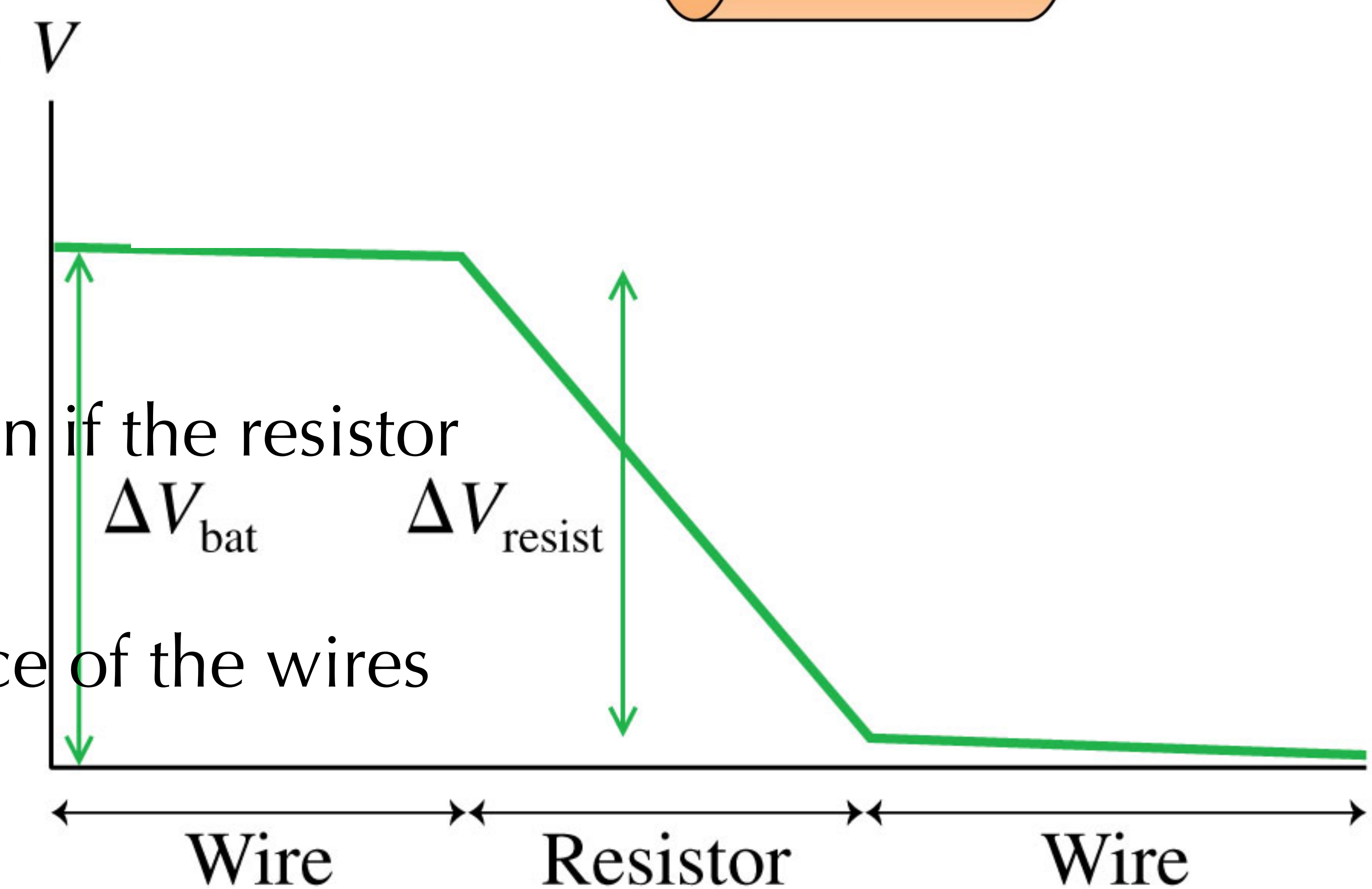


What would happen if the resistor was removed?

$$I = \frac{\Delta V}{R}$$







What would happen if the resistor was removed?

What if the resistance of the wires were not small?

An electric utility company supplies a customer's house from the main power lines (120 V) with two copper wires, each of which is 50.0 m long and has a resistance of 0.108 Ohms per 300 m. Find the voltage at the customer's house for a load current of 110 A.

Draw a circuit diagram for this problem and try to provide a conceptual(no math) description of what is being asked.

