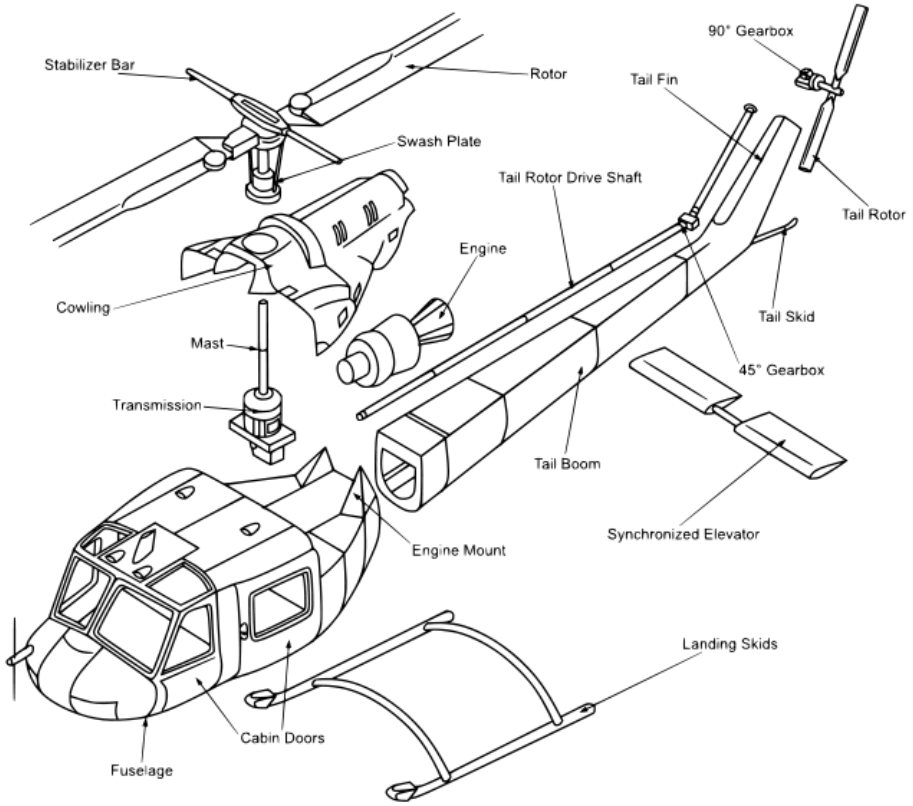
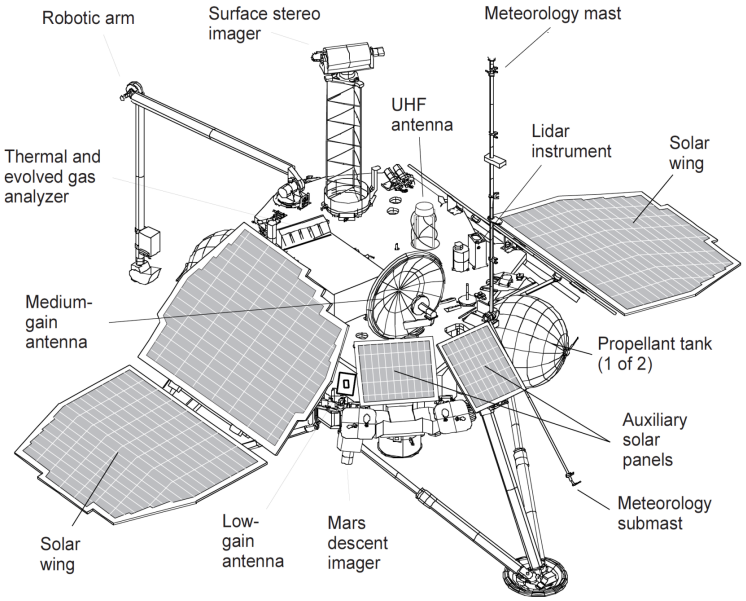
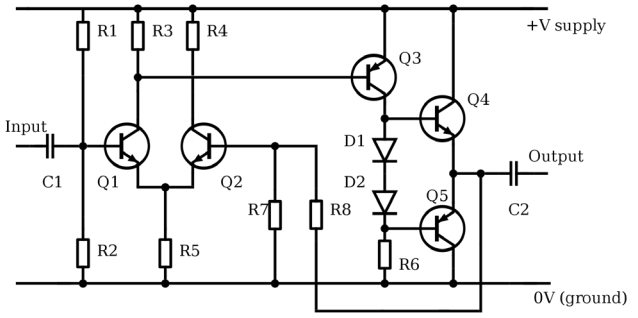




Lecture 5 – Electronics

Andrés Faíña (anfv@itu.dk)



Before start

Materials

- Ask for materials to TAs or me
- Use leftovers (box next to the laser cutter)
- Quality of the prints
  - Do you really need (extra) fine quality?
  - Increase layer height to 0.2mm (or 0.3 if nozzle >0.6mm)
- Think before cut!
  - Put your part next to previous cuts or edges
  - Do not cut your part in the centre of the sheet

Group project

Projects:

- Mechanics, Electronics and Embedded Programming
- Works (problems should be documented)
- Good technical documentation

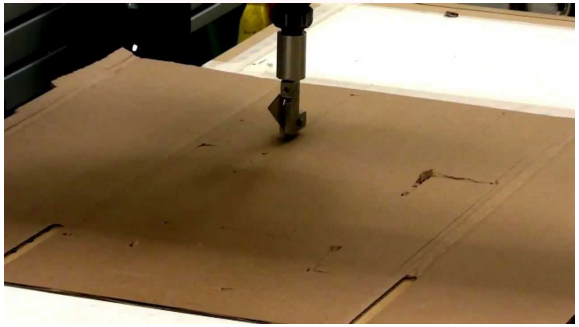
Project mode: 1 month (plan in advance), start now

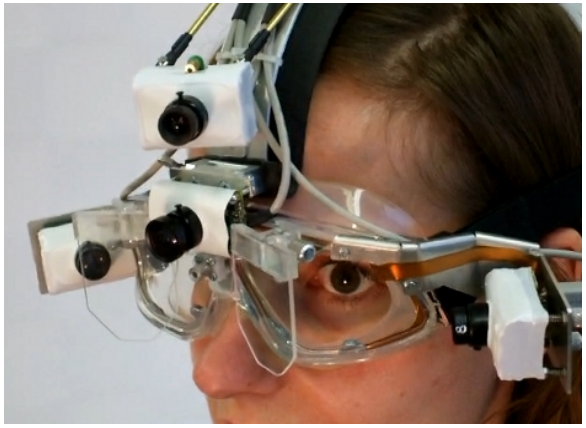
Reuse open source/DIY projects is allowed, but:

- cite them
- try to improve/modify them, mention the changes

Doubts about topic, scope, etc., **ask!**

Group project ideas





Overview

- Basic electronics
  - Power supply
  - Multimeter
  - Basic circuits with resistors
  - Schematics
- Sensors
  - Basic sensors: Switch, potentiometer
- Motors
  - DC motor with switches
- Transistors

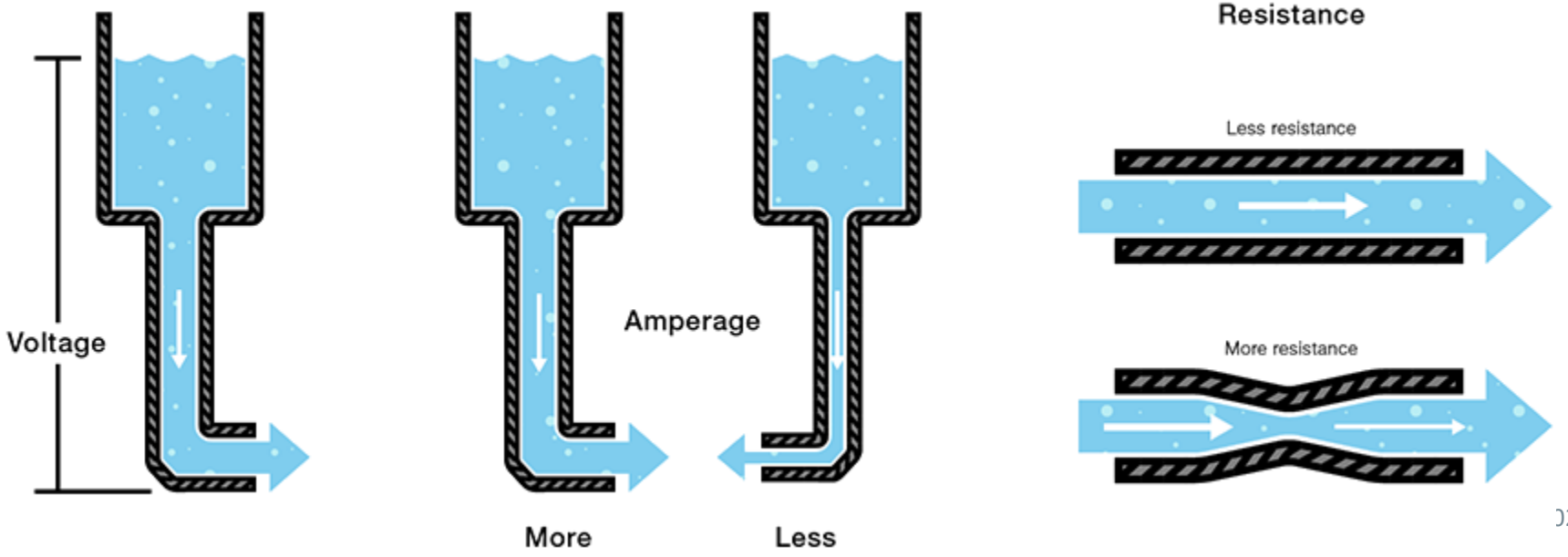
Voltage and Current

Voltage (V): electric potential energy per unit charge
or electric potential

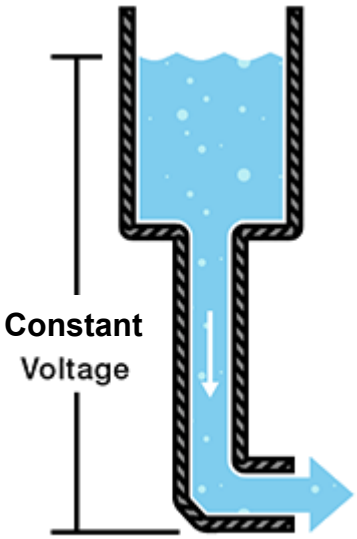
Current (A): flow of electric charge

Resistance (Ω): difficulty to pass an electric current through a conductor

$$V = R * I$$



Power supply



Resistors

US

International

Limit the amount of current that flows through a circuit

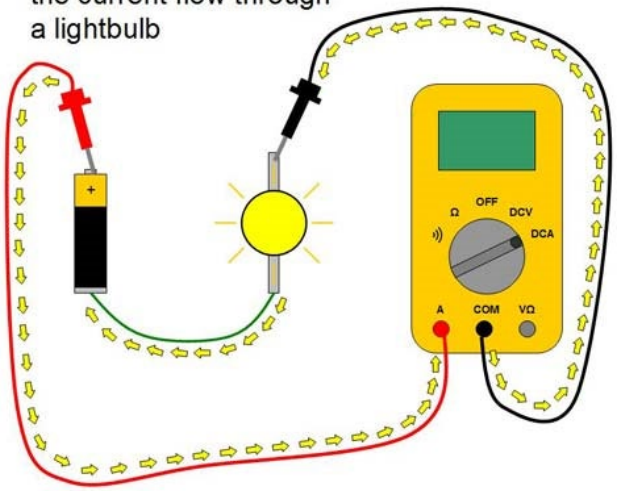
Component with **2 terminals**

No polarity

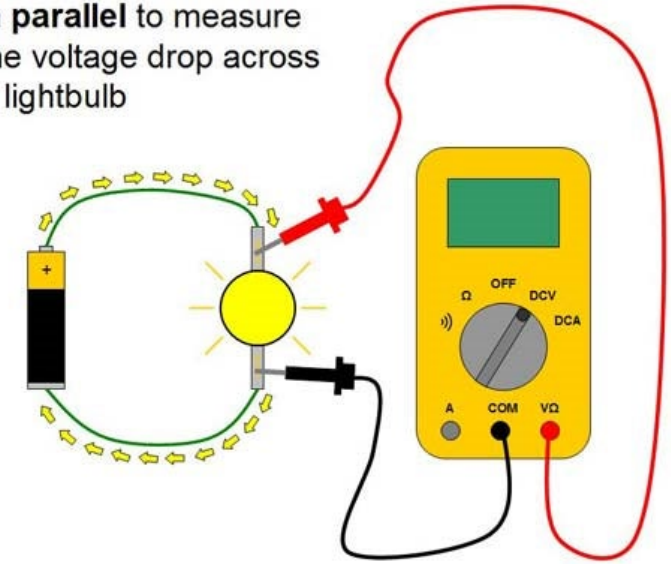
$$V = R * I$$

Multimeter

Connect a multimeter in **series** to measure the current flow through a lightbulb



Connect a multimeter in **parallel** to measure the voltage drop across a lightbulb



Mode selector

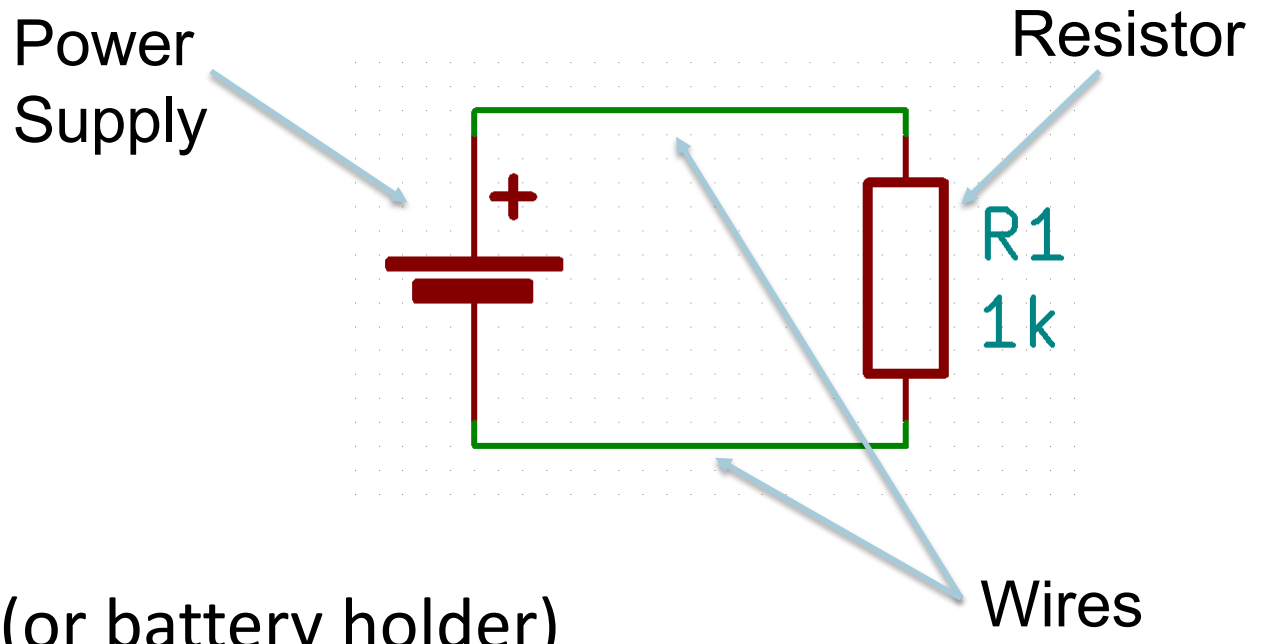
Current mode
High current measurements

Current mode
Low current measurements

Voltage mode
Voltage, resistance measurements

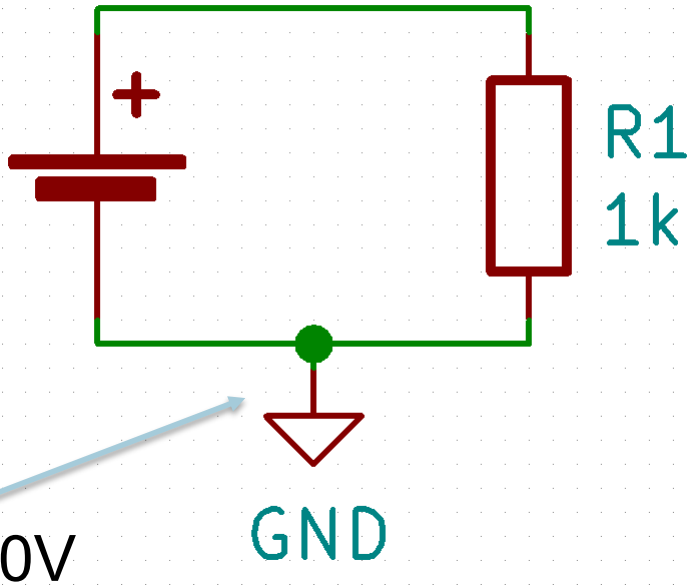
COM (Reference)
Always connected

Setup (2 min)



Take a

- Power supply (or battery holder)
- A red and blue solid wire
- A multimeter
- An Arduino kit



Reference
(This point has 0V
by convention)

Exercise #0

Test the Ohm´s low

- Connect a resistor to a power supply
- Vary the voltage (<15V)
- Check voltage and current
- Measure voltage with a multimeter
- Calculate resistance (R=V/I)

