Introduction to Robotics
Course no. 1

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About the course: details

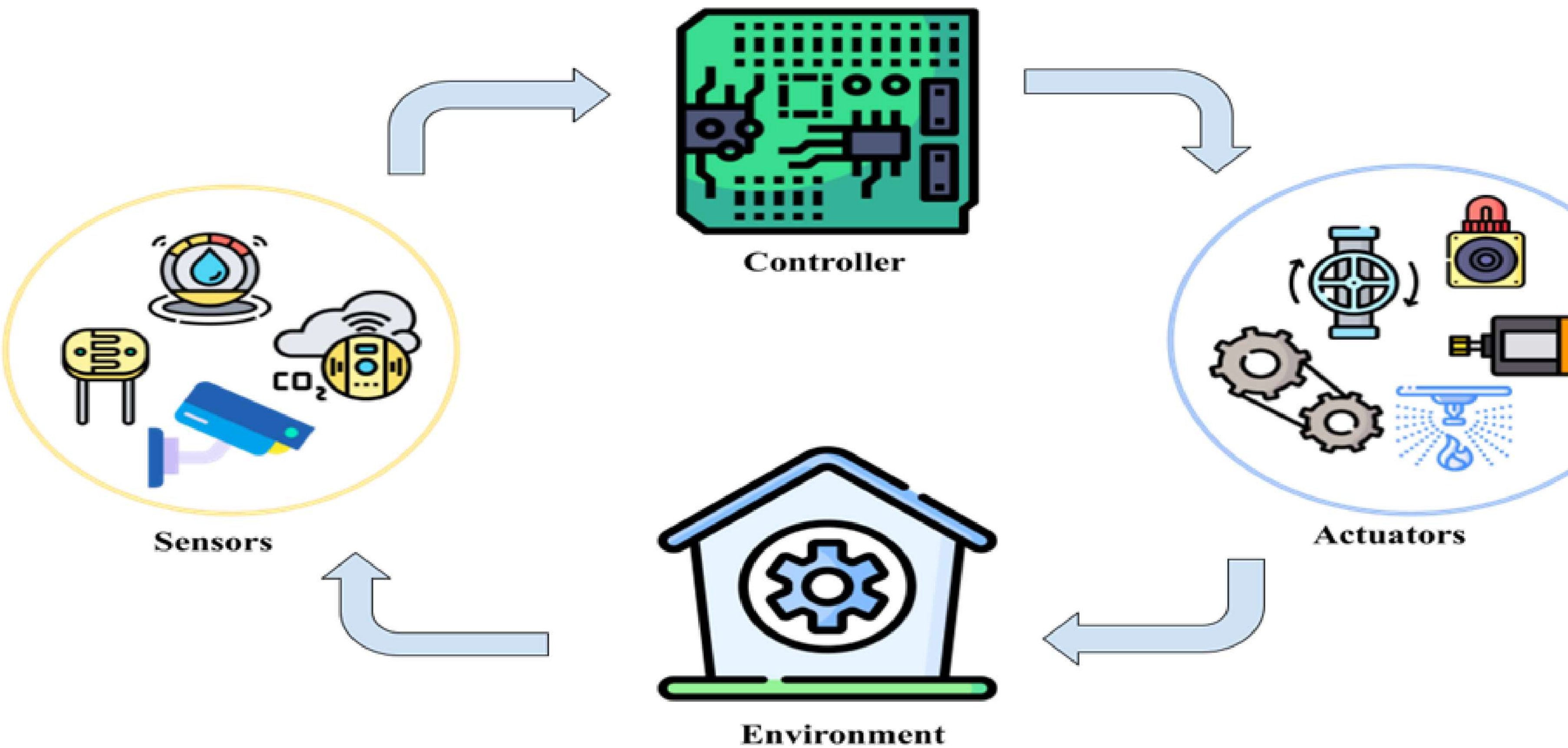
- Grading:
  - 1p laboratory, course and/or relevant extra-curricular activity
  - 4p weekly homeworks
  - 2.5p project 1: matrix game (bomberman, tetris etc)
  - 2.5p project 2: line follower
  - 1p: bonus (activities and/or anything extra on the ones above)
  - Total: 11p

Today’s agenda

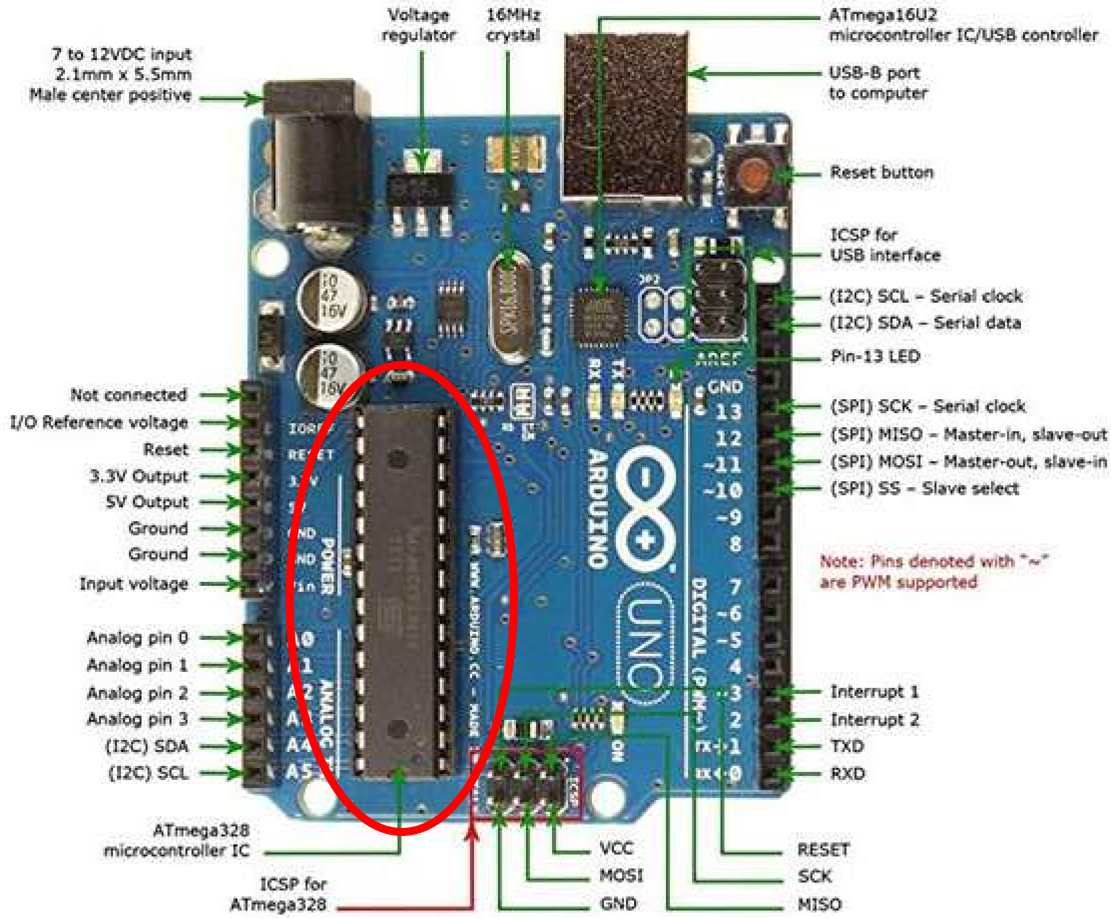
- Arduino - what is it?
- Electrical Current
  - Voltage, Current and Resistance
  - AC vs DC
- Electric components
  - Voltage Source
  - Resistors
  - Capacitors
  - Diodes
- Ohm’s law
- Reading a datasheet

Sense. Analyse. Act.

Sense. Analyse. Act.



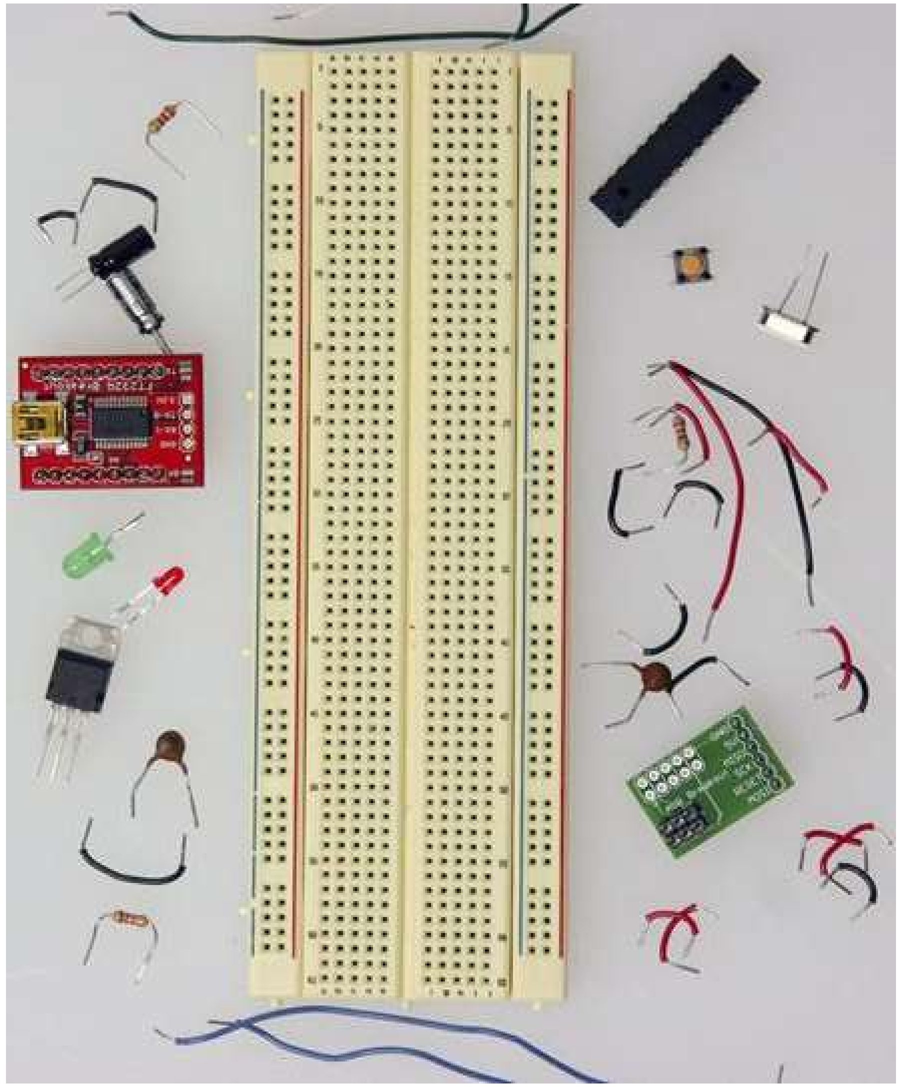
Arduino Uno board

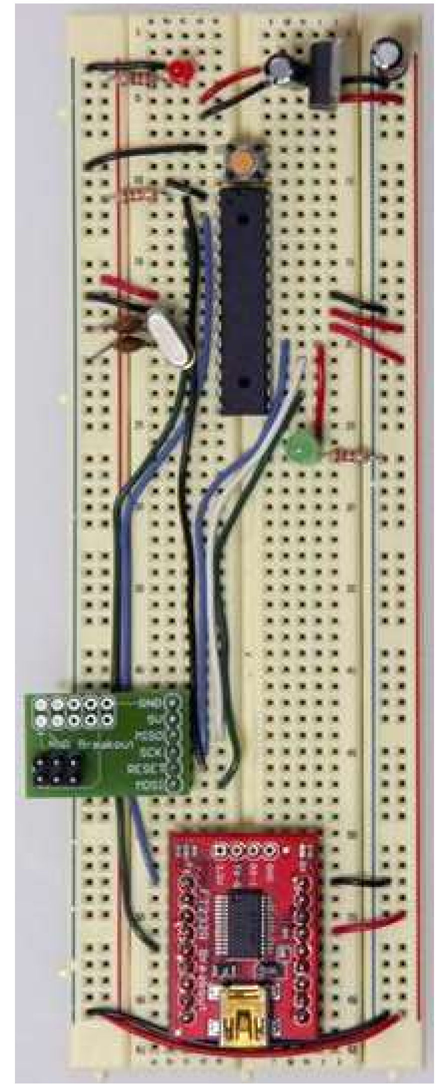


Arduino Uno board on a breadboard

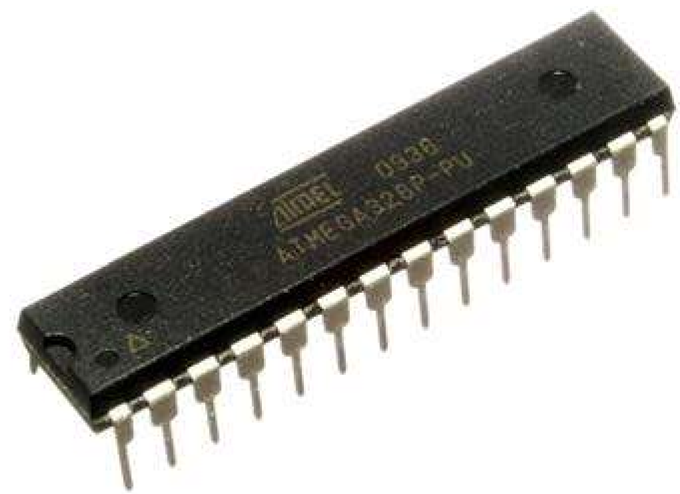
https://www.arduino.cc/en/main/standalone

https://www.sciencebuddies.org/science-fair-projects/references/how-to-use-a-breadboard





This is a microcontroller (AVR ATmega328)



But what’s a microcontroller?

