Module 13: Batteries and Circuit Elements

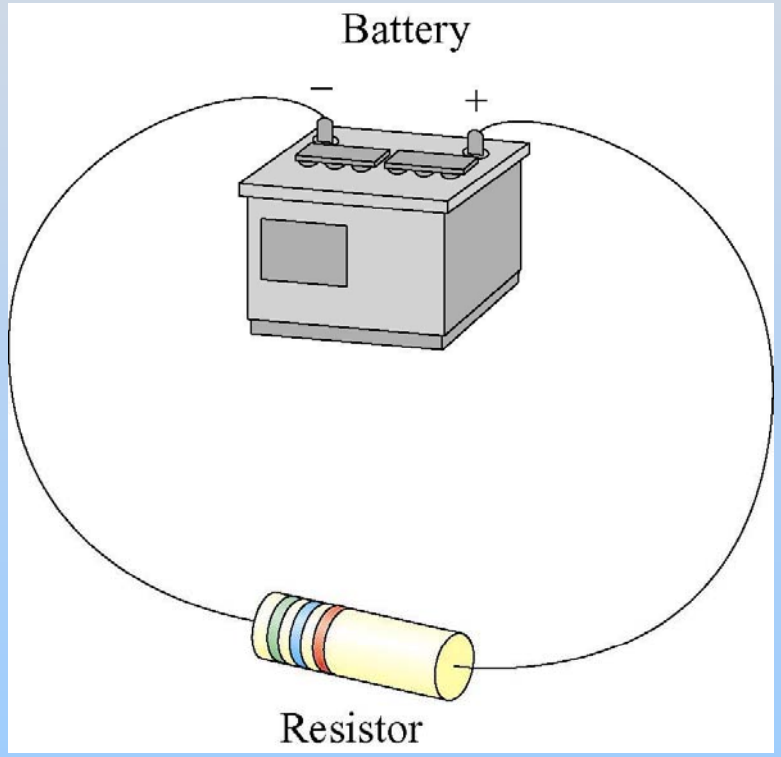
Class 13: Outline

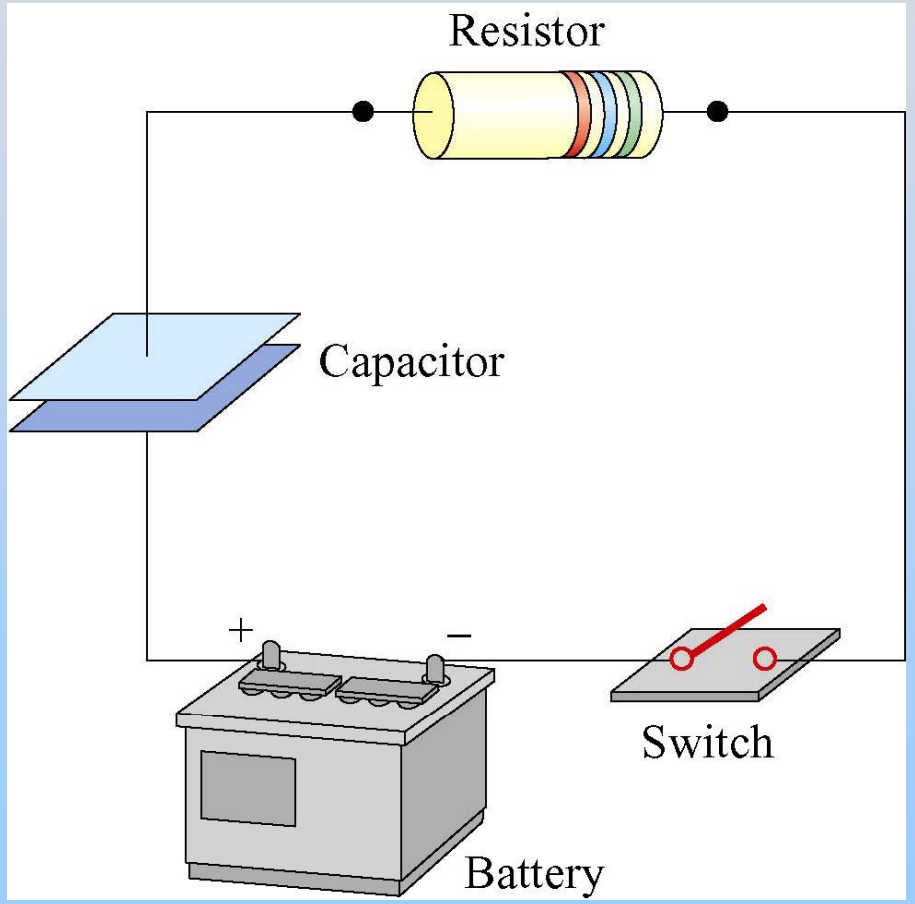
DC Circuits and Kirchhoff's Loop Rules

Batteries & Elementary Circuits

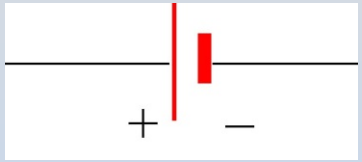
DC Circuits

Examples of Circuits

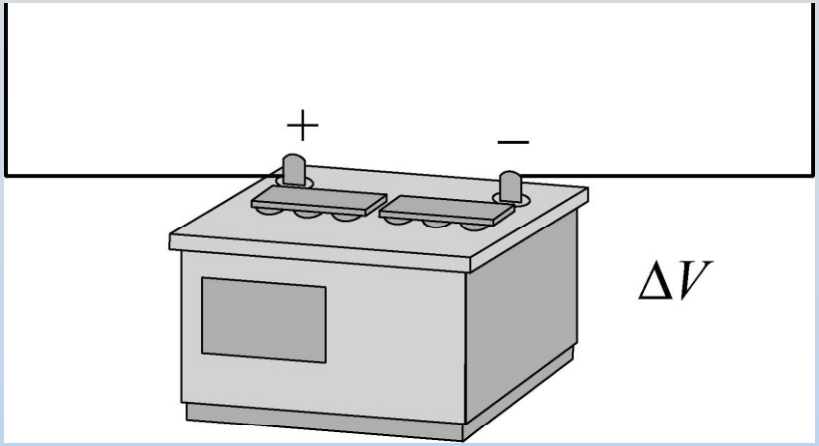


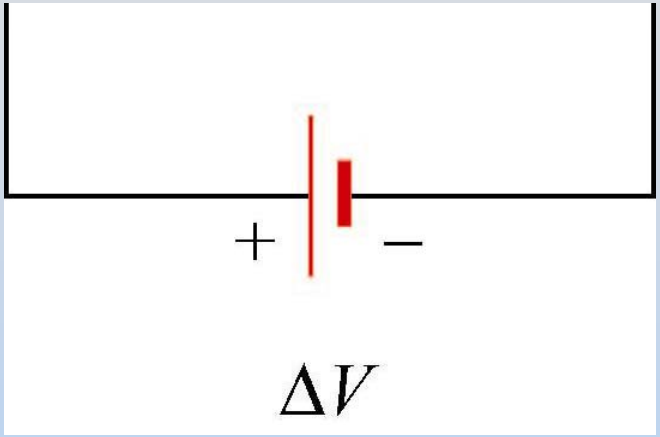


Symbols for Circuit Elements