Equations so far

$$v_d = \frac{eE}{m}\tau$$

$$C = \frac{\epsilon_0 A}{d}$$

$$i_e = \frac{n_e A e E \tau}{m}$$

$$\boldsymbol{\kappa \equiv \frac{E_0}{E}}$$

$$J = \sigma E$$

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$$

$$R = \frac{\rho L}{A}$$

$$C = \frac{Q}{\Delta V_{\text{C}}}$$

$$I = \frac{\Delta V}{R}$$

$$\sum I_{\text{in}} = \sum I_{\text{out}}$$

$$U_C = \frac{Q^2}{2C} = \frac{1}{2} C (\Delta V_C)^2$$

$$C_{\text{eq}} = C_1 + C_2 + C_3 + \ldots$$

$$i_e = n_e A v_d$$

Equations so far

9

$$v_d = \frac{eE}{m}\tau$$

3

$$C = \frac{\epsilon_0 A}{d}$$

10

$$i_e = \frac{n_e A e E \tau}{m}$$

8

$$\kappa \equiv \frac{E_0}{E}$$

4

$$J = \sigma E$$

11

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$$

6

$$R = \frac{\rho L}{A}$$

5

$$C = \frac{Q}{\Delta V_{\text{C}}}$$

7

$$I = \frac{\Delta V}{R}$$

12

$$U_C = \frac{Q^2}{2C} = \frac{1}{2}C(\Delta V_C)^2$$

13

$$\sum I_{\text{in}} = \sum I_{\text{out}}$$

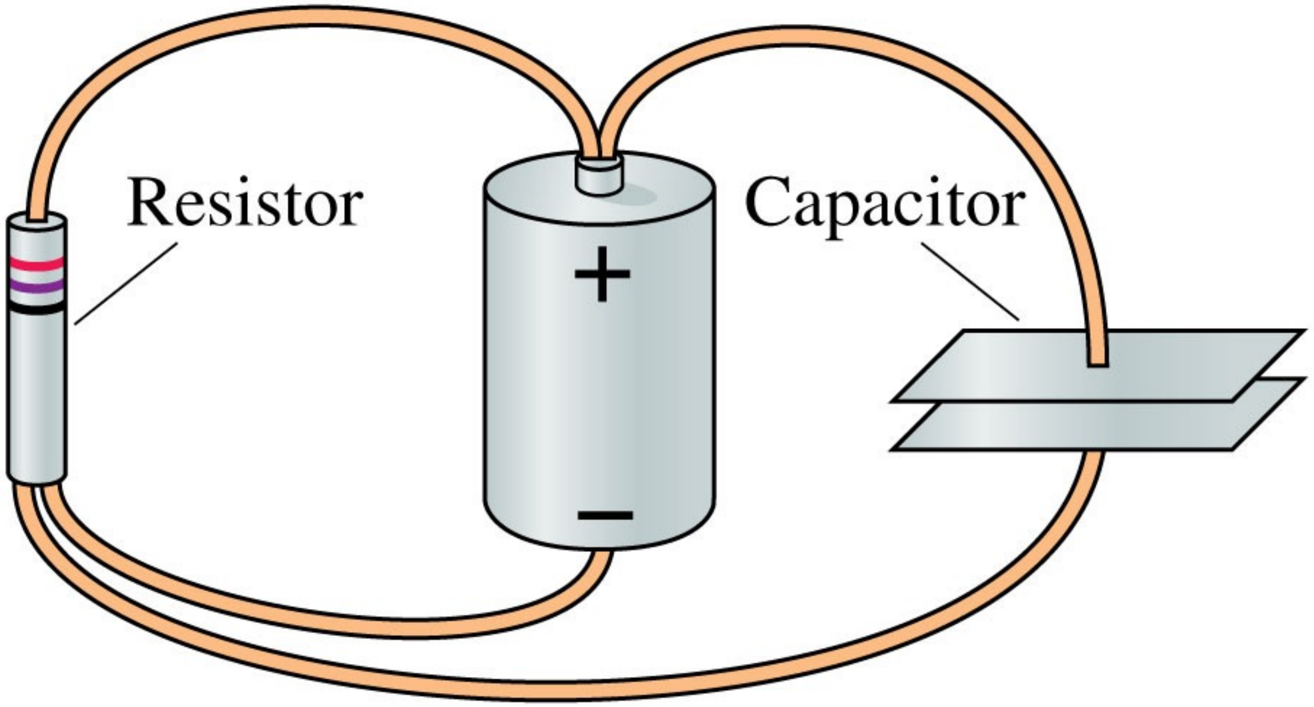
1

$$i_e = n_e A v_d$$

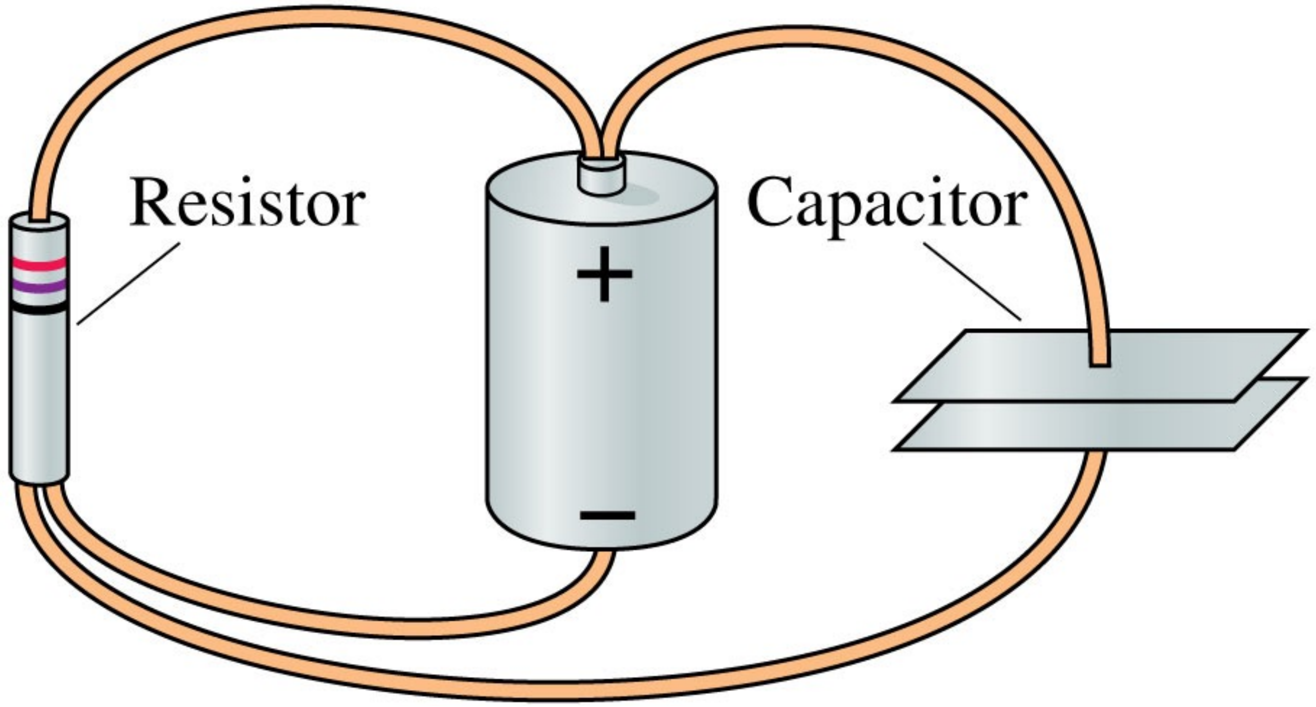
2

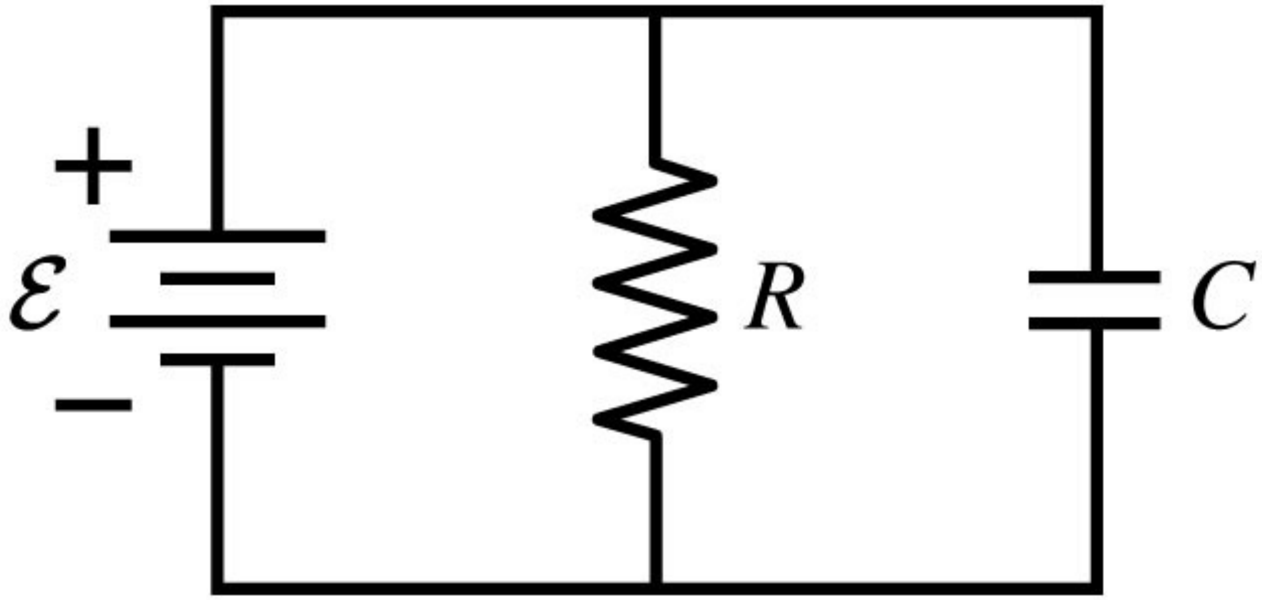
$$C_{\text{eq}} = C_1 + C_2 + C_3 + \ldots$$