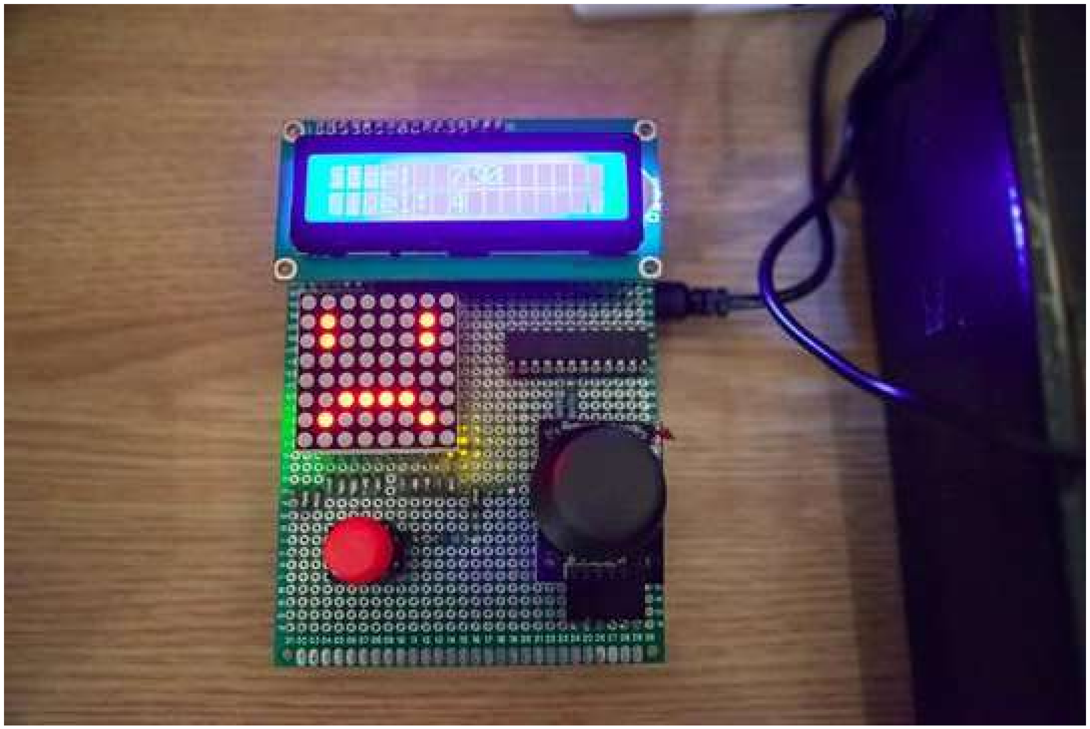
- An integrated circuit
- Basically a tiny computer
- Can run small, simple software programs
- Low power enough to be run on simple batteries for days
- Fast enough to process data efficiently
- A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip

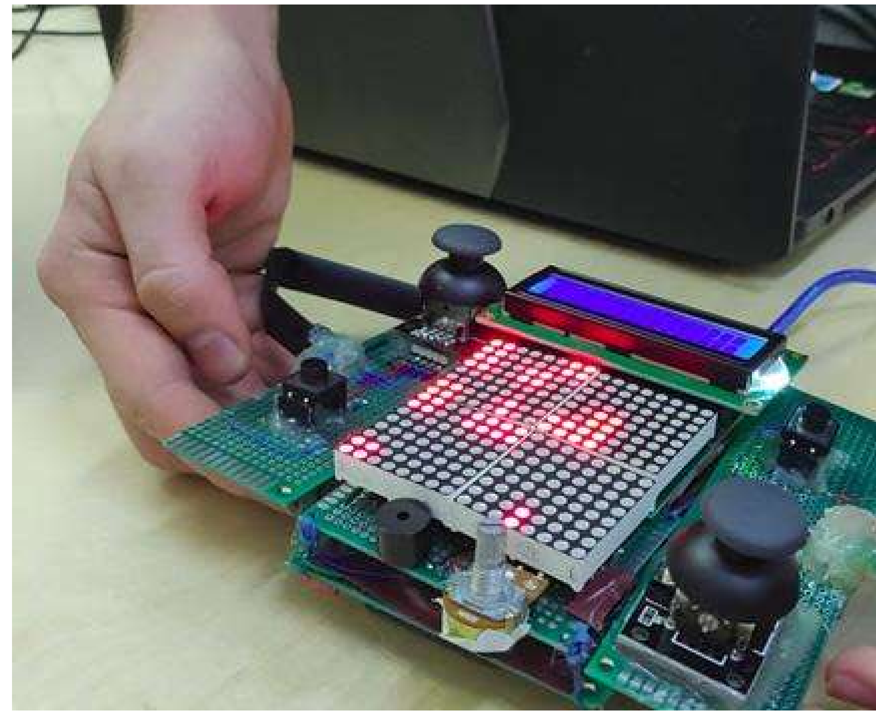
WARNING

We will work with the HIGH-LEVEL concepts and integrated circuits.

It is not our purpose to design IC, but to understand:

- how to select an IC
- how to connect an IC
- how to understand its limits
- how to use its capabilities



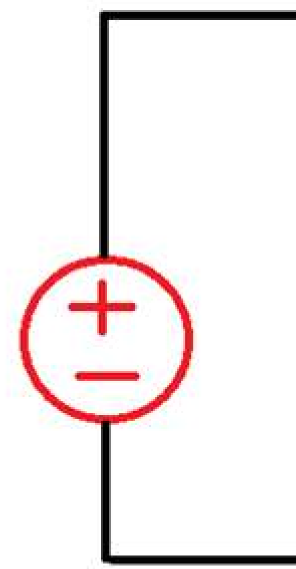


Electric Current

Before you understanding those, though, you need to understa
fundamentals, starting with the electrical current.

Electric circuit: a closed loop that carries electricity.

Picture on the right is correct, but what's wrong with it?



https://www.youtube.com/watch?v=gYvXIv7Sj3s

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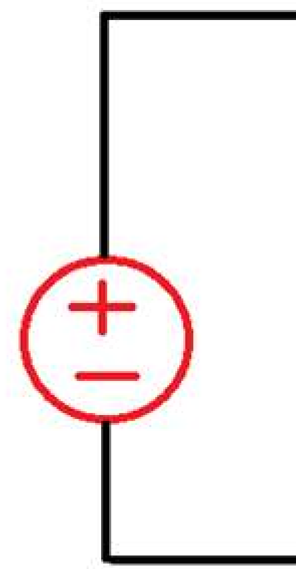
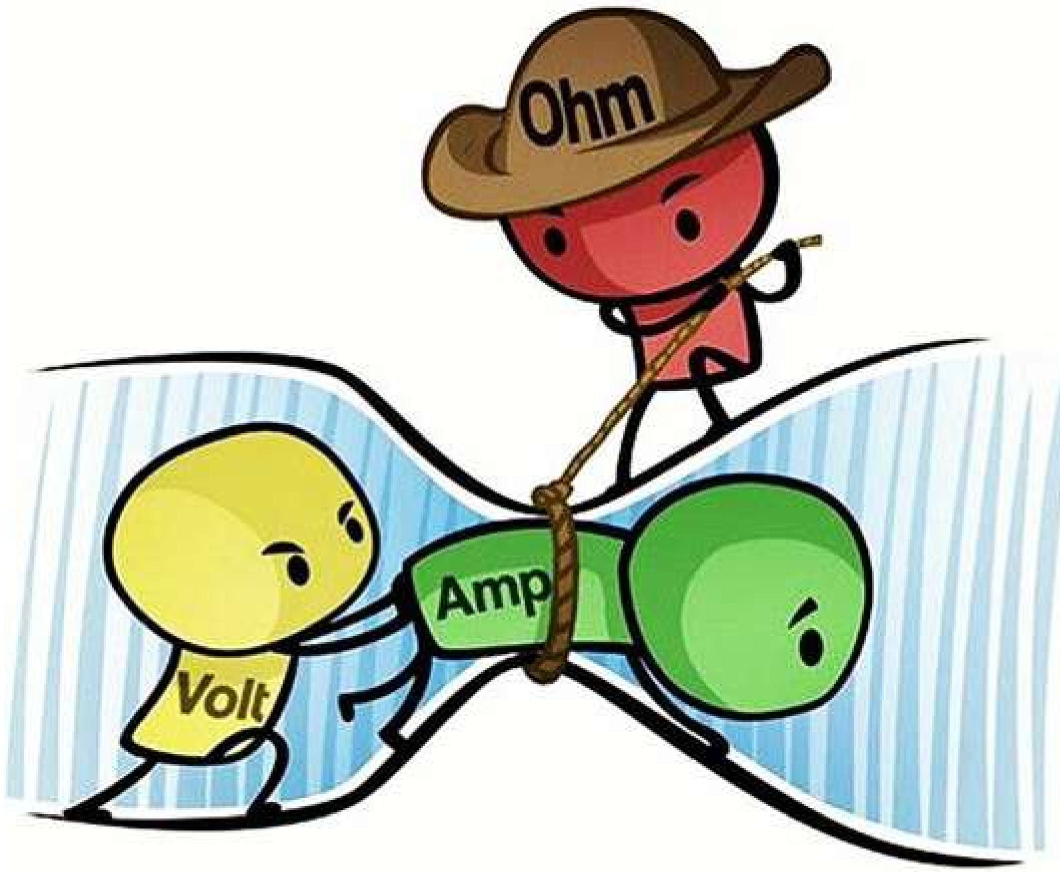
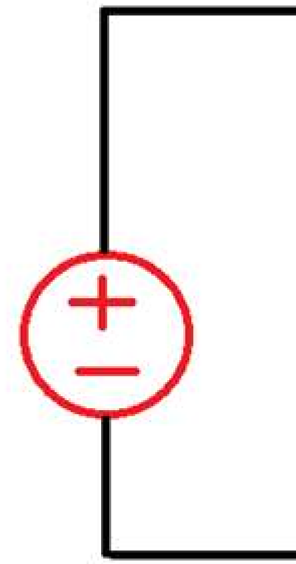


In a circuit like this there is no resistance, which can cause overheat and even fire.
Usually there is a consumer in the circuit.

Current, Voltage and Resistance





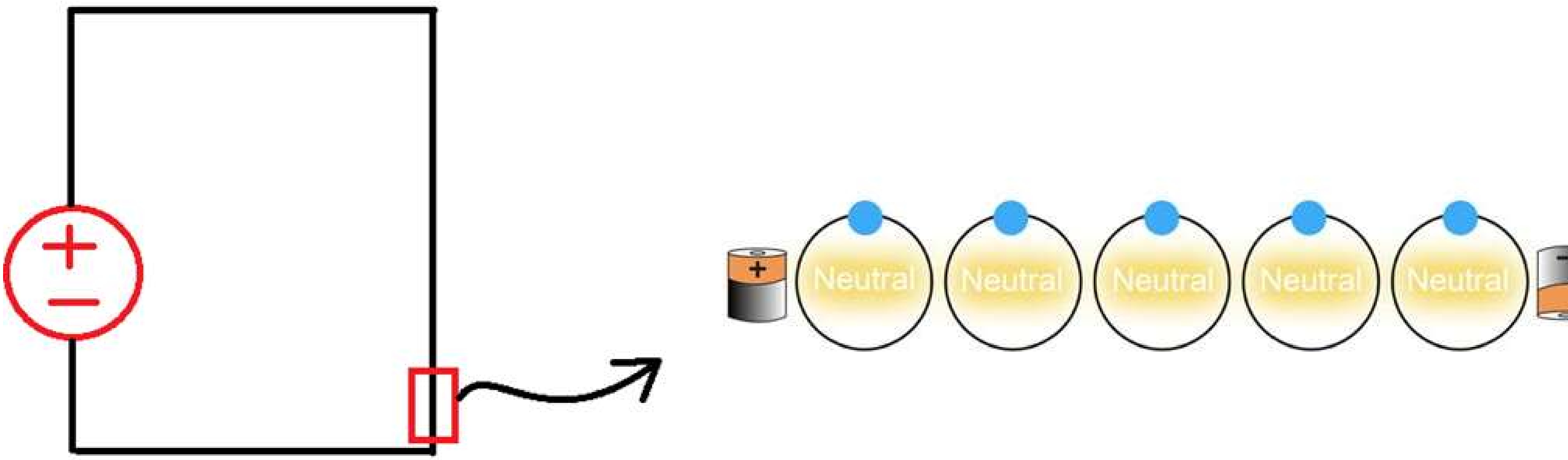
Electric Current

Electric current: flow of electrons in a circuit.
It is the **movement**, do not confuse it with voltage.

Some analogies include a water current that moves the boat or a wind current that pushes the sail.

