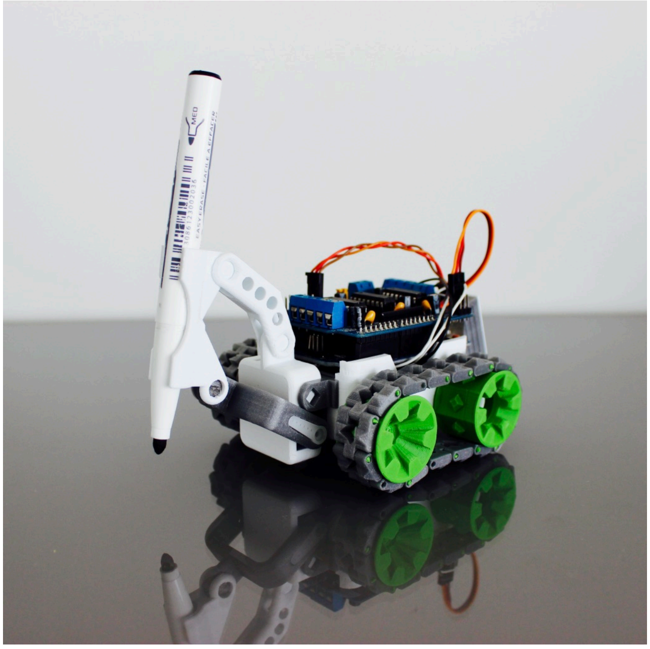


ROBOTICS LESSON WITH SMARS

Student course concept

GUIDELINE FOR THE FIRST LESSON WITH SMARS

Kevin Thomas

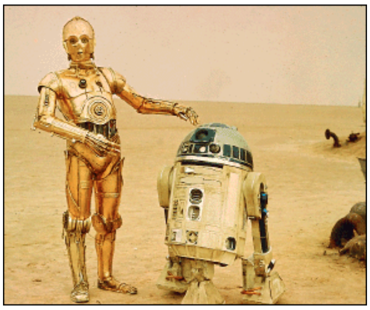
Basics of robotics

Summary

Overview:

History of robotics

Origins of "robot" and "robotics"



The word "robot" conjures up a variety of images, from R2D2 and C3PO of *Star Wars* fame; to human-like machines that exist to serve their creators (perhaps in the form of the cooking and cleaning Rosie in the popular cartoon series *the Jetsons);* to the Rover Sojourner, which explored the Martian landscape as part of the Mars Pathfinder mission. Some people may alternatively perceive robots as dangerous technological ventures that will someday lead to the demise of the human race, either by outsmarting or outmuscling us and taking over the world, or by turning us into completely technology-dependent beings who passively sit by and program robots to do all of our work. In fact, the first use of the word "robot" occurred in a play about mechanical men that are built to work on factory assembly lines and that rebel against their human masters. These machines in *R.U.R.* (*Rossum's Universal Robots*), written by Czech playwright Karl Capek in 1921, got their name from the Czech word for slave.

The word "robotics" was also coined by a writer. Russian-born American science-fiction writer Isaac Asimov first used the word in 1942 in his short story "Runabout." Asimov had a much brighter and more optimistic opinion of the robot's role in human society than did Capek. He generally characterized the robots in his short stories as helpful servants of man and viewed robots as "a better, cleaner race." Asimov also proposed three "Laws of Robotics" that his robots, as well as sci-fi robotic characters of many other stories, followed:

Law One

A robot may not injure a human being or, through inaction, allow a human being to come to harm.

Law Two

A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

Law Three

A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Definitions of "robot"

So what exactly is a robot? This actually turns out to be a rather difficult question. Several definitions exist, including the following:

"A reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of task."
Robot Institute of America, 1979

"An automatic device that performs functions normally ascribed to humans or a machine in the form of a human."
Webster's Dictionary

"a reprogrammable manipulator device"
British Department of Industry

"Robotics is that field concerned with the intelligent connection of perception to action."
Mike Brady

Early Conceptions of Robots

One of the first instances of a mechanical device built to regularly carry out a particular physical task occurred around 3000 B.C.: Egyptian water clocks used human figurines to strike the hour bells. In 400 B.C., Archytus of Taremtum, inventor of the pulley and the screw, also invented a wooden pigeon that could fly. Hydraulically-operated statues that could speak, gesture, and prophecy were commonly constructed in Hellenic Egypt during the second century B.C.