- Power off the power supply and check resistance with a multimeter

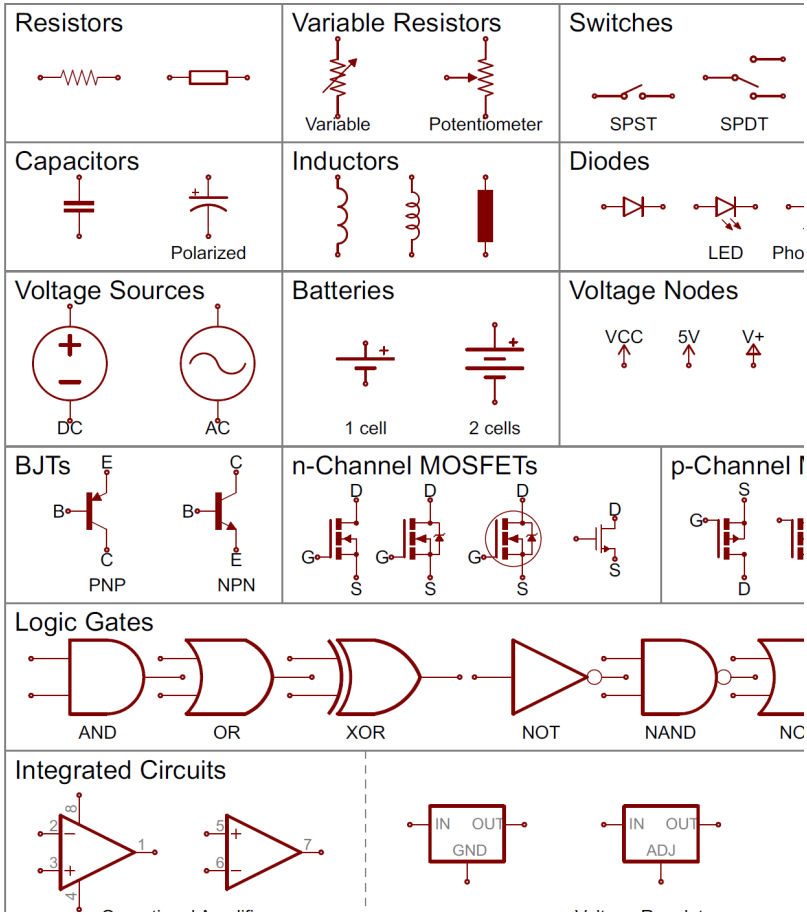
How to read schematics

Electronic schematics or circuit diagrams represent an electrical circuit:

Components

Resistors, Capacitors, ICs

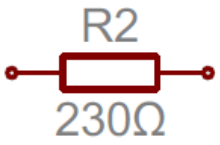
Connections between components



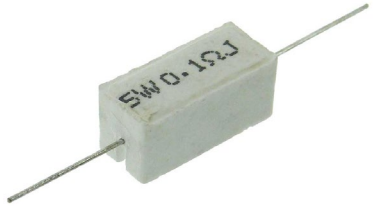
https://learn.sparkfun.com/tutorials/how-to-read-a-schematic

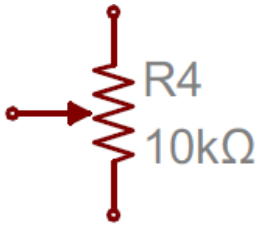
Basic components

US

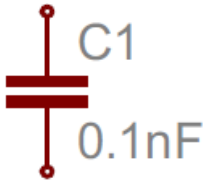


International

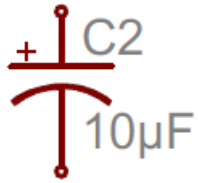




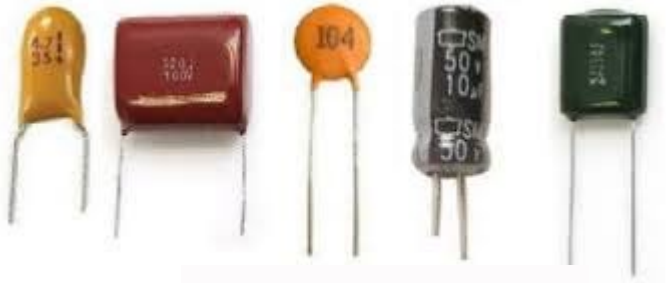
Potentiometer

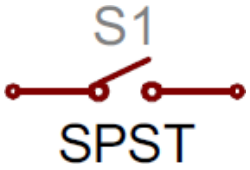


Non-polarized



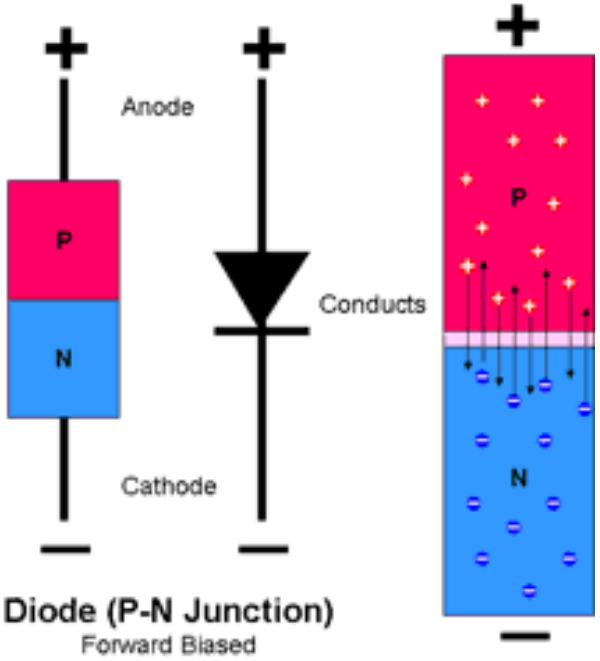
Polarized

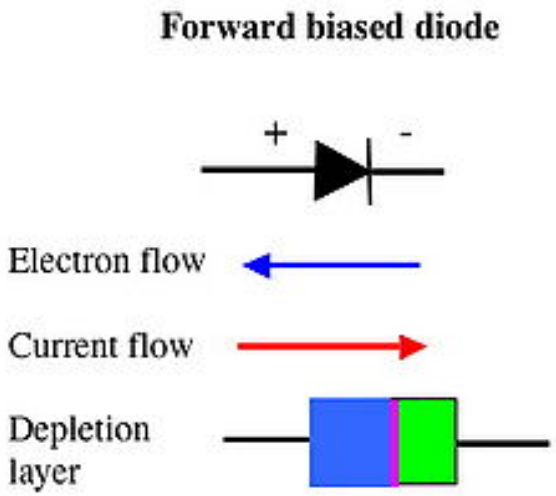


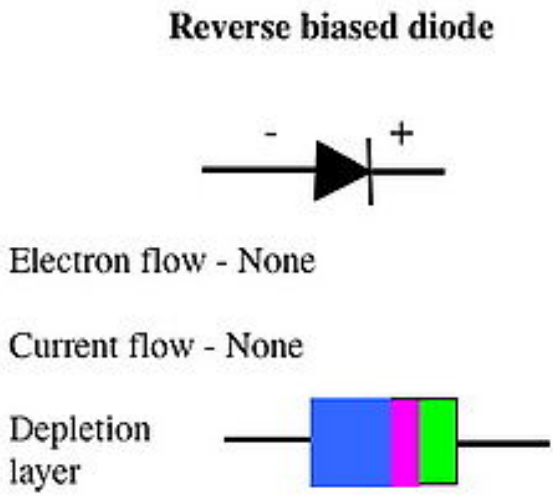


SPST

Diode







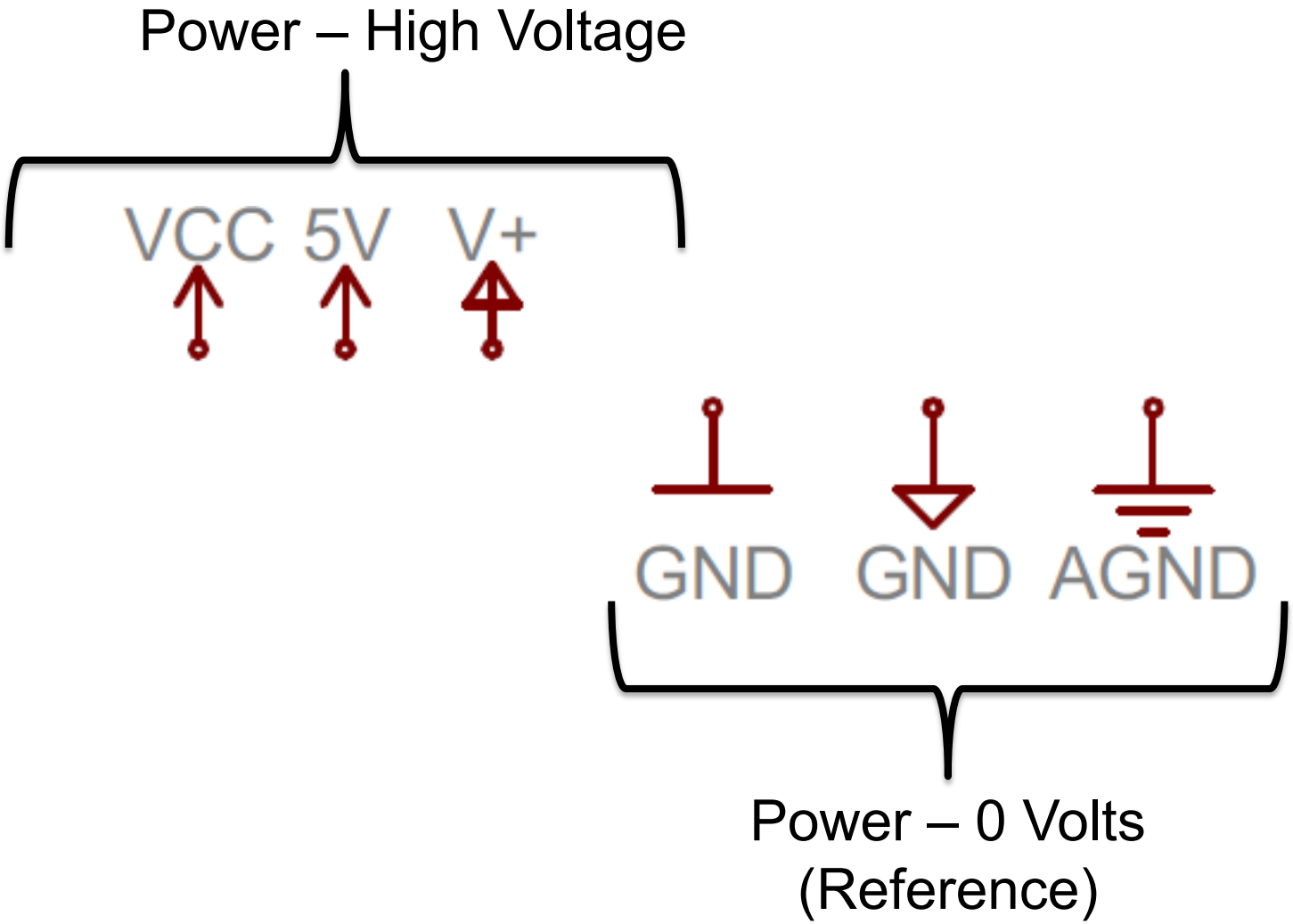
2 terminal

Polarity

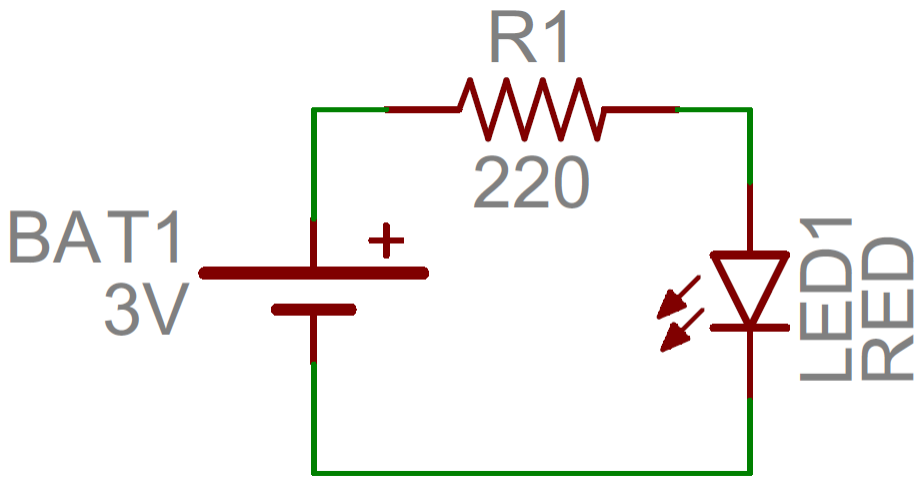
If current flows => $V \approx 2.1v$

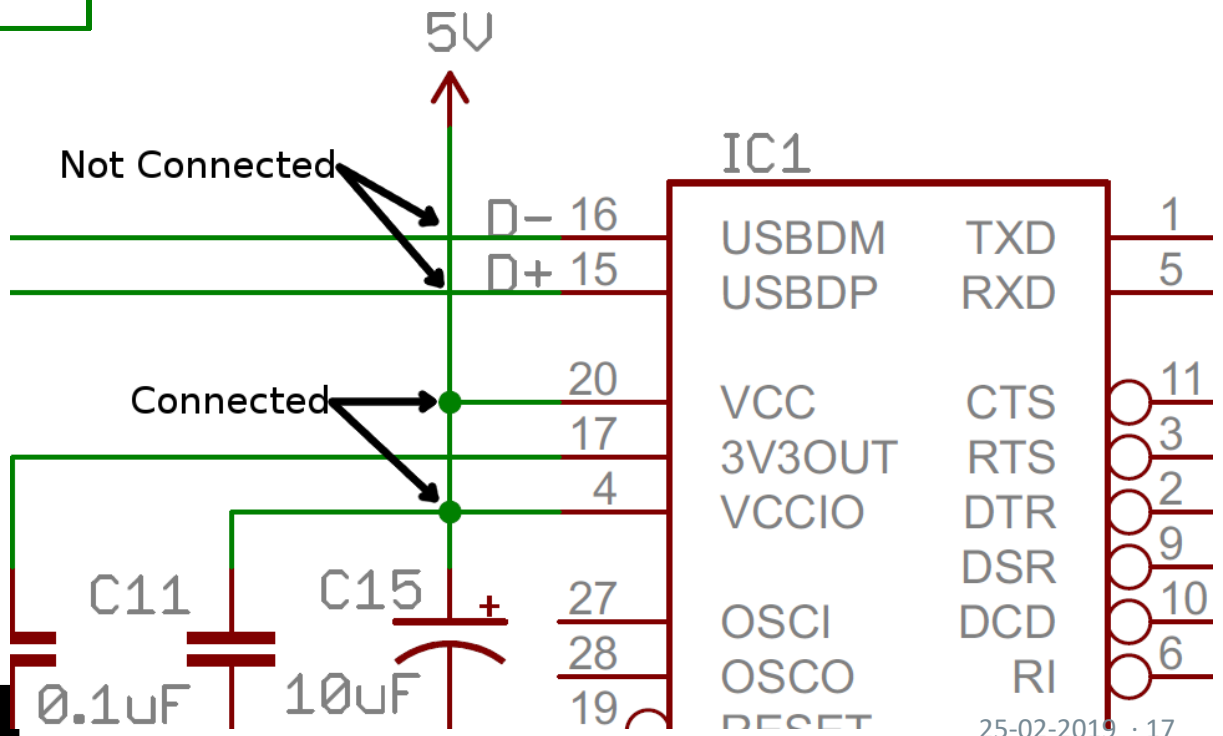
A LED is a diode that emits light!

