INTERACTIVE PERVASIVE COMPUTING

ELECTRICITY

ELECTRICITY IS THE PHYSICAL MANIFESTATION OF THE MOVEMENT OF *ELECTRONS*, LITTLE SPECKS OF SUBATOMIC MATTER THAT CARRY A NEGATIVE ELECTRICAL CHARGE

ELECTRICITY

Electricity involves two fundamental phenomena: **electric charge** and **electric current.** ***Electric charge*** is a basic characteristic of matter and is the result of something having too many electrons (negative charge), or too few electrons (positive charge) with regard to what it would otherwise need to be electrically neutral. An atom with a negative or positive charge is sometimes called an *ion*.

ELECTRICITY

- A basic characteristic of electric charges is that charges of the same kind repel one another, and opposite charges attract. This is why electrons and protons are bound together in an atom
- This implies negative charge will repel electrons, and a positive charge will attract them. Therefore electrons flows from –ve to +ve in the circuit
- The movement of electrons through a circuit of some kind is called *electric current*, or *current flow*

BASIC EXAMPLE HOW ELECTRON FLOW

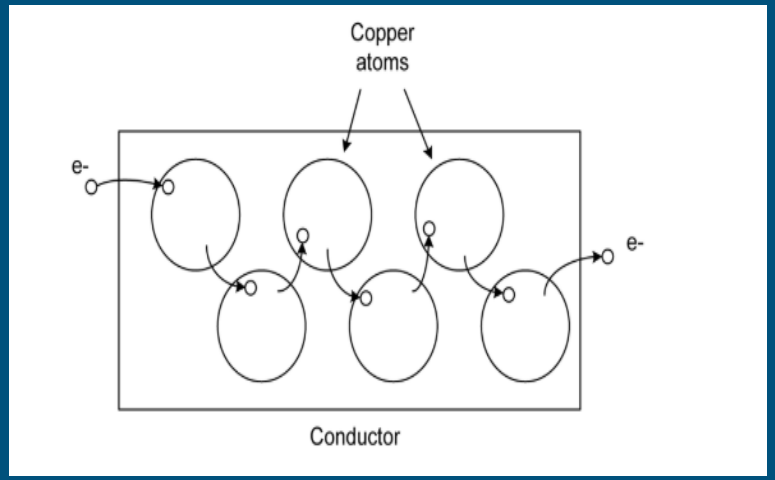
Electrons move toward things that are positive, so if you have a small light bulb attached to a battery with some wires (sometimes also known as a *flashlight*), the electrons move out of the negative terminal of the battery, through the light bulb, and return back into the positive terminal. Along the way, they cause the filament in the lamp to get white-hot and glow.

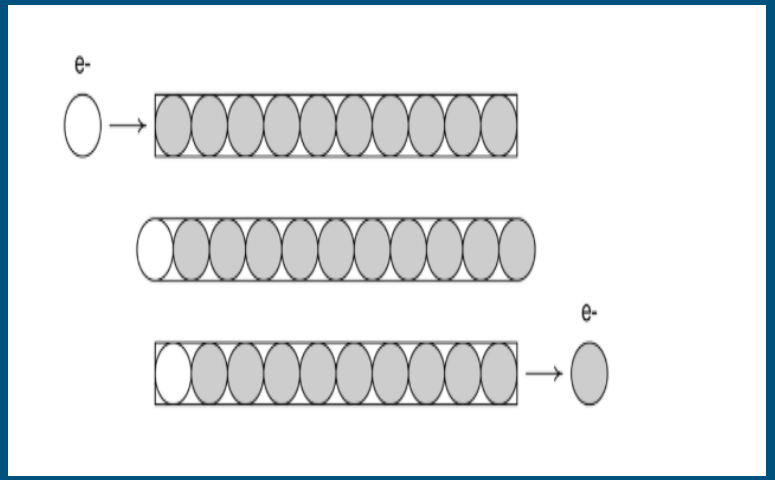
ELECTRON FLOW ON WIRE

- When an electron is introduced into one end of the wire, it causes the first atom to become negatively charged. It now has too many electrons.
- The new electron cannot exit the way it came in, so it moves to the next available neutral atom
- This atom is now negative and has a surplus electron. In order to become neutral again (the preferred state of an atom), it then passes an extra electron to the next (neutral) atom, and so on, until an electron appears at the other end of the wire