In the first century A.D., Petronius Arbiter made a doll that could move like a human being. Giovanni Torriani created a wooden robot that could fetch the Emperor's daily bread from the store in 1557. Robotic inventions reached a relative peak (before the 20th century) in the 1700s; countless ingenius, yet impractical, automata (i.e. robots) were created during this time period. The 19th century was also filled with new robotic creations, such as a talking doll by Edison and a steam-powered robot by Canadians. Although these inventions throughout history may have planted the first seeds of inspiration for the modern robot, the scientific progress made in the 20th century in the field of robotics surpass previous advancements a thousandfold.

The first modern robots

The earliest robots as we know them were created in the early 1950s by George C. Devol, an inventor from Louisville, Kentucky. He invented and patented a reprogrammable manipulator called "Unimate," from "Universal Automation." For the next decade, he attempted to sell his product in the industry, but did not succeed. In the late 1960s, businessman/engineer Joseph

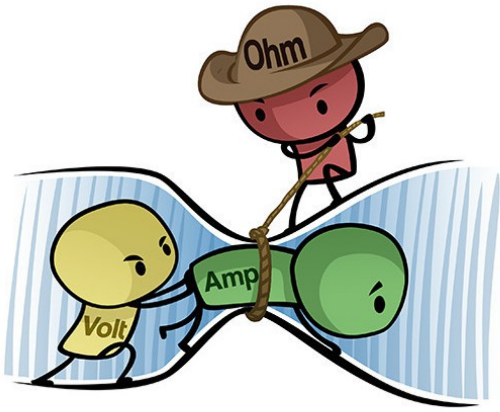
Engleberger acquired Devol's robot patent and was able to modify it into an industrial robot and form a company called Unimation to produce and market the robots. For his efforts and successes, Engleberger is known in the industry as "the Father of Robotics."

Academia also made much progress in the creation new robots. In 1958 at the Stanford Research Institute, Charles Rosen led a research team in developing a robot called "Shakey." Shakey was far more advanced than the original Unimate, which was designed for specialized, industrial applications. Shakey could wheel around the room, observe the scene with his television "eyes," move across unfamiliar surroundings, and to a certain degree, respond to his environment. He was given his name because of his wobbly and clattering movements.

Source: https://cs.stanford.edu/people/eroberts/courses/soco/projects/1998-99/robotics/history.html

Basics of electronics

Voltage, Current and Resistance



In a circuit, current is the flow of electrons. Voltage is the electrical potential difference between two points. Resistance is something that resists the flow of electrons.If this sounds Greek to you, don't worry. Think about it this way: If you have water running in a pipe, the amount of water running is the equivalent of the current in an electrical circuit.Then imagine that the pipe is clogged at some point. And only a little bit of water gets through. The water pressure on one side of the clog will be higher than on the other side. This difference in pressure between the two points is the equivalent to voltage. You always measure voltage as a voltage difference between two points.

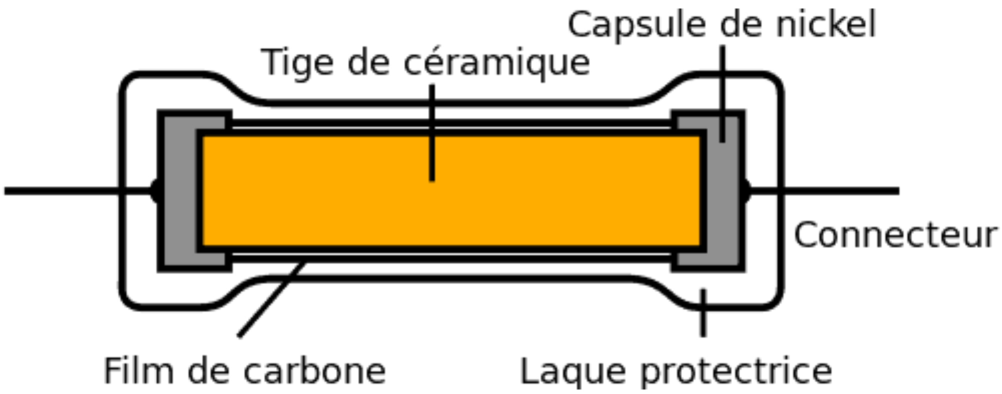
- Current is measured in Amp or A
- Voltage is measured in Volt or V
- Resistance is measured in Ohm or Ω

Source https://www.build-electronic-circuits.com/electronics-for-beginners/

Resistor

A resistor is nothing magic. Take a long wire and measure the resistance, and you will realize that resistance is just a normal property of wires (except for superconductors).