Power

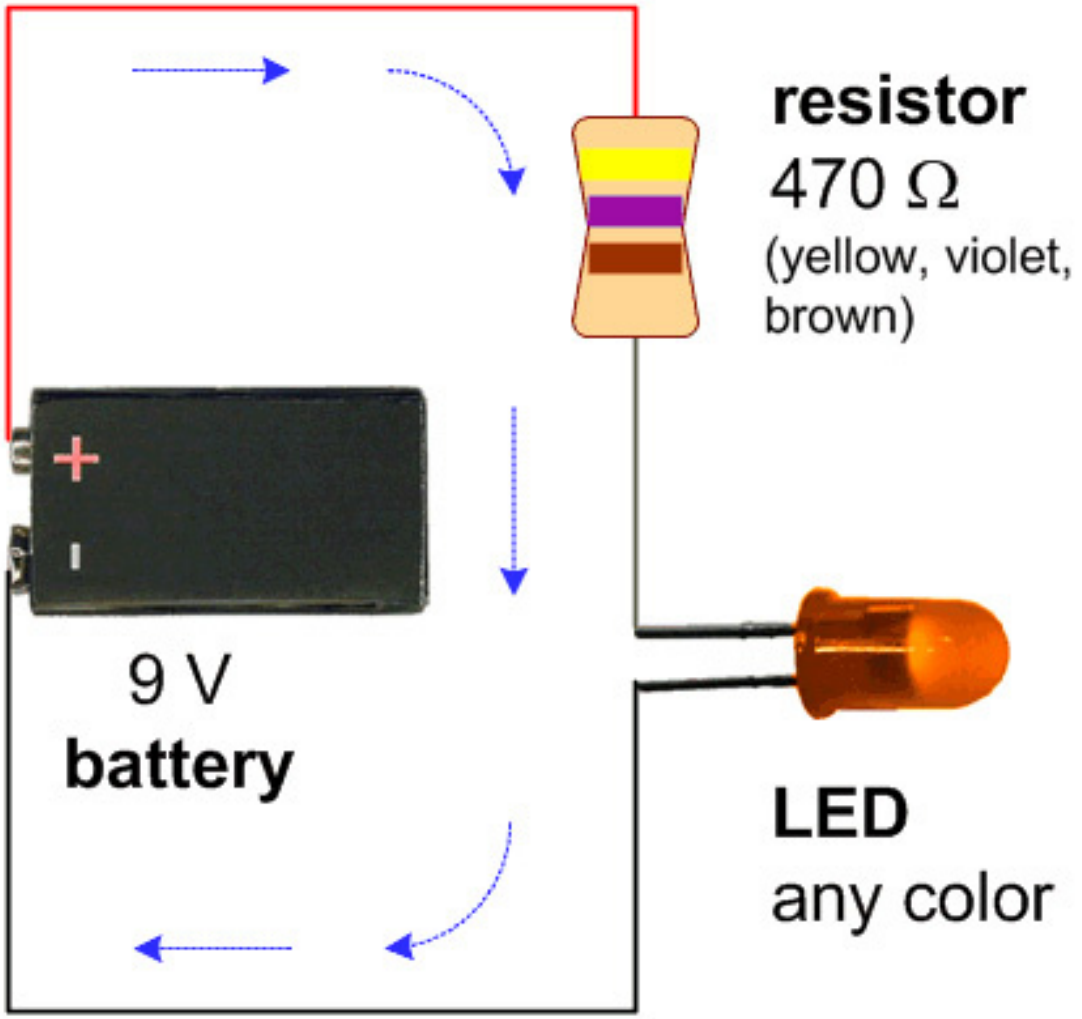

Power – High Voltage
VCC
5V
V+
GND
GND
AGND
Power – 0 Volts
(Reference)

Connections – Wires and junctions





Exercise #1: Your first circuit



resistor
470 Ω
(yellow, violet, brown)

or

350Ω
Orange, Green, Brown

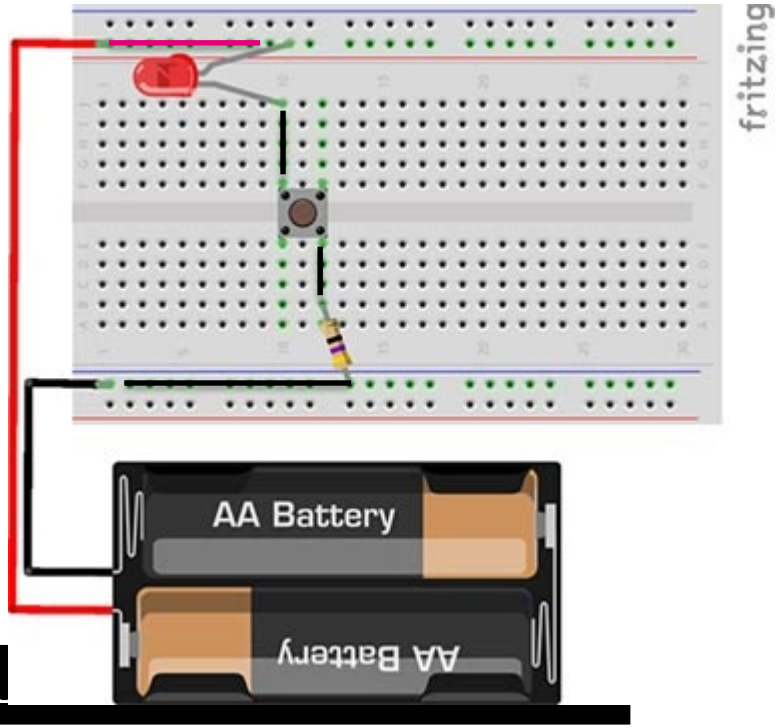
9 V
battery

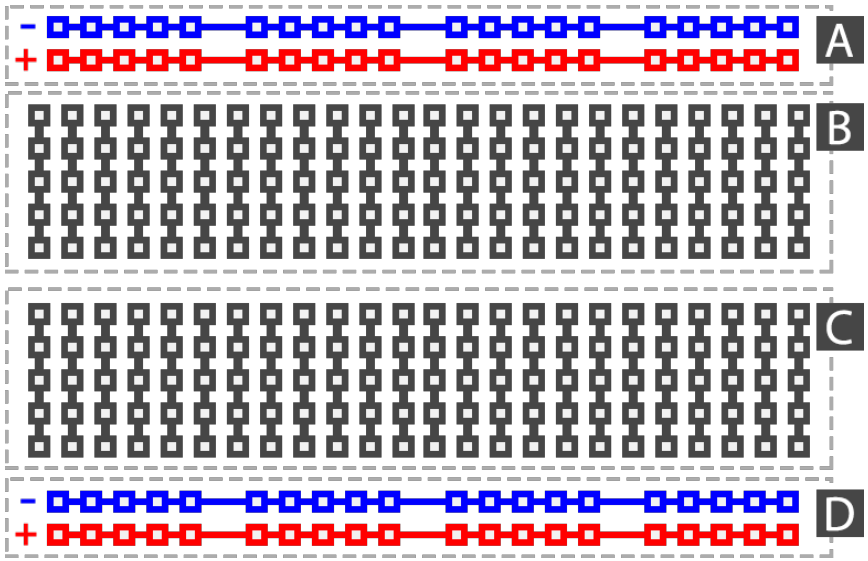
LED
any color

Breadboards

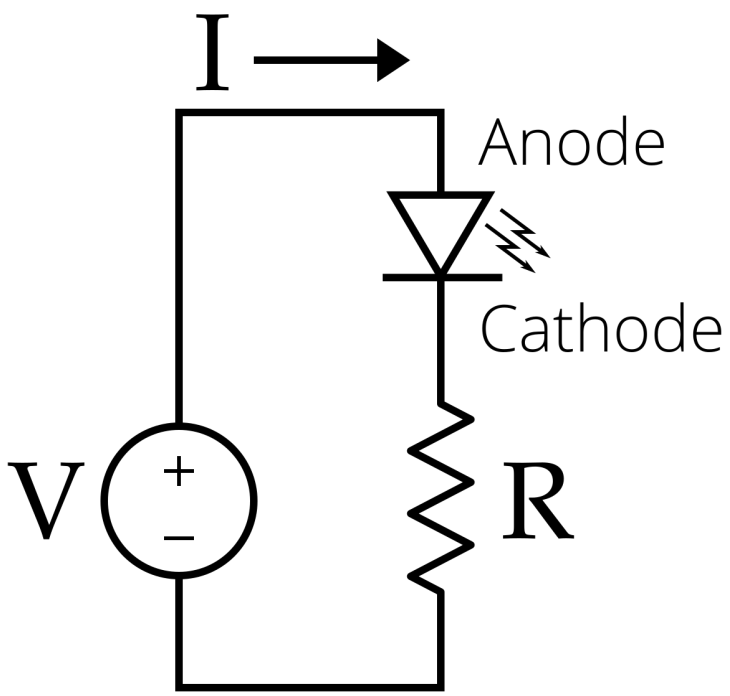
How to Use a Breadboard

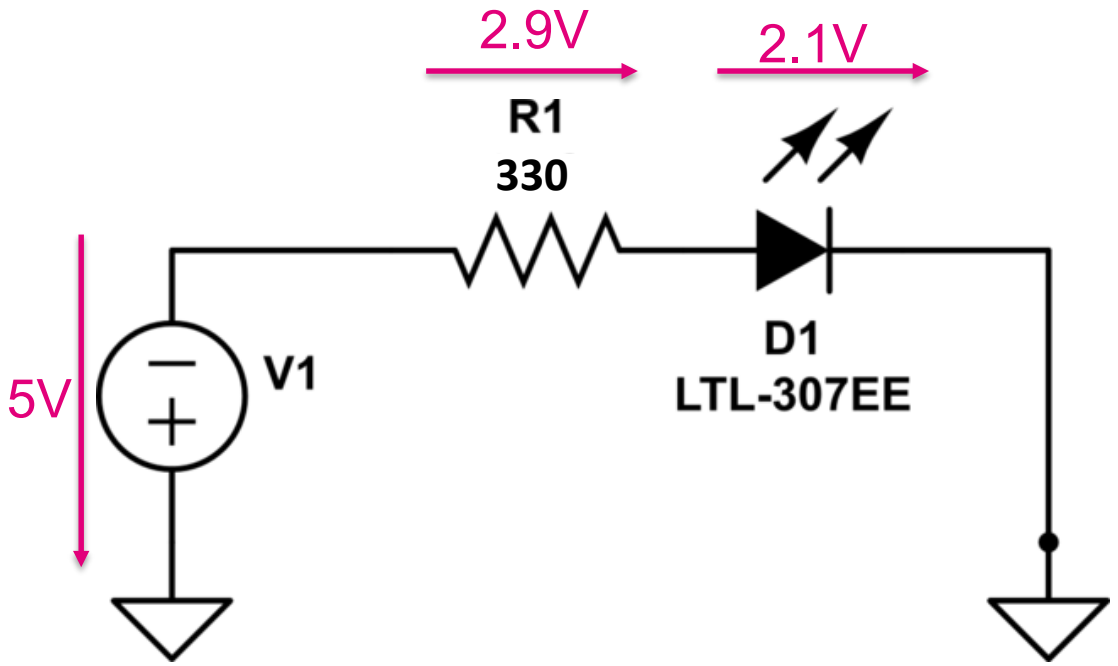
https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard





Your first circuit



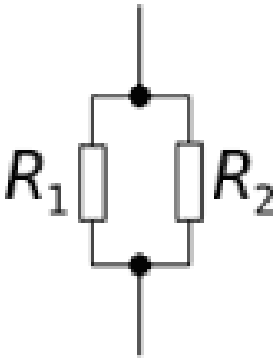


$I = V/R = 2.9/330 = 0.009A = 9mA$

What happens if we don't add the resistor???

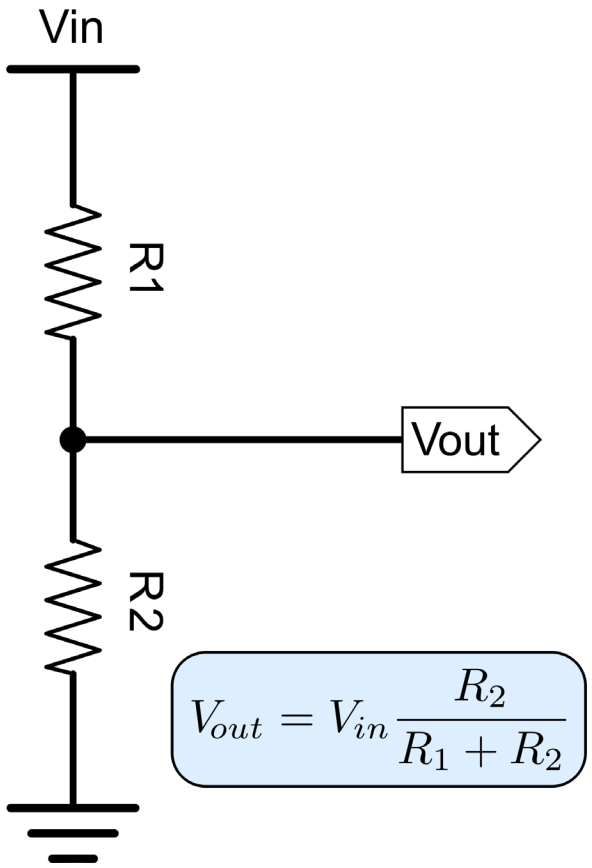
Resistors in series/parallel

$$R_{TOTAL} = R_1 + R_2 \ldots R_n$$



$$\frac{1}{R_{TOTAL}} = \frac{1}{R_1} + \frac{1}{R_2} \cdots \frac{1}{R_n}$$

Voltage divider



$$V_{out} = V_{in} \frac{R_2}{R_1 + R_2}$$

Sensors

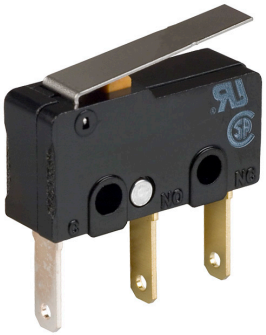
Sensing physical properties of the world

List of simple sensors

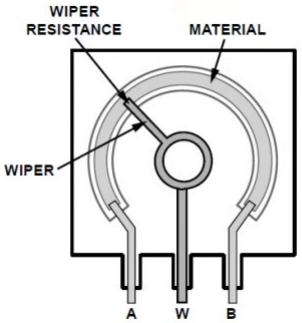
- Switches
- Resistive position sensors (Potentiometer)
- Light sensors
- Reflective optosensors
- Break beam optosensors

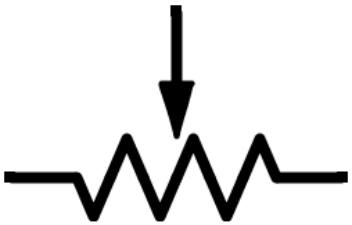
Switch and potentiometer

Switch

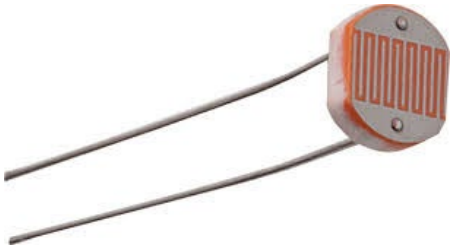


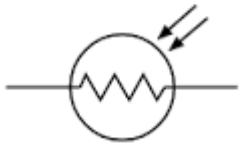
Potentiometer



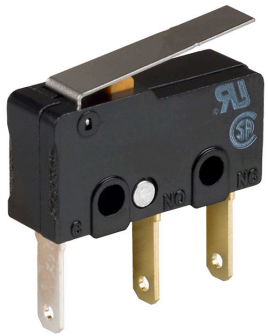


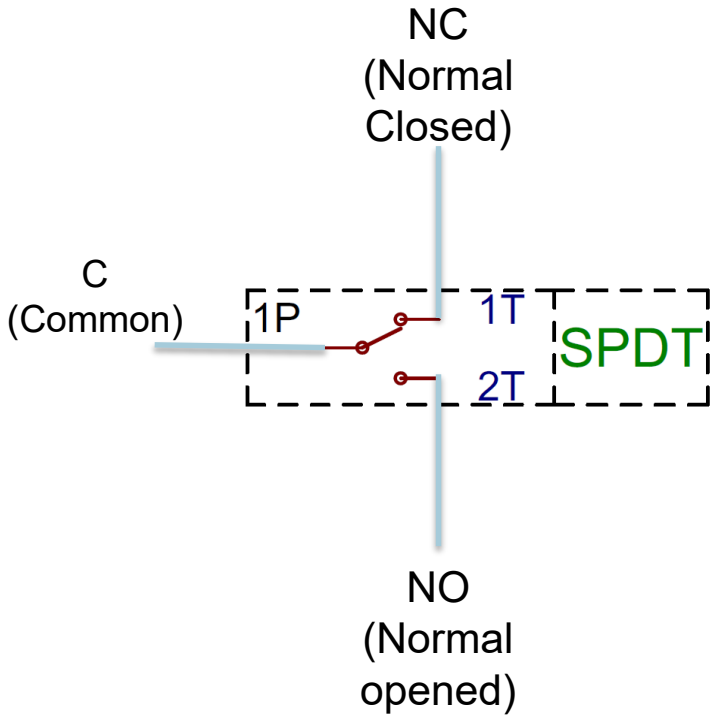
Light dependent Resistor (photoresistor)

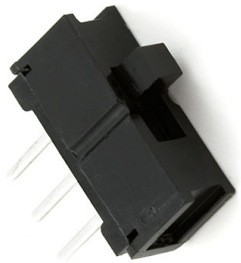




Switches

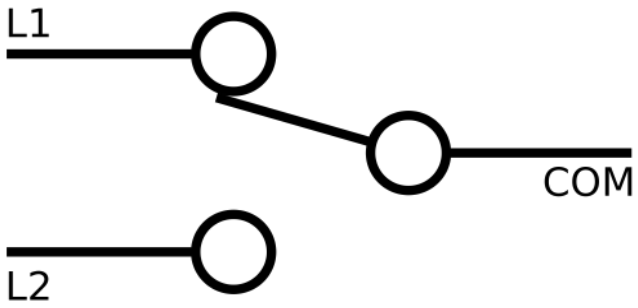



NC
(Normal
Closed)
C
(Common)
1P
1T
2T
SPDT
NO
(Normal
opened)

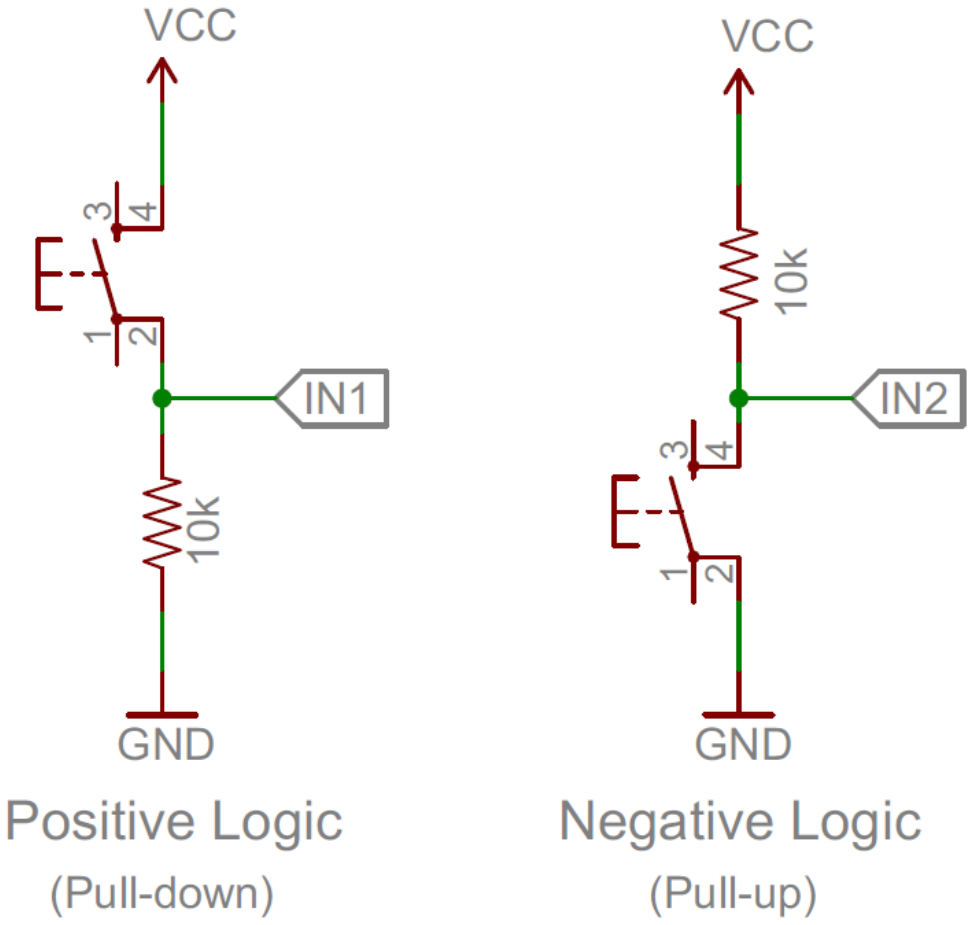



3
4
1
2

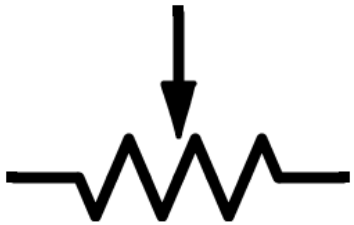

1
2


L1
COM
L2

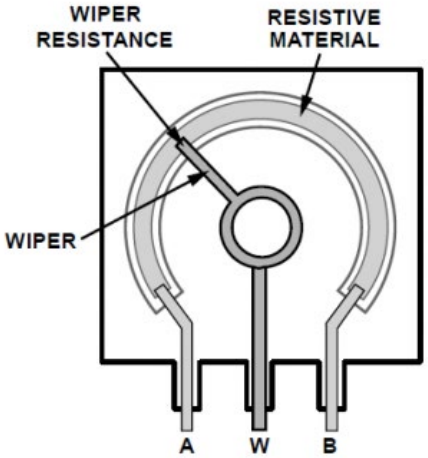
How to read a switch?