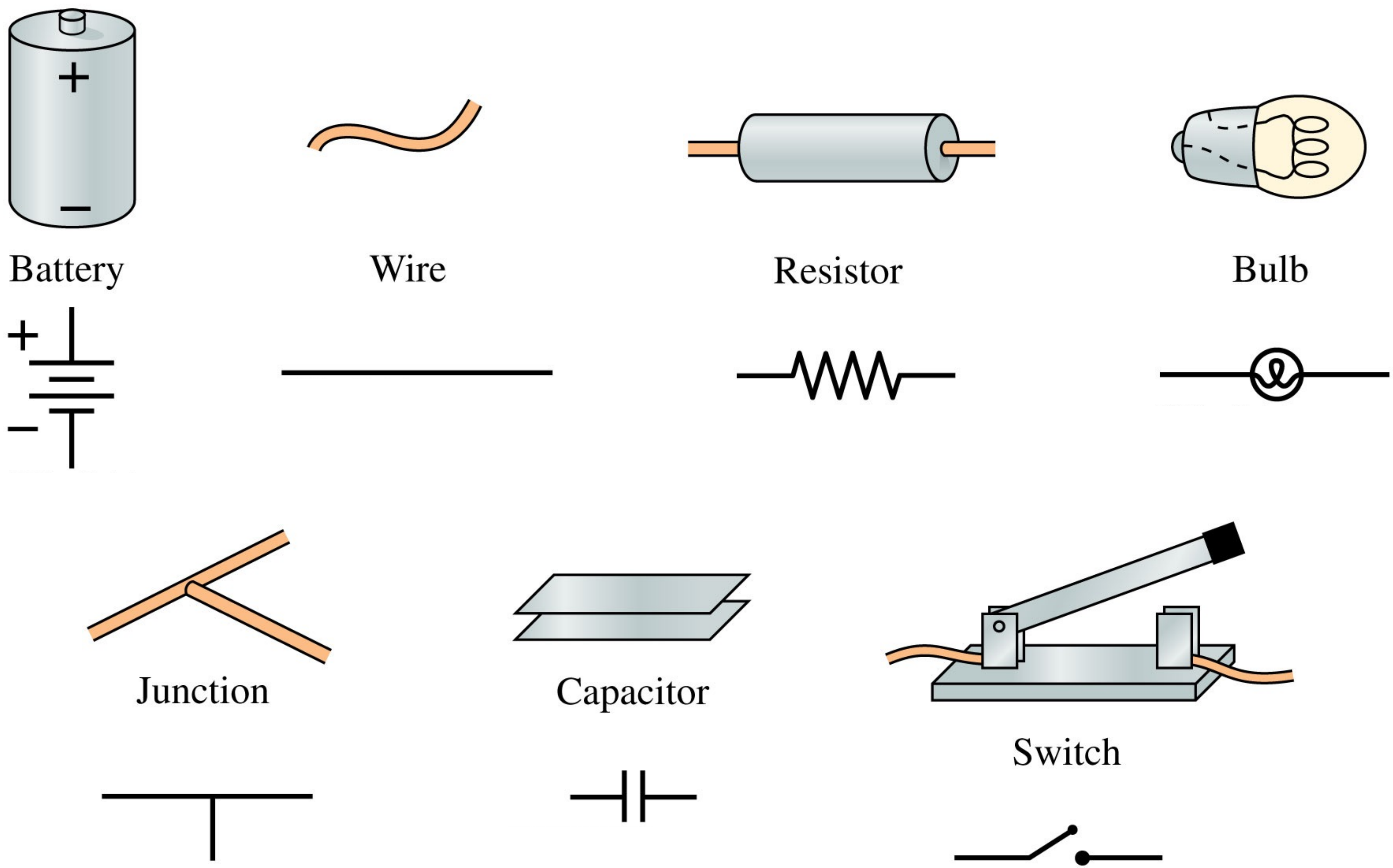
Circuit Diagrams



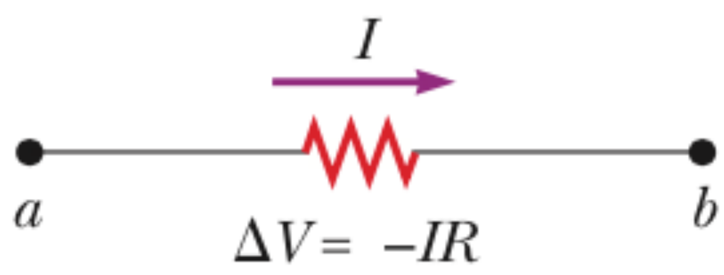
Circuit Diagrams

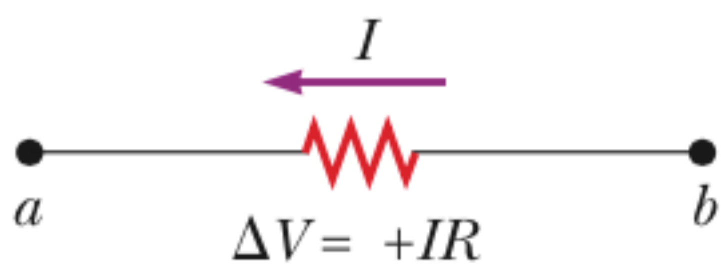


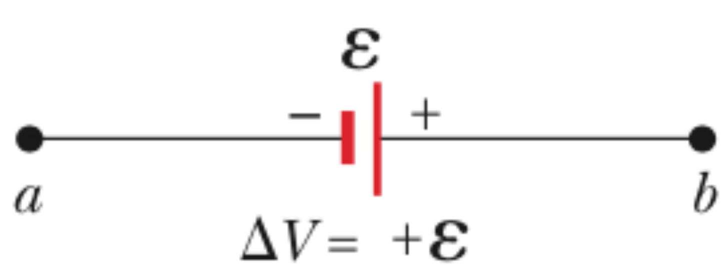


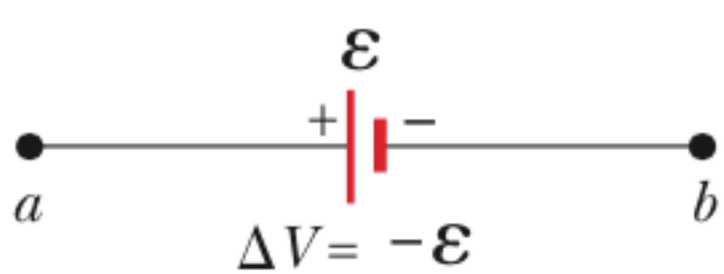

Battery
Wire
Resistor
Bulb
+
−
Junction
Capacitor
Switch

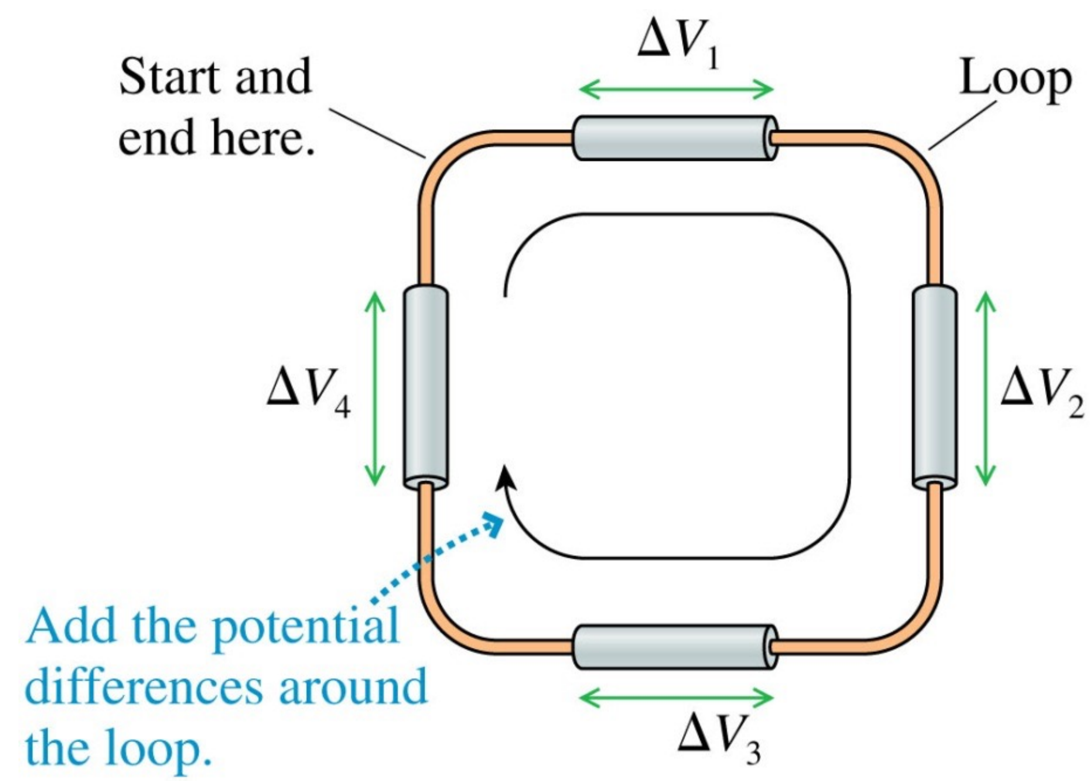
Kirchoff's Loop Rule







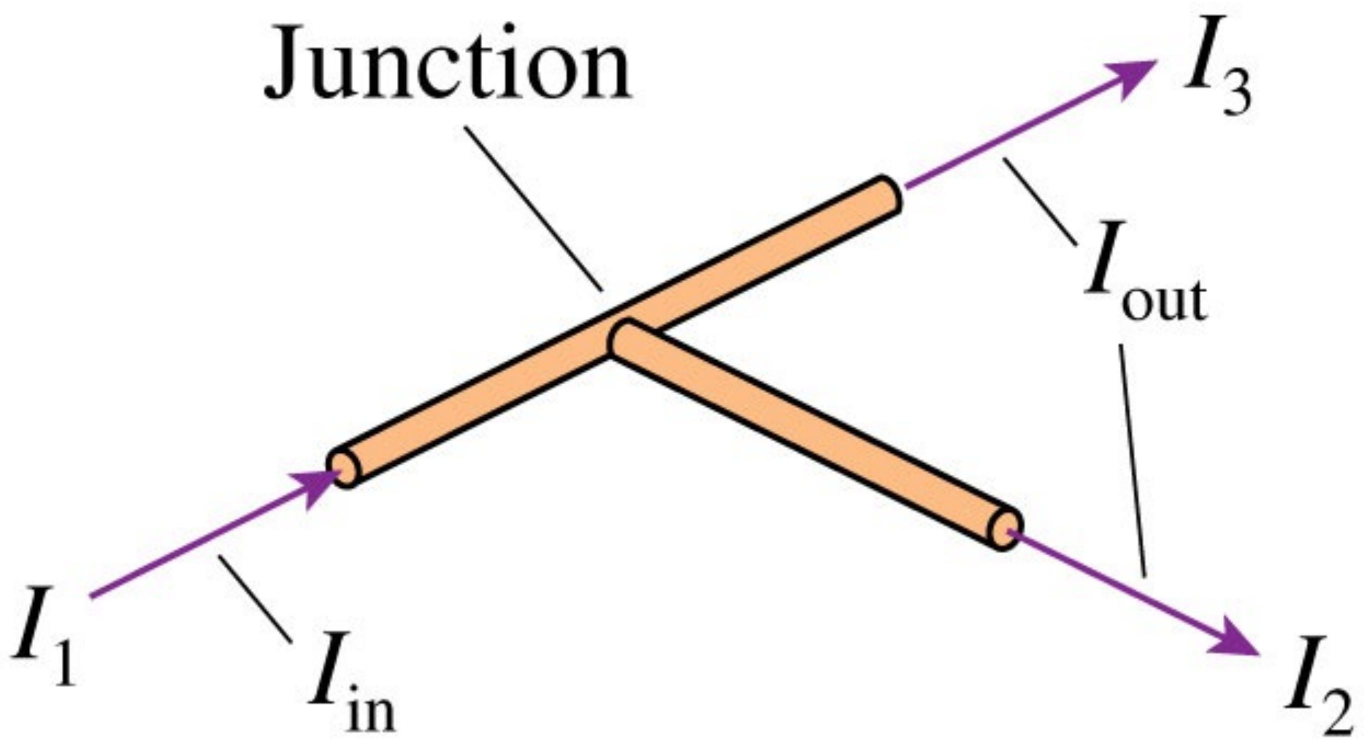




Loop law: $\Delta V_1 + \Delta V_2 + \Delta V_3 + \Delta V_4 = 0$

$$\Delta V_{\text{loop}} = \sum (\Delta V)_i = 0$$