Why do electrons “jump” from one atom to the other?

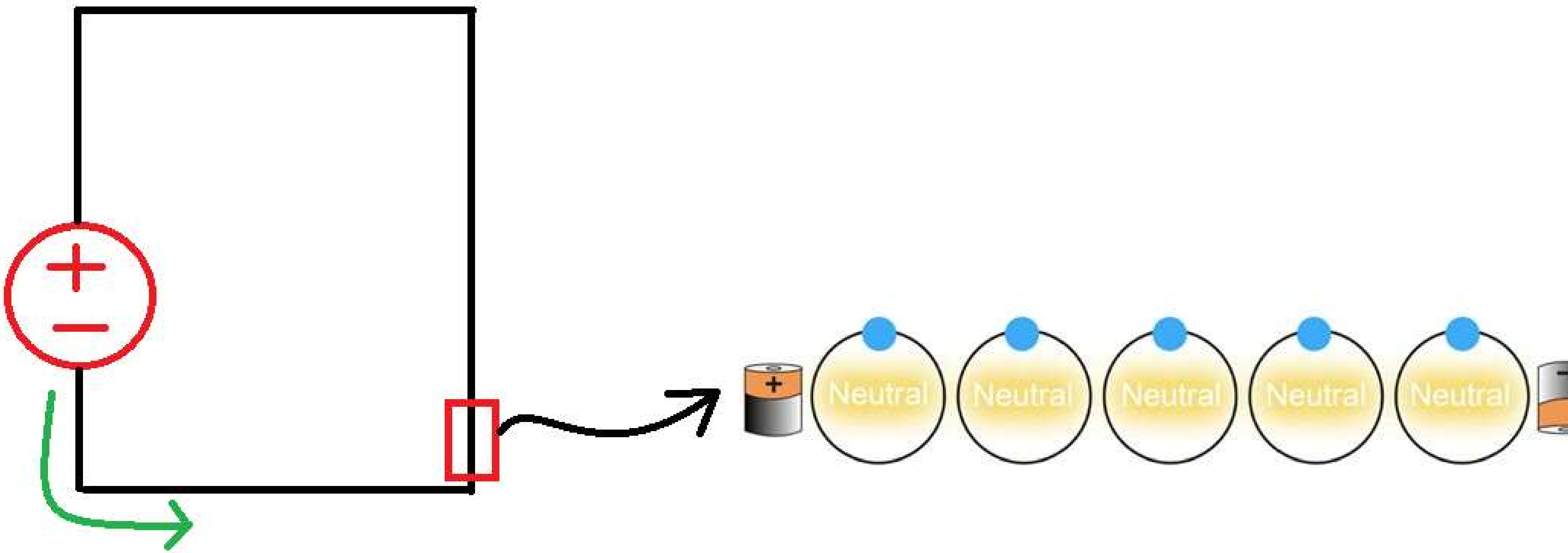
- Basically, it’s the potential (the voltage) that pushes the electrons. Each ion (positively charged atom) attracts an new ion. We’ll leave some info for diving deeper.



Electric Current

Understanding the difference between conventional electric current flow
because it leaves a "hole" behind) and electron current flow.

Reasons vary from historic decisions and not wanting to have a lot of "-" ir

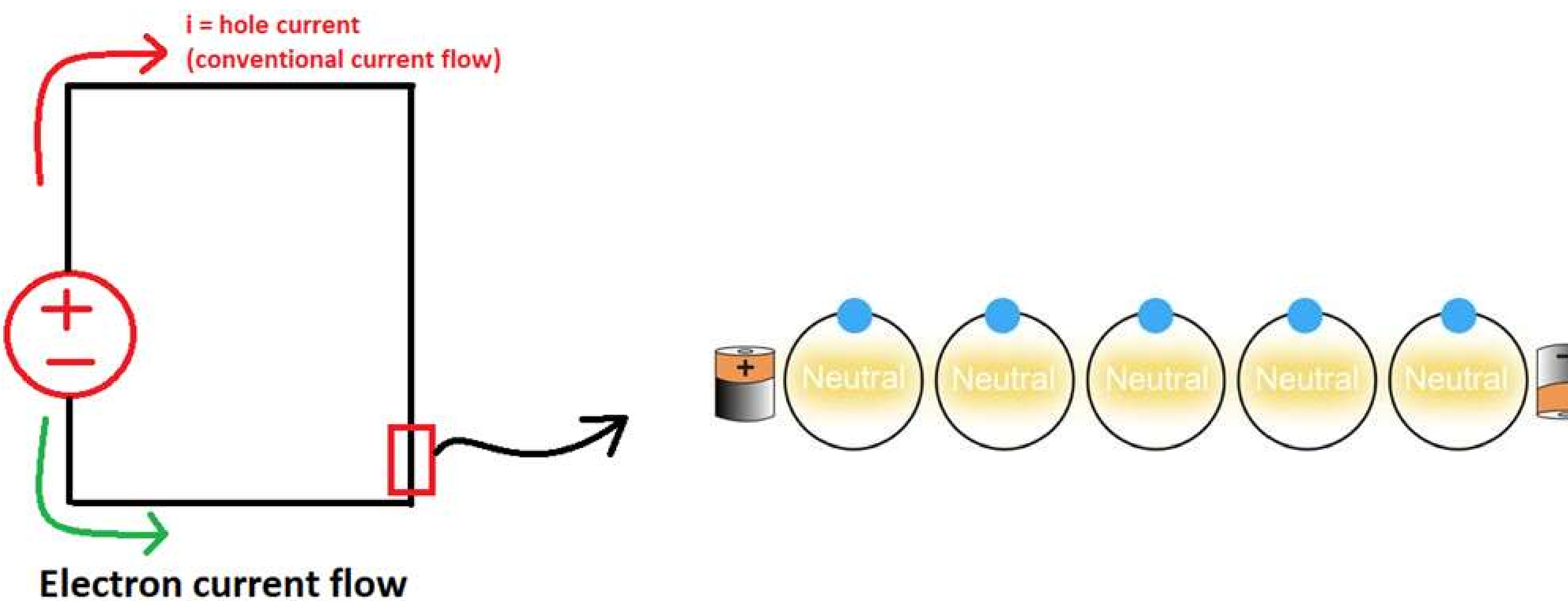


Electron current flow

Electric Current

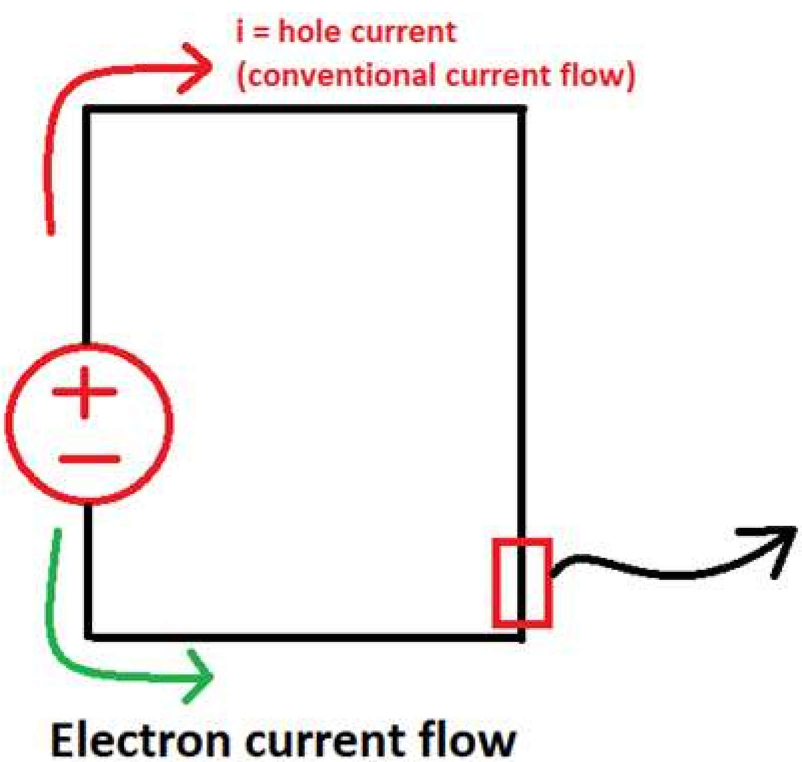
Imagine instead of seeing the electrons (thus, the negative charge) moving from minus to
say - and it would be mathematically correct - that the positive charge moves from plus t

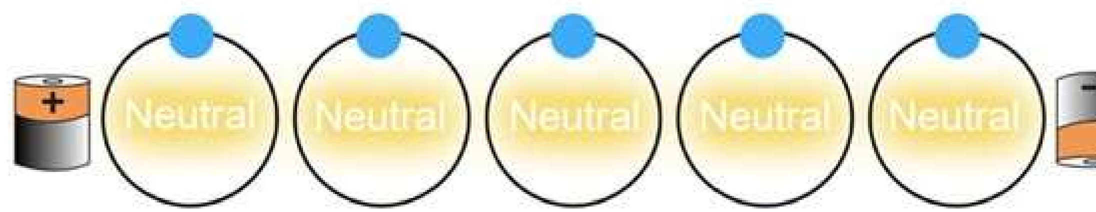
We will be working with conventional current flow.



Electric Current

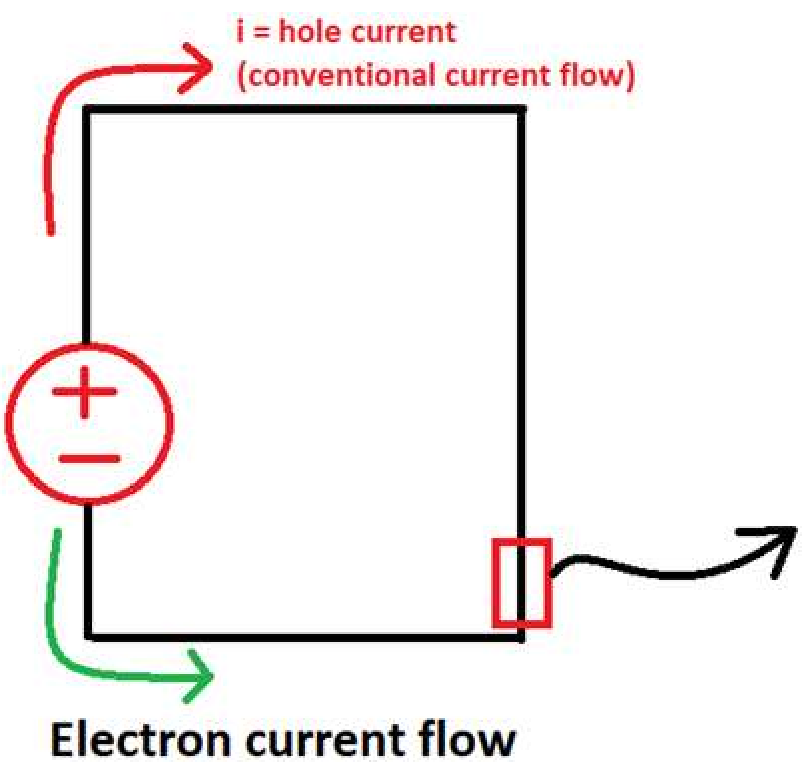
This is all very basic, yet super important concept. Take a mome
internalize it. **All the calculations are done using hole current**, e
reality the electrons are moving from minus to plus.

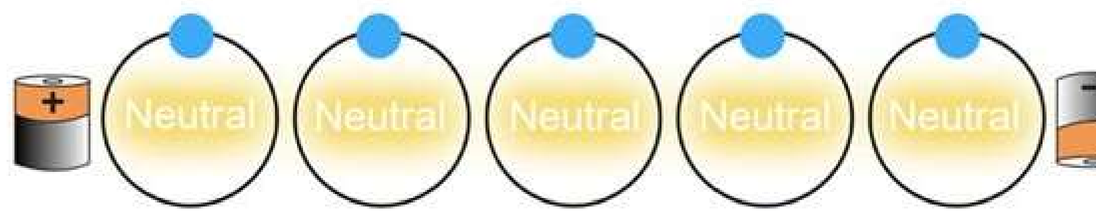




Electric Current

Units = Ampere (Amp, or “A”).
We will be working with milliamps (mA)
Amps is the stuff that kills you.





Electric Current

To sum it up:

- current in real life is the flow of electrons
- in all circuits we’re not gonna talk about that
- we’re gonna say that current comes out the positive termina
  the unit of measure is the ampere.

Voltage

Do not confuse with current.

Voltage = the “push” that causes current to flow.

You cannot have any current flowing without something to pus
When you see that “you can be killed by 10000 volts” it’s incorr
The current kills you, the voltage only causes that current.

Think of blowing through a straw. The air movement is the curr
pressure is the voltage. (can you guess which is resistance?)

Voltage

Do not confuse with current.

Voltage = the “push” that causes current to flow.

Units = Volt (V)

We will be working mostly with 5V, but generally with an interv
3.3V and 12V.