Battery	
Resistor	
Capacitor	
Switch	

Ideal Battery





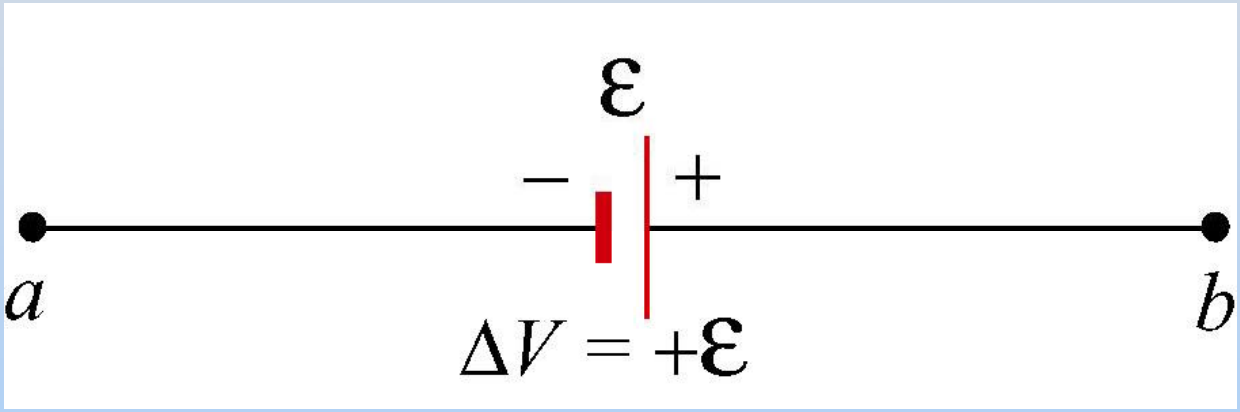
Fixes potential difference between its terminals

Sources as much charge as necessary to do so

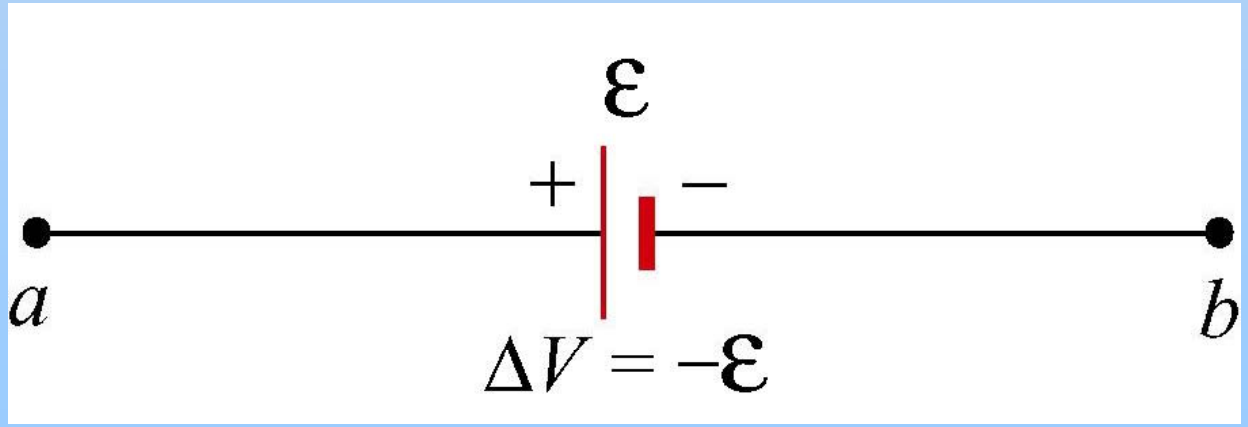
Think: Makes a mountain

Sign Conventions - Battery

Moving from the negative to positive terminal of a battery **increases** your potential