Kirchoff's Junction Rule

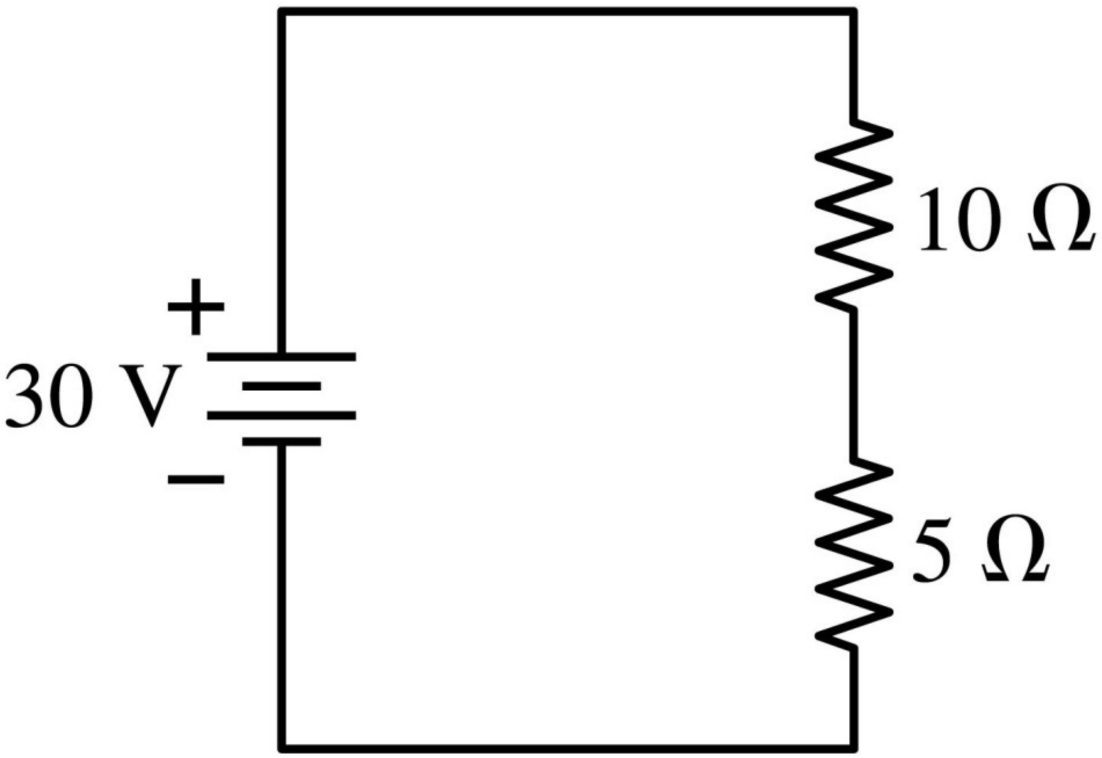


Junction law: $I_1 = I_2 + I_3$

Quiz Question

The potential difference across the 10 resistor is

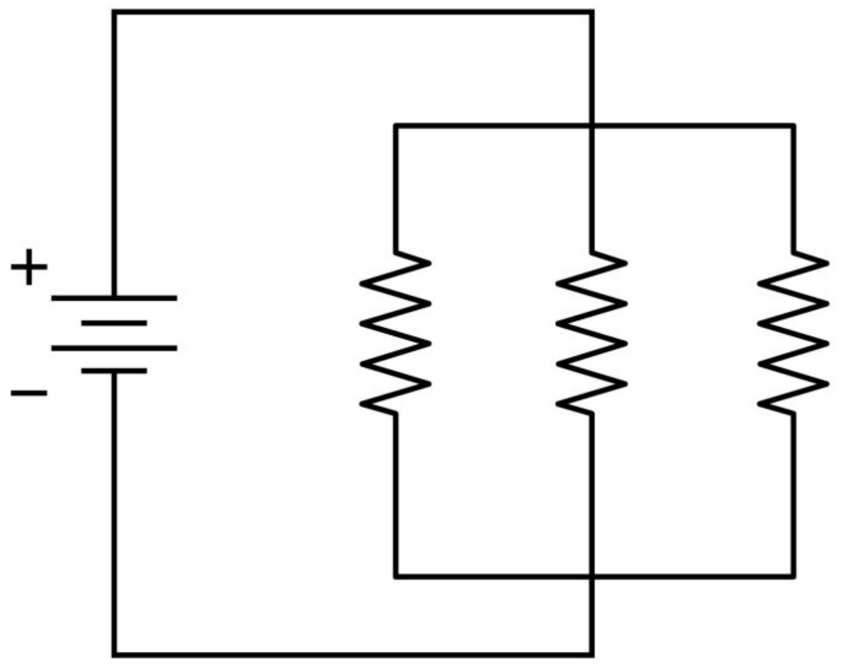
A. 30 V.
B. 5 V.
C. 15 V.
D. 10 V.
E. 20 V.



Quiz Question

What things about the resistors in this circuit are the same for all three?

A. Current I.
B. Potential difference ΔV.
C. Resistance R.
D. A and B.
E. B and C.



Power

$$P = \frac{dU}{dt}$$

In words, state the meaning of power?