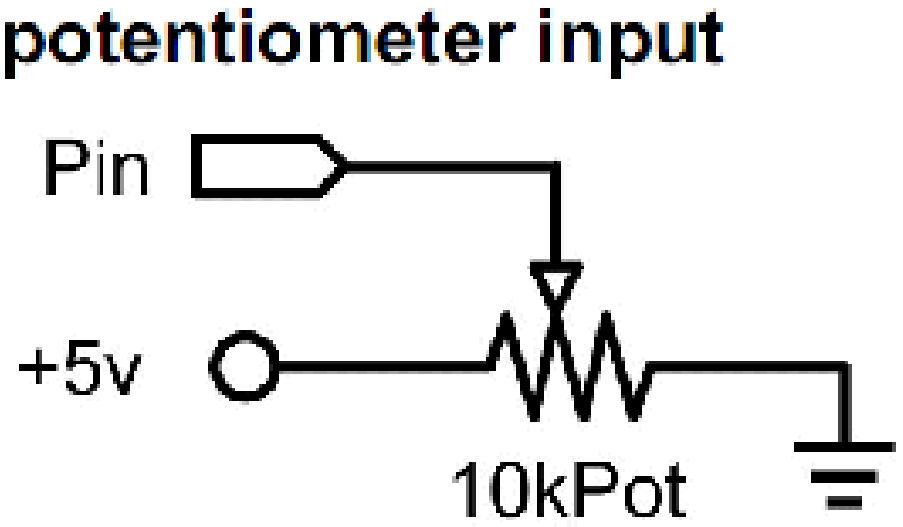
Potentiometer



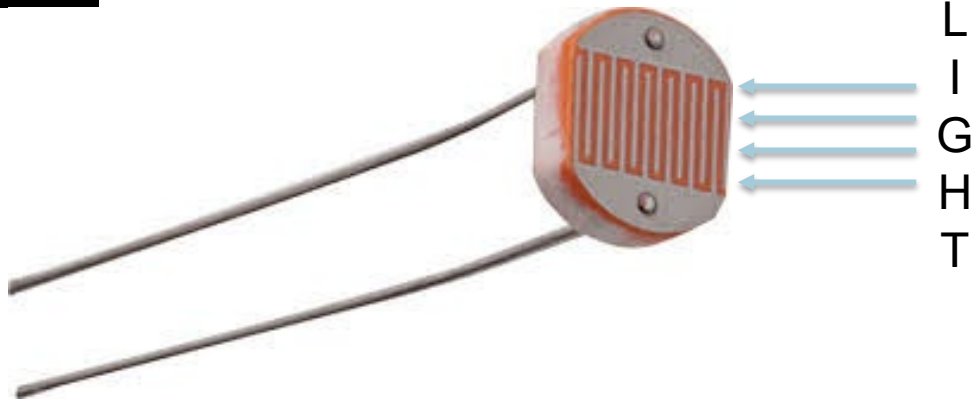
3 terminals
Polarity



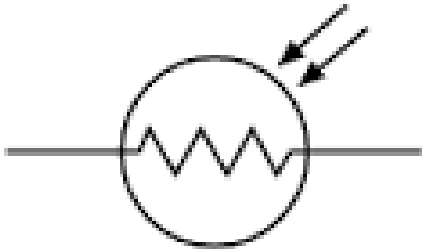
How to read a potentiometer?



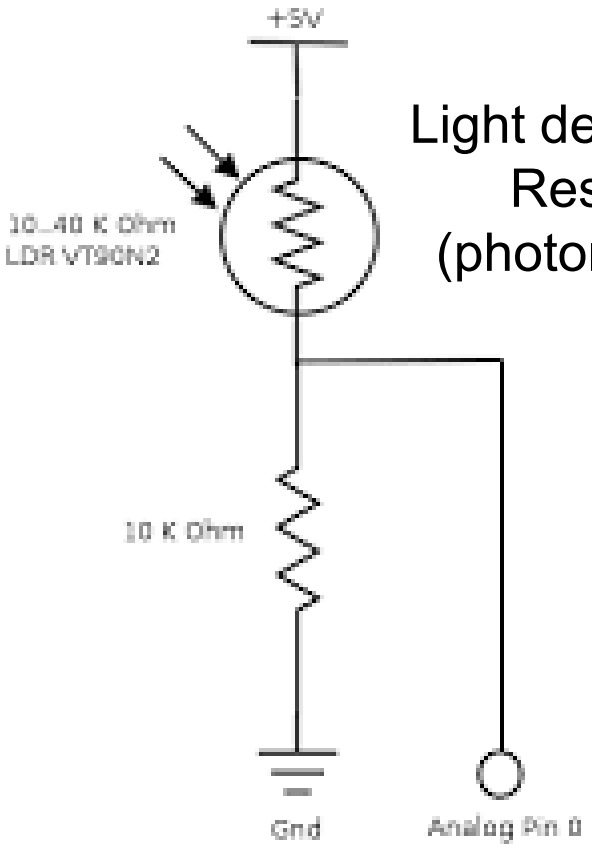
Light dependent Resistor (photoresistor)



2 Terminals
No polarity
Like a resistor
Resistance changes with received light



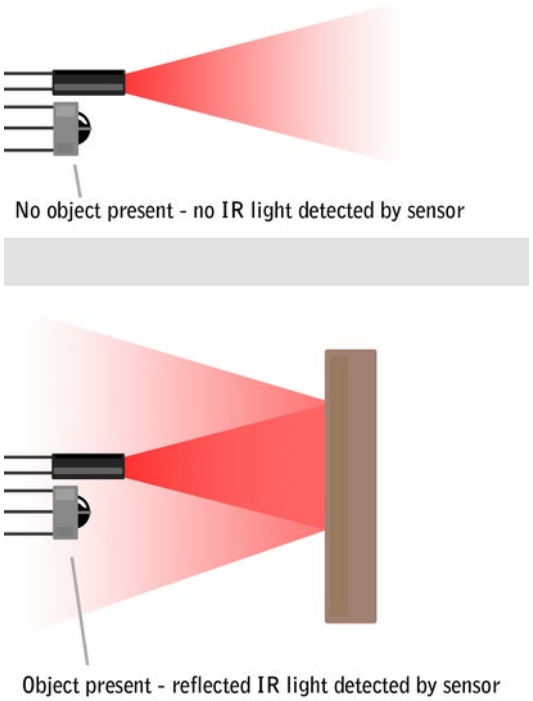
How to read a photoresistor?



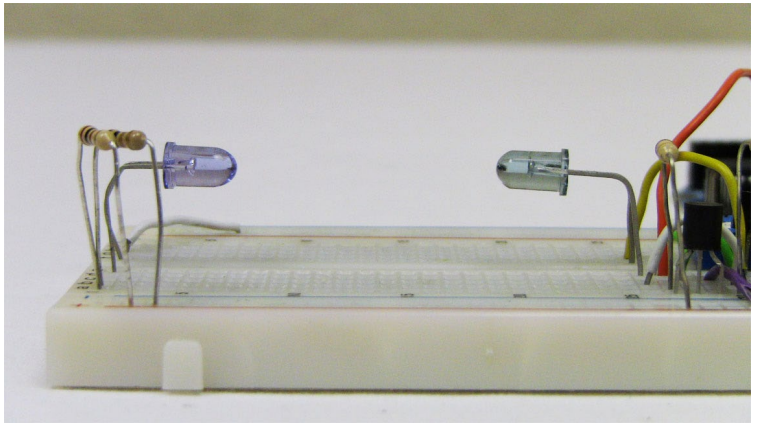
Light dependent Resistor (photoresistor)