ELECTRON FLOW ON WIRE

So long as there is a source of electrons under pressure connected to the wire and a return path for the electrons back to the source, current will flow. The pressure and force of the source that pass electrons is called *voltage.*





ELECTRICITY AC/DC

TWO TYPES OF ELECTRICAL SIGNAL AC, DC

- **AC: THE DIRECTION OF ELECTRICITY FLOWS THROUGHOUT THE CIRCUIT IS CONSTANTLY REVERSING**
- **THE RATE OF REVERSAL IS MEASURED IN HERTZ, WHICH IS THE NUMBER OF REVERSALS PER SECOND**
- **THE RATE AT WHICH THE CURRENT CHANGES DIRECTION IS CALLED THE FREQUENCY AND IS MEASURED IN CYCLES PER SECOND IN UNITS OF HERTZ**
- **60 HZ, MEANS THAT IT IS REVERSING 120 TIMES PER SECOND**
- **DC: ELECTRICITY FLOWS IN ONE DIRECTION BETWEEN POWER AND GROUND**
- **IN THIS ARRANGEMENT THERE IS ALWAYS A POSITIVE SOURCE OF VOLTAGE AND GROUND (0V) SOURCE OF VOLTAGE**
- **ELECTRICITY IS TYPICALLY DEFINED AS HAVING A VOLTAGE (V) AND A CURRENT RATING (AMPS)**

OHMS LAW

- Here is a fundamental relationship between voltage, current, and resistance. This is the famous equation called *Ohm's law*. It looks like this
- V=IR (where *V* is voltage (in volts), *I* is current (in amperes), and *R* is resistance (in ohms))
- I=V/R