Some resistors are made up of just that. A long wire.



But you can also find resistors made of other types of materials. Like this carbon film resistor:

What Does The Resistor Do To My Circuit?

The resistor is a passive device and doesn't do anything actively to your circuit.

It's actually a pretty boring device. If you add some voltage to it, nothing really happens. Well, maybe it gets warm, but that's it.

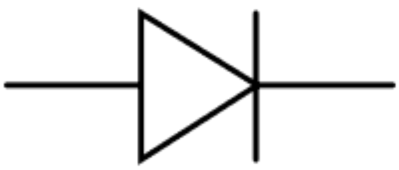
BUT, by using resistors, you can design your circuit to have the currents and voltages that you want to have in your circuit.

Source: https://www.build-electronic-circuits.com/what-is-a-resistor/

Diode

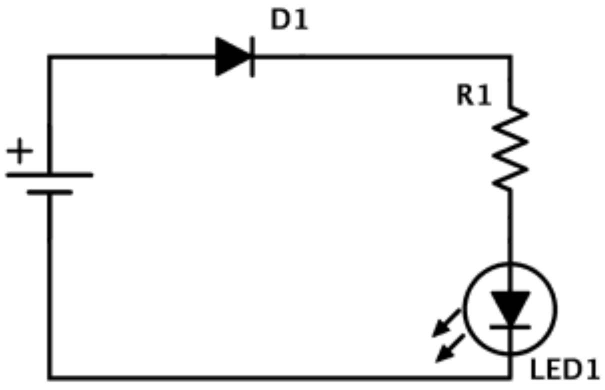
a diode is an electronic component that conducts current in one direction and blocks current from flowing in the other direction.

The diode symbol looks like this:



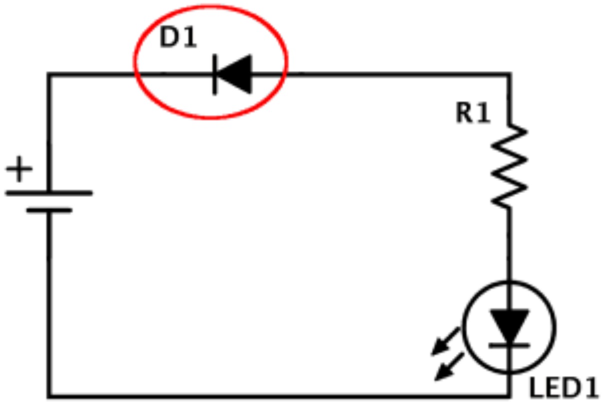
How To Connect A Diode

Let’s look at an example.



In the circuit above the diode is connected in the right direction. This means current can flow through it so that the LED will light up.

But what happens if we connect it the other way around?



In this second circuit the diode is connected the wrong way. This means that no current will flow in the circuit and the LED will be turned OFF.

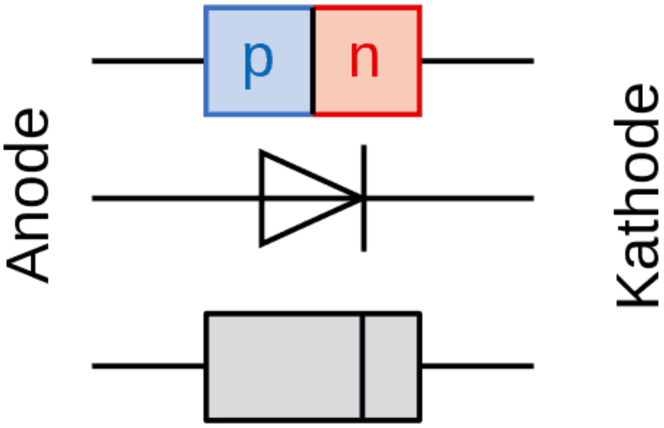
What Is a Diode Used For?

Diodes are very often used in power supplies. From the power outlet in your wall you get alternating current (AC). A lot of the devices we use need direct current (DC). To get DC from AC we need a rectifier circuit. It’s a circuit that converts from alternating current (AC) to direct current (DC). Diodes are the main components in rectifier circuits.

How a Diode Works

The diode is created from a PN junction. You get a PN junction by taking negative doped and positive doped semiconductor material and putting it together.

At the intersection of these two materials a “depletion region” appears. This depletion region acts as an insulator and refuses to let any current pass.



When you apply a positive voltage from the positive side to the negative side, the “depletion layer” between the two materials disappears and the current can flow from the positive to the negative side.