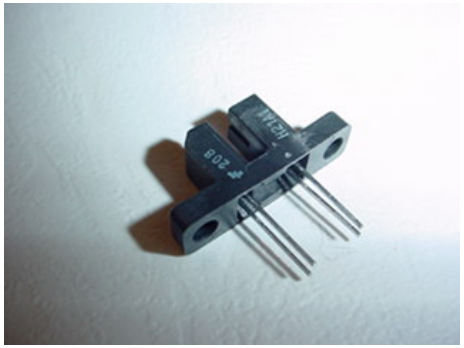
Optosensors

Reflective optosensors



Break beam optosensors

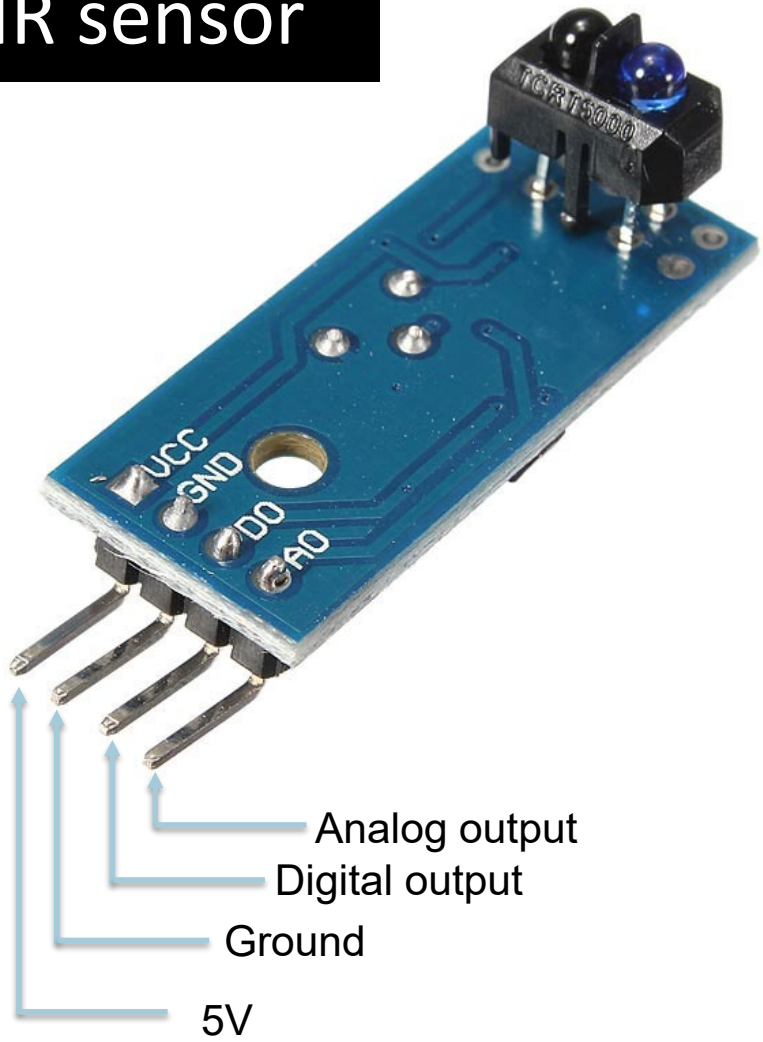


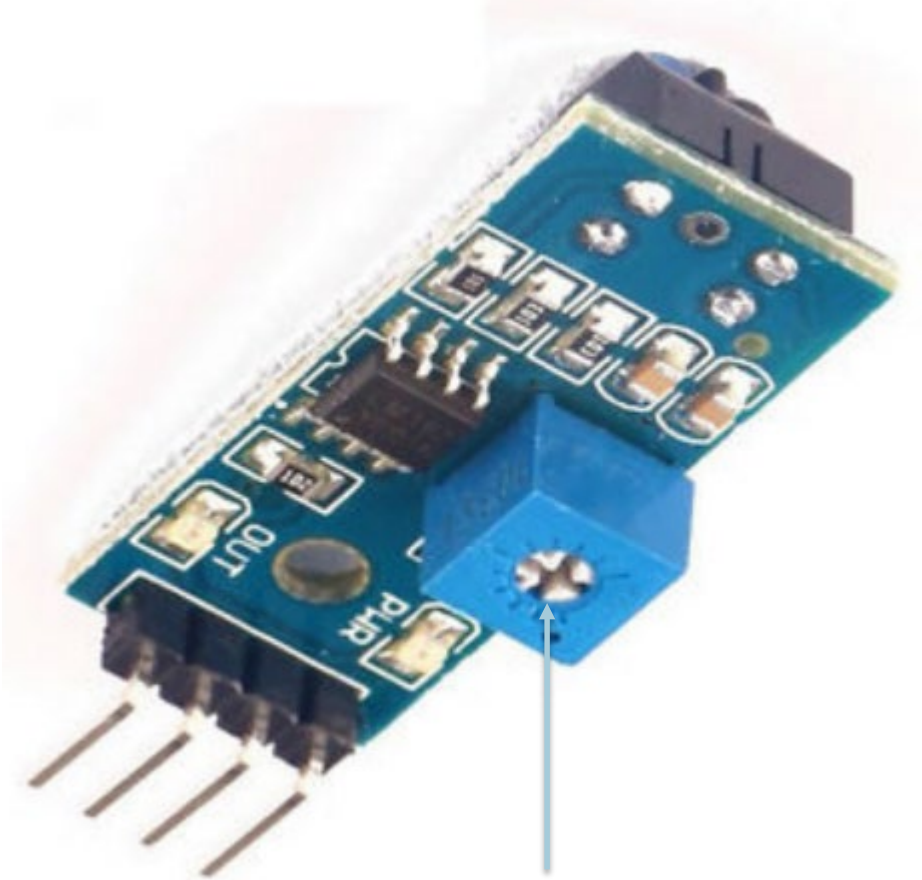


Light sensor tricks

- Polarized light
- Infrared light
- Modulation/demodulation

An IR sensor

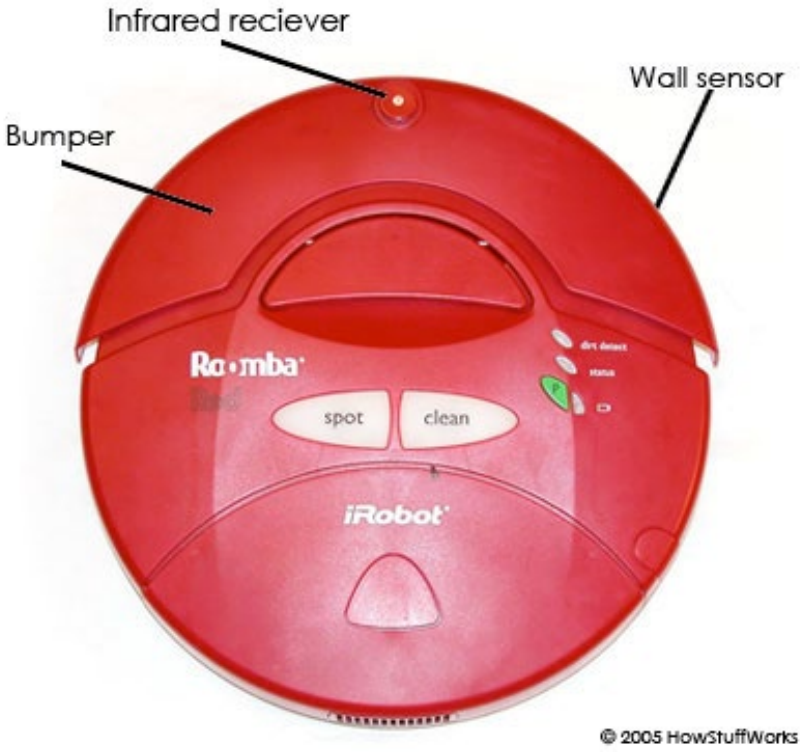




Digital output: 0 or 5V, <10mA

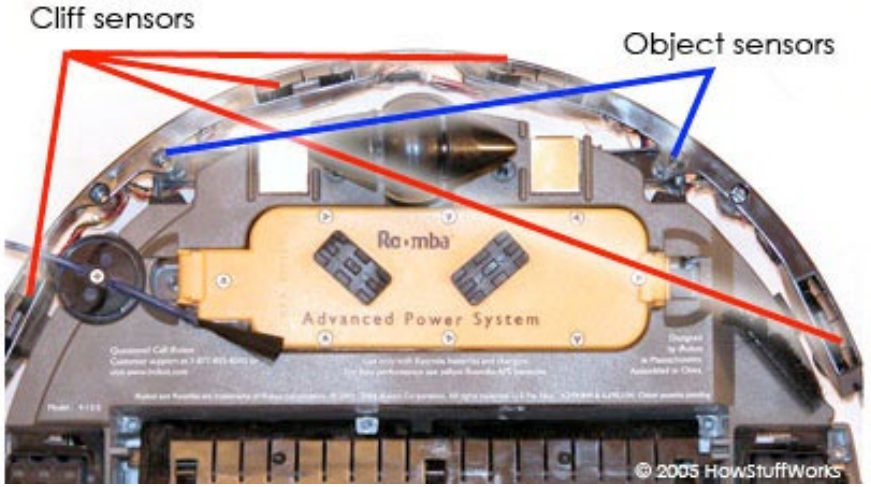
Analog output: 0 – 5V, <10mA

Roomba



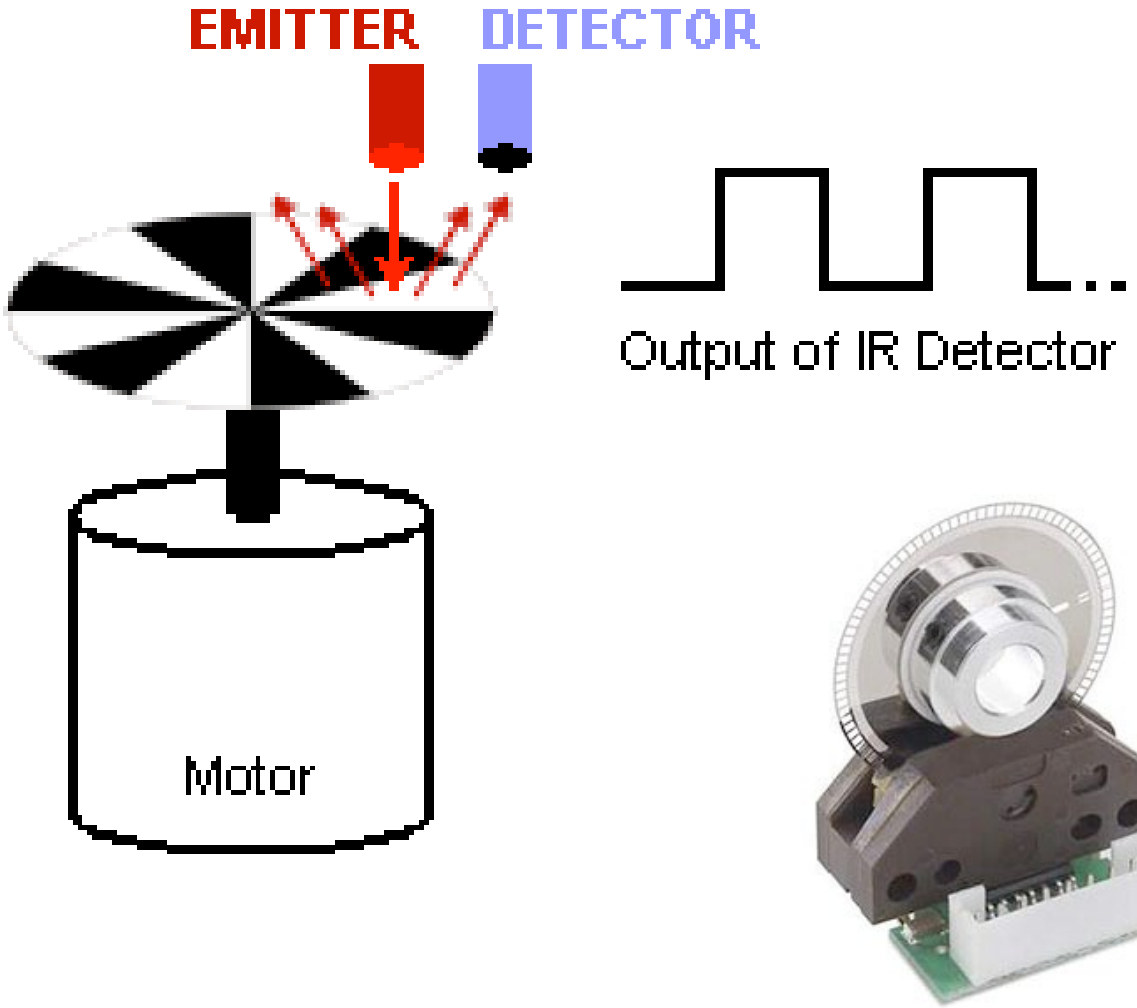
Reflective optosensor

Switches



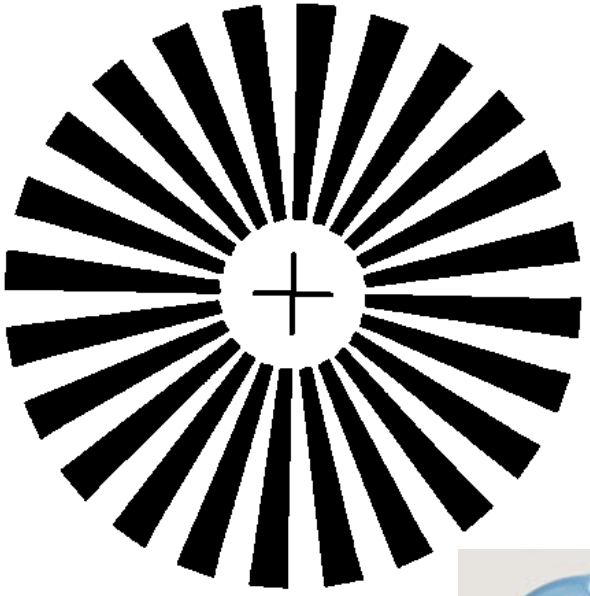
http://electronics.howstuffworks.com/gadgets/home/robotic-vacuum2.htm

Shaft encoders

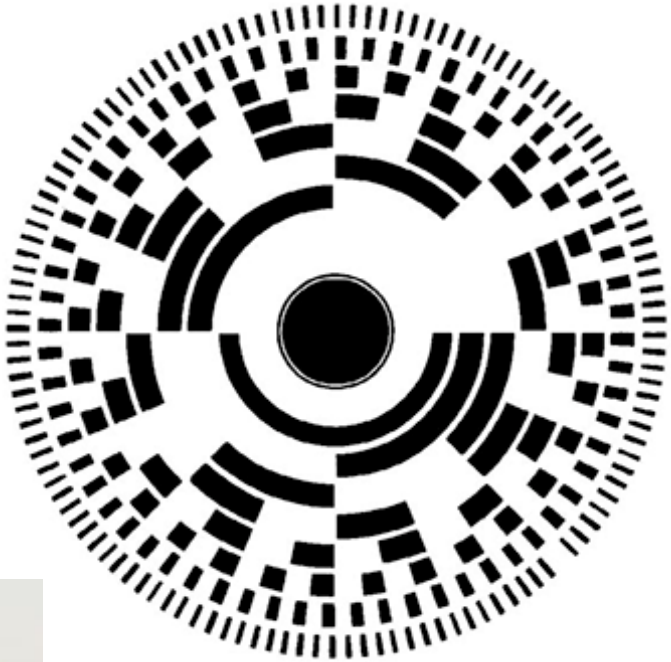


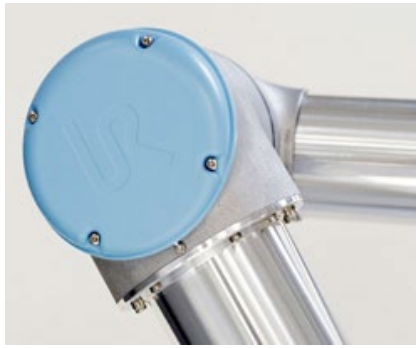
Robot arm joint uses shaft encoders

Relative position



Absolut position





Bar codes also possible

Advanced sensors

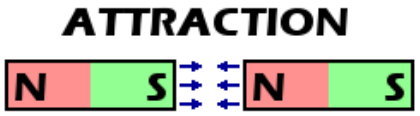
- Ultra-sonic and sonar sensors (sound's time of flight)
- Laser sensing (pinpoint accuracy, light's time of flight)
- Visual sensing (array of light sensors, cameras)
- Microphones