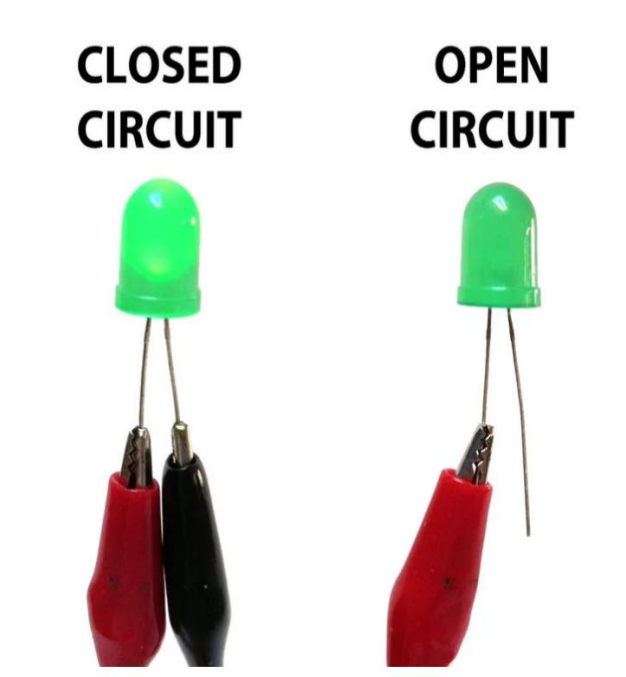
POWER

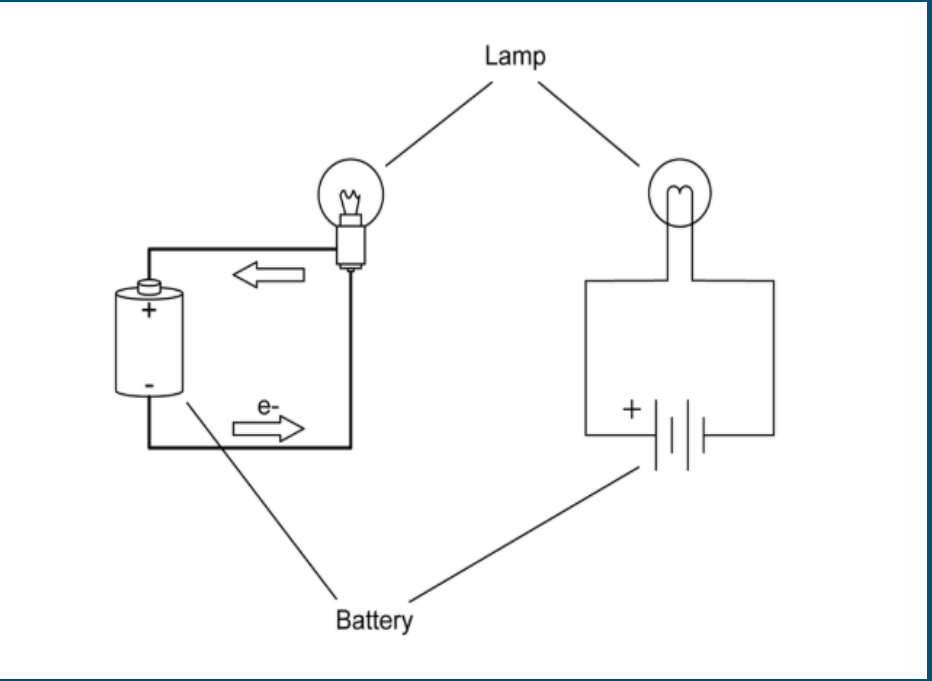
- *Power* is the rate of doing work per unit of time, and is measured in watts. One watt is defined as the use or generation of 1 joule of energy per second.
- In an electrical circuit, a watt can also be defined as 1 ampere of current moving through a resistance at 1 volt of potential, and when charges move from a high voltage to a low voltage (a potential difference) across a resistive device, the energy in the potential is converted to some other form, such as heat or mechanical energy.

POWER CONT….

- We can calculate power (*P*) in a DC circuit by multiplying the voltage by the current:
- P = EI
- In the case of the simple flashlight circuit, the power used to force the current through the filament is expressed as heat, and subsequently as light when the filament gets hot enough to glow.

CIRCUITS





CIRCUIT

- Electricity flows when a closed circuit allows for the electrons to move from a high potential to a lower potential in a closed loop.
- Current flow requires a source of electrons with a force to move them, as well as a return point for the electrons.
- Electric current flow (a physical phenomenon) is characterized by or dependent on four fundamental quantities: voltage, current, resistance, and power
- Current: *The measurement of current is the determination of the quantity of electrons in motion.*
- Current flow is often used to mean movement of electrical charges.