Resistance

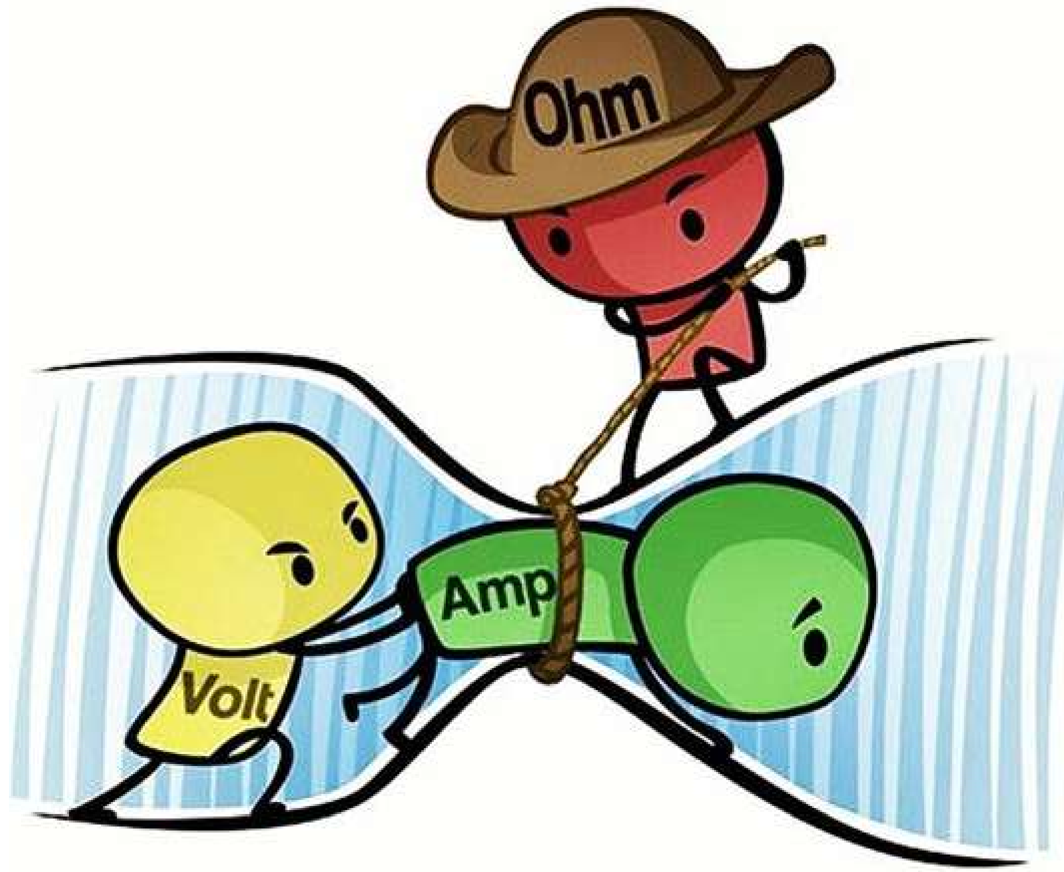
It opposes the current flow in a circuit.

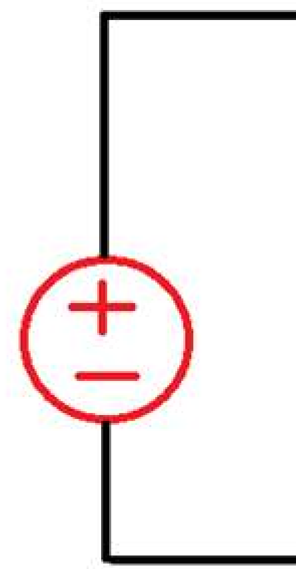
Think about the straw. What happens if you increase or decreas
diameter?

Units = Ohm (Ω)

We will be working with units from 110 ohms to few thousand

Current, Voltage and Resistance





AC - Alternating Current - Current moves back and forth.

The wall sockets that you use have alternating current.

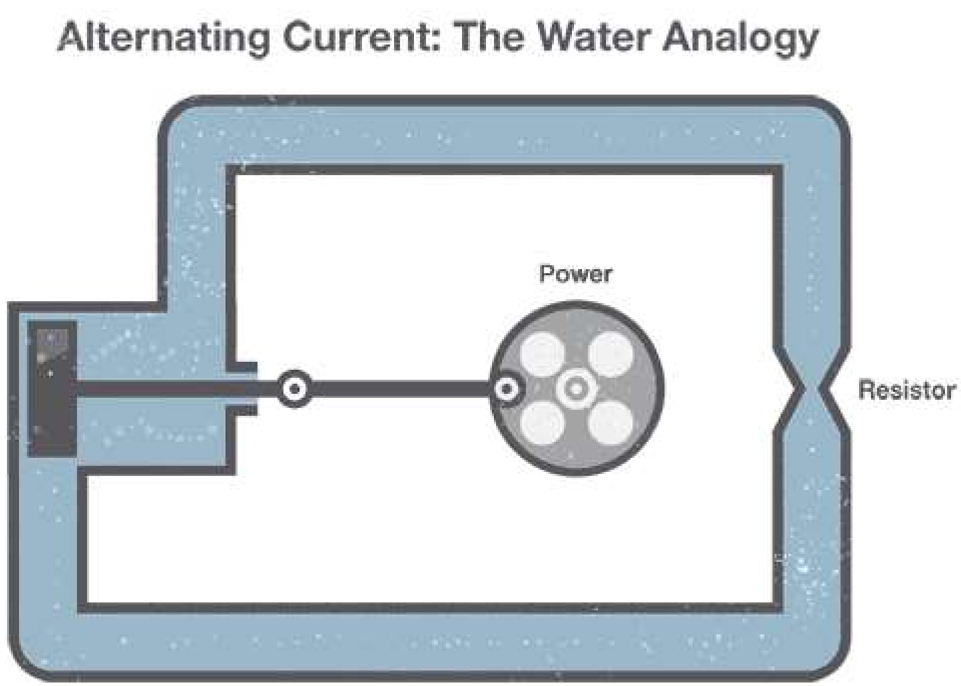
DC - Direct Current - Constant current flow.

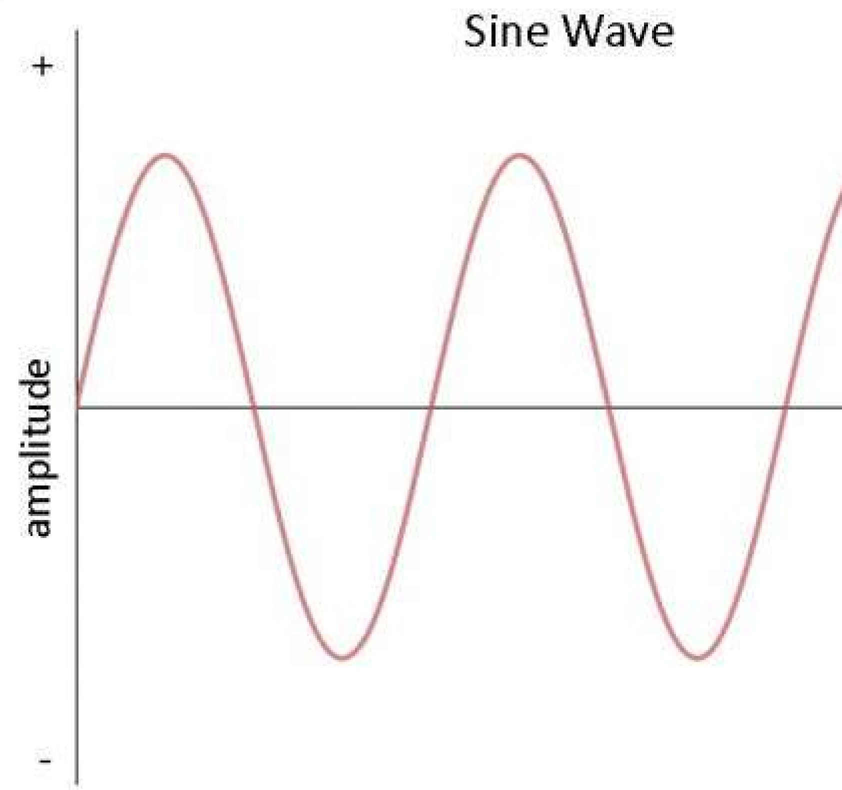
All the batteries you used generate direct current. It gives you c
voltage at the source location (in reality, the battery does die do
current gets weaker, but in a snapshot it’s constant).

AC

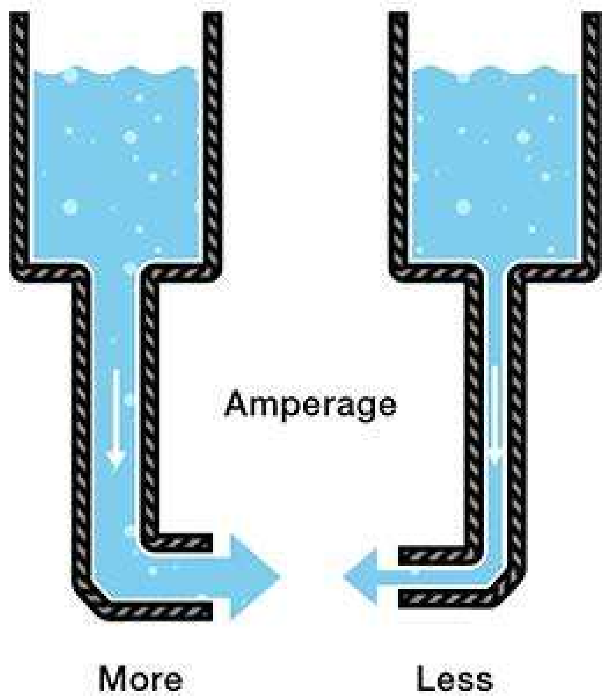
The sine wave is the most common waveform for AC, but not th

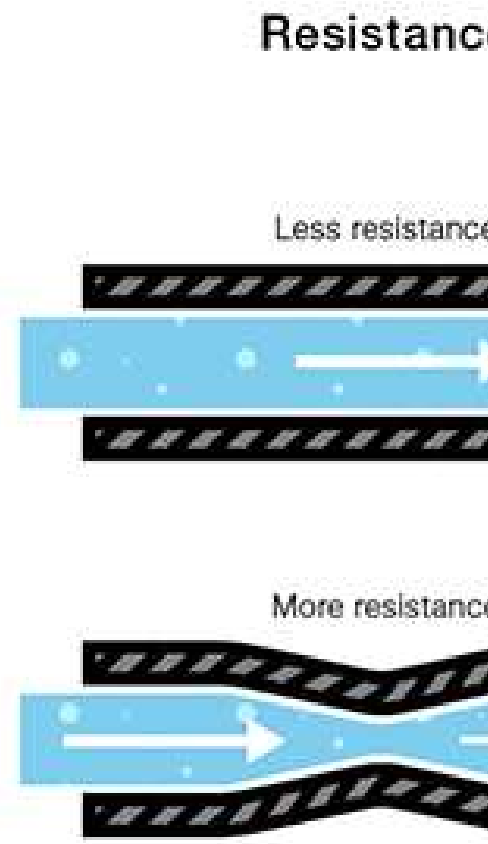
https://www.youtube.com/watch?v=WhATiUHgzxQ





DC


Amperage
More
Less


Resistanc
Less resistanc
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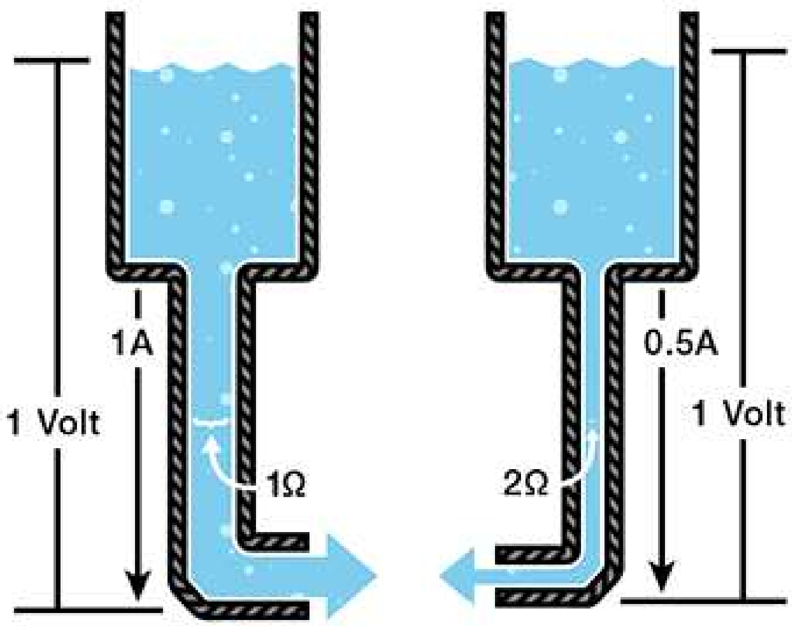
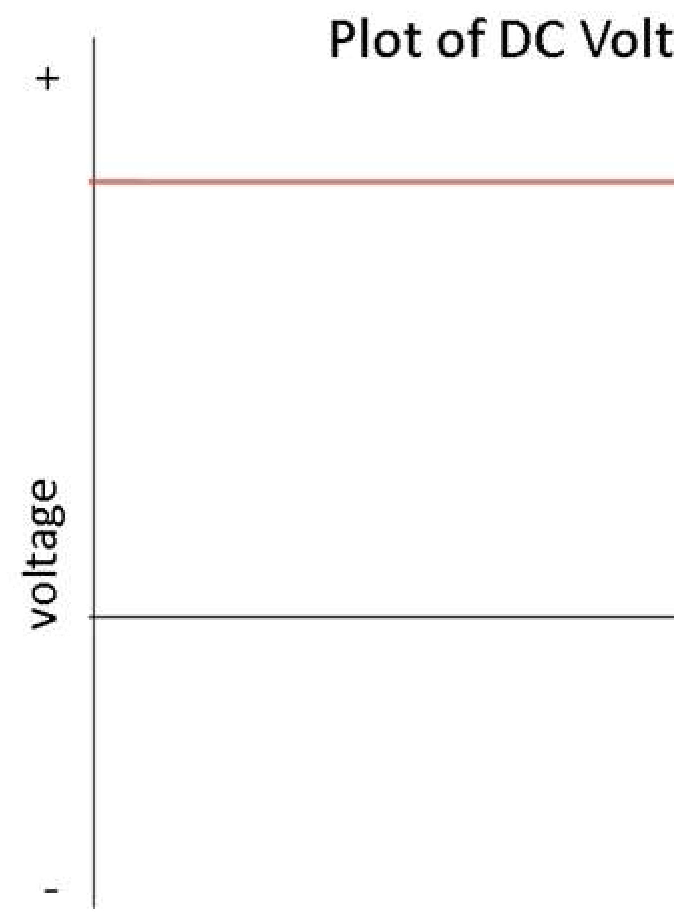
DC





AC/DC

The choice for AC over DC in households has been due to AC be
transport over long distances.