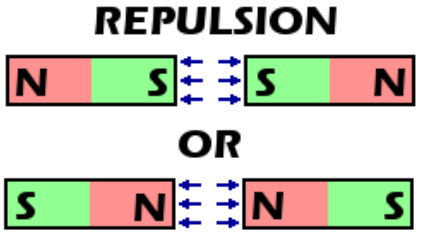
Exercise #2 - Test simple sensors

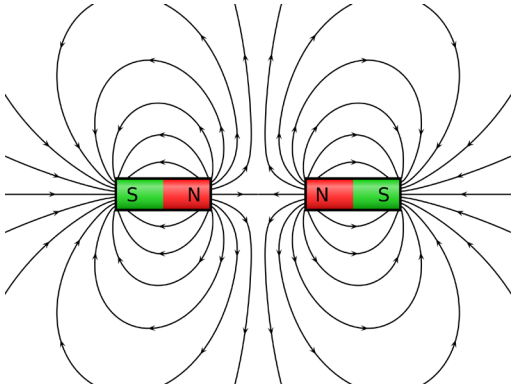
Actuators

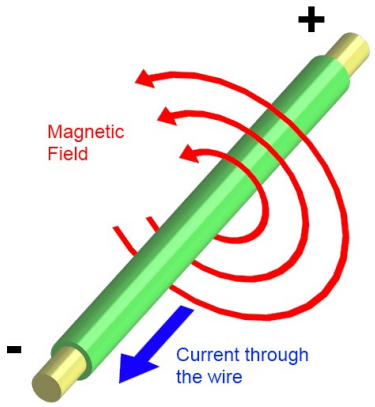
Making things move

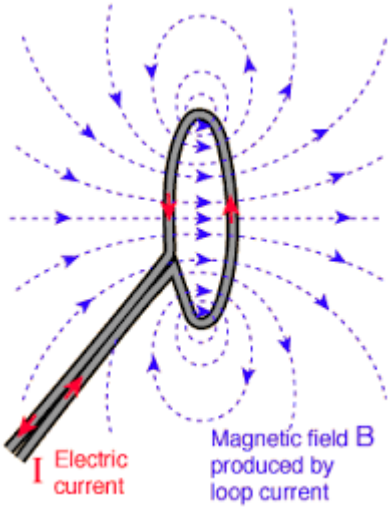
Basics concepts

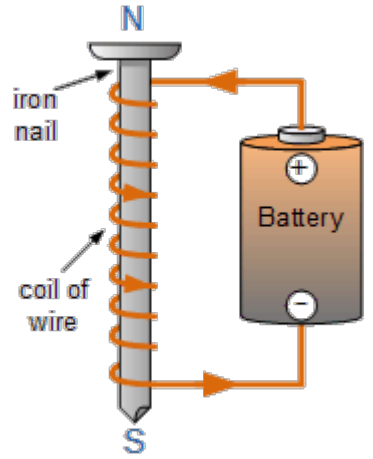


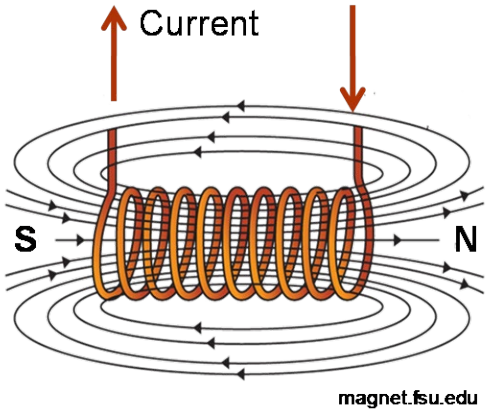




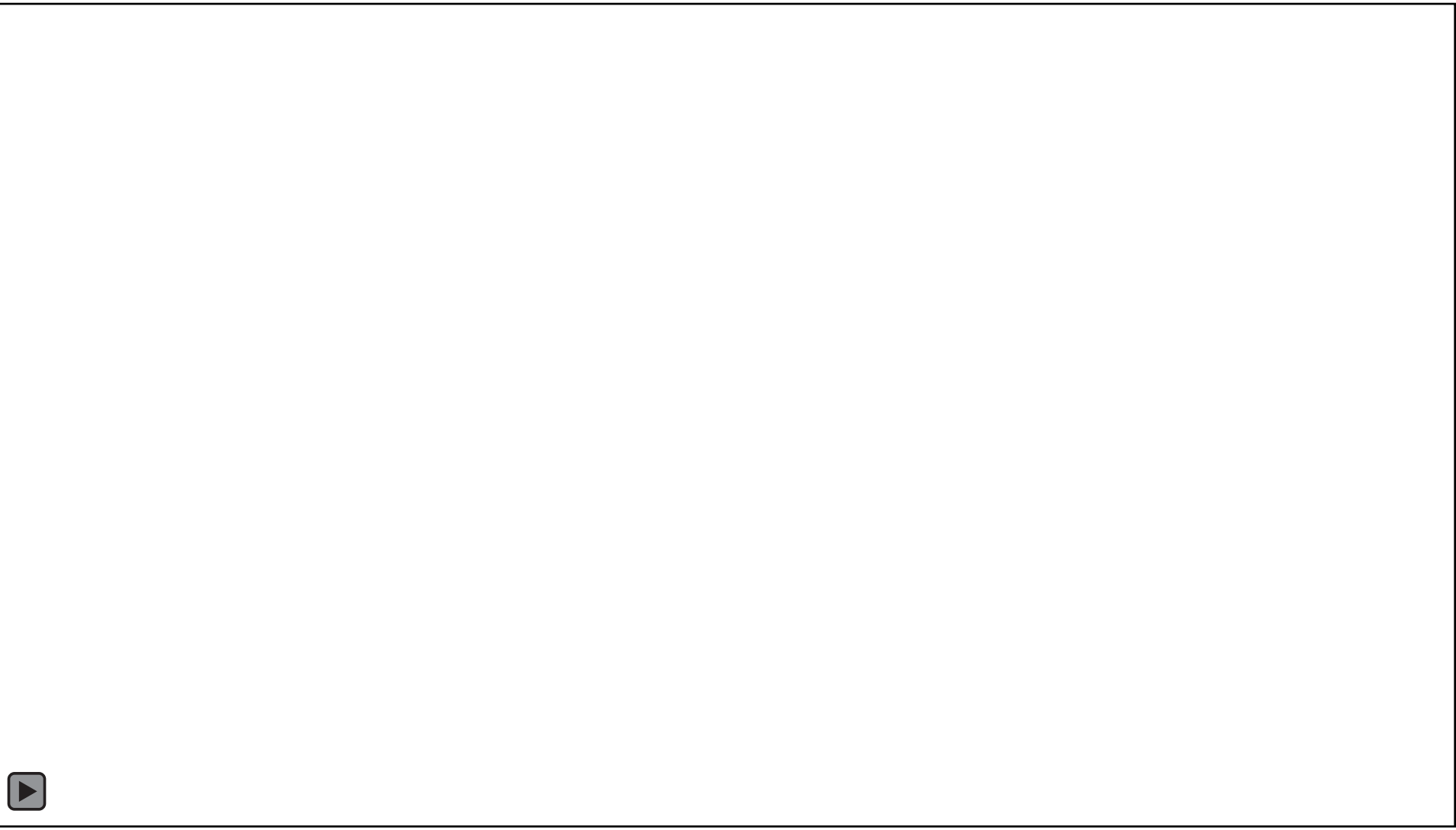




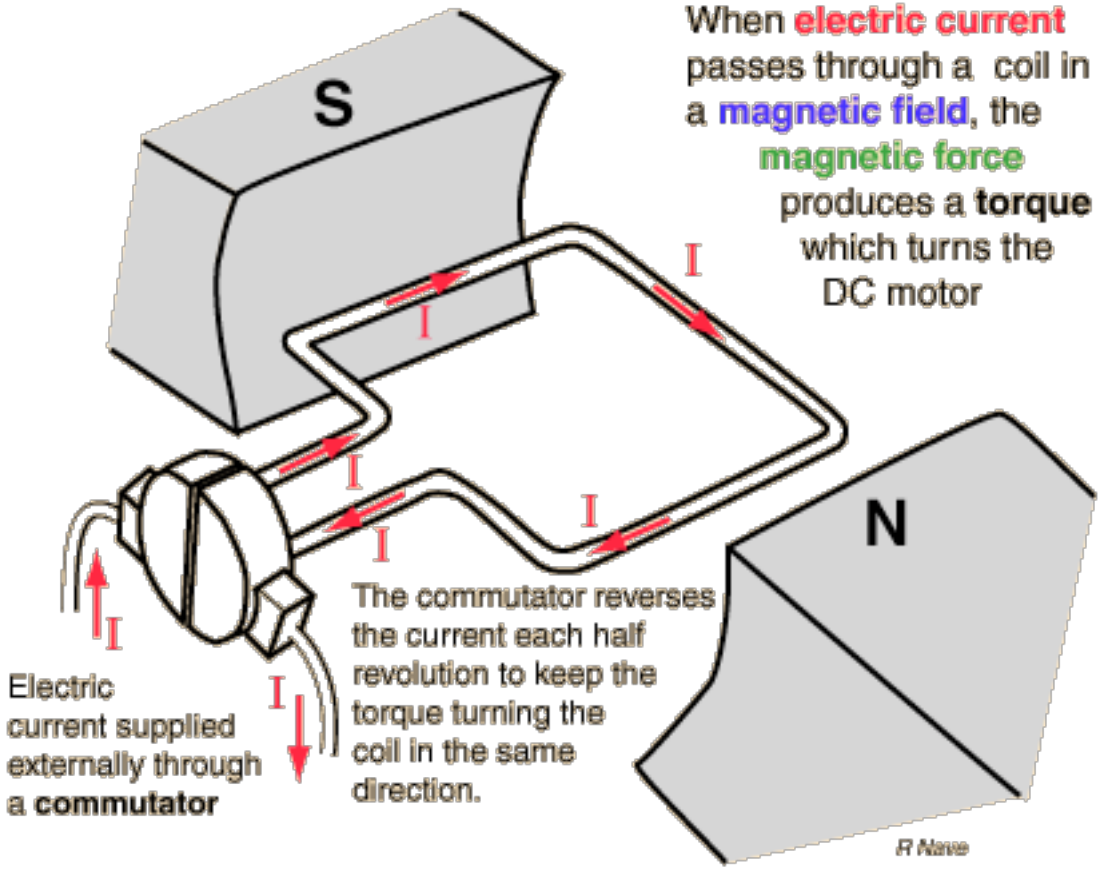




DC - Motor



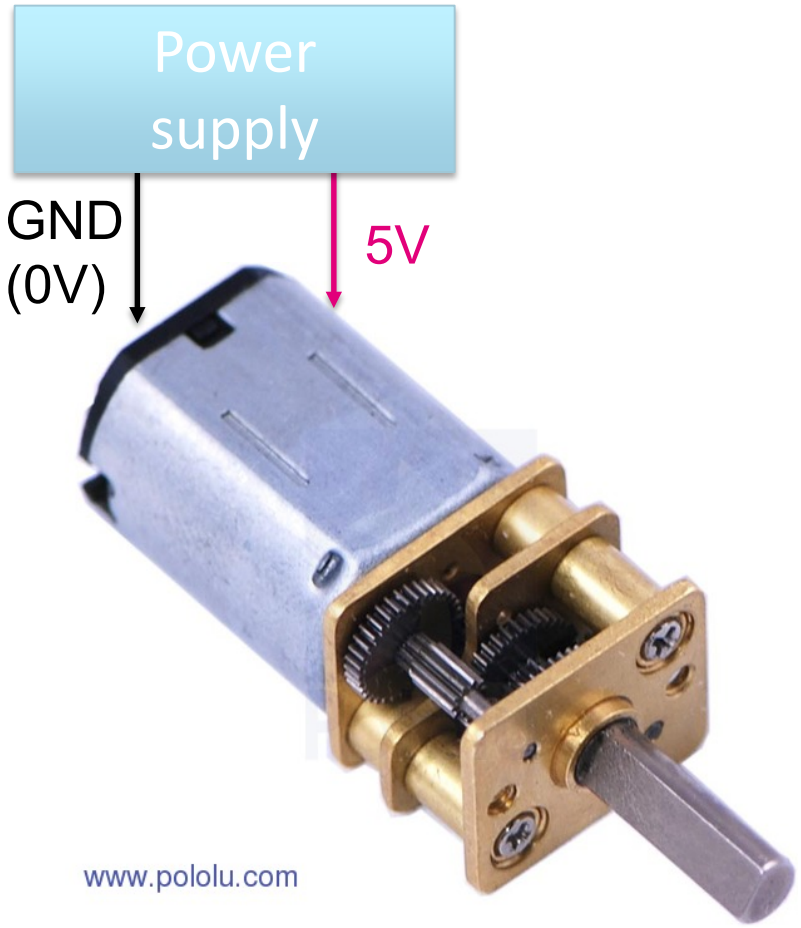
DC – Motor – The clever bit



Brushed DC motor

Many variation of this design used

DC motor + reduction



Motor Type	Stall Current @ 6 V	No-Load Speed @ 6 V	Approximate Stall Torque @ 6 V	 Single-Shaft (Gearbox Only)
high-power, carbon brushes **(HPCB)**	1600 mA	3000 RPM	4 oz-in	10:1 HPCB
		1000 RPM	9 oz-in	30:1 HPCB
		625 RPM	15 oz-in	50:1 HPCB
		400 RPM	22 oz-in	75:1 HPCB
		320 RPM	30 oz-in	100:1 HPCB
		200 RPM	40 oz-in	150:1 HPCB
		140 RPM	50 oz-in	210:1 HPCB
		120 RPM	60 oz-in	250:1 HPCB
		100 RPM	70 oz-in	298:1 HPCB
		32 RPM	125 oz-in	1000:1 HPCB

Exercise #3 – Test a DC motor

Connect the dc motor to a power supply

Always use less than 6V!

What happens if

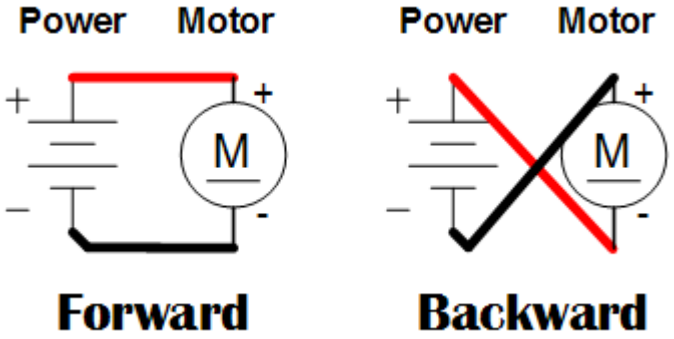
you change the polarity

you change the voltage (**<6V**)

brake the shaft of the motor (**don't stop it**)

Check also what happens with the intensity

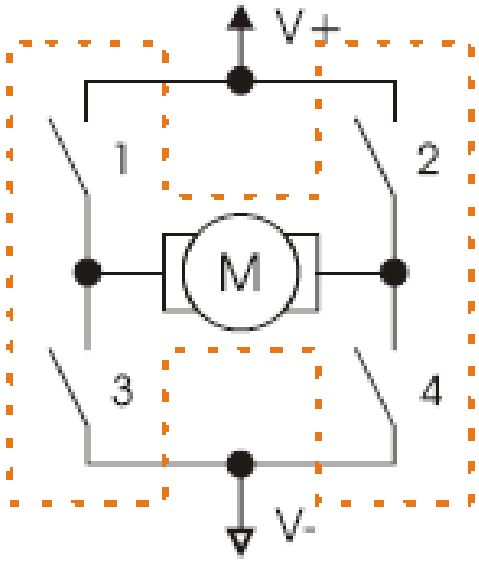
DC motor - Control

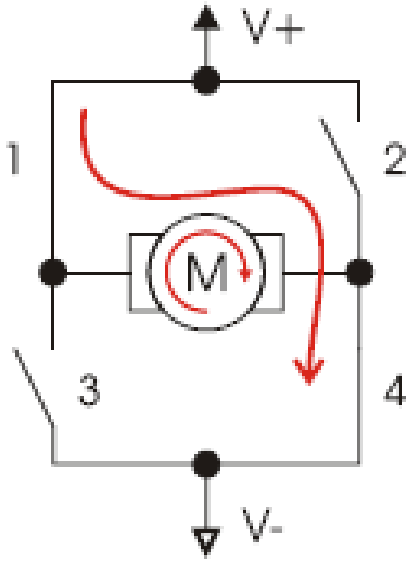


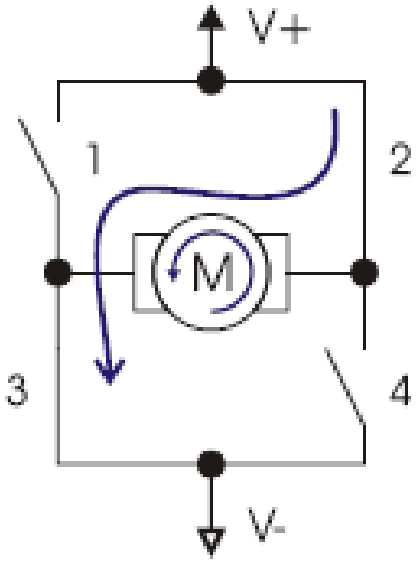
- Constant voltage
- Change direction
  - Reverse polarity
- Speed proportional to the voltage
- Speed depends on the load
- Torque proportional to the I

A motor consumes a lot of current (>200mA)!

DC motor – H-bridge





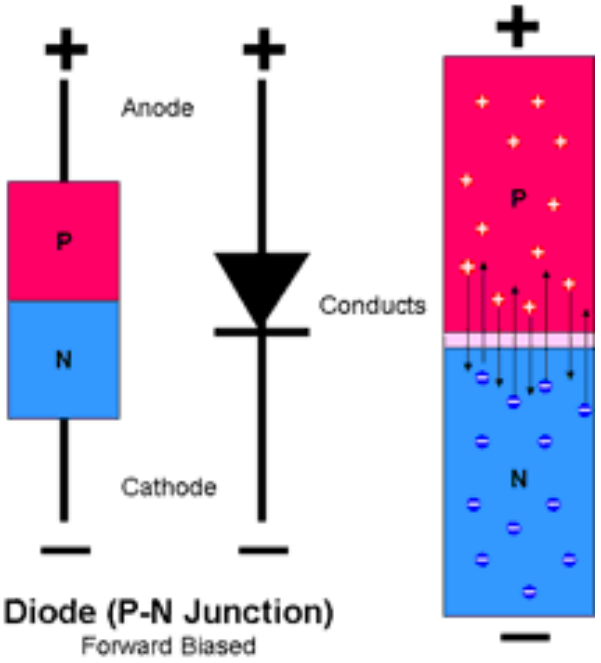


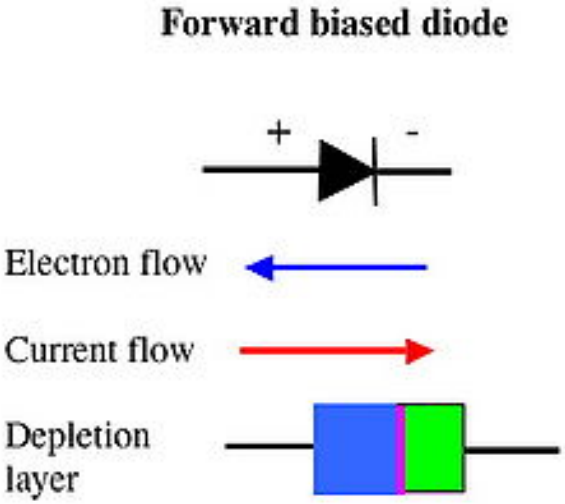
Problem

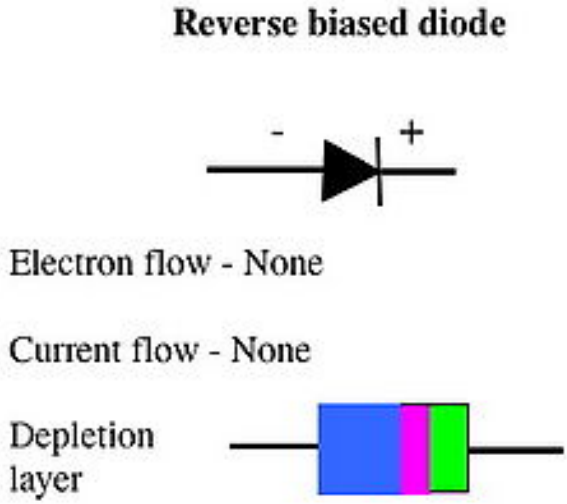
Our motor consumes high currents (>200mA)
Our IR sensors are only able to give 10mA

How can we control our robots?????

Diode

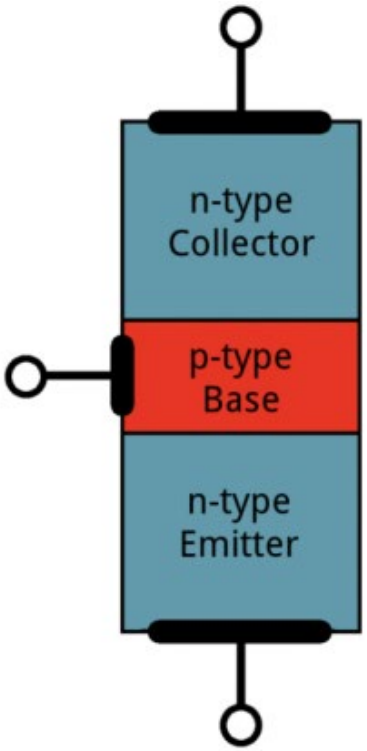




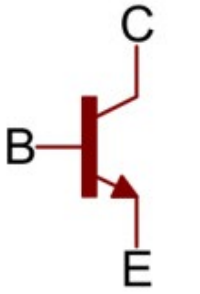


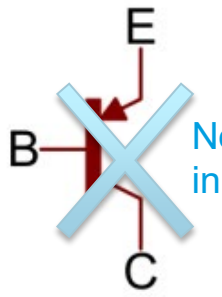
A LED is a diode that emits light!