When you apply a voltage in the other direction, from the negative to the positive side, the depletion region expands and resists any current flowing.

Things To Note About Diodes

You have to apply enough voltage in the “right” direction – from positive to negative – for the diode to start conducting. Usually this voltage is around 0.7V.

The diode have limits and cannot conduct unlimited amounts of current.

Diodes are not perfect components. If you apply voltage in the wrong direction, there will be a little bit of current flowing. This current is called “leakage current”.

If you apply a high enough voltage in the “wrong” direction, the diode will break down and let current pass in this direction too.

Types of Diodes

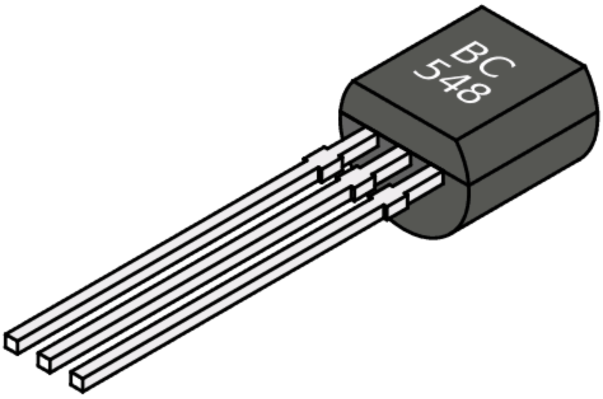
There are many different types of diodes. The most common ones are signal diodes, rectifier diodes, zener diodes and Light-Emitting Diodes (LED). Signal and rectifier diodes are pretty much the same thing except that rectifier diodes are built to handle more power.

Zener diodes are diodes that make use of the breakdown voltage when applying voltage the “wrong” way. They act as very stable voltage references.

Source: https://www.build-electronic-circuits.com/what-is-a-diode/

Transistor

The transistor is like an electronic switch. It can turn a current on and off. A simple way you can think of it is to look at the transistor as a relay without any moving parts. A transistor is similar to a

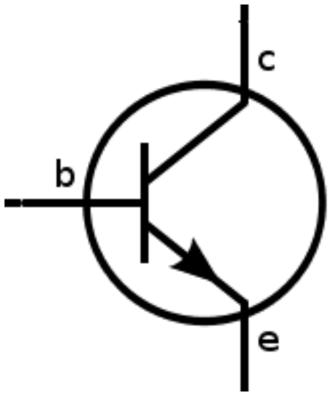


relay in the sense that you can use it to turn something ON and OFF.

Check out the video explanation I made on the transistor:

There are different types of transistors. A very common one is the “bipolar junction transistor” or “BJT”. And it usually looks like this:

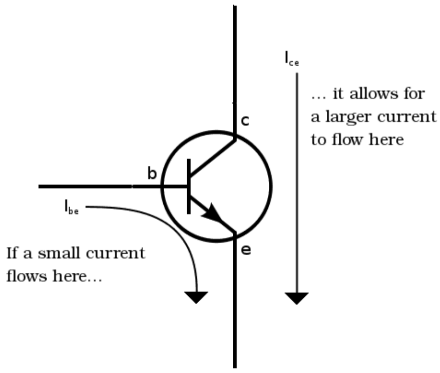
It has three pins: Base (b), collector (c) and emitter (e). And it comes in two versions: NPN and PNP. The schematic symbol for the NPN looks like this:



How transistors work

The transistor works because of something called a semiconducting material. A current flowing from the base to the emitter “opens” the flow of current from the collector to the emitter.

In a standard NPN transistor, you need to apply a voltage of about 0.7V between the base and the emitter to get the current flowing from base to emitter. When you apply 0.7V from base to emitter



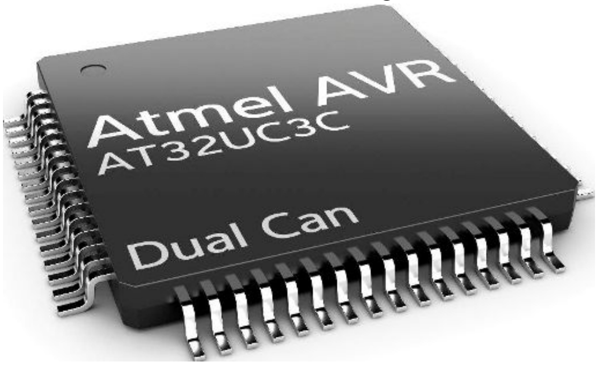
you will turn the transistor ON and allow a current to flow from collector to emitter.