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Power delivered by a source (battery)

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$$U = qV$$

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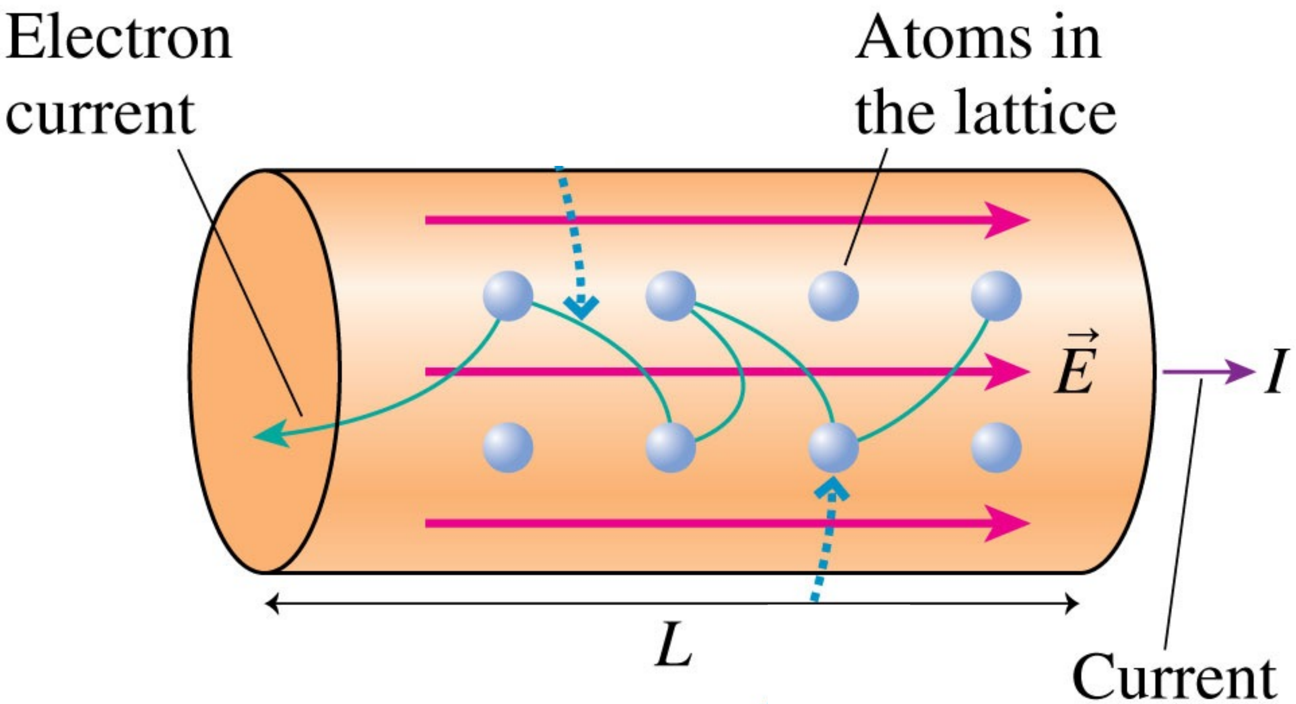
$$= I\Delta V$$

Power delivered by a source (battery)

$$P_{\text{res}} = I\Delta V = I^2 R = \frac{\Delta V^2}{R}$$

Power dissipated by a resistor.

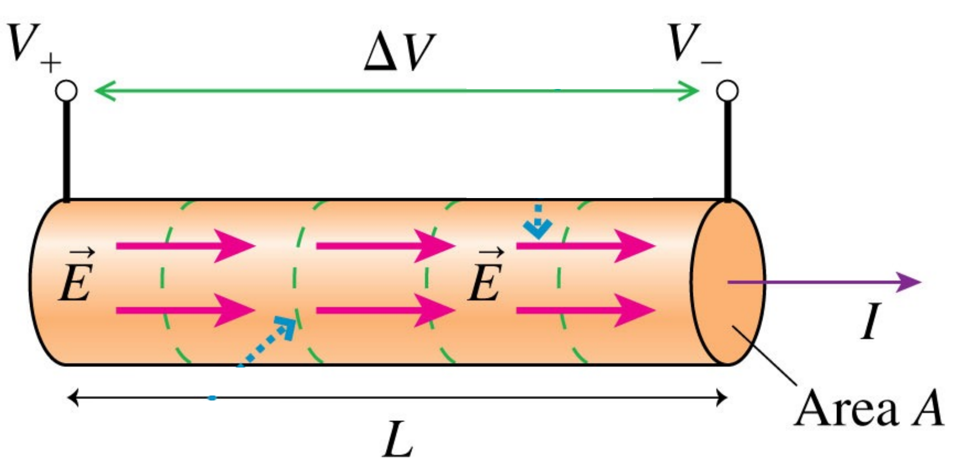
Deeper Thinking



$$P_{\text{res}} = I\Delta V = I^2 R = \frac{\Delta V^2}{R}$$

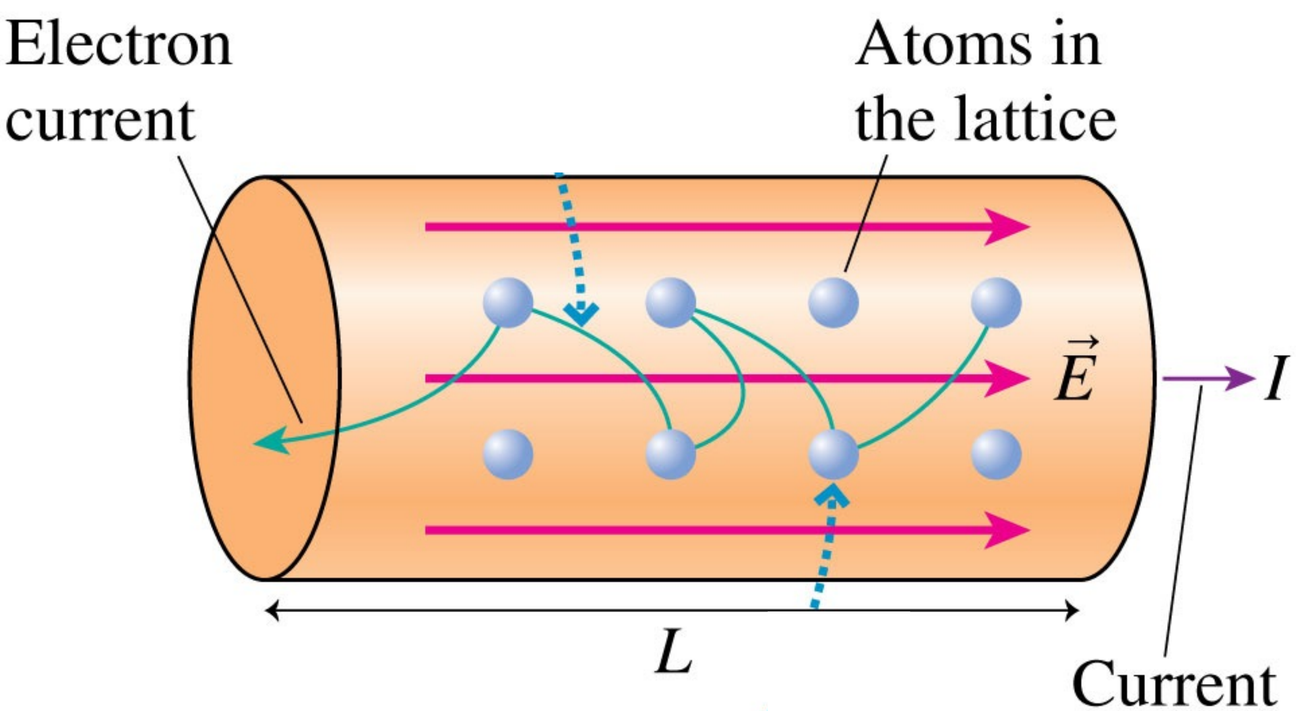
Explain how an increase/decrease of the variable will affect the power dissipated. (Don't just follow the math, explain it conceptually too)

$$E_{\text{chem}} \rightarrow U \rightarrow K \rightarrow E_{\text{th}}$$



The energy from the battery is delivered to the resistor as thermal energy.