CIRCUIT CONT…

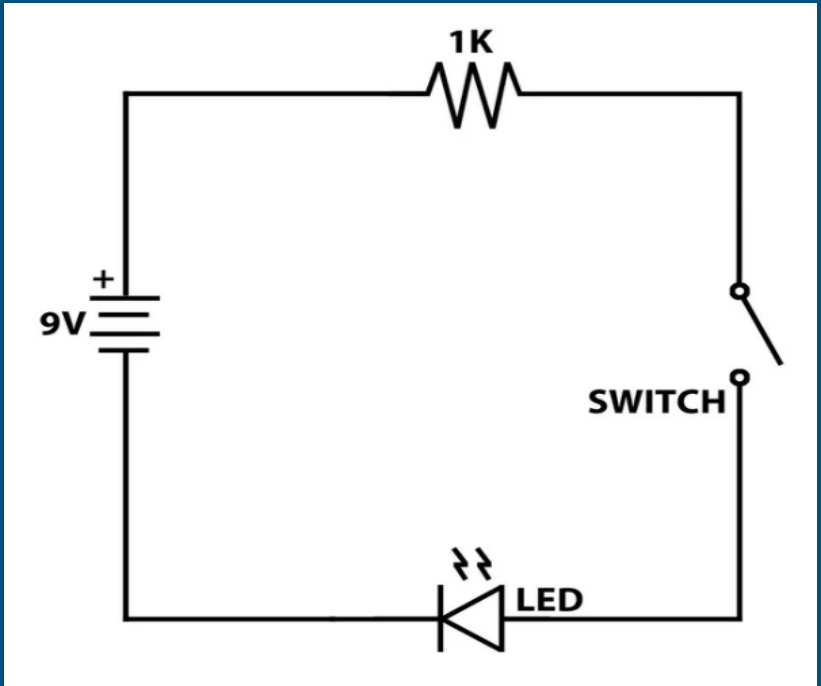
A CIRCUIT IS A COMPLETE AND CLOSED PATH THROUGH WHICH ELECTRIC CURRENT CAN FLOW

A CLOSED CIRCUIT WOULD ALLOW THE FLOW OF ELECTRICITY BETWEEN POWER AND GROUND

OPEN CIRCUIT WOULD BREAK THE FLOW OF ELECTRICITY BETWEEN POWER AND GROUND

ANYTHING THAT IS PART OF THIS CLOSED SYSTEM AND THAT ALLOWS ELECTRICITY TO FLOW BETWEEN POWER AND GROUND IS CONSIDERED TO BE PART OF THE CIRCUIT.

SAMPLE CIRCUIT



RESISTANCE

Resistance **is the measure of how much the current flow is impeded in a circuit, and it is measured in units of ohms, named after German physicist Georg Simon Ohm**

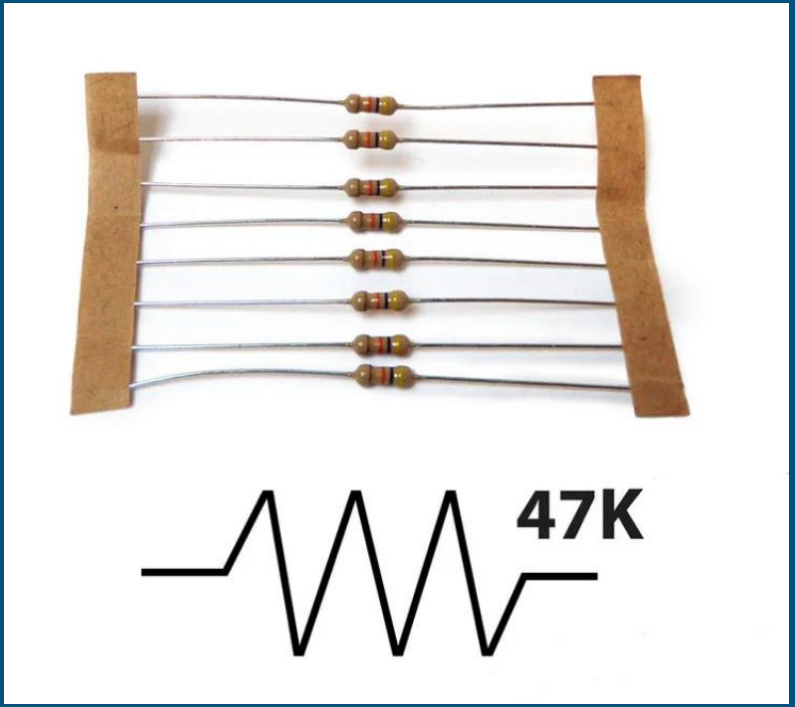
You can also think of resistance as the degree of “stickiness” that an atom’s valence shell, therefore, Atoms that can give up or accept electrons easily will have low resistance, whereas those that want to hold onto their electrons will exhibit higher resistance

Carbon, for example, will conduct electricity, but not as easily as copper. Carbon is a popular material for fabricating the components called resistors used in electronic circuits

RESISTANCE CONT….