Transistor – npn

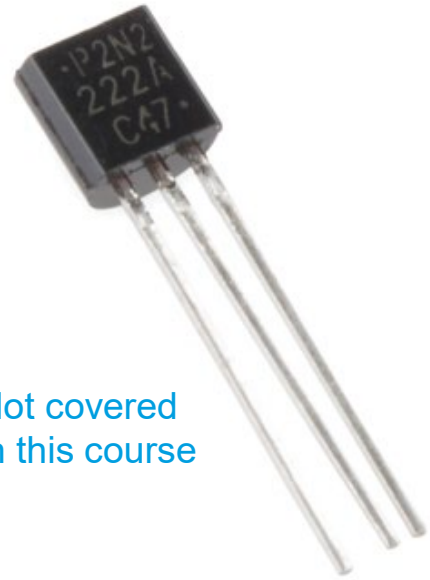


npn



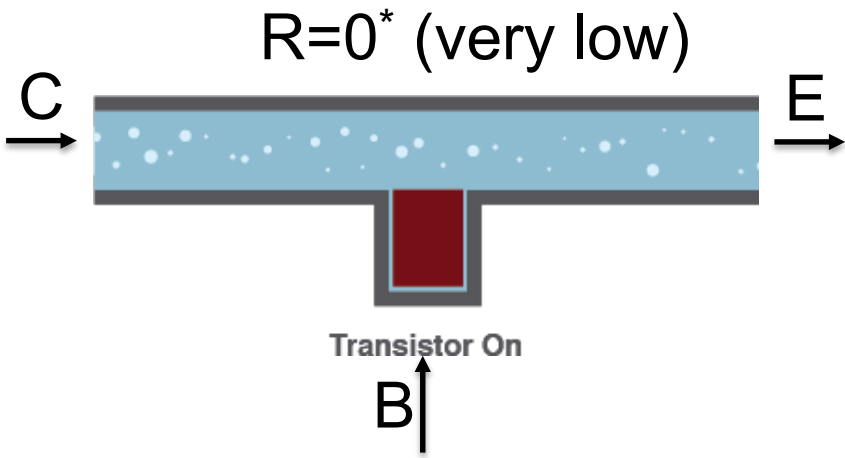


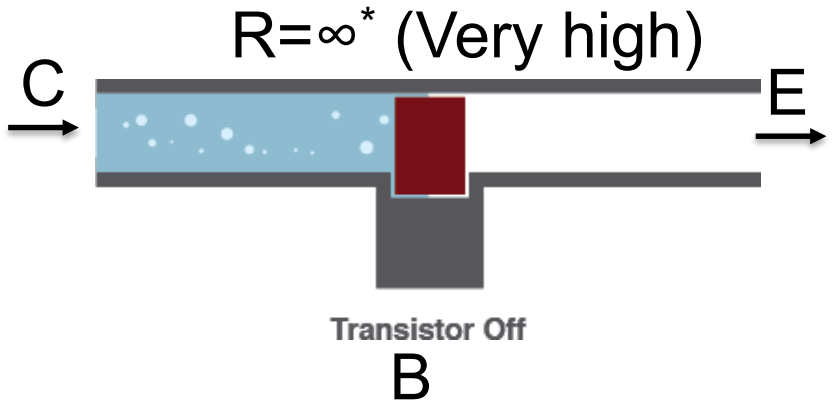
Not covered in this course

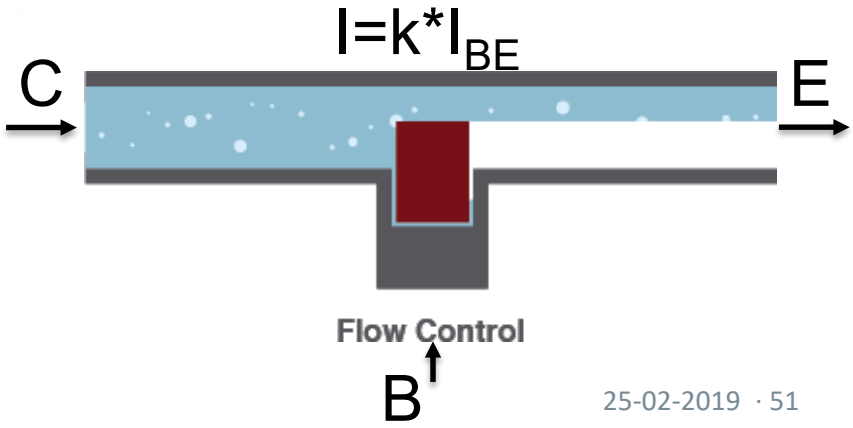


pnp

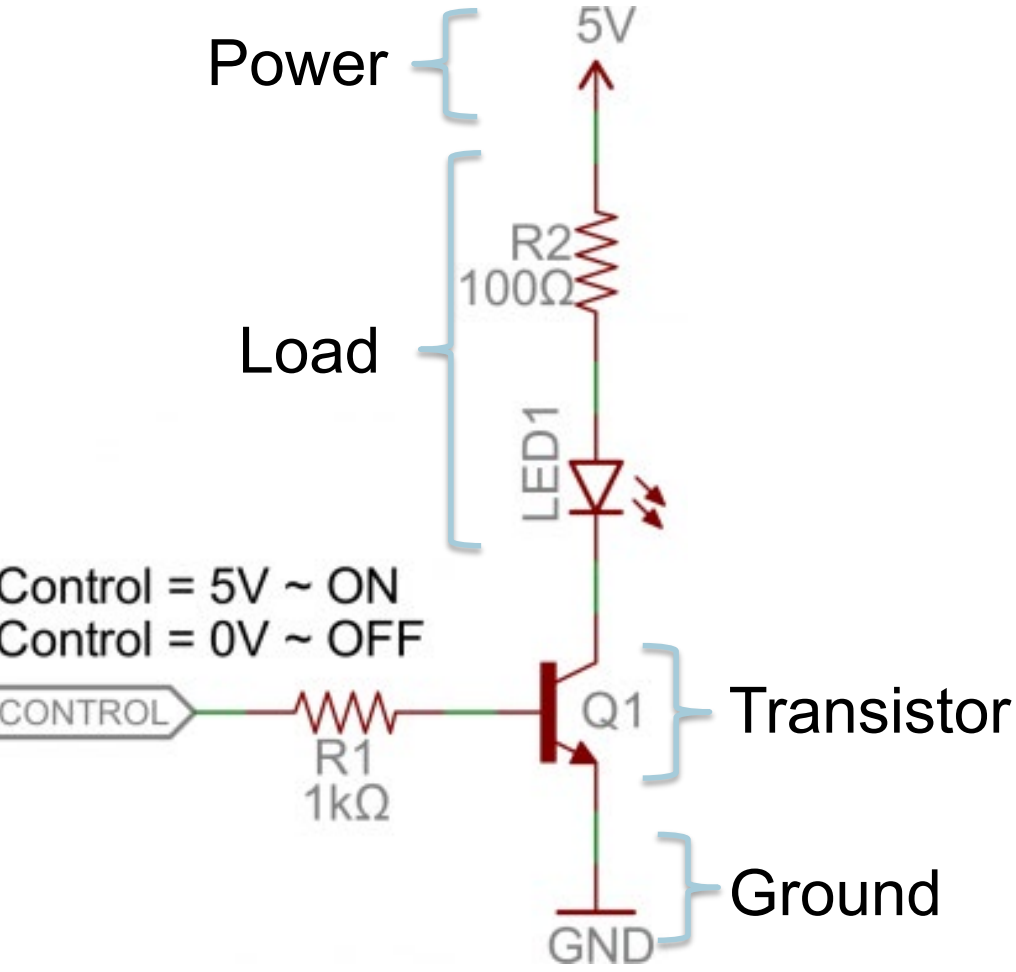
Some of them are able to handle high currents from collector to emitter!

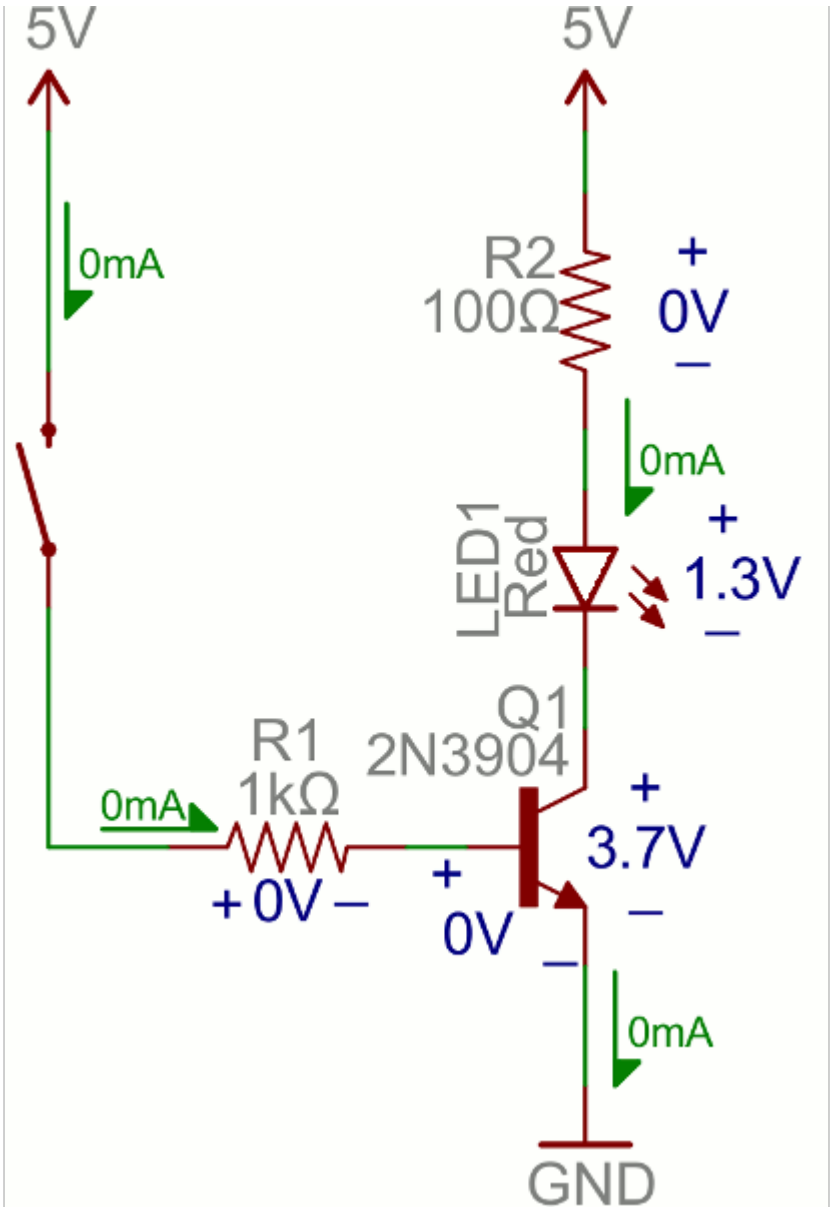




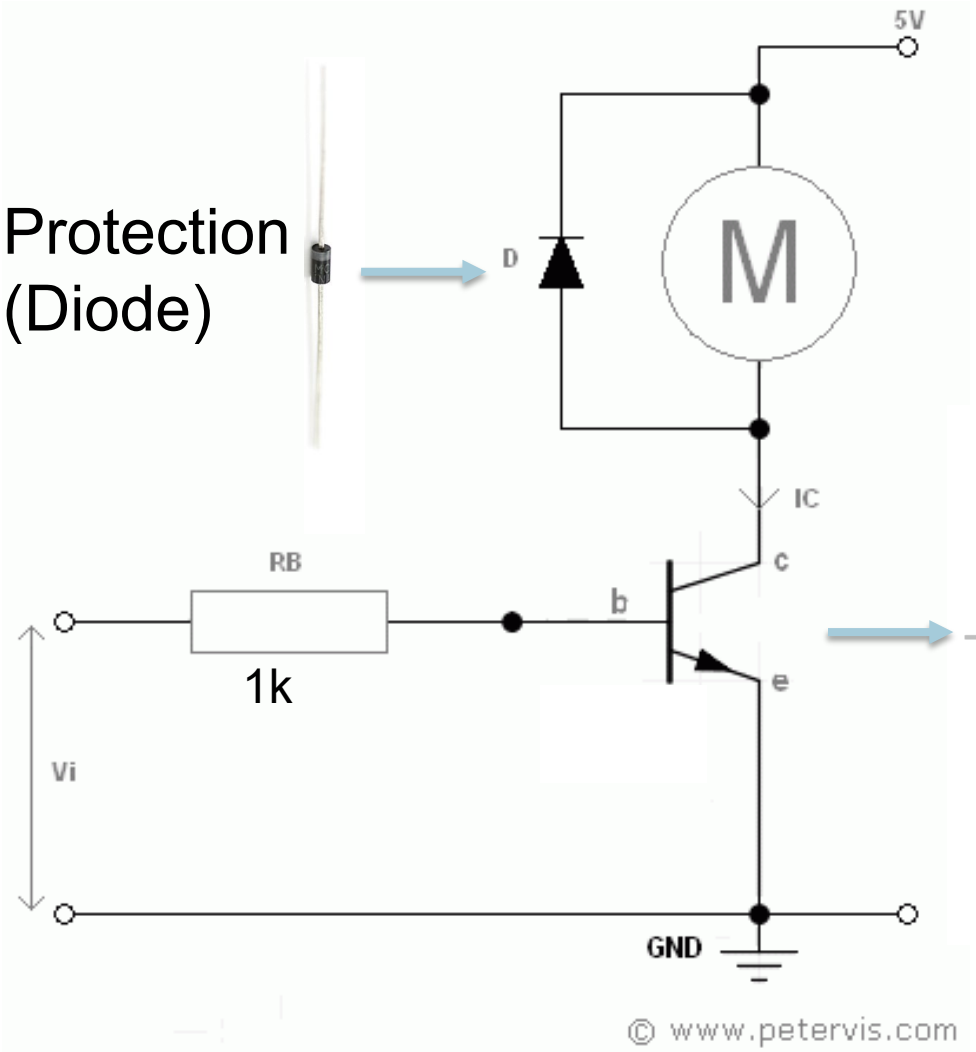


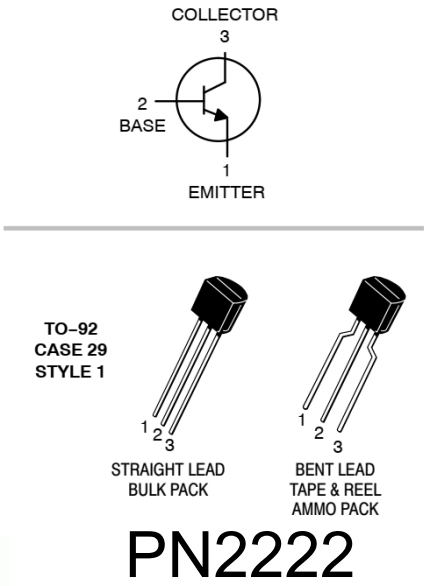
Transistor – Circuit



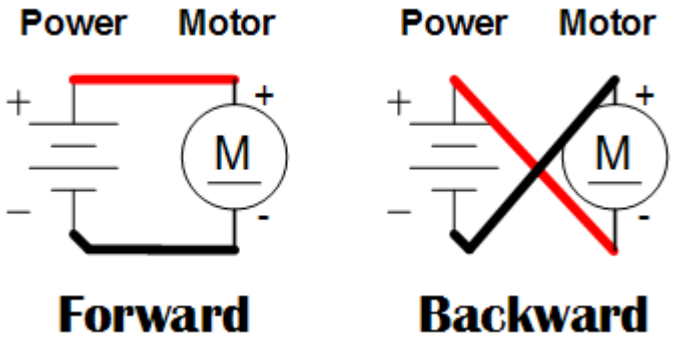


Transistor – Switch applications

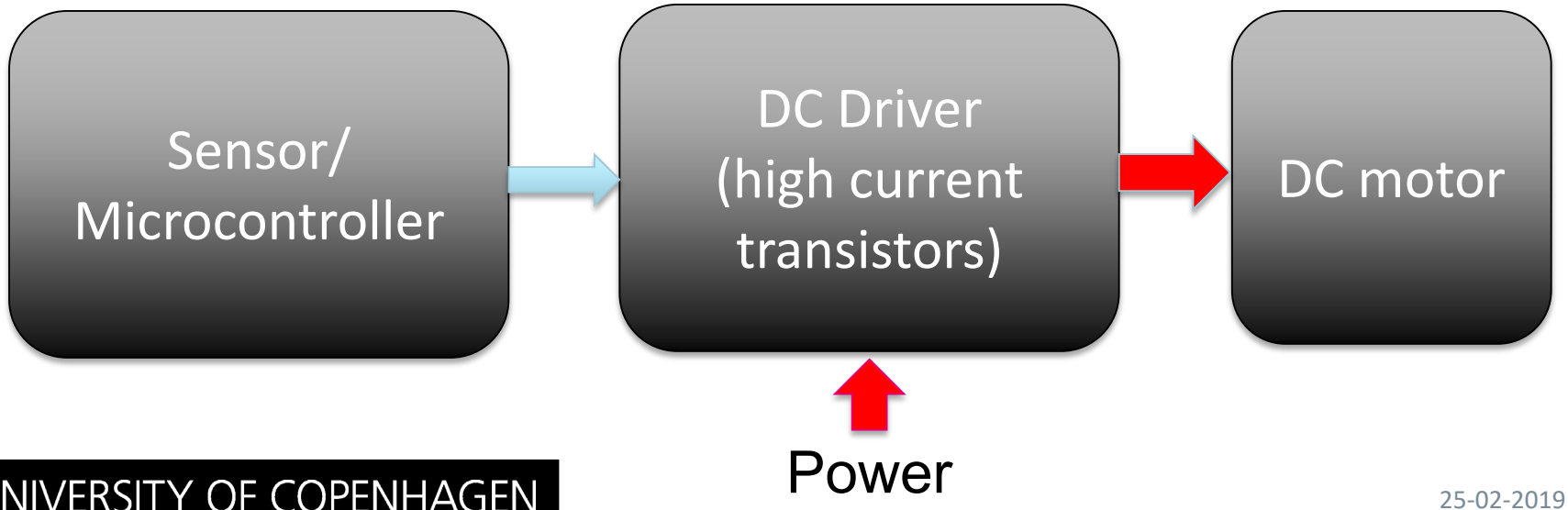




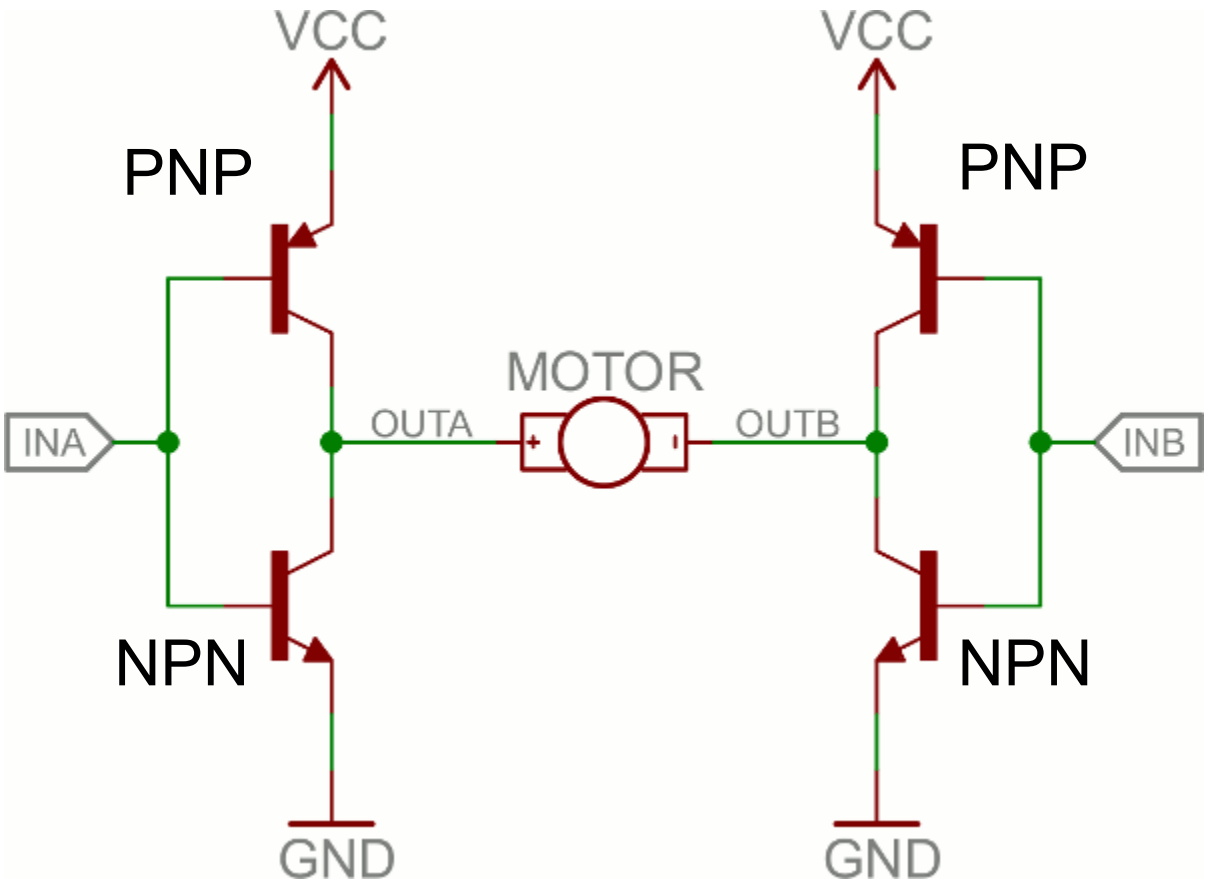
DC motor - Control



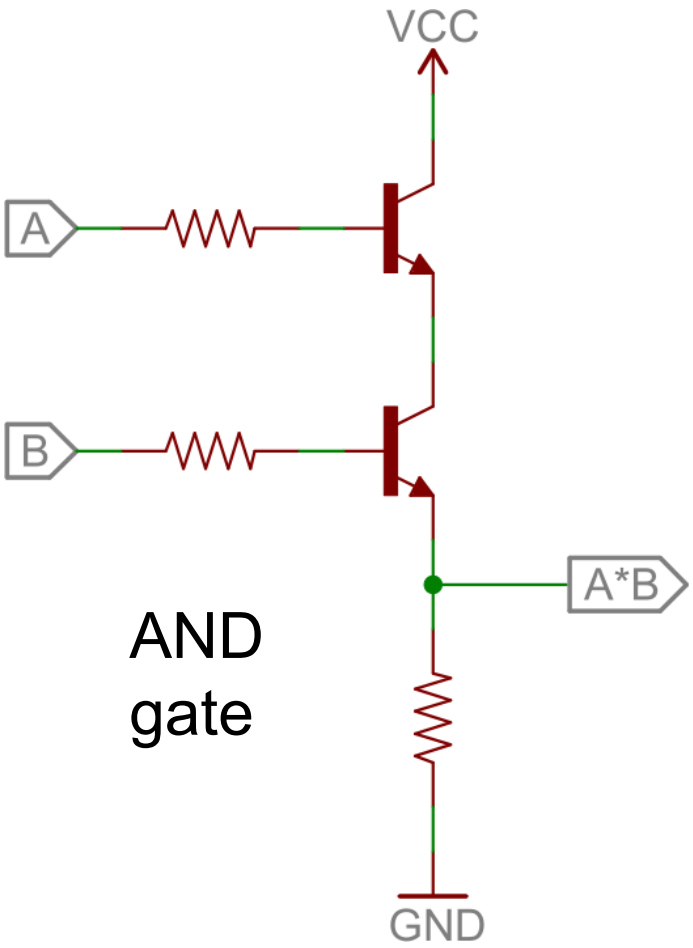
- Change direction
  - Reverse polarity
- Constant voltage
- Speed proportional to the voltage