Deeper Thinking



$$P_{\text{res}} = \overset{\boxed{1}}{I\Delta V} = \overset{\boxed{3}}{I^2 R} = \frac{\overset{\boxed{2}}{\Delta V^2}}{R}$$

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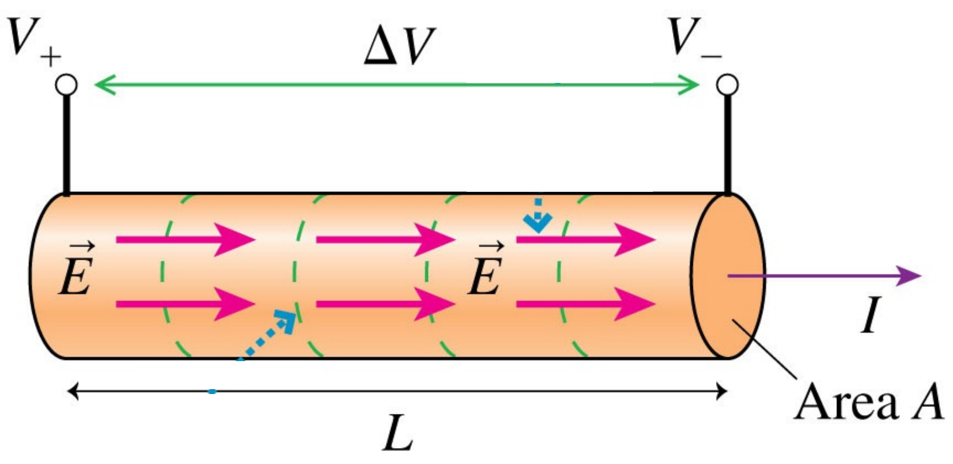
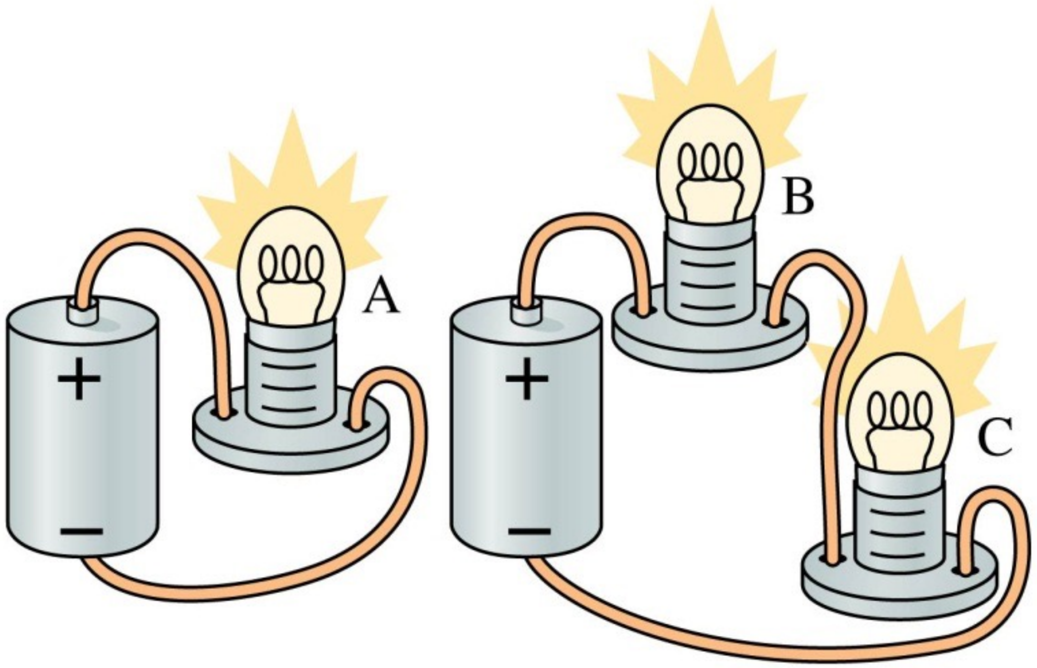


The energy from the battery is delivered to the resistor as thermal energy.

Quiz Question

The three bulbs are identical and the two batteries are identical. Compare the brightnesses of the bulbs.



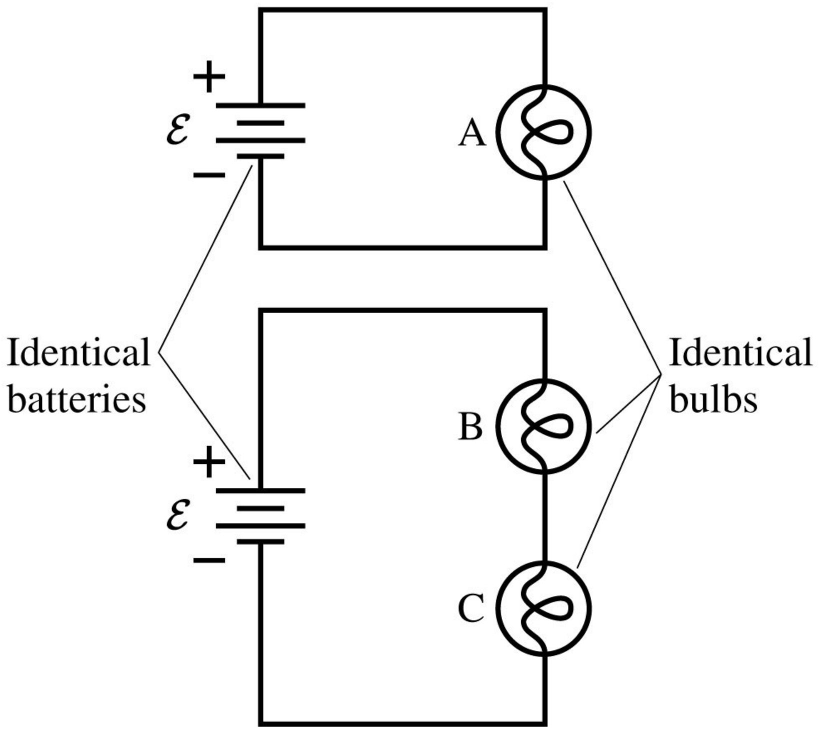
A. A > B > C.

B. A > C > B.

C. A > B = C.

D. A < B = C.

E. A = B = C.



Quiz Question

The three bulbs are identical and the two batteries are identical. Compare the brightnesses of the bulbs.

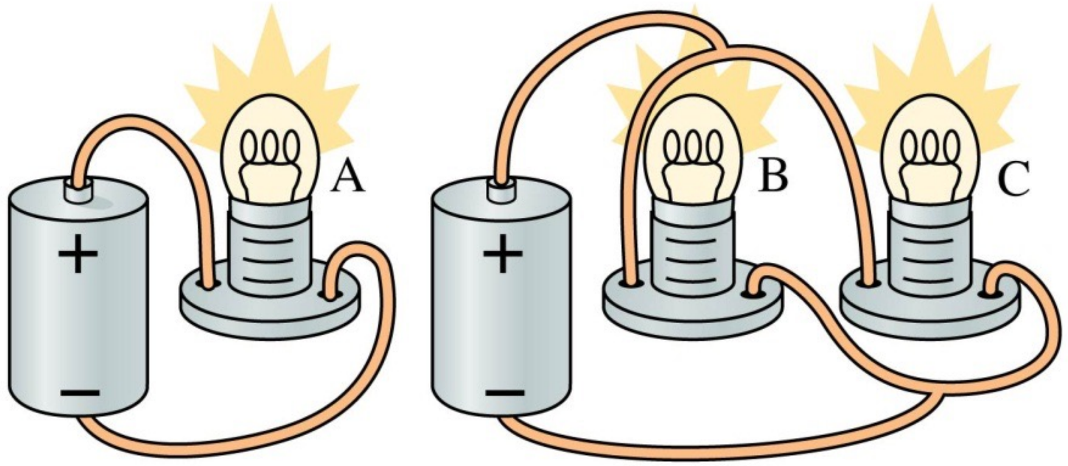
A. A > B > C.

B. A > C > B.

C. A > B = C.

D. A = B = C.

E. A < B = C.



Quiz Question

Which has a larger resistance, a 60 W lightbulb or a 100 W lightbulb?

