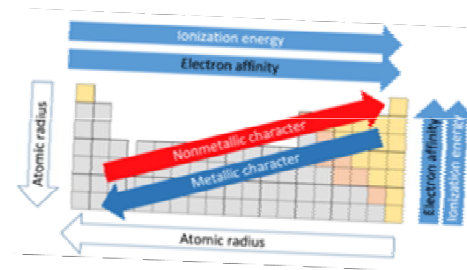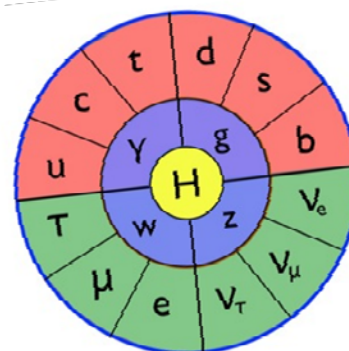# SPS Presents: A Cosmic Lunch!

- Who: Dr. Brown will be speaking about "Evolution of the Elements: from Periodic table to Standard Model and Beyond"!

- When: October 17th at 11am

- Where: CP-179 (by the front office)

- There will be pizza and soft drinks!

Particles of the Standard Model

Resistors in series and parallel

Why so similar, but yet so opposite?

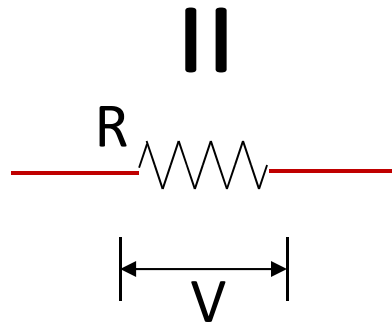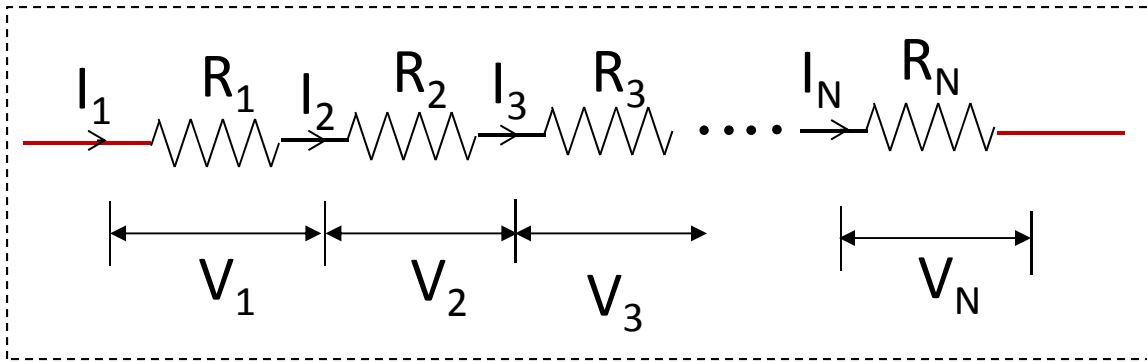The formula for capacitors and resistors in parallel and series are oppositely switched:

	Resistors	Capacitors
In series	$R_{eff} = R_1 + R_2 + \cdots R_N$	$\dfrac{1}{C_{eff}} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \cdots \dfrac{1}{C_N}$
In parallel	$\dfrac{1}{R_{eff}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \cdots \dfrac{1}{R_N}$	$C_{eff} = C_1 + C_2 + \cdots C_N$

$$R = \frac{V}{I} \qquad\qquad C = \frac{Q}{V}$$

The formula will looks the same if we use conductance G=I / V instead of R.