- If electricity passes through a component (or group of components) that does not add enough resistance to the circuit, a short will likewise occur
- It is very important to prevent short circuits by making sure that the positive voltage is never wired directly to ground.
- *electricity always follows the path of least resistance to ground. What this means is that if you give positive voltage the choice to pass through a motor to ground, or follow a wire straight to ground, it will follow the wire because the wire provides the least resistance. This also means that by using the wire to bypass the source of resistance straight to ground, you have created a short circuit. Always make sure that you never accidentally connect positive voltage to ground while wiring things in parallel.*

RESISTORS



RESISTORS CONT....

Resistors add resistance to the circuit and reduces the flow of electrical current

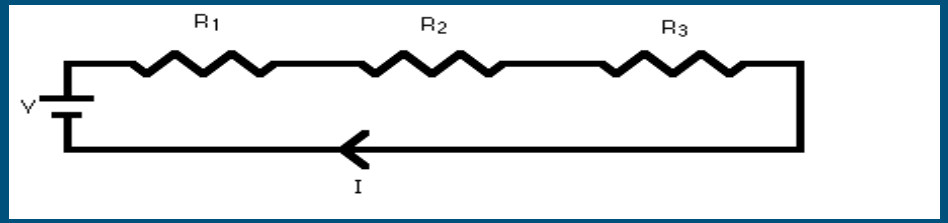
And is denoted by 

The different markings on the resistor represent different values of resistance. These values are measured in ohms.

http://www.dannyg.com/examples/res2/resistor.htm

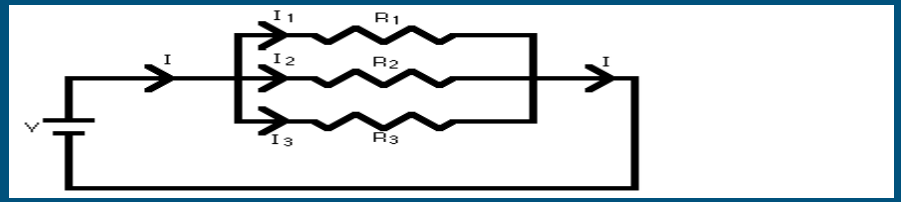
SERIES CIRCUIT

- In series, things are wired one after another, such that electricity has to pass through one thing, then the next thing, then the next, and so on.
- The total resistance of the circuit is found by simply adding up the resistance values of the individual resistors:
- equivalent resistance of resistors in series : $R = R_1 + R_2 + R_3 + ...$
- Eg: A series circuit is shown in the diagram above. The current flows through each resistor in turn. If the values of the three resistors are:
- With a 10 V battery, by V = I R the total current in the circuit is:
- I = V / R = 10 / 20 = 0.5 A. The current through each resistor would be 0.5 A.



PARALLEL CIRCUIT

- In parallel, they are wired side by side, such that electricity passes through all of them at the same time, from one common point to another common point.
- The current in a parallel circuit breaks up, with some flowing along each parallel branch and re-combining when the branches meet again. The voltage across each resistor in parallel is the same.
- The total resistance of a set of resistors in parallel is found by adding up the reciprocals of the resistance values, and then taking the reciprocal of the total:
- equivalent resistance of resistors in parallel: $1 / R = 1 / R_1 + 1 / R_2 + 1 / R_3 + ...$



PARALLEL CIRCUIT ..

A parallel circuit is shown in the diagram above. In this case the current supplied by the battery splits up, and the amount going through each resistor depends on the resistance. If the values of the three resistors are: r1=8,r2=8,r3=4ohms

With a 10 V battery, by V = I R the total current in the circuit is: I = V / R = 10 / 2 = 5 A.