A. The 100 W bulb.
B. The 60 W bulb.
C. Their resistances are the same.
D. There's not enough information to tell.

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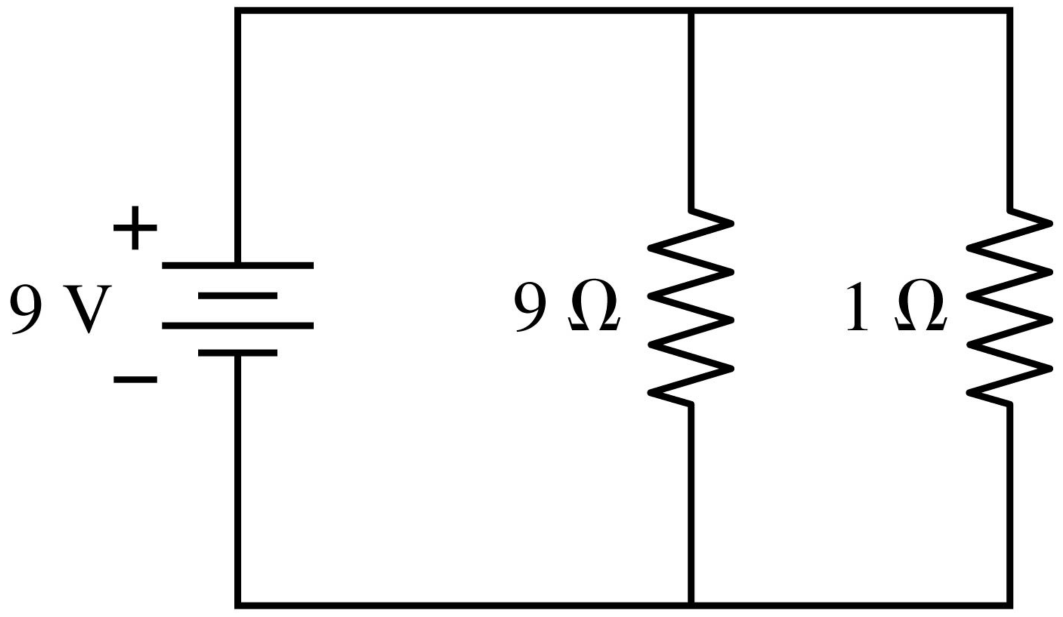
$$P_{\mathrm{res}} = I\Delta V = I^2 R = \frac{\Delta V^2}{R}$$

Quiz Question

Which resistor dissipates more power?

A. The 9 Ω resistor.
B. The 1 Ω resistor.
C. They dissipate the same power.

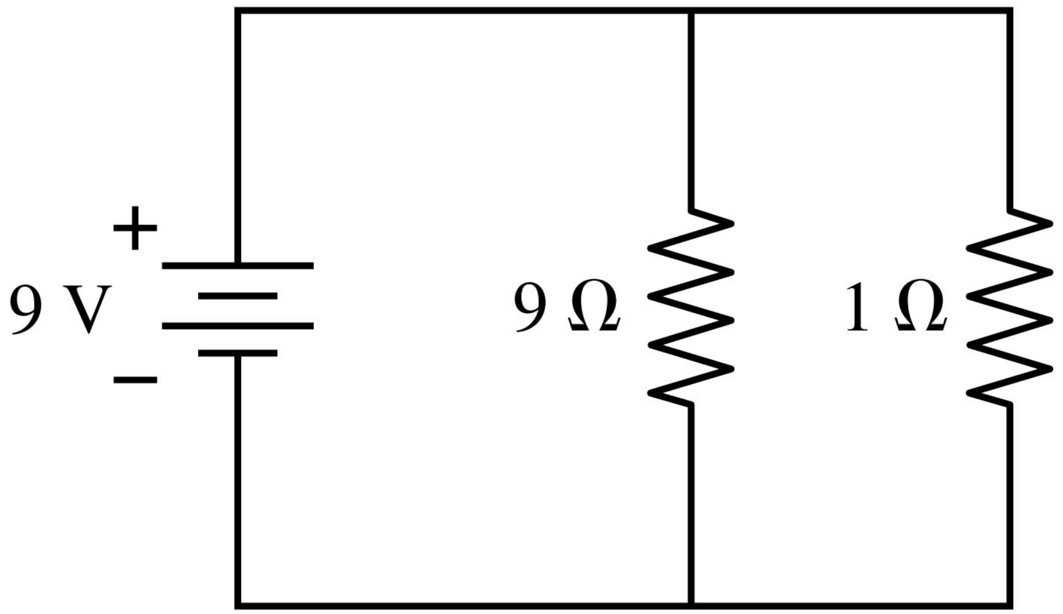


Quiz Question

$$P = \frac{(\Delta V)^2}{R}$$

Which resistor dissipates more power?

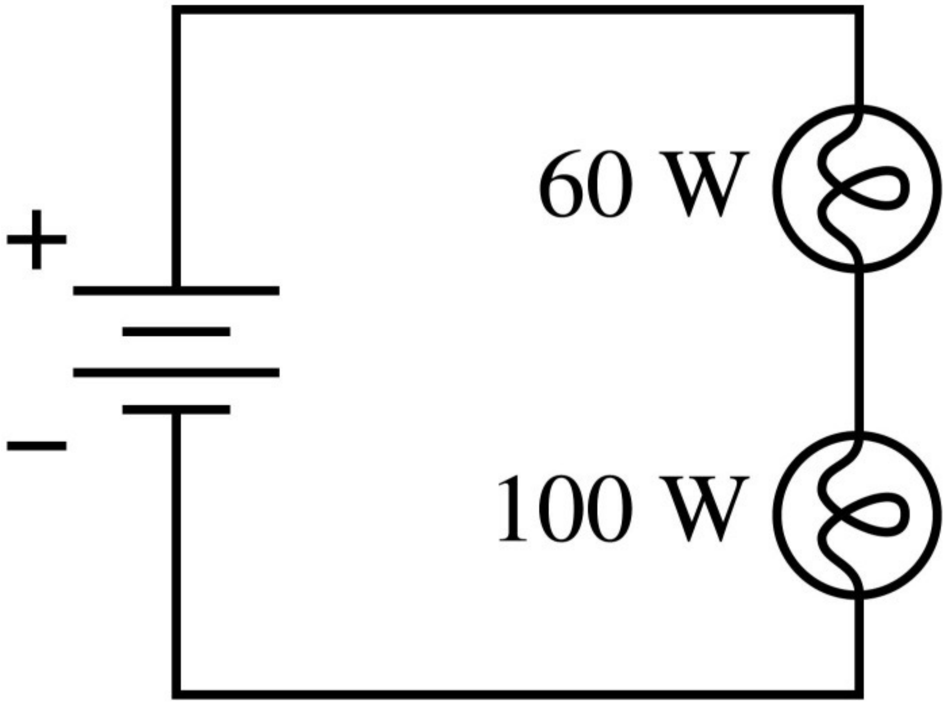
A. The 9 Ω resistor.
B. The 1 Ω resistor.
C. They dissipate the same power.

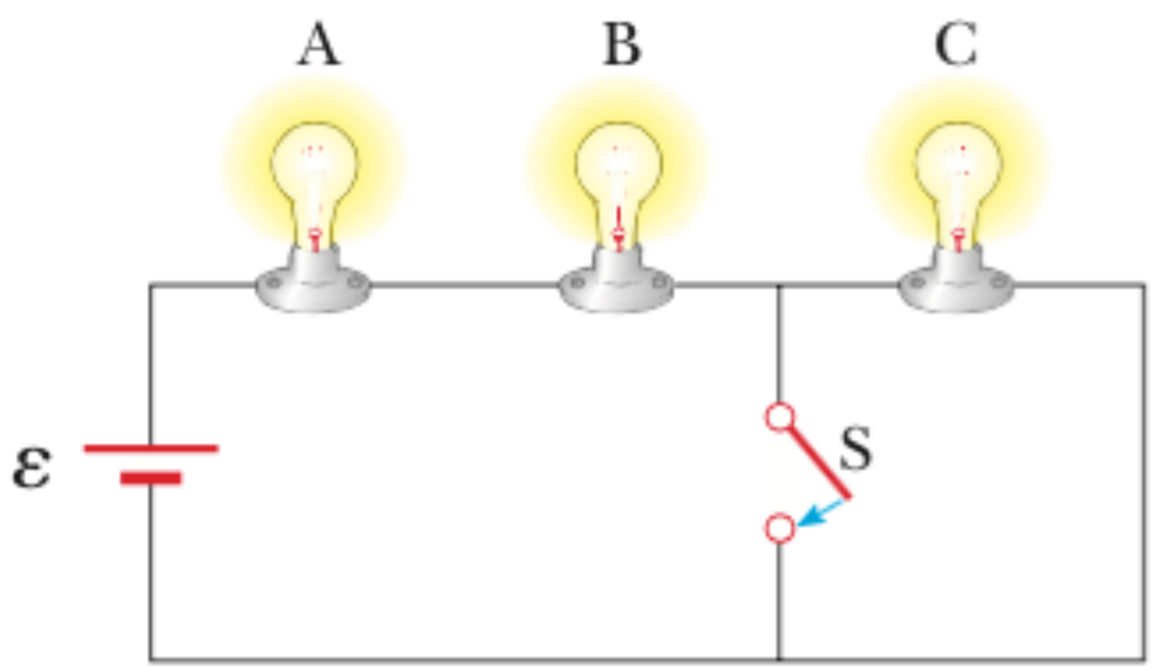


Question #50

Which bulb is brighter?