It’s also easier to generate at power plants etc since they gener
that creates steam and moves a generator. The wind farms wor

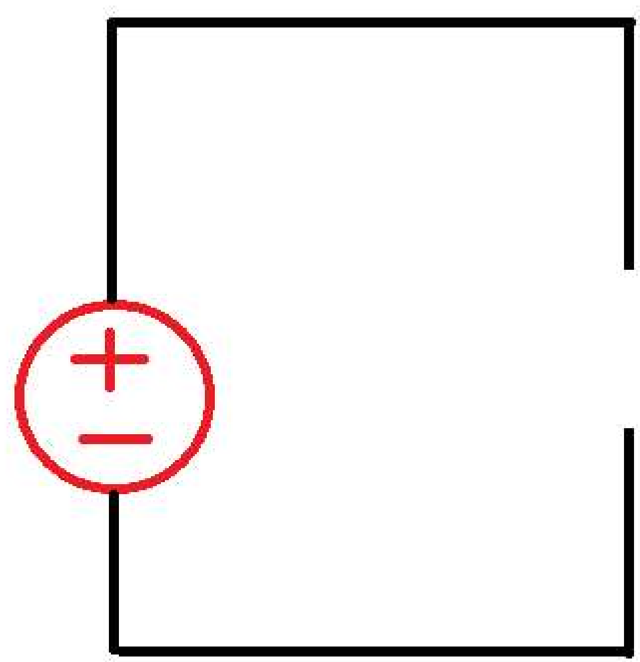
Exceptions are batteries, that have a chemical reaction, and sol
These generate direct current.

We will not be directly using AC in this course.

Q: why isn’t the light flickering in the house since you use AC?

Open Circuit

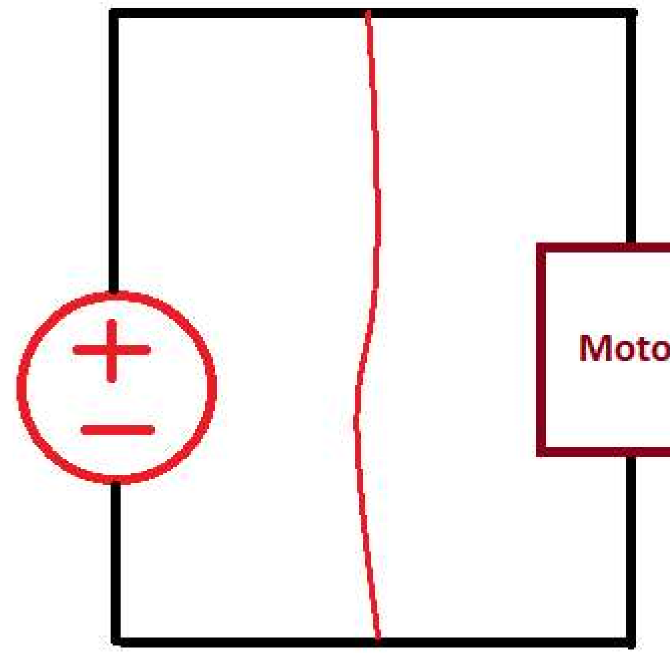
An interrupted circuit through which current does not flow.



Short Circuit

When you have a circuit with a consumer, but inside it a piece c
accidentally connects to two terminals (parts of the circuit).

What do you think will happen?



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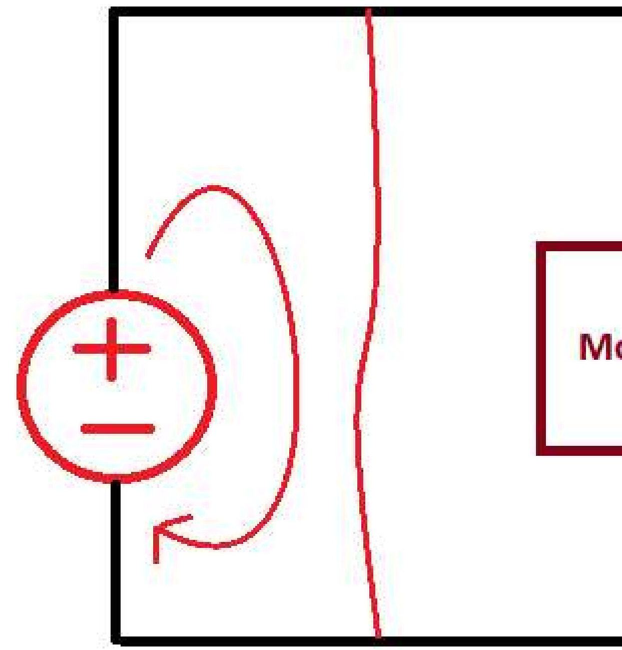


Remember the foam cutter?

It will generate a lot heat.

And maybe stop the current. Why?

Electrical Components

You might've heard of them in random conversations.

We'll present a few and look at a big picture overview of what t

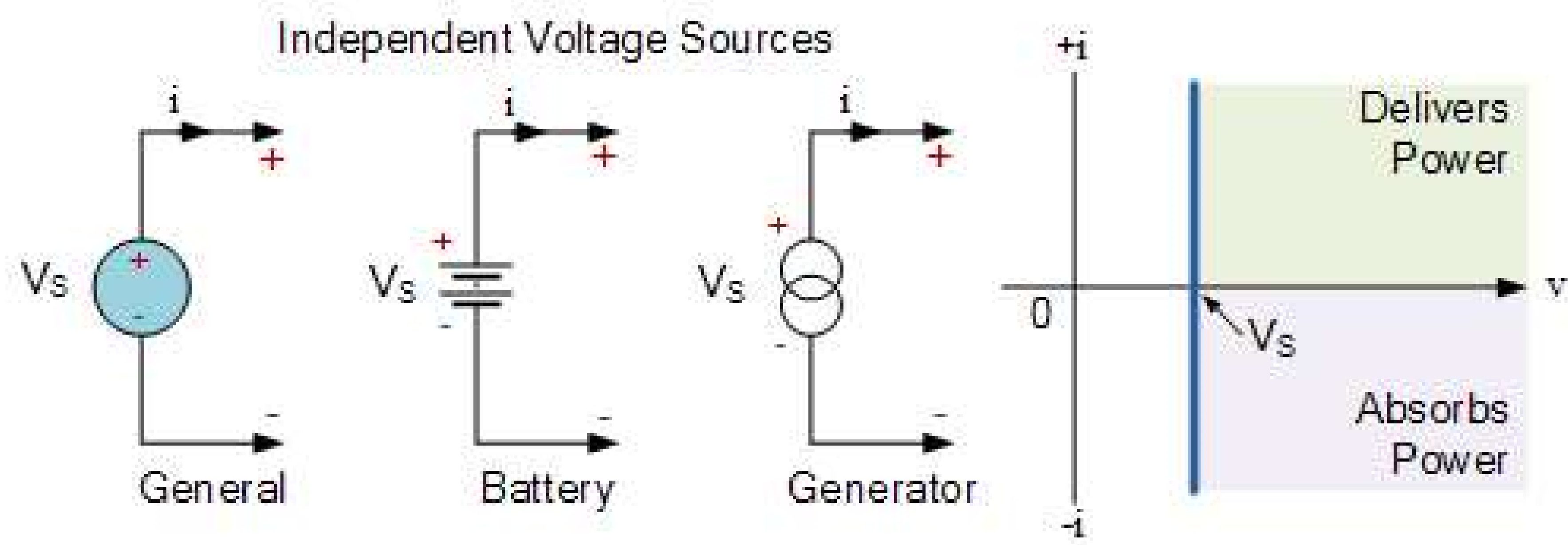
Electrical Source

Source Voltage or battery.

Most of the information we'll present is taken from here:
https://www.electronics-tutorials.ws/dccircuits/voltage-source.

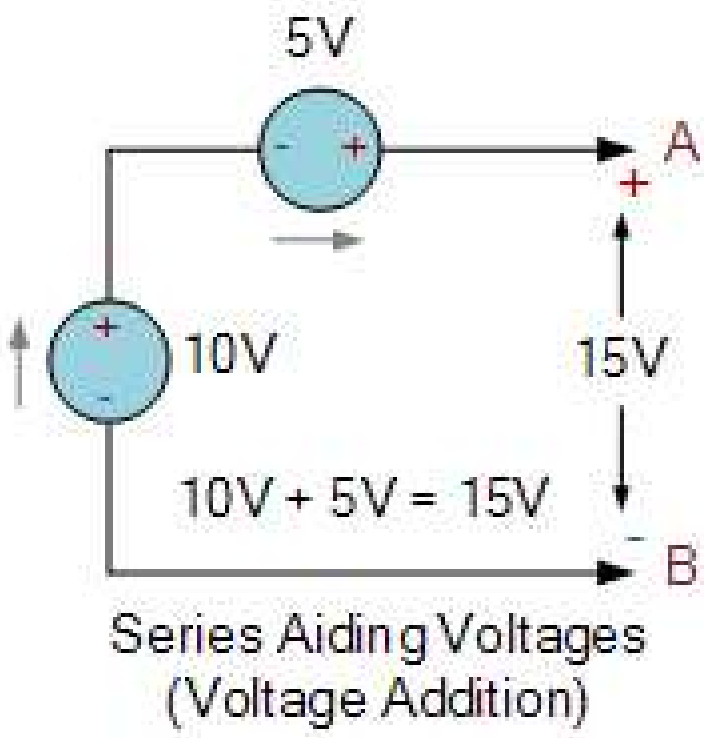
Electrical Source

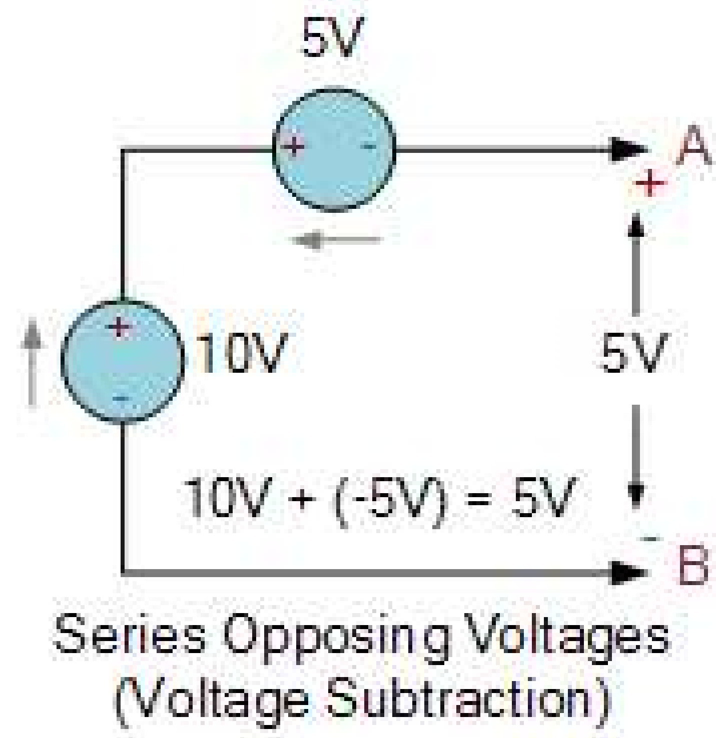
Source Voltage or battery.



Electrical Source

Connecting sources.