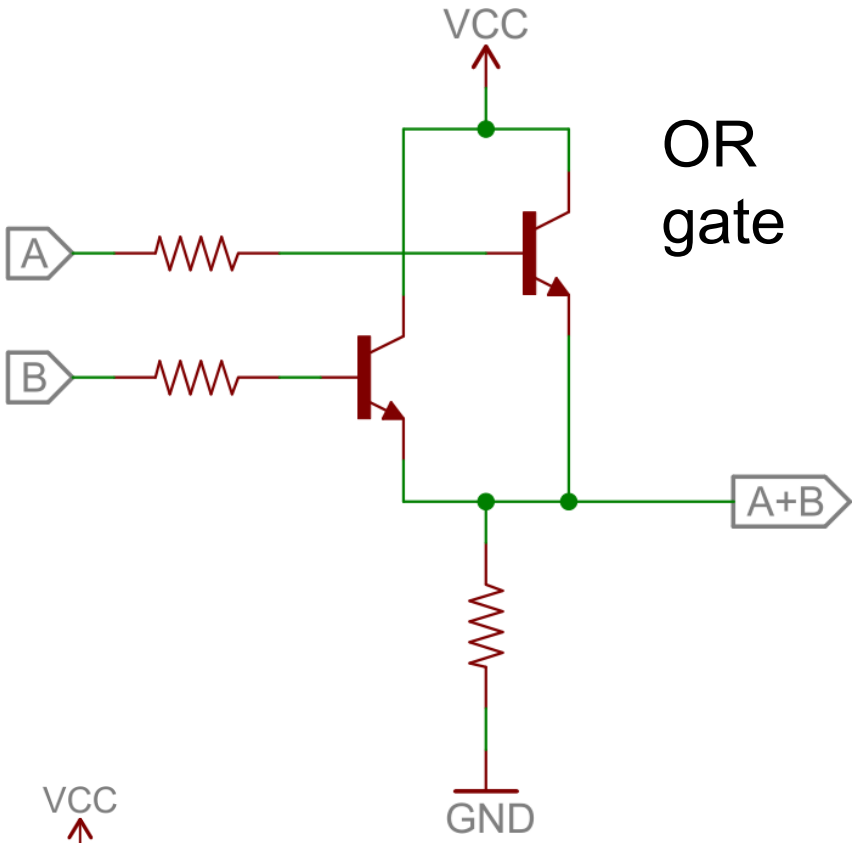
Transistor - H-bridge



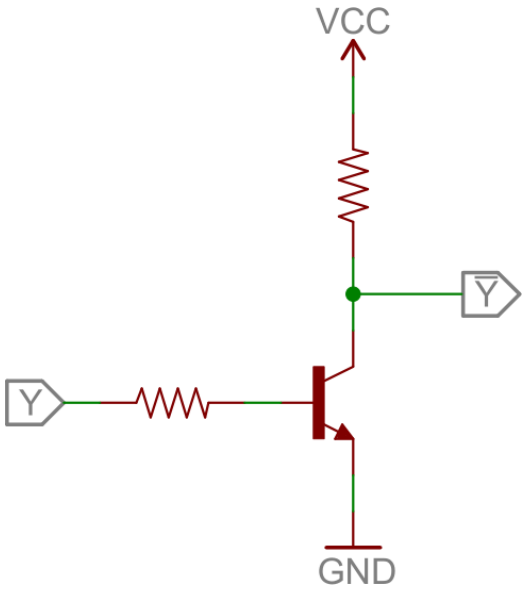
Transistor – Logic switches



AND gate

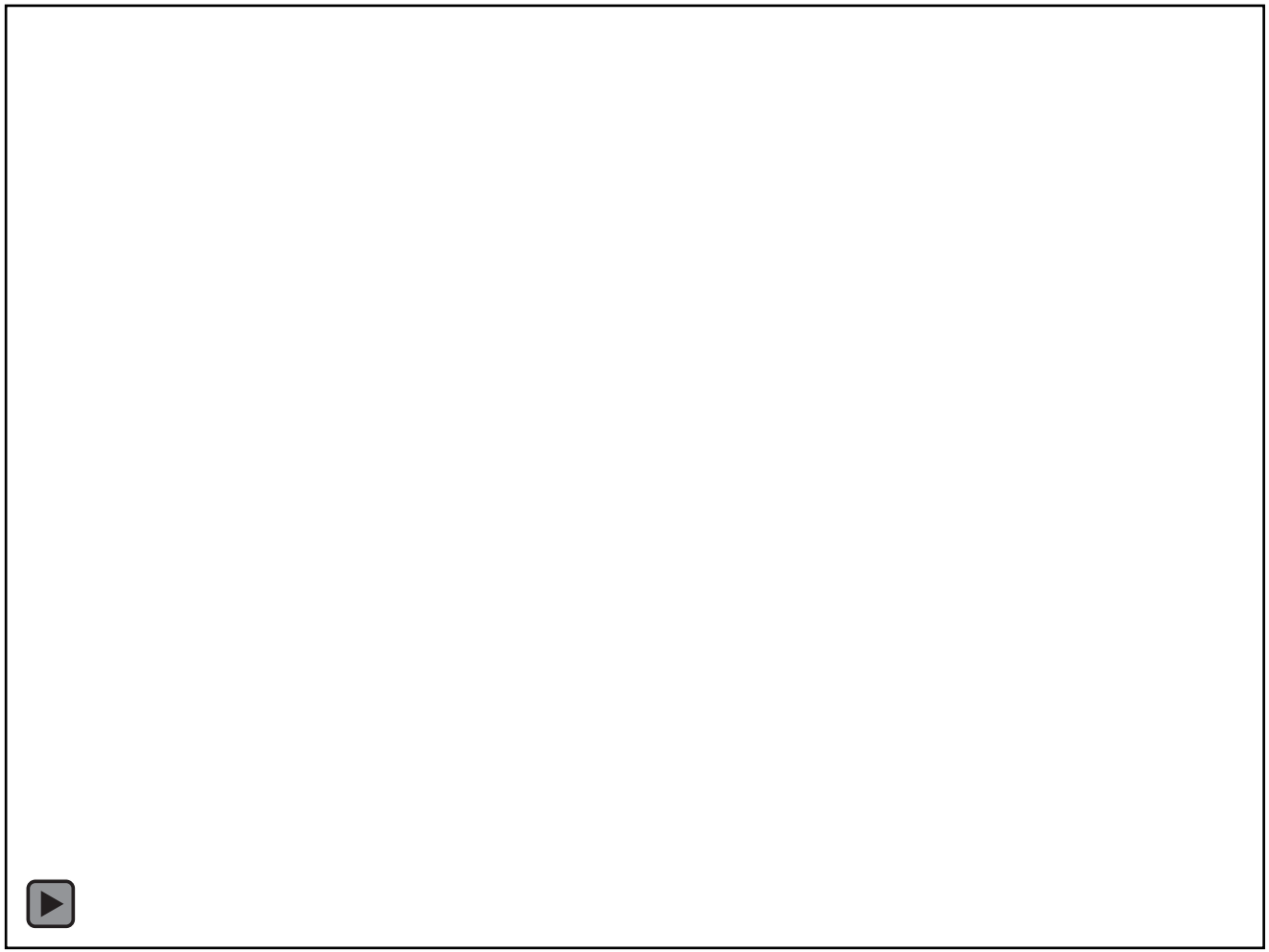


OR gate



NOT gate

Do we really need computers?



Tortoise - Grey Walters – 1948 - 1951

Mandatory assignment

Use **IR sensors** to make a robot that follows a line
Use **switches** to make a robot that avoids obstacles

- Place the sensors on the robot
  - (double sided tape/hot glue?)
- Use the digital or analog output of the sensors
- Check how the output of the IR sensor changes
  - with different surfaces/objects
  - with different distance to object
  - with different lights
  - measure noise
- Use two transistors to control the motors

If your robot uses stepper drivers:

- Use a dc motor + sensors from the kit
- Do not use your robot (we will use it in next lecture)

Danger!

Motors, electronic components (and students) can be damaged easily
Double check the wiring
Take care of different voltage levels

If you are not sure, ASK!

Where to find electric components?

Components:

- Sensors
- Shields
- Breakout boards

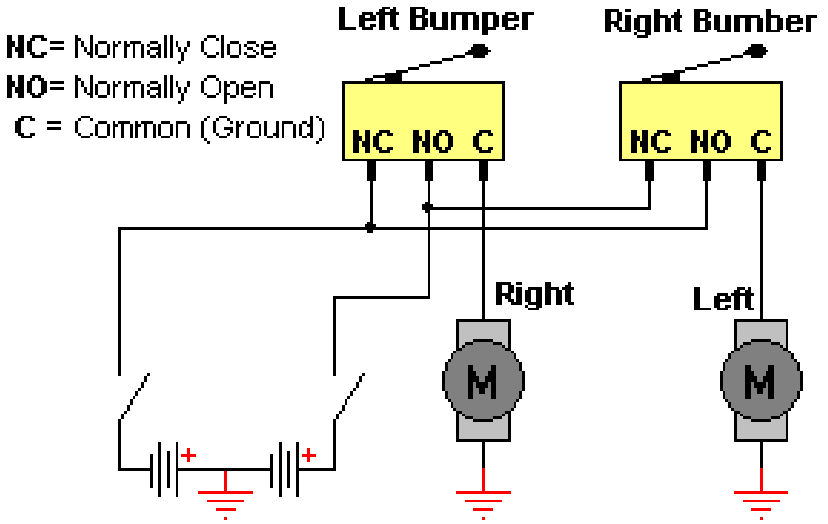
Distributors:

- RS Components (*www.rs-components.com/*)
- Mouser (*www.mouser.dk/*)
- TME (https://www.tme.eu/en/)

DIY shops (with tutorials and libraries):

- Adafruit (*https://www.adafruit.com/*)
- Sparkfun (*https://www.sparkfun.com/*)

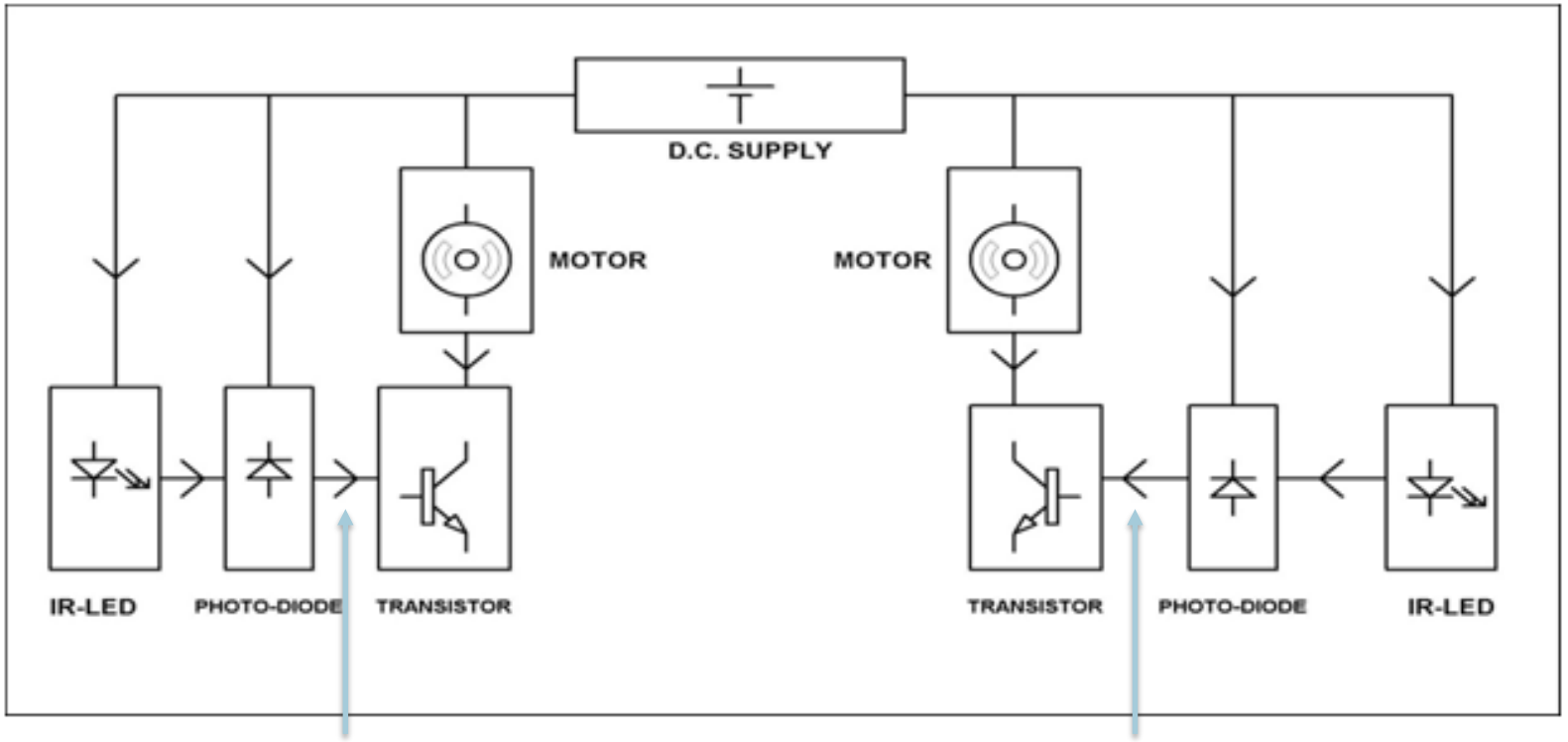
Tips – Obstacle avoidance



Parts:

Mouse Switch	x2
Motor	x2
On/Off Switch	x2
Battery	x2

Tips – Line follower



Remember the resistors on the base of the transistors (470 ohm)

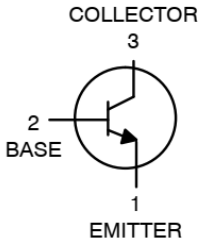
Transistors

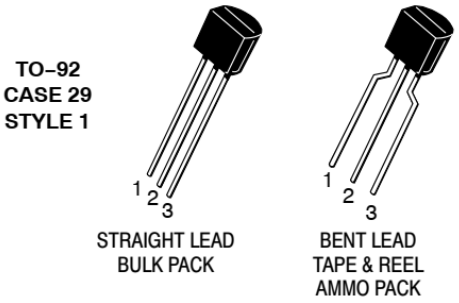
Do not use the temp sensor (same shape)

We have two different kind of transistors:

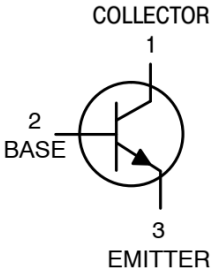
PN2222, BC337

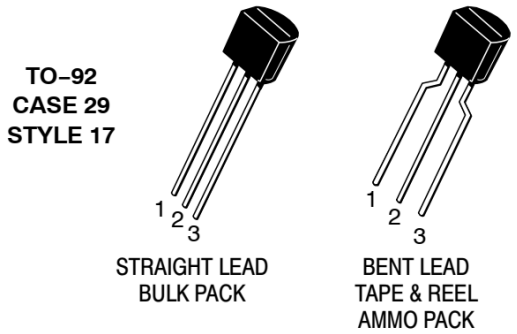
Check how to wire them





PN2222





BC337

Ready?

Let´s connect some wires!

Andrés Faíña, 4D26
anfv@itu.dk