$$\Delta V = V_b - V_a$$

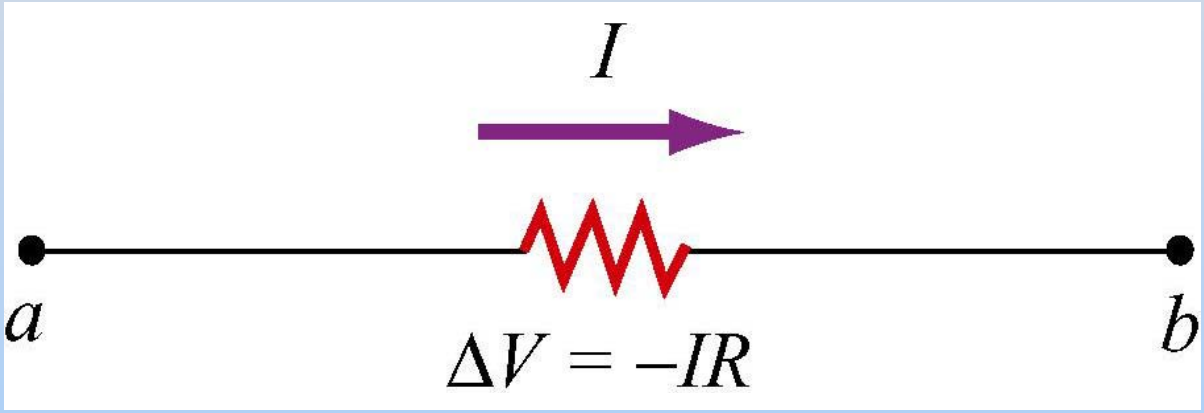


Think:

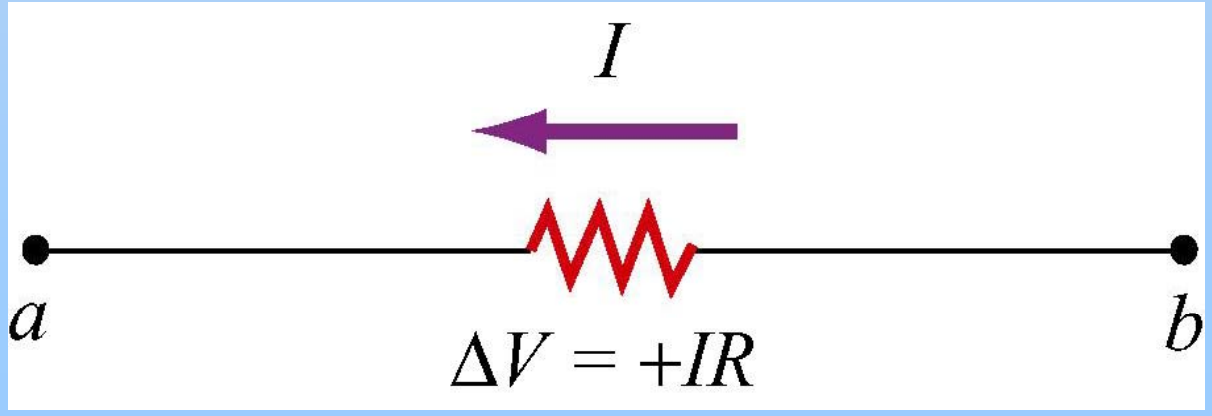
Ski Lift

Sign Conventions - Resistor

Moving across a resistor in the direction of current **decreases** your potential



$$\Delta V = V_b - V_a$$

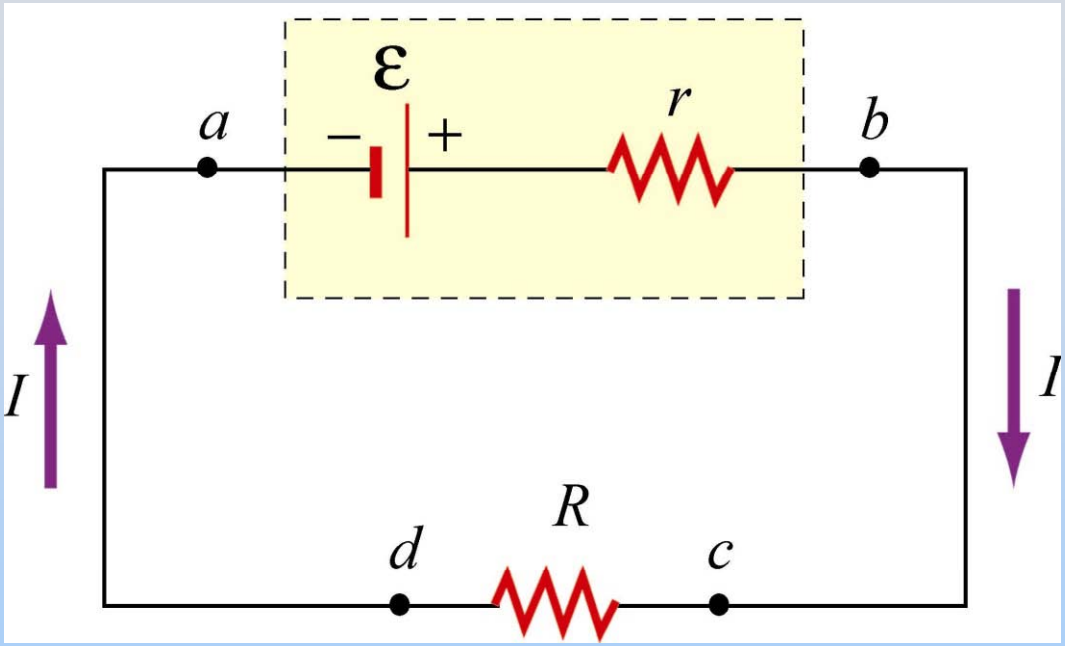


Think:

