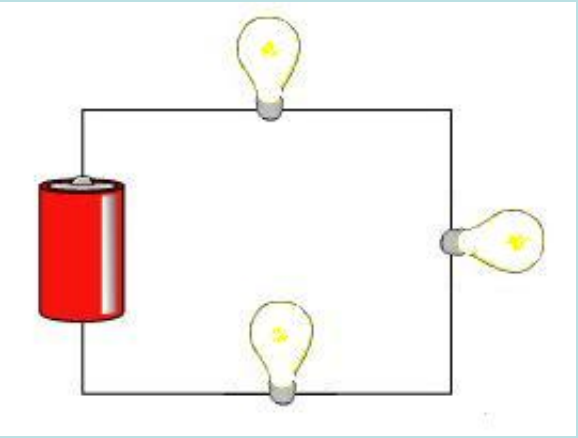
Series and Parallel

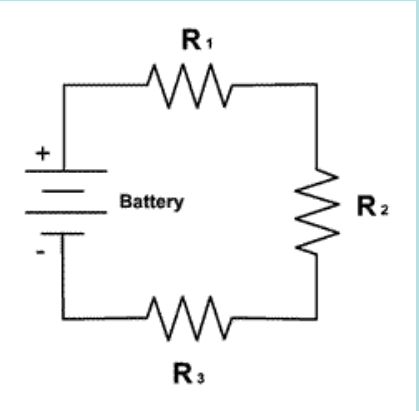
How we wire the world

Series vs Parallel Circuits

Series Circuit

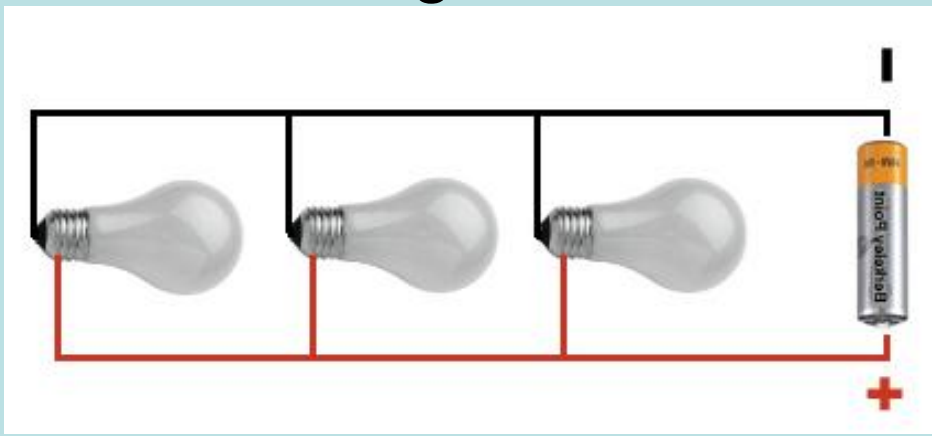
- Electrons only have one path to flow through.

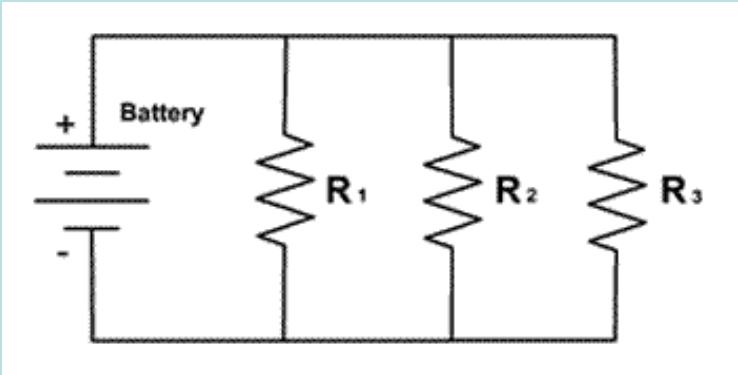




Parallel Circuit

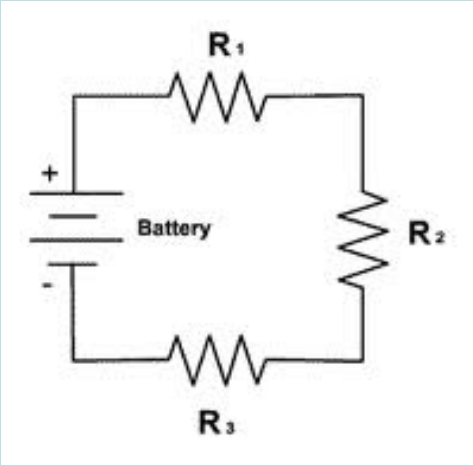
- There are MULTIPLE paths for the current to flow through.