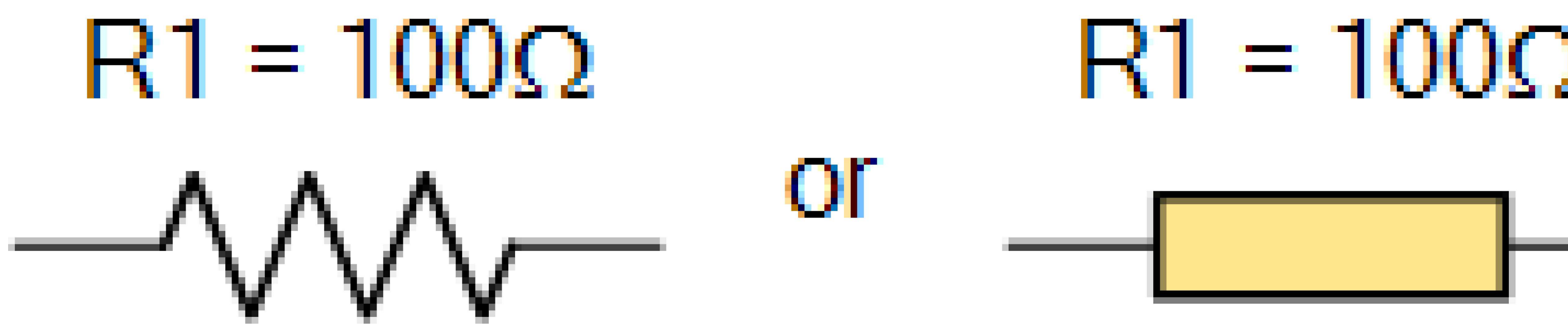




Resistor

Rezistor

https://www.electronics-tutorials.ws/resistor/res_1.html



Resistors

- Electrical components that limit current in a circuit
- Their values can be calculated depending on the color bands
- There can have, 3, 4, 5 and even 6 color bands, but we'll mostly be with 5. We need to use a table for identifying the value of the color
  - 1st band: 1st digit of the value
  - 2nd band: 2nd digit of the value
  - 3rd band: 3rd digit of the value
  - 4th band: multiplier
  - 5th band: tolerance ---- aka, error
  - 6th band: temperature coefficient
- For this course, we can ignore tolerance and temperature coefficie

Resistor value

6 BAND CODE

1st Digit . 2nd Digit . 3rd Digit x Multiplier ± Tolerance ; Temperature Coefficient

= 10.3 kΩ ± 5% ; 100 ppm/°C

COLOR	1st DIGIT	2nd DIGIT	3rd DIGIT	MULTIPLIER	TOLERANCE	TEMP .Co
BLACK	0	0	0	1Ω		
BROWN	1	1	1	10Ω	± 1% (F)	100
RED	2	2	2	100Ω	± 2% (G)	50
ORANGE	3	3	3	1kΩ	± 3%	15
YELLOW	4	4	4	10kΩ	± 4%	25
GREEN	5	5	5	100kΩ	± 0.5% (D)	
BLUE	6	6	6	1MΩ	± 0.25% (C)	10
VIOLET	7	7	7	10MΩ	± 0.10% (B)	5
GREY	8	8	8	100MΩ	± 0.05% (A)	
WHITE	9	9	9	1GΩ		
GOLD				0.1Ω	± 5% (J)	
SILVER				0.01Ω	± 10% (K)	

Resistors

- In order to orient them correctly, pay careful attention to the tolerance ring, as it should be farther apart, but this is not always obvious.
- For cheap and easy to find resistors, the tolerance ring is often gold (5%, 4 band, E12) or red (2%, 5 band, E96)

What value
have?

Resistors

- In order to orient them correctly, pay careful attention to the tolerance ring, as it should be farther apart, but this is not always obvious.
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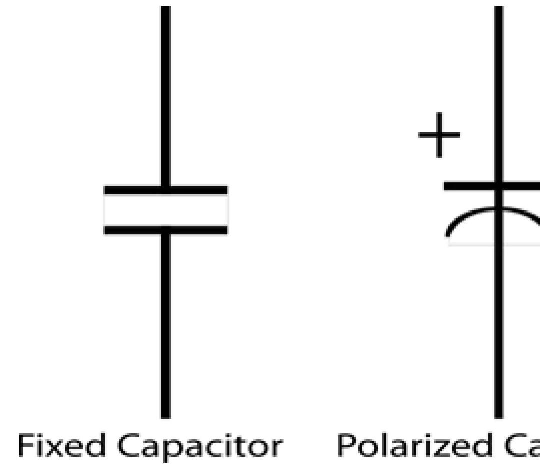
A 2260 Ω, 1
with 5 color
from top 2-
brown band
multiplier (×
tolerance. T
the toleranc
difficult to c

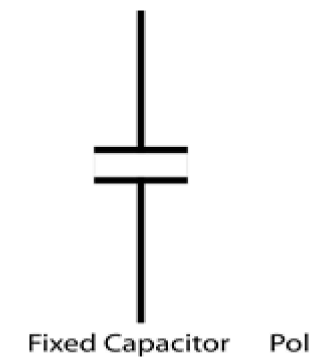
Capacitor (sau condensator electric

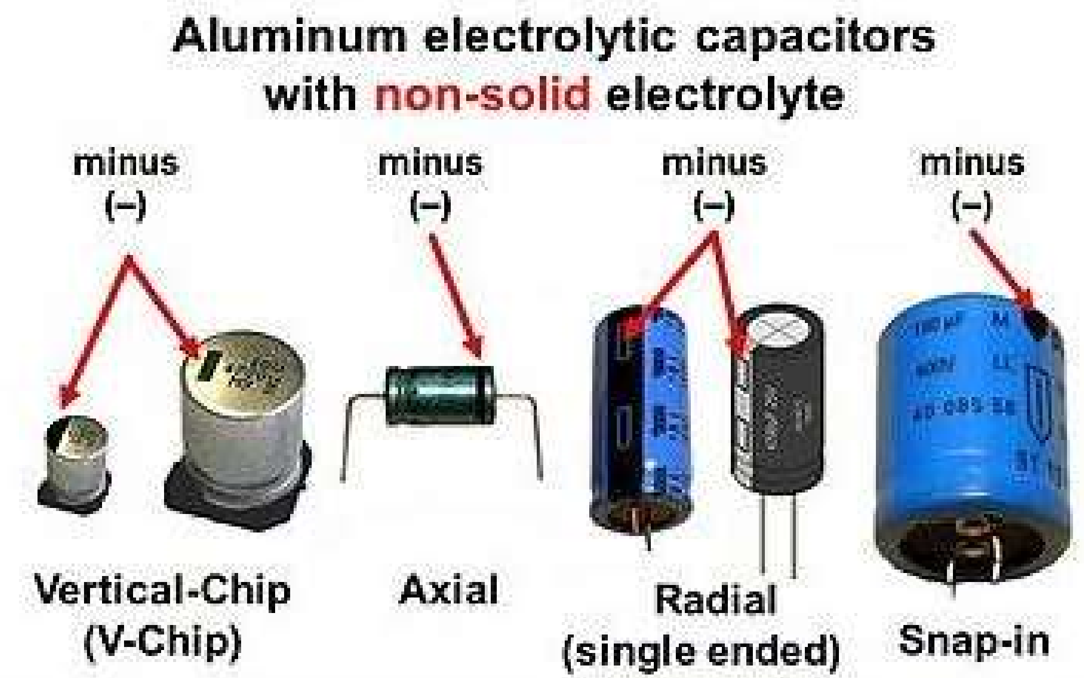
- https://www.electronics-tutorials.ws/capacitor/cap_1.html
- The capacitor is a component which has the ability or "capacity" to store energy in the form of an electrical charge producing a potential difference (Static Voltage) across its plates, much like a small rechargeable battery.
- Has faster discharge rate than a battery.
- Ever heard a blitz charging?



Capacitor (sau condensator electric

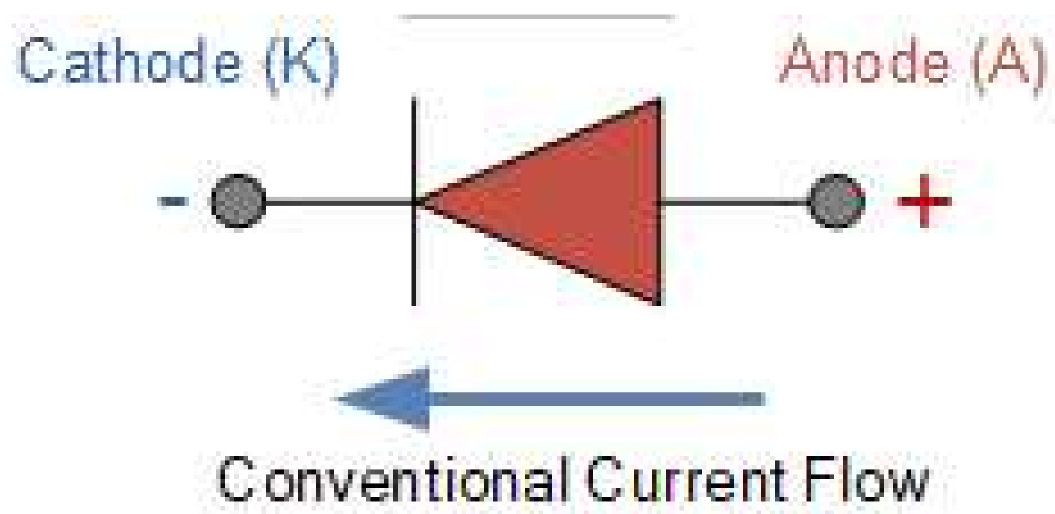
- Unit = Farad(F)
- 1F is a huge value, we will use µF usually
- Are used to also absorb noise in a system





Diode

- https://www.electronics-tutorials.ws/diode/diode_1.html
- Diodes are basic unidirectional semiconductor devices that v allow current to flow through them in one direction only, ac like a one way electrical valve (Forward Biased Condition).
- Can you image how such a component would be built?



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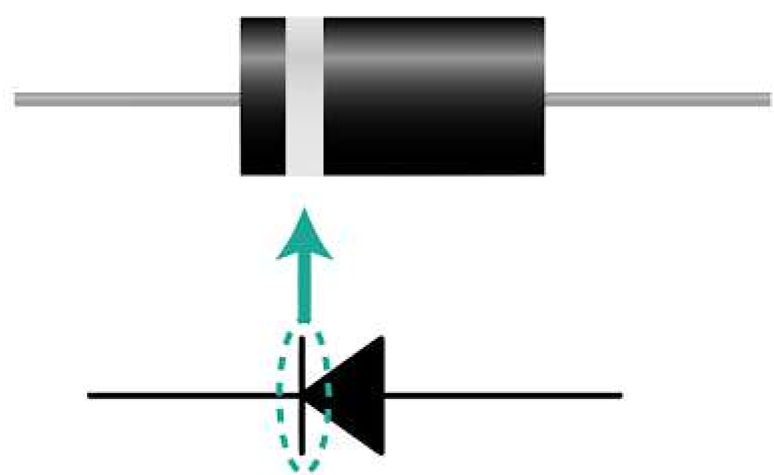