Ski Slope

Internal Resistance

Real batteries have an internal resistance, r, which is small but non-zero



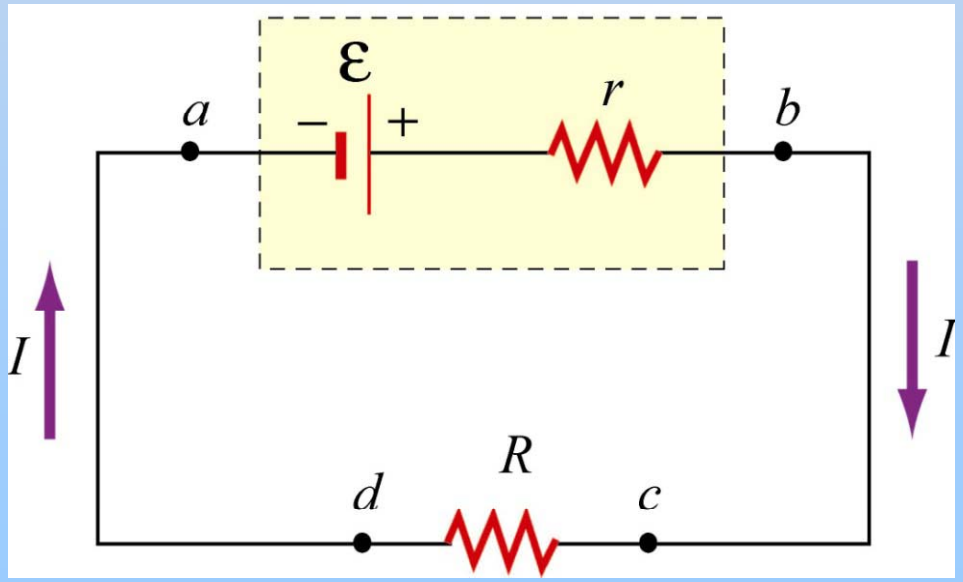
Terminal voltage: $\Delta V = V_b - V_a = \mathcal{E} - I r$

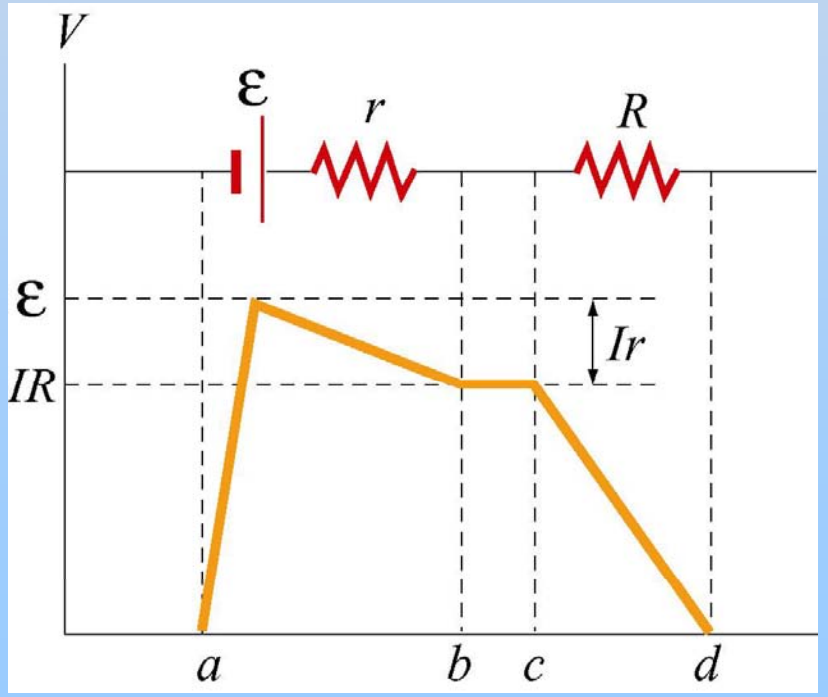
(Even if you short the leads you don't get infinite current)

Potential Difference Around a Closed Path

Sum of potential differences across all elements around any closed circuit loop must be zero.