Series Circuit

- When electrons have to flow through one part to get to the next part

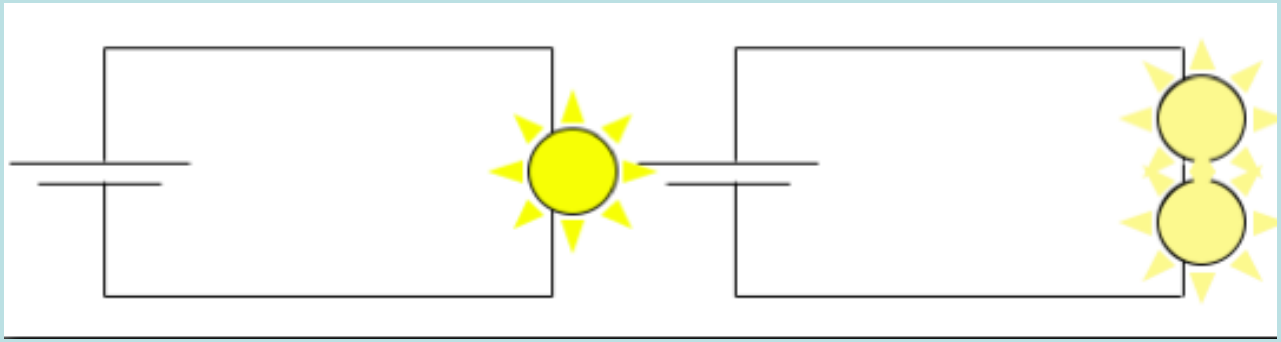


  - More components = more resistance
  - Increase resistance = decrease current (flow)
  - Less current = less bright bulbs
  - As voltage increases, current increases

Series Circuit – Pros & Cons

<u>Problems with Series</u>:

- The more devices (resistors) in a series circuit, the less current passes through (dimmer bulbs).



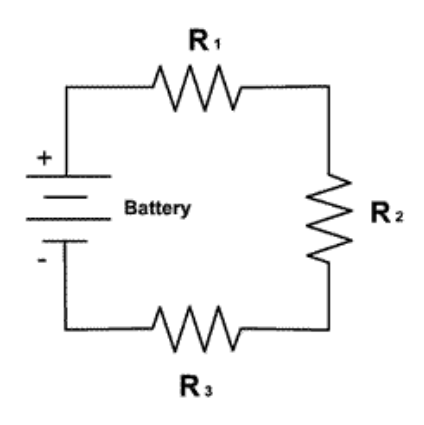
- If one resistor breaks (a bulb goes out) the entire series is turned off.

Series Circuit - Resistance

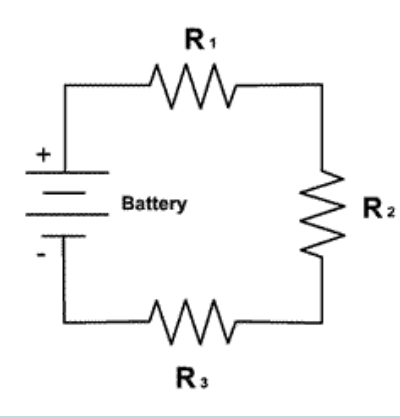
- Resistors – resists the flow of electrical current
- Increased resistance will reduce the rate at which charge flows (aka current)

- Total resistance goes UP with each resistor since the current has must go through each resistor.
- Total Resistance = Sum of all resistors in the series

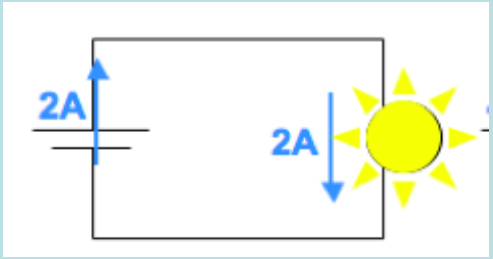
$$R_{eq} = R_1 + R_2 + R_3 \ldots$$



Series Circuit - Current



- Current = amount of charge (flow of electrons)
  - Like the flow of water
- A current can't just disappear (appear)
  - Since only one path if some electrons flow through R1, then they have to continue flowing through R2 and R3.