Connecting Resistors in Series

$$R_{eff} = R_1 + R_2 + R_3 + \cdots + R_N$$
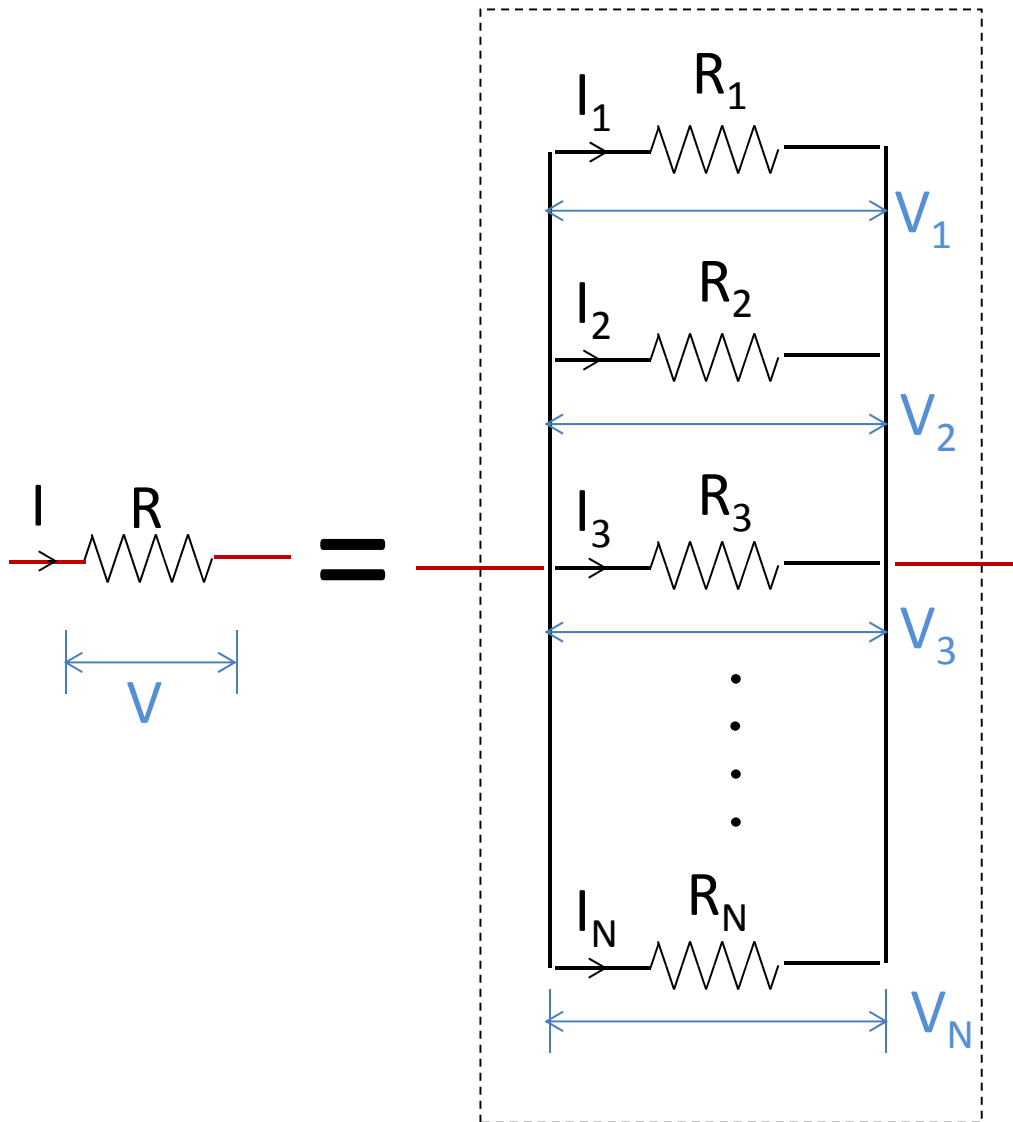
$$I = I_1 = I_2 = I_3 = \cdots = I_N$$

$$V = V_1 + V_2 + V_3 + \cdots + V_N$$

1. Current through each individual resistor is the same: (why?)

$$I = I_1 = I_2 = I_3 = \cdots = I_N$$

$$\Rightarrow \frac{V}{R} = \frac{V_1}{R_1} = \frac{V_2}{R_2} = \frac{V_3}{R_3} = \cdots = \frac{V_N}{R_N}$$

2. Potential difference across each individual resistor should be different (unless they have the same resistance).

Connecting Resistors in Parallel

$$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots \frac{1}{R_N}$$

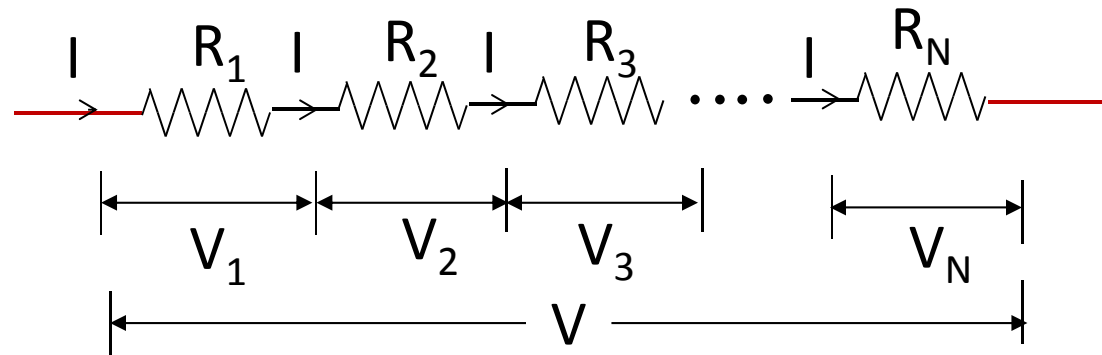$$I = I_1 + I_2 + I_3 + \cdots I_N$$

$$V = V_1 = V_2 = V_3 = \cdots V_N$$

1. Potential difference across each individual resistor is the same: (why?)

$$V = V_1 = V_2 = V_3 = \cdots V_N$$

$$\Rightarrow I_1 R_1 = I_2 R_2 = I_3 R_3 = \cdots I_N R_N$$

2. Current through each individual resistor should be different (unless they have the same resistance).

Voltage Divider

Current through each individual resistor is the same

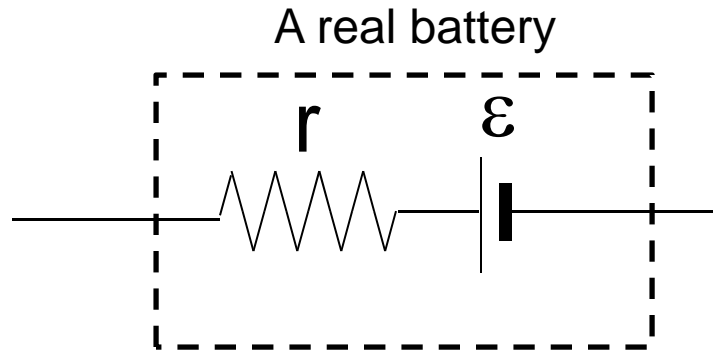$$\frac{V_1}{R_1} = \frac{V_2}{R_2} = \cdots \frac{V_N}{R_N} = \frac{V}{R_{eff}}$$