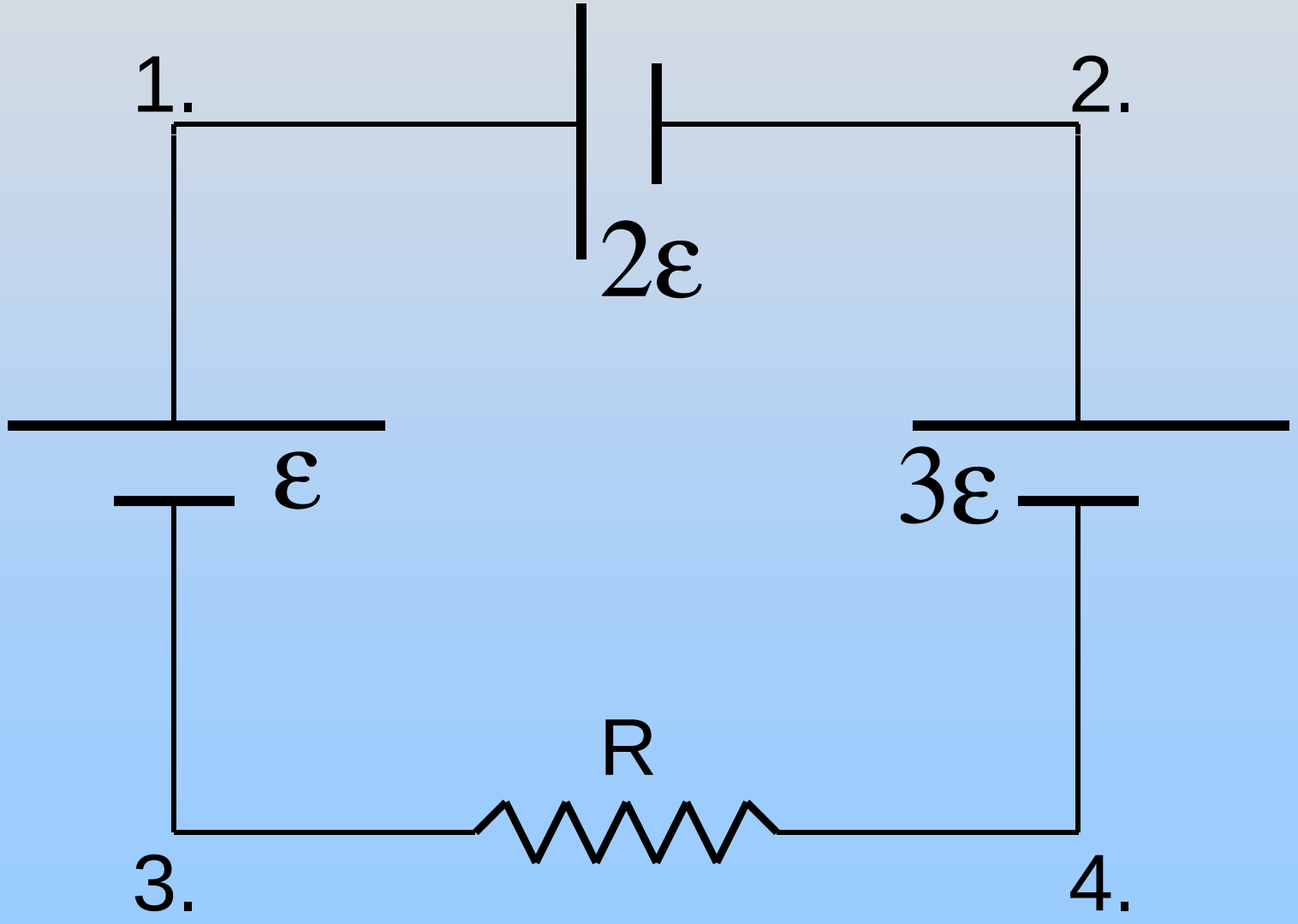
$$\Delta V = -\oint_{\text{Closed Path}} \vec{\mathbf{E}} \cdot d\vec{\mathbf{s}} = 0$$





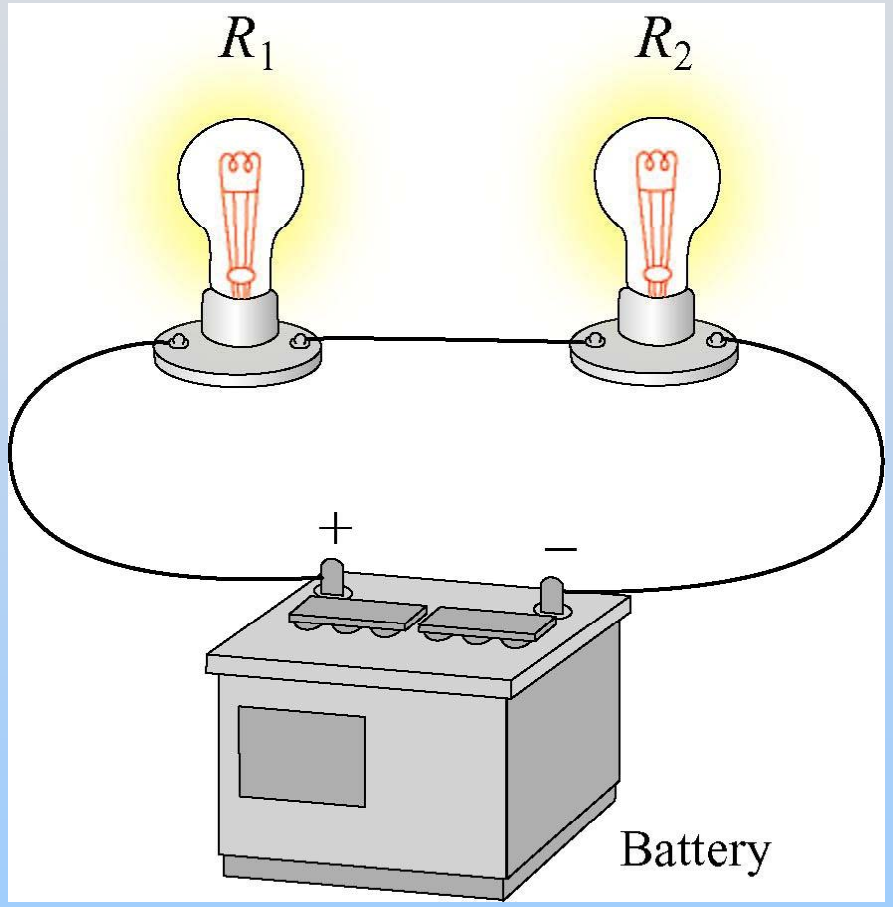
Concept Question: Potential in Circuits

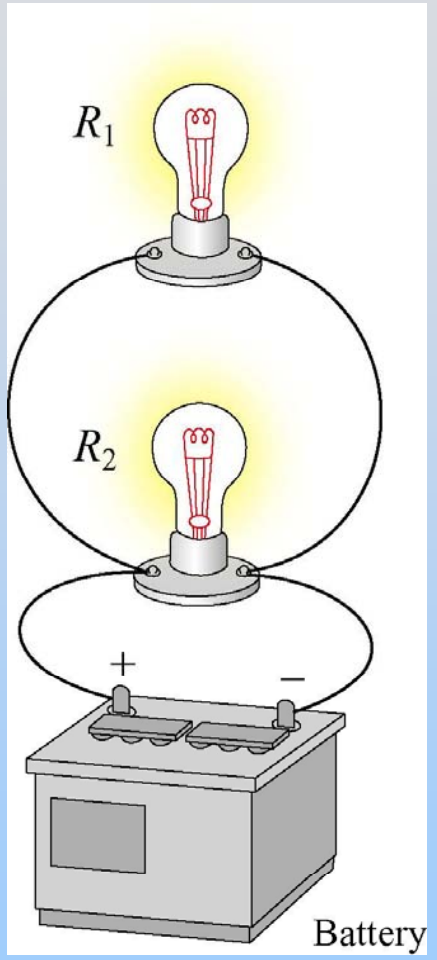
Where is the potential the highest in the below circuit?