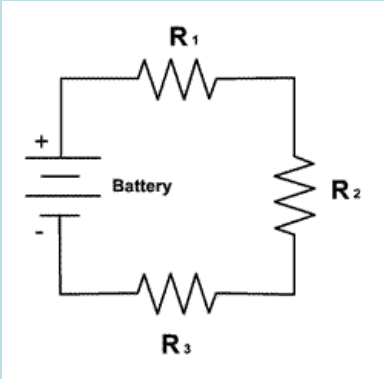
  - Since the Current is the same through the entire circuit $I_T=I_1=I_2=I_3$

Series Circuit - Voltage

- Voltage is the electric equivalent of water pressure.
  - The higher the voltage, the faster electrons will flow through the conductor.
- Each component has resistance that causes a drop in voltage (reduction in voltage).

- Total Voltage = The sum of voltages across each series resistors

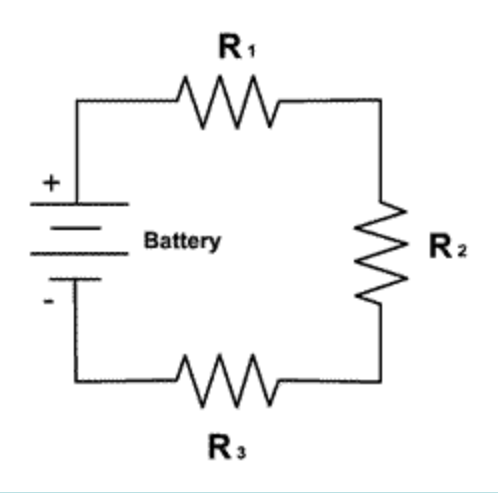
$$V_T = V_1 + V_2 + V_3...$$



Series vs Parallel Chart

	Series	Parallel
Voltage (V)	$V_{tot} = V_1 + V_2 + V_3\ldots$	
Current (I)	$I_{tot}=I_1=I_2=I_3$	
Resistance (R)	$R_{eq} = R_1+R_2+ R_3\ldots$	

Series Circuit - Example



- Given
  - $V_{battery}$ = 12 V
  - R_1 = 50 Ω, R_2 = 100 Ω, R_3 = 100 Ω
- **Complete the following table**

	V	=	I	R
1				
2				
3				
---	---	---	---	---
T				

Parallel Circuit – Pros and Cons

Advantages

- The more devices (resistors) in a parallel circuit, does not decrease the current (does not dim bulbs).
- If one resistor breaks (a bulb goes out) the rest do not.

Problems

- Current doesn't stay the same for entire circuit
  - So energy is used up quicker
  - So the total current increases = faster electrons = hotter wire = fire?

Which is better? Series or Parallel?

Parallel

- Most things are wired in parallel
- Because of the fact that the more you plug in, the intensity doesn't decrease.
- Of course, this also increases the risk of fire
- This is why homes have fuses or circuit breakers. They turn off everything in the circuit when current moves too fast.

Toll Booth Explanation

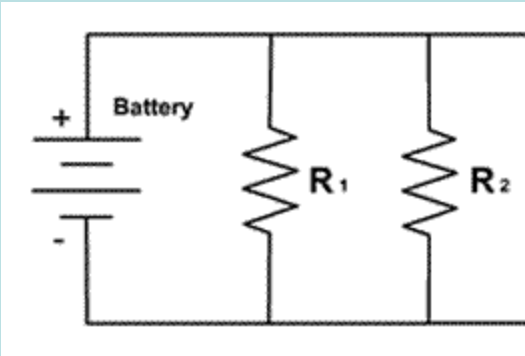
- Adding toll booths in series increases resistance and slows the current flow.
- Adding toll booths in parallel lowers resistance and increases the current flow.

Parallel Circuit - Resistance

- Resistors added side-by-side
- The more paths, the less TOTAL resistance.

$$1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3$$

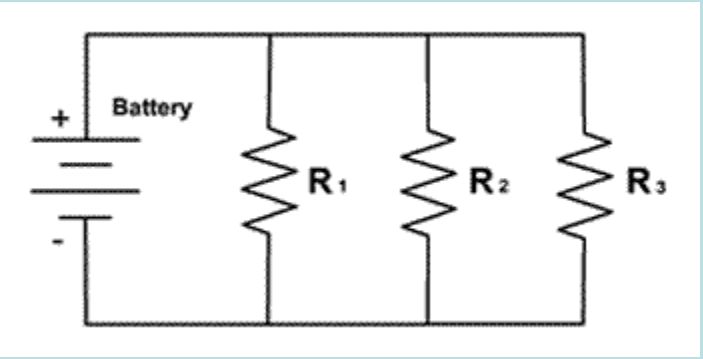
- Ex. 2 resistors in parallel with 4Ω each.
  - Since the circuit offers two *equal* pathways for charge flow, only 1/2 the charge will *choose* to pass through a given branch.