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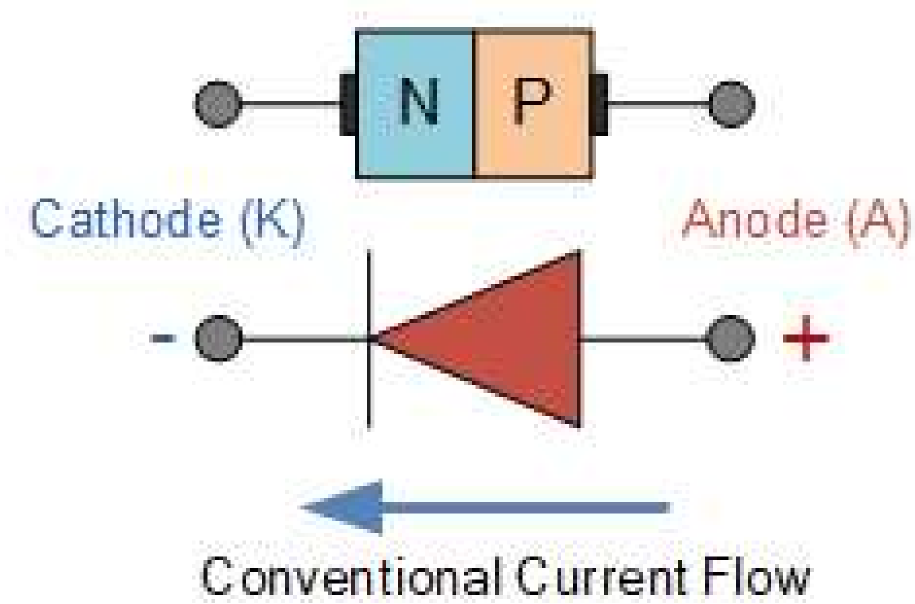
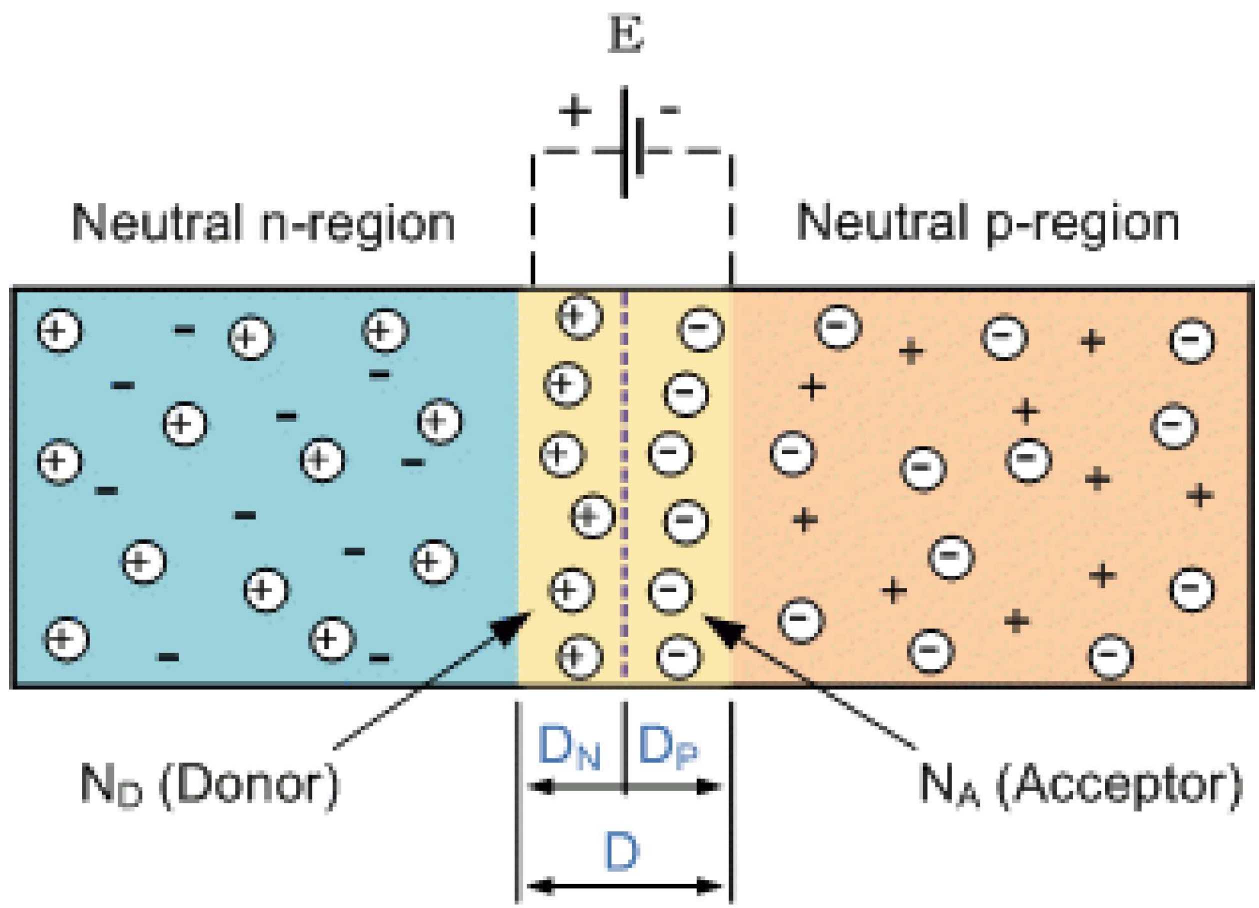


PN Junction Diode

- https://www.electronics-tutorials.ws/diode/diode_3.html
- More precisely:

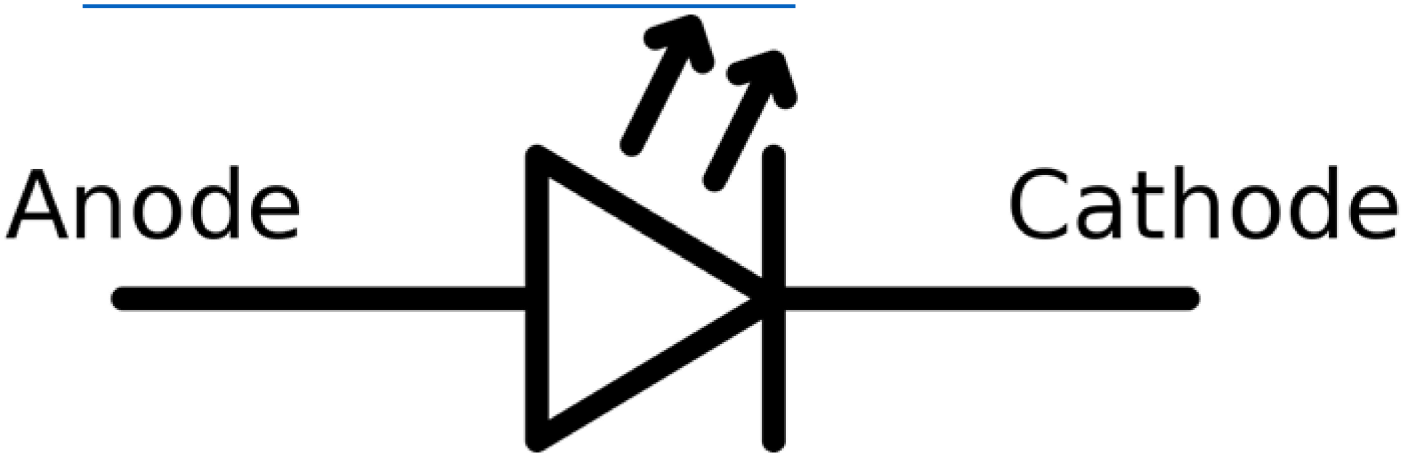


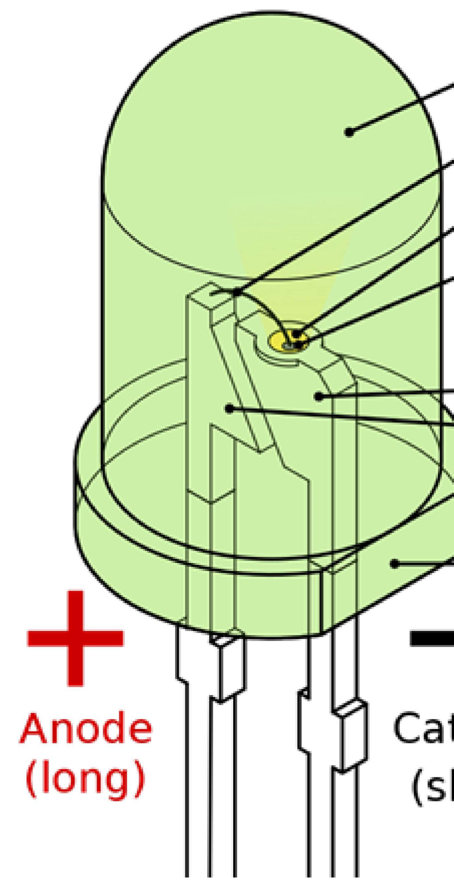
LED

- What does it stand for?

LED - Light Emitting Diode

- A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it.
- Aka a diode that just happens to emit light.
- The invention of the blue LED won the nobel prize: https://www.bbc.com/news/science-environment-29518521

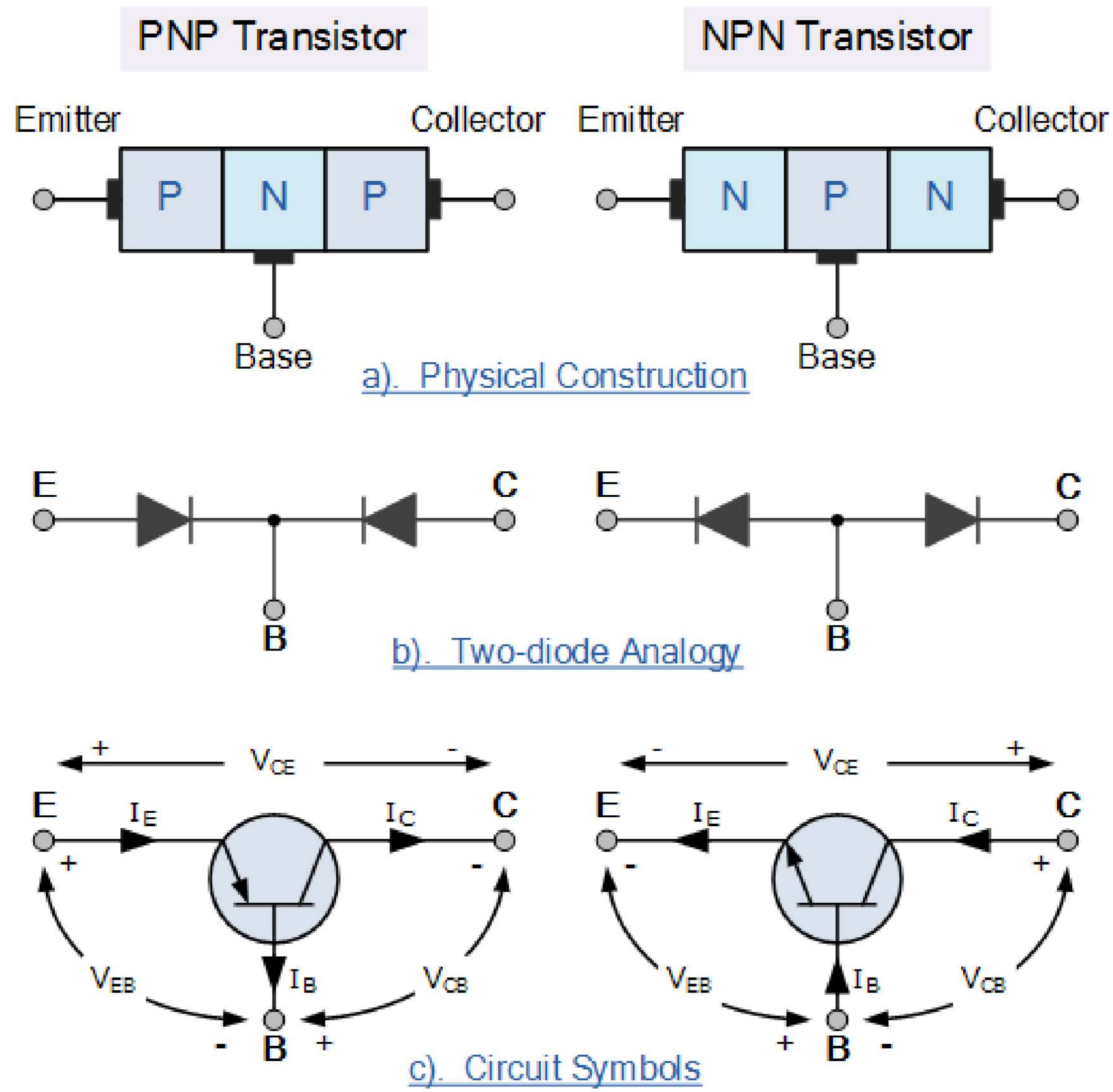




Transistor

- Surely you’ve heard of it.
- Super important.
- Present in pretty much every electrical component.
- Most of the technology in the past 50+ years has been made possible by advancing transistors.
- It’s hard to overstate their importance.
- It can do 2 things:
  - Act as an electronic switch with nothing moving inside (main use)
  - Act as an amplifier

Transistor



PNP Transistor
NPN Transistor
Emitter
Collector
P
N
P
N
P
N
Base
a). Physical Construction
E
C
B
b). Two-diode Analogy
VCE
IE
IC
IB
VEB
VCB
+
-
c). Circuit Symbols

Transistor

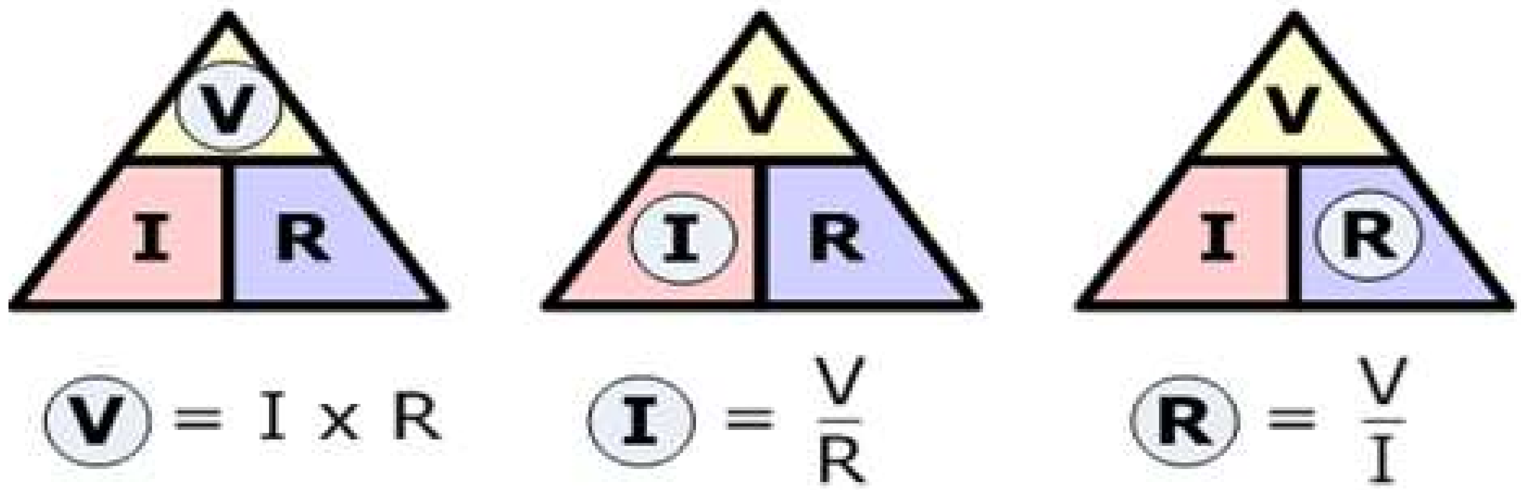
- Take a few million of these and you can do lots of calculatior
  very quickly.
- You basically have a digital binary system.
- They can turn on and off very fast.
- Chips progressed by making transistors faster, smaller and p
  more on chips (roughly).