1. 1
2. 2
3. 3
4. 4

Series vs. Parallel



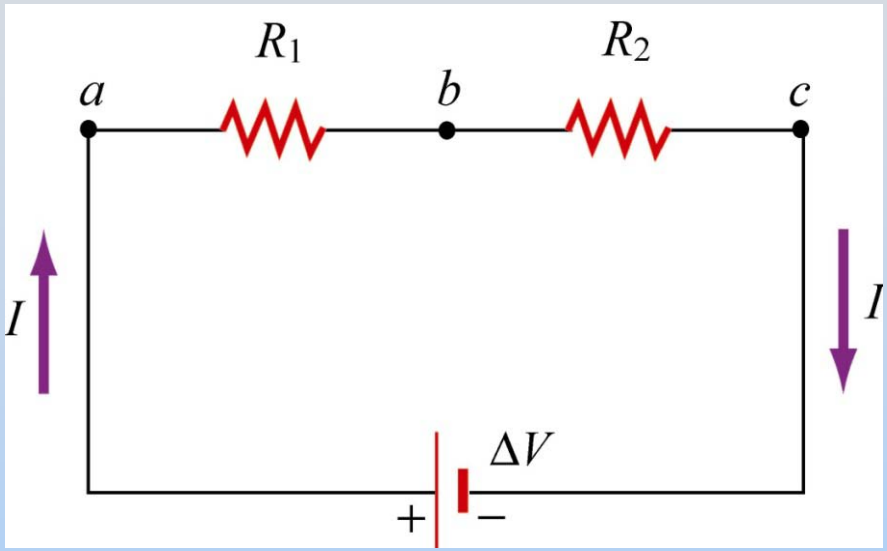


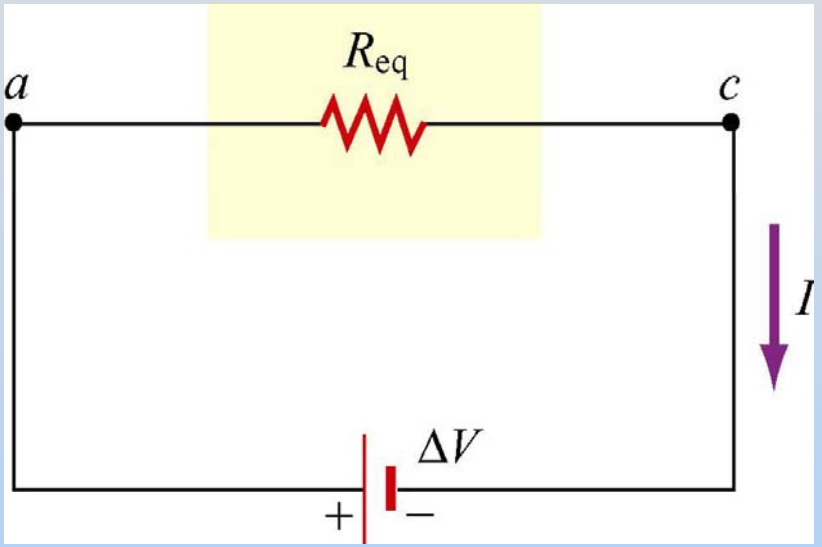
Series

Parallel

Resistors In Series

The same current *I* must flow through both resistors



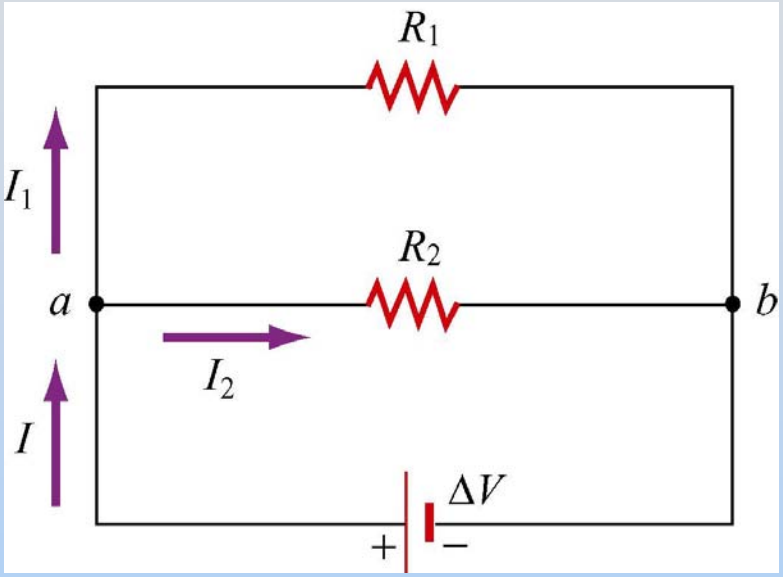


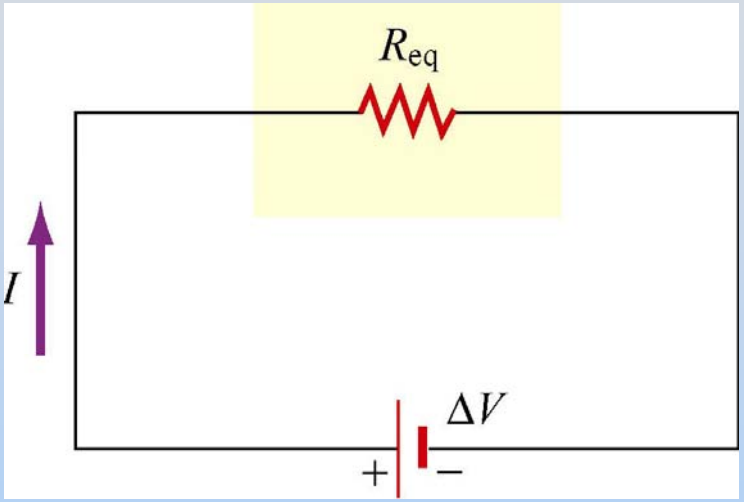
$$\Delta V = I R_1 + I R_2 = I(R_1 + R_2) = I R_{eq}$$