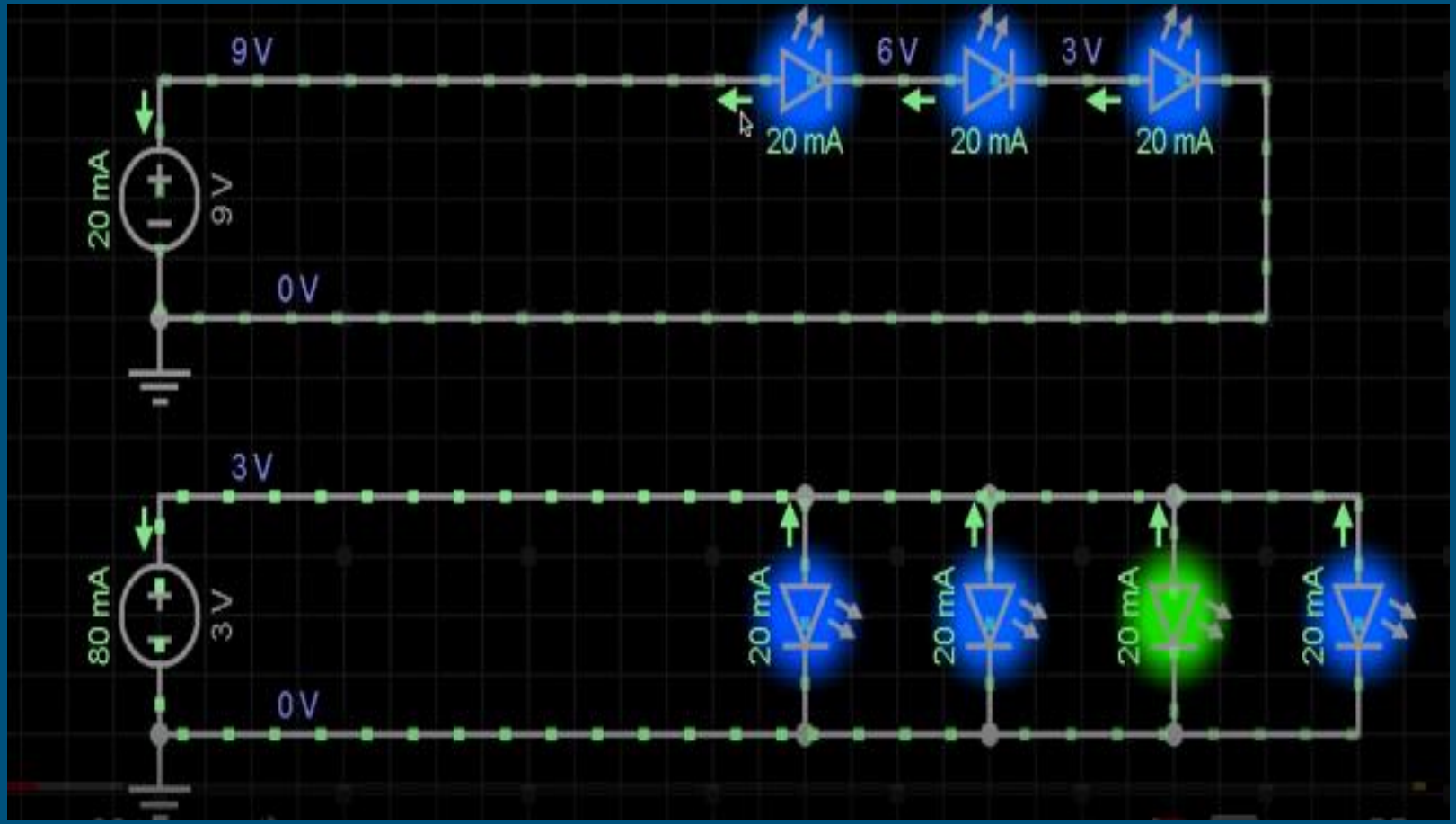
The individual currents can also be found using I = V / R. The voltage across each resistor is 10 V, so:

I1 = 10 / 8 = 1.25 A

I2 = 10 / 8 = 1.25 A

I3=10 / 4 = 2.5 A