Source: https://www.build-electronic-circuits.com/how-transistors-work/

Robot components

Microcontroller

A microcontroller (abbreviated MCU or µC) is a computer system on a chip that does a job. It contains an integrated processor, memory (a small amount of RAM, program memory, or both), and programmable input/output peripherals, which are used to interact with things connected to the chip. A microcontroller is different than a microprocessor which only contains a CPU (the kind used in a Personal Computer).



First released in 1971 by the Intel company, microcontrollers began to become popular in their first few years. The extremely useful Intel 8008 microprocessor was then released, but it was still impractical because of high cost for each chip. These first microcontrollers combined different types of computer memory on one unit.[3] After people began to see how useful they were, micro controllers were constantly being upgraded, with people trying to find new ways to make them better. Cost was reduced over time and by the early 2000s, micro controllers were widely used across the world.

Other terms for a microcontroller are embedded system and embedded controller, because the microcontroller and its support circuits are often built into, or embedded in, a single chip.

In addition to the usual arithmetic and logic elements of a general microprocessor, the microcontroller also has additional elements such as RAM for data storage, read-only memory for program storage, flash memory for permanent data storage, and other devices (peripherals).[5]

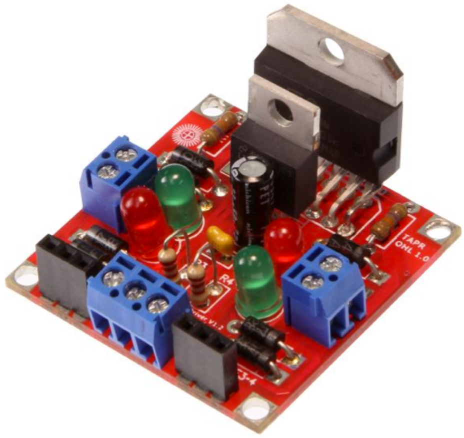
Microcontrollers often operate at very low speed compared to microprocessors (at clock speeds of as little as 32 kHz), but this is useful for typical applications. They also consume very little power (milliwatts or even micro watts).

Microcontrollers are used in automatic products and devices, such as car engine systems, remote controls, machines, appliances, power tools, and toys. These are called embedded systems. Microcontrollers can also be found at work in solar power and energy harvesting, anti-lock braking systems in cars, and have many uses in the medical field as well.

Source: https://simple.wikipedia.org/wiki/Microcontroller

Motor Driver

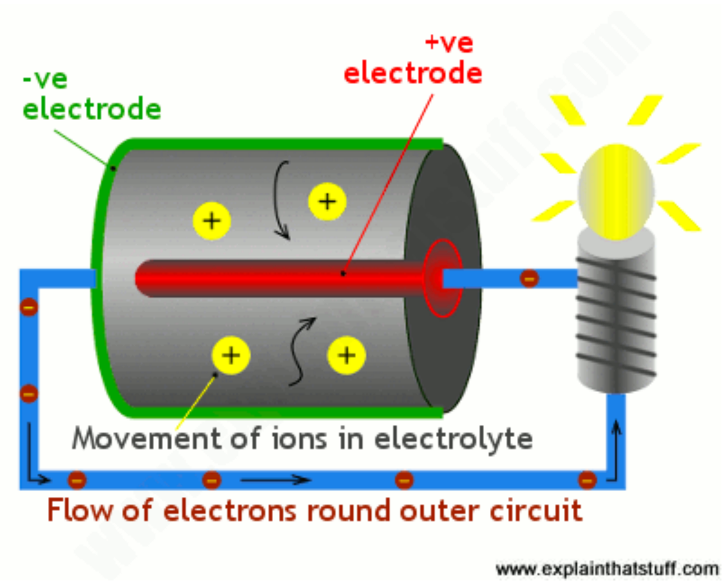
A **motor controller** is a device or group of devices that serves to govern in some predetermined manner the performance of an electric motor. A motor controller might include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and faults.



Source https://en.wikipedia.org/wiki/Motor_controller

Battery

A battery is a self-contained, chemical power pack that can produce a limited amount of electrical energy wherever it's needed. Unlike normal electricity, which flows to your home through



wires that start off in a power plant, a battery slowly converts *chemicals* packed inside it into electrical energy, typically released over a period of days, weeks, months, or even years.

The basic idea of portable power is nothing new; people have always had ways of making energy on the move. Even prehistoric humans knew how to burn wood to make fire, which is another way of producing energy (heat) from chemicals (burning releases energy using a *chemical* reaction called combustion).