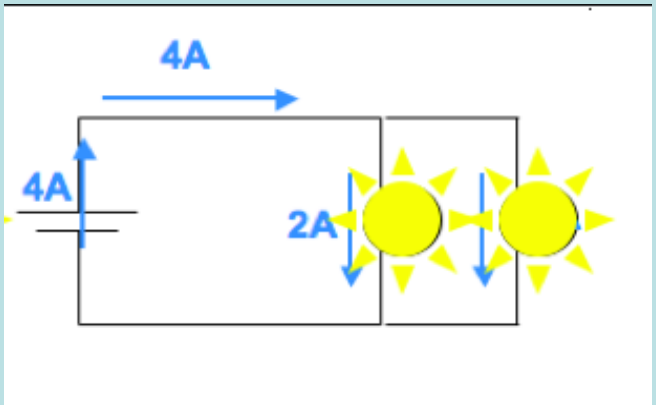


Parallel Circuit - Current

- ALL paths are used!
  - But the charge *divides* up into all branches
  - One branch can have more current than another branch (depends on resistance in branch).
- Total current = sum of current in each path

$$I_T = I_1 + I_2 + \ldots$$

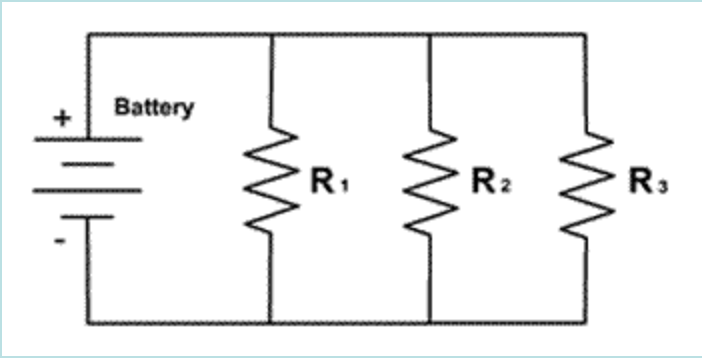




Parallel Circuit - Voltage

- A charge only passes through a single resistor.
- Voltage drop across the resistor that it *chooses* to pass through must equal the voltage of the battery.
- Total voltage = the voltage across each individual resistor

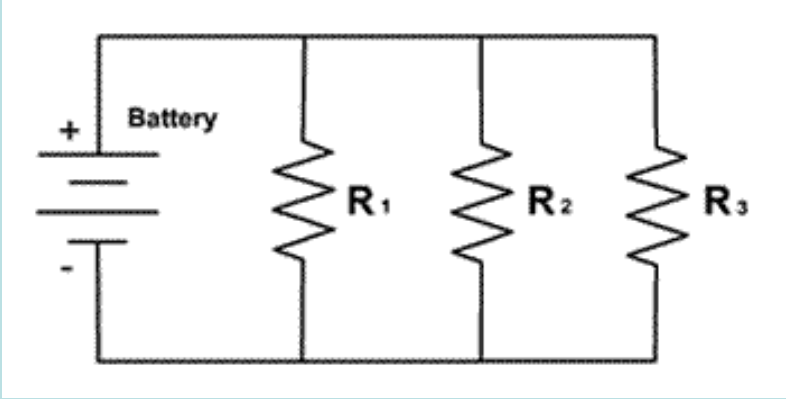
$$V_T = V_1 = V_2 = \ldots$$



Series vs Parallel Chart

	Series	Parallel
Voltage (V)	$V_{tot} = V_1 + V_2 + V_3 \ldots$	$V_{tot} = V_1 = V_2 = \ldots$
Current (I)	$I_{tot} = I_1 = I_2 = I_3$	$I_{tot} = I_1 + I_2 + \ldots$
Resistance (R)	$R_{eq} = R_1 + R_2 + R_3 \ldots$	$1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3$

Parallel Circuit - Example



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Two Types of Current

- DC—Direct Current
  - produced by solar cells and chemical cells (batteries)
  - Current only flows in one direction.
- AC—Alternating Current
  - Current flows back and forth (alternates)
  - Found in homes
  - Generators produce AC current