$$\boxed{R_{eq} = R_1 + R_2}$$

Resistors In Parallel

Voltage drop across the resistors must be the same



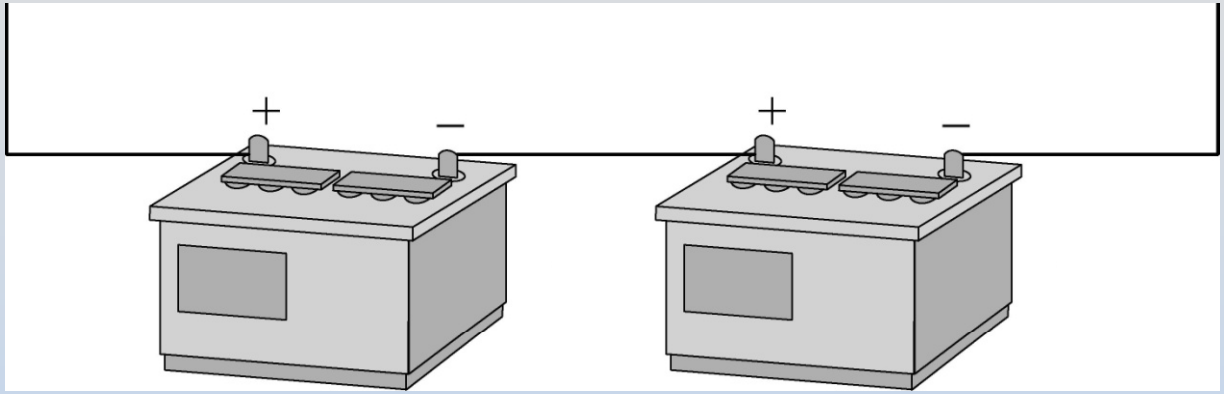


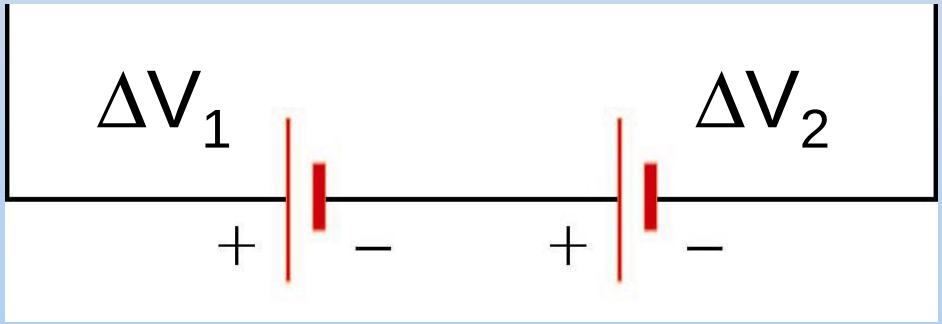
$$\Delta V = \Delta V_1 = \Delta V_2 = I_1 R_1 = I_2 R_2 = I R_{eq}$$

$$I = I_1 + I_2 = \frac{\Delta V}{R_1} + \frac{\Delta V}{R_2} = \frac{\Delta V}{R_{eq}}$$