By the time of the Industrial Revolution (in the 18th and 19th centuries), we'd mastered the art of burning lumps of coal to make power, so fueling things like steam locomotives. But it can take an hour to gather enough wood to cook a meal, and a locomotive's boiler typically takes several hours to get hot enough to make steam. Batteries, by contrast, give us instant, portable energy; turn the key in your electric car and it leaps to life in seconds!

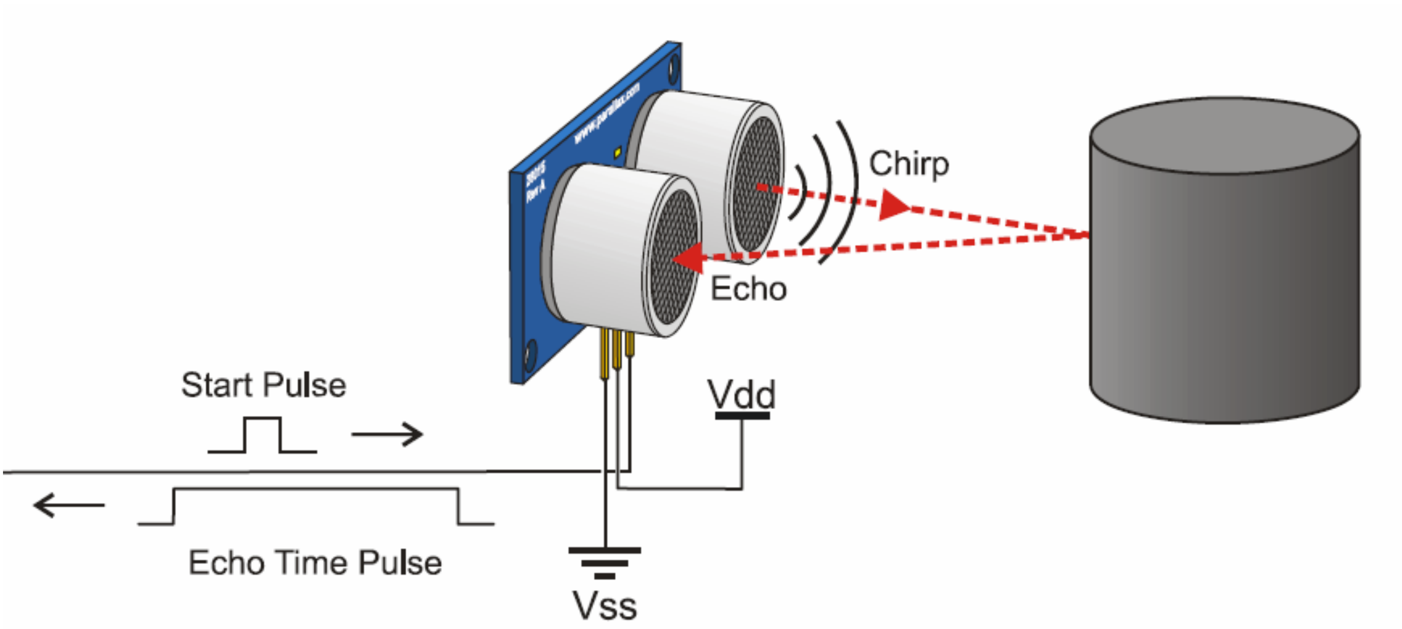
The basic power unit inside a battery is called a **cell**, and it consists of three main bits. There are two **electrodes** (electrical terminals) and a chemical called an **electrolyte** in between them. For our convenience and safety, these things are usually packed *inside* a metal or plastic outer case. There are two more handy electrical **terminals**, marked with a plus (positive) and minus (negative), on the *outside* connected to the electrodes that are inside. The difference between a battery and a cell is simply that a battery consists of two or more cells hooked up so their power adds together.

When you connect a battery's two electrodes into a circuit (for example, when you put one in a flashlight), the electrolyte starts buzzing with activity. Slowly, the chemicals inside it are converted into other substances. Ions (atoms with too few or too many electrons) are formed from the materials in the electrodes and take part in chemical reactions with the electrolyte. At the same time, electrons march from one terminal to the other through the outer circuit, powering whatever the battery is connected to. This process continues until the electrolyte is completely transformed. At that point, the ions stop moving through the electrolyte, the electrons stop flowing through the circuit, and the battery is flat.

Source: http://www.explainthatstuff.com/batteries.html

Sensors

a **sensor** is an electronic component, module, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. A sensor is always used with other electronics, whether as simple as a light or as complex as a computer.



Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base, besides innumerable applications of which most people are never aware. With advances in micromachinery and easy-to-use microcontroller platforms, the uses of sensors have expanded beyond the traditional fields of temperature, pressure or flow measurement,[1] for example into MARG sensors. Moreover, analog sensors such as potentiometers and force-sensing resistors are still widely used. Applications include manufacturing and machinery, airplanes and aerospace, cars, medicine, robotics and many other aspects of our day-to-day life.

A sensor's sensitivity indicates how much the sensor's output changes when the input quantity being measured changes. For instance, if the mercury in a thermometer moves 1 cm when the temperature changes by 1 °C, the sensitivity is 1 cm/°C (it is basically the slope Dy/Dx assuming a linear characteristic). Some sensors can also affect what they measure; for instance, a room temperature thermometer inserted into a hot cup of liquid cools the liquid while the liquid heats the thermometer. Sensors are usually designed to have a small effect on what is measured; making the sensor smaller often improves this and may introduce other advantages. Technological progress allows more and more sensors to be manufactured on a microscopic scale as microsensors using MEMS technology. In most cases, a microsensor reaches a significantly higher speed and sensitivity compared with macroscopic approaches.

A good sensor obeys the following rules:

- it is sensitive to the measured property
- it is insensitive to any other property likely to be encountered in its application, and
- it does not influence the measured property.

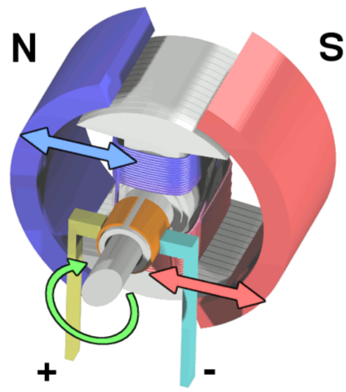
Most sensors have a linear transfer function. The sensitivity is then defined as the ratio between the output signal and measured property. For example, if a sensor measures temperature and has a voltage output, the sensitivity is a constant with the units [V/K]. The sensitivity is the slope of the transfer function. Converting the sensor's electrical output (for example V) to the measured units (for example K) requires dividing the electrical output by the slope (or multiplying by its reciprocal). In addition, an offset is frequently added or subtracted. For example, -40 must be added to the output if 0 V output corresponds to -40 C input.

For an analog sensor signal to be processed, or used in digital equipment, it needs to be converted to a digital signal, using an analog-to-digital converter.

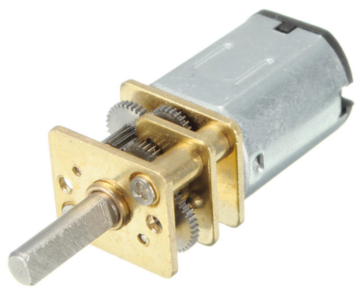
Source: https://en.wikipedia.org/wiki/Sensor

Motors

An **electric motor** is an electrical machine that converts electrical energy into mechanical energy. The reverse of this is the conversion of mechanical energy into electrical energy and is done by an electric generator, which has much in common with a motor. Most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force. In certain applications, such as in regenerative braking with traction motors in the transportation industry, electric motors can also be used in reverse as generators to convert mechanical energy into electric power.



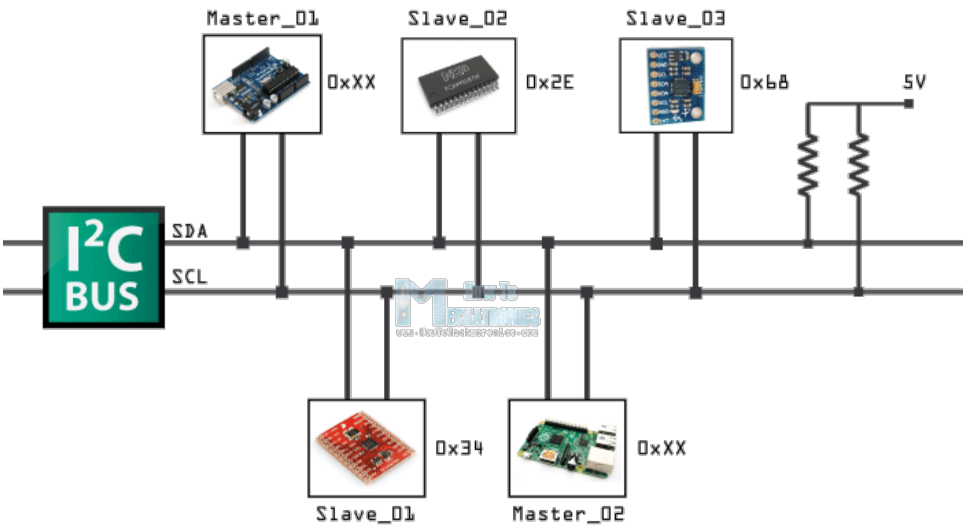
Found in applications as diverse as industrial fans, blowers and pumps, machine tools, household appliances, power tools, and disk drives, electric motors can be powered by direct current (DC) sources, such as from batteries, motor vehicles or rectifiers, or by alternating current (AC) sources, such as from the power grid, inverters or generators. Small motors may be found in electric watches. General-purpose motors with highly standardized dimensions and characteristics provide convenient mechanical power for industrial use. The largest of electric motors are used for ship propulsion, pipeline compression and pumped-storageapplications with ratings reaching 100 megawatts. Electric motors may be classified by electric power source type, internal construction, application, type of motion output, and so on.