Ohm’s Law

- Super simple - super important, serving as a foundation.
- We’ve talked about:
  - Current being what actually moves in a system.
  - Voltage being what pushes and creates movement.
  - Resistance being whatever is in the way and trying to slow down th
    movement.
- We are going to look at very simple systems and apply Ohm’

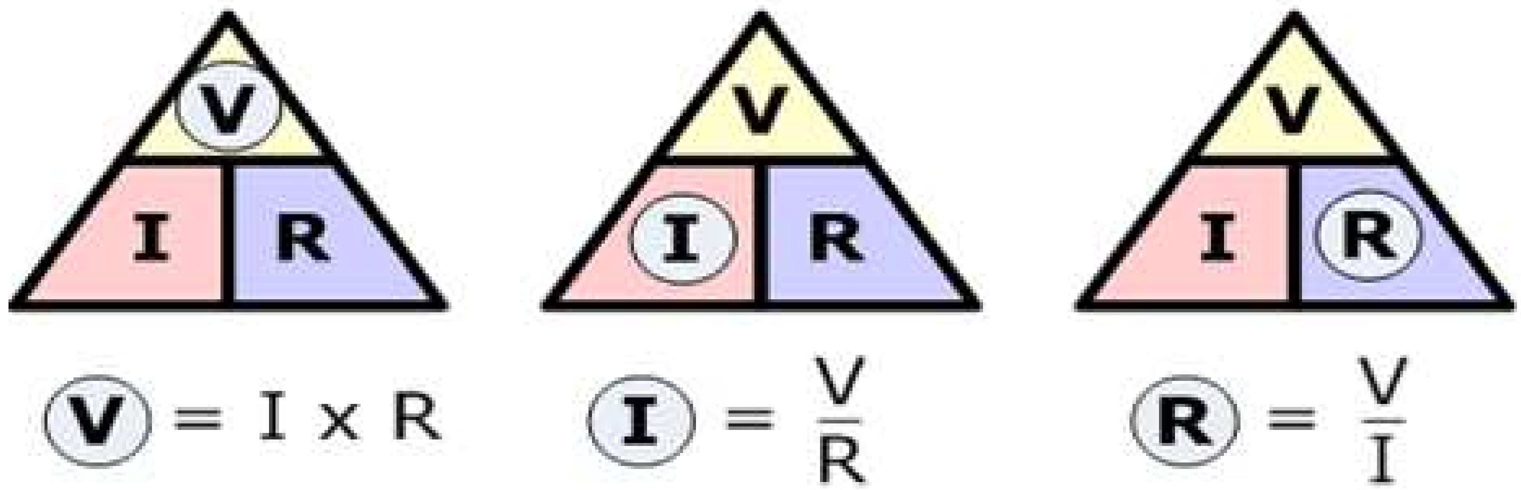
Ohm’s Law

- V = IR
  - V -> Voltage (Romanian: U)
  - I -> Current
  - R -> Resistance



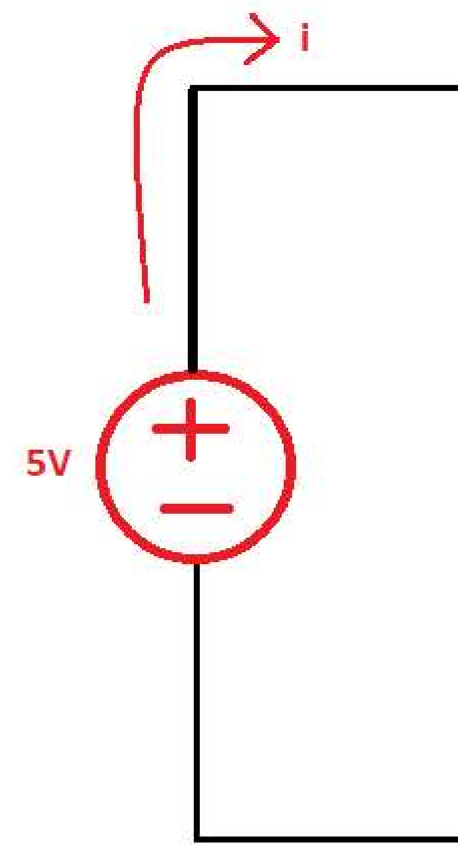
Ohm's Law

- Think about it logically. I = V / R
  - Increasing the voltage increases the current
  - Increasing the resistance decreases the voltage



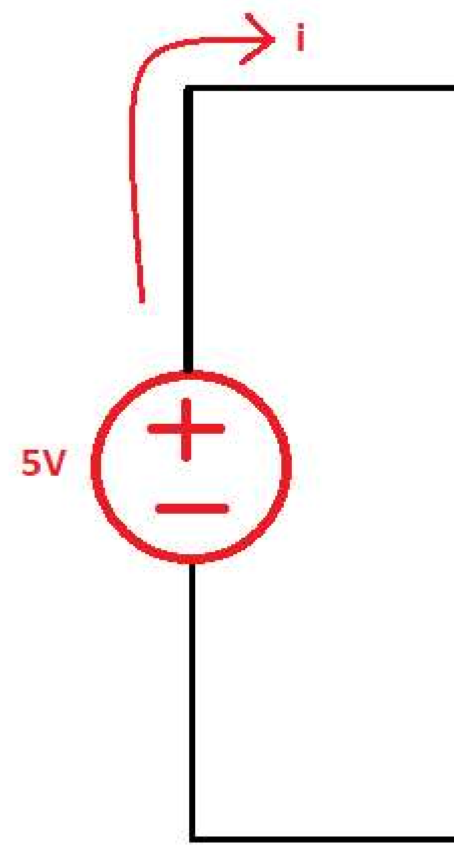
Ohm’s Law

- Some simple examples
- What’s the current here?



Ohm’s Law

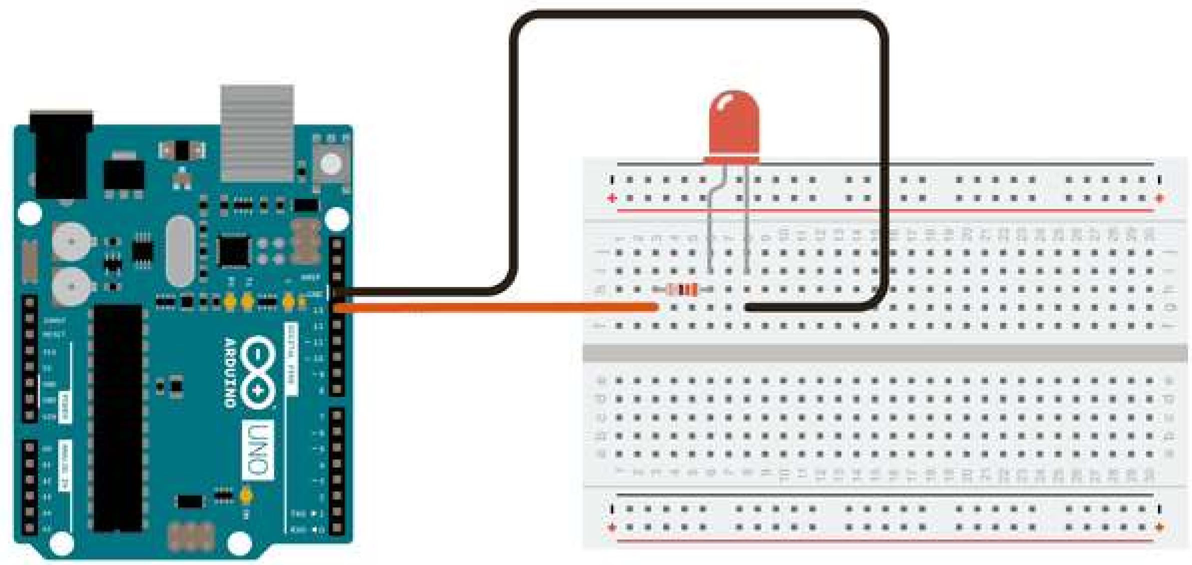
- Some simple examples
- What’s the current here?
- I = V / R -> I = 5V / 2Ω -> I = 2.5 A (quite a lot)



Ohm's Law

Practical example: let's light up an LED. The arduino provides 5V

What resistor value do we use? R = V / I -> R = V / 20mA



Ohm’s Law

Practical example: let’s light up an LED. The arduino provides 5V

First, let’s check the datasheet for the LED:

https://learn.adafruit.com/all-about-leds/the-led-datasheet

Ohm’s Law

We learnt that:

- Arduino provides 5V
- The LED has a running current of (about) 20mA
- The LED has a voltage drop of 1.8V
- The formula is: $R = V / I$ ($V = 3.2$, $I = 20mA$)

What numbers do we plug in?

Ohm’s Law

Well, we calculate the “remaining voltage”:

V_remainder = V_in - V_drop

Ohm’s Law

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We apply the formula: R = V / I

Ohm's Law

Well, we calculate the "remaining voltage":

V_remainder = V_in - V_drop

V_remainder = 5V - 1.8V = 3.2V

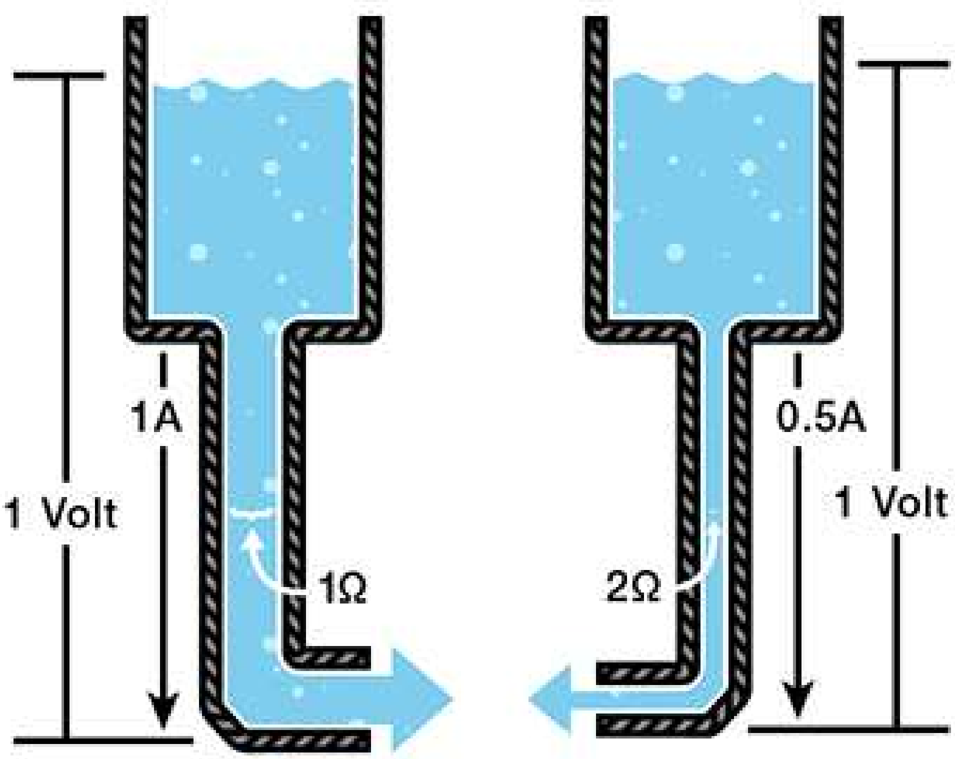
We know the desired current: 20mA

We apply the formula: R = V / I

R = 3.2V / 20mA = 160 Ω

We will use 220 Ω (closest common value) or 330 Ω if we want i
dimmer.

DC - maybe the difference makes more sens



Useful Links

- Electronics guide: https://www.electronics-tutorials.ws
- Simple electronics guide:
  - Voltage, Current and Resistance: https://www.youtube.com/watch?v=OGa_b26eK2c
  - Overview of Circuit Components: https://www.youtube.com/watch?v=RHpo4wKo8p
  - Ohm's Law: https://www.youtube.com/watch?v=lf0lMDZVwTI
- Kirchoff's Law:
  - KVL and KCL examples (haven't watched it, but from the same series)
  - KVL: https://www.youtube.com/watch?v=6F_rmZ1nXFQ
- Series and parallel circuits (long video)
- Super useful channel: Basic electronics tutorials (list)
- Resistor before or after LED?
- How to use a breadboard
- How to calculate correct resistor for LEDs
- Detailed overview or resistors (pretty cool video)

Just use google, though. Each year I find resources that are better and better.

[Source]

Attendance check