$$\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}}$$

Batteries in Series

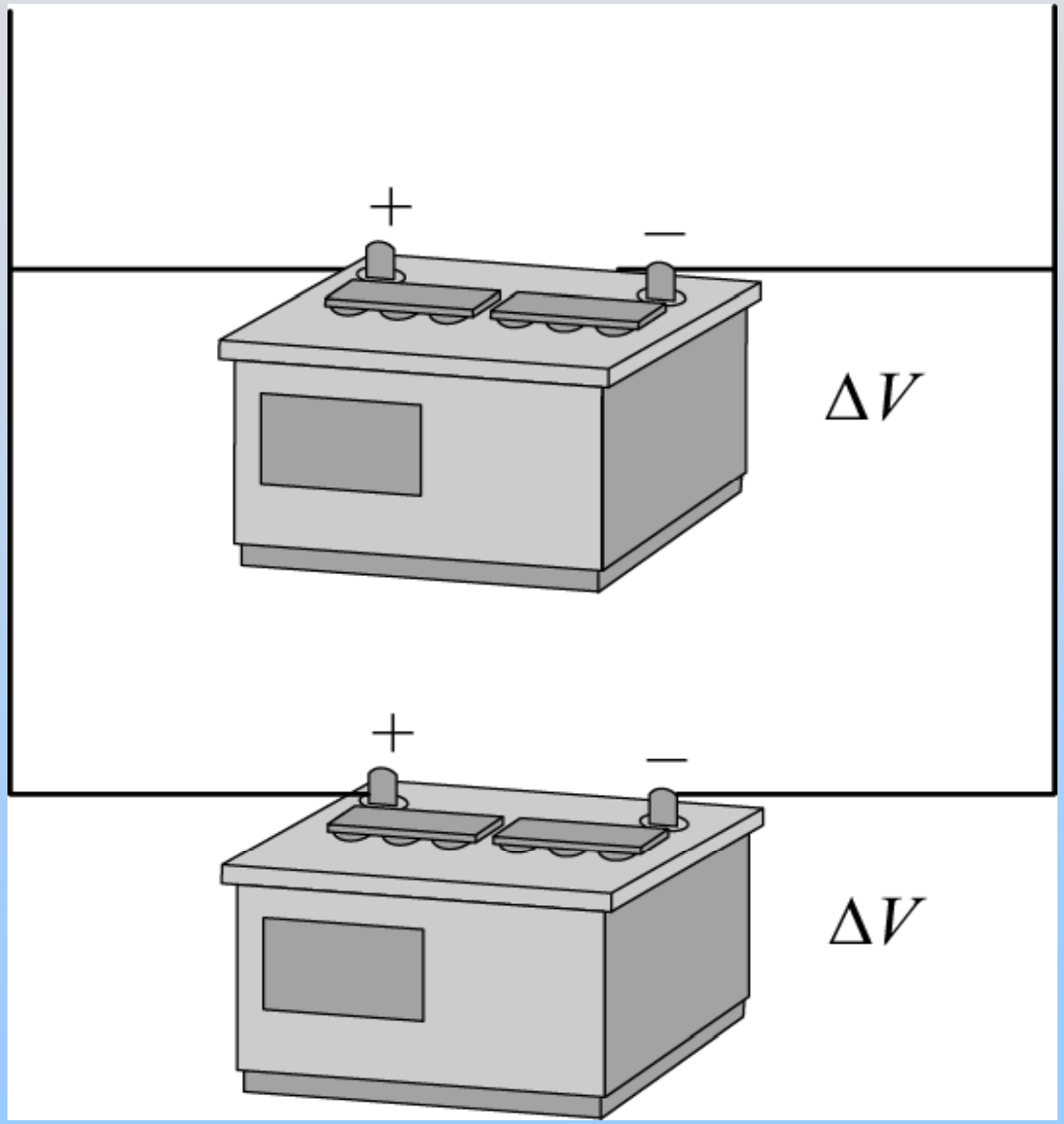




Net voltage change is $\Delta V = \Delta V_1 + \Delta V_2$

Think: Two Mountains Stacked

Batteries in Parallel

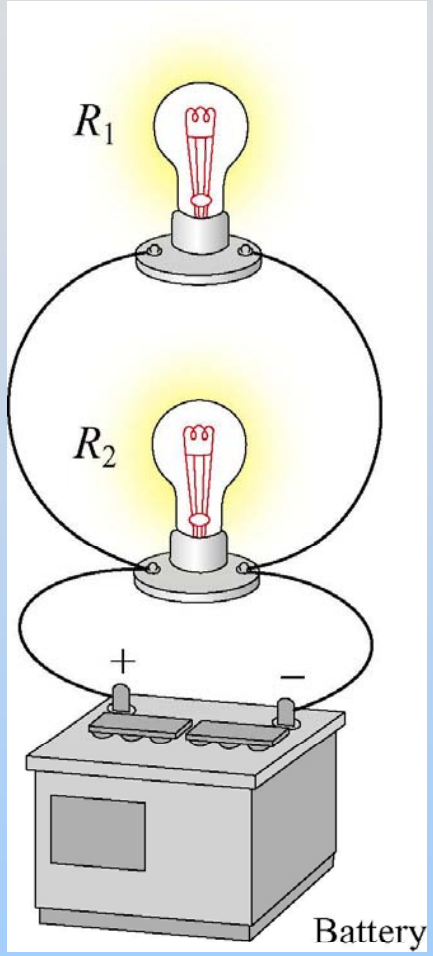


Net voltage still ΔV

Concept Question Questions: Two Light Bulbs

Concept Question: Bulbs & Batteries

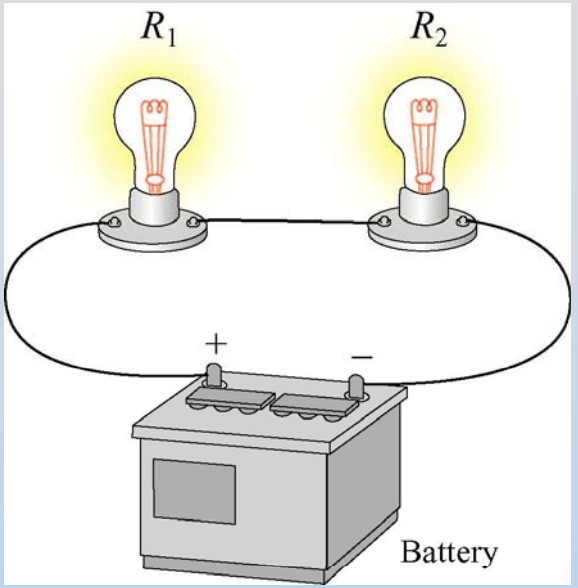
An ideal battery is hooked to a light bulb with wires. A second identical light bulb is connected in parallel to the first light bulb. After the second light bulb is connected, the current from the battery compared to when only one bulb was connected.



1. Is Higher
2. Is Lower
3. Is The Same
4. Don’t know

Concept Question: Bulbs & Batteries

An ideal battery is hooked to a light bulb with wires. A second identical light bulb is connected in series with the first light bulb. After the second light bulb is connected, the current from the battery compared to when only one bulb was connected.



1. Is Higher
2. Is Lower
3. Is The Same
4. Don’t know

8.02SC Physics II: Electricity and Magnetism

Fall 2010