Electric motors are used to produce linear or rotary force (torque), and should be distinguished from devices such as magnetic solenoids and loudspeakers that convert electricity into motion but do not generate usable mechanical powers, which are respectively referred to as actuators and transducers.

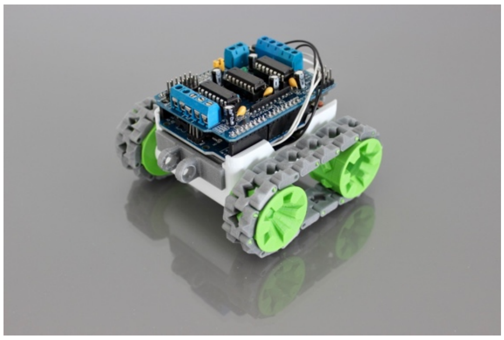
Connectivity

A robot can communicate in a variety of ways. basically we can divide these communications into wired and wireless. Among cabling, there are buses (I2C, SMBUS, etc.), all managed by communication protocols such as Ethernet.



In our family of wireless connections, we find WiFi, cellular networks, Bluetooth, RFID and various other types of radio connection (each with different frequencies and modulation).

Meet SMARS



SMARS, a diminutive of the Screwless Modular Assemblable Robotic System, is a small open source robot designed primarily for educational or research purposes.
The basic configuration of SMARS, mounts two mechanically reduced brushed motors, a 9V battery, an Arduino one, and a 4-stroke motor shield.
The robot can mount external peripherals, downloaded from the internet or designed by you. SMARS is compatible with all Arduino sensors available on the market and a case has been designed for the two main sensors: ultrasonic and infrared. The features of SMARS are the ease of assembly, low cost of realization and the fast hook-up of new peripherals

Safety Rules

1. Do not connect together the negative and positive pole of the battery
2. Do not reverse the polarity (flip - & +)
3. Connect the battery only where indicated by the instructions.
4. Don’t play with tools

Questionnaire

1) The Current is:
   a) The flow of electrons in a conductor and its unit is Volt
   b) The difference of potential between two points of a conductor
   c) The flow of electrons in a conductor and its unit is Ampère
   d) The flow of electrons in a conductor and its unit is Ohm.

2) If the resistance augments:
   a) The current will be stronger
   b) The tension will be higher
   c) The resistance doesn't matter
   d) The current will be lower

3) A resistor is a component that:
   a) reduce the current in the circuit
   b) let current flow in only one direction
   c) makes current stronger
   d) augment the tension on other components

4) A diode is:
   a) A component that stores current
   b) A component that lets current flow in a single direction and could glow
   c) Simply a light bulb
   d) It's like a resistor

5) 9V is
   a) a current
   b) a tension
   c) a capacity
   d) a resistance

6) A microcontroller is
   a) The same as a CPU
   b) The brain of the robot
   c) A part of the RAM
   d) A part of the CPU

7) A simple motor driver can't:
   a) control the speed of the motor
   b) control the direction of the motor
   c) stop the motor
   d) count the RPM of the motor

8) The cell is:
   a) Composed by many batteries
   b) An element of a battery
   c) The core of the motor driver
   d) A passive component

9) A sensor converts:
   a) Different types of energy into electrical signals
   b) Electrical signals into mechanical energy
   c) Digital signals into analog signals
   d) Current into tension

10) A motor works with:
   a) Electric field
   b) Magnetic field
   c) Mechanical field
   d) Electronic field

Notes