or $\boxed{V_1 = V \cdot \dfrac{R_1}{R_1 + R_2 + \cdots R_N}}$
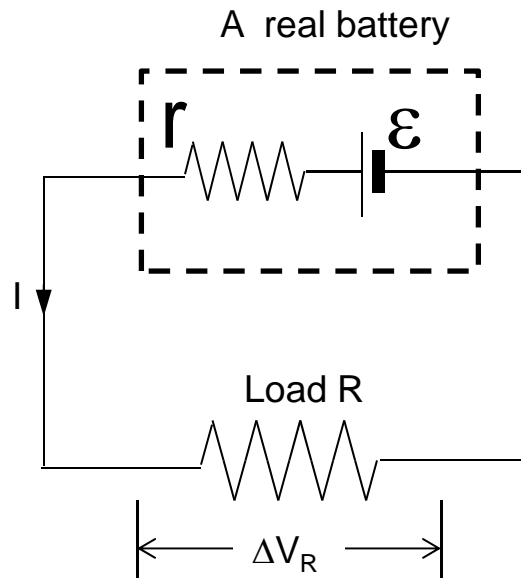
and similar for other resistors

Series resistors divide and share the <u>voltage</u> "proportionally". (Larger R get the bigger share)

Class 23 Electromotive force
and internal resistance

Electromotive Force and Internal Resistance

A real battery

When connected externally:

A real battery

Electromotive force (emf ε) is the work done by a battery in moving a unit charge from one terminal to the other. It equals to the maximum possible voltage the battery can provide between its terminal. You can think it like the voltage of an ideal battery with no internal resistance.

$$I = \frac{\varepsilon}{R + r}$$

$$\Delta V_R = IR = \frac{\varepsilon R}{R + r}$$

Voltage across the load resistance R will drop if more current is drawn from the battery (by making R smaller).
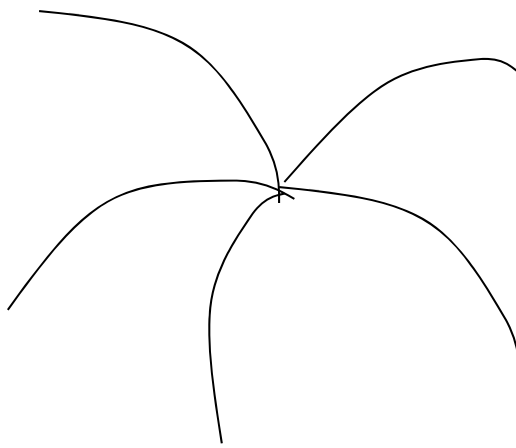
Kirchhoff's Rules

About Kirchhoff's Rules

1. There are two Kirchhoff rules – Kirchhoff's current rule (junction rule) and Kirchhoff's voltage rule (loop rule).

2. More complex circuits cannot be broken down into parallel and series units. The two Kirchhoff's rules allow us to solve for any circuits, no matter how complex it is (at least theoretically).

Kirchhoff's Current Rule (Junction Rule)

Kirchhoff's current rule is a result of conservation of charges:

At any junction, the sum of currents must equal zero.

$$\sum_{junction} I = 0$$

Junction formed by twisting many wires together.

Kirchhoff's Voltage Rule

Kirchhoff's voltage rule is a result of conservation of energy:

The sum of the potential differences across all elements around any closed circuit loop must be zero.

$$\sum_{closed\ loop} \Delta V = 0$$

Conservation of energy:
Work done by battery = Energy stored in conservative elements (e.g. capacitors) + Energy dissipated by resistive elements (e.g. resistors)

Kirchhoff's Voltage Rule – sign convention

1. Use only currents as unknown variables. ΔV can always be written in terms of currents or derivatives or integrals of currents.

2. Assign current direction to every path in a circuit. Apply Kirchhoff's current rule as much as you can to reduced the number of unknown variables.

3. Across every component in the circuit determine which end has a higher potential (mark it with a + sign) and which end has a lower potential (mark it with a - sign). This will depend on the current direction you assume in step 2.

4. Pick up a loop and travel around it either clockwise or anticlockwise. If you travel from – to + across a component, then ΔV across the component is positive. If you travel from + to – across a component, then ΔV across the component is negative. You can reverse this convention as long as you do it consistently for the whole loop.

5. If you get a negative current, that means the current direction you assume in step 2 is wrong and you should reverse that direction.