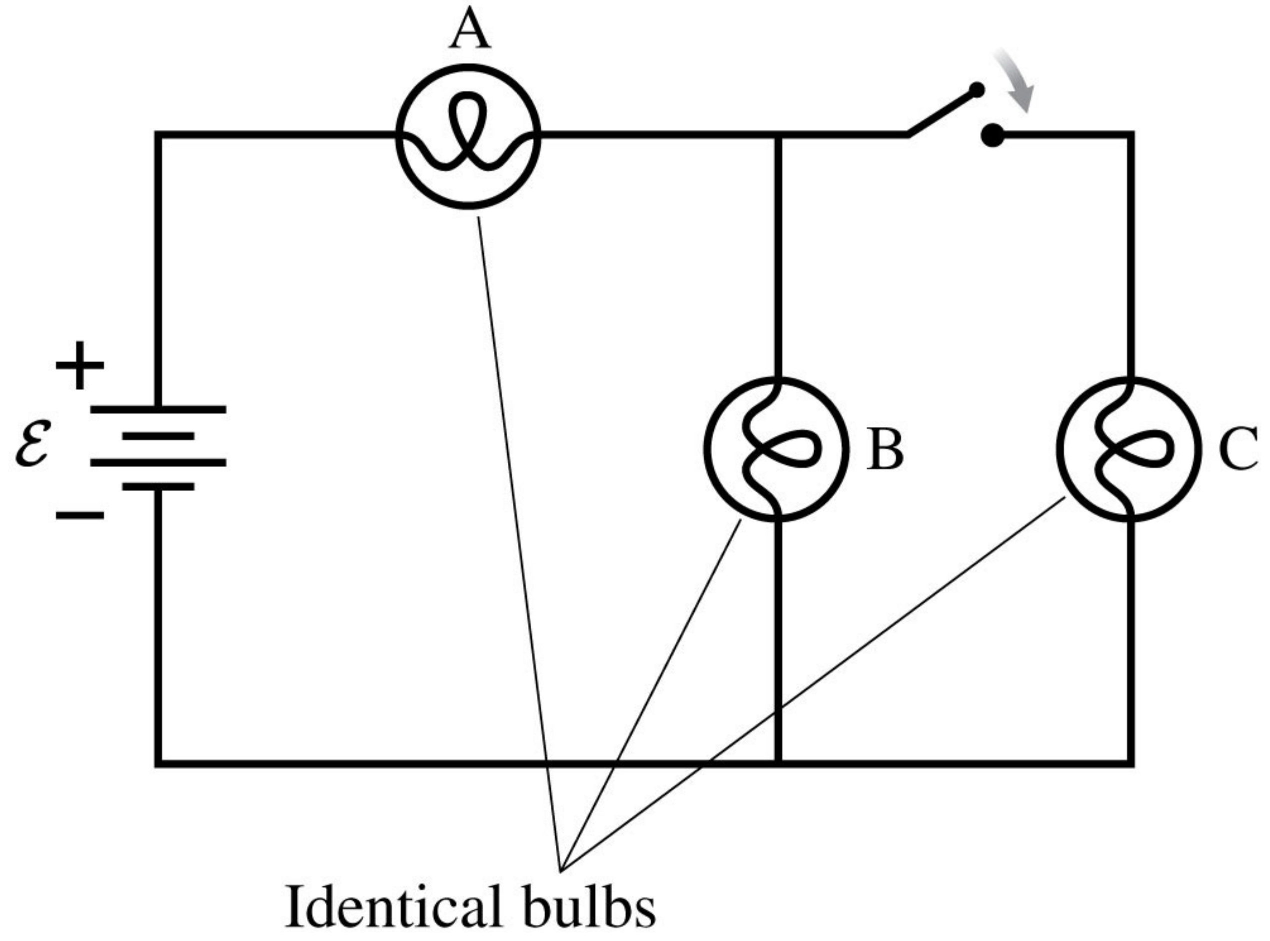
A. The 100 W bulb.
B. The 60 W bulb.
C. Their brightnesses are the same.





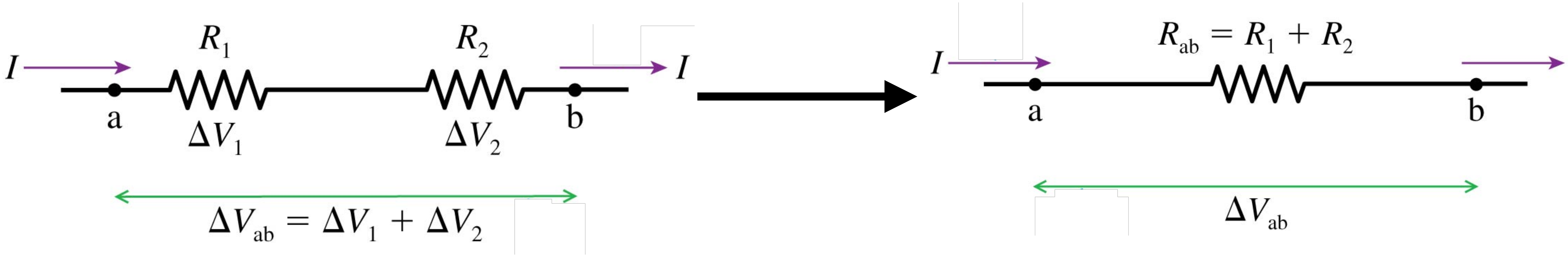
What will happen to the brightness of the bulbs when the switch is closed

What happens to the brightness of the bulbs when the switch closes?



Series Resistors

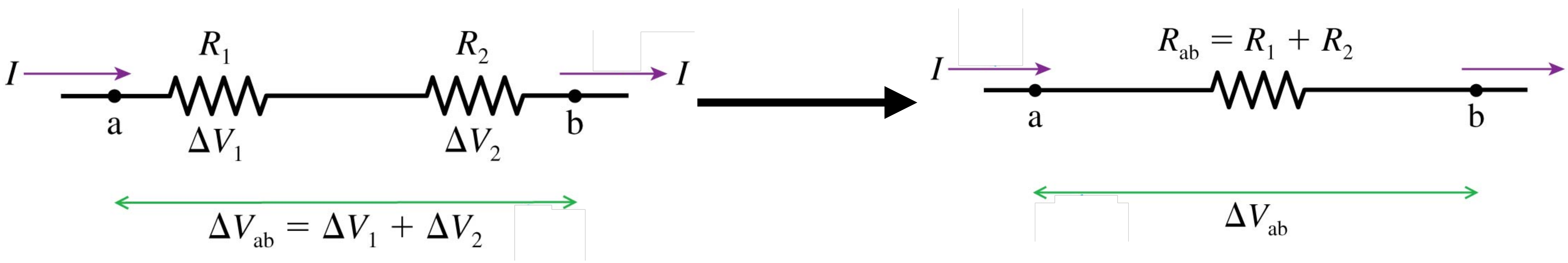
Write the potential difference between a and b



Series Resistors

$$\Delta V_{ab} = \Delta V_1 + \Delta V_2 = IR_1 + IR_2 = I(R_1 + R_2)$$

Write the potential difference between a and b



Series Resistors

$$\Delta V_{ab} = \Delta V_1 + \Delta V_2 = IR_1 + IR_2 = I(R_1 + R_2)$$

$$R_{ab} = \frac{\Delta V_{ab}}{I} = \frac{I(R_1 + R_2)}{I} = R_1 + R_2$$

Write the potential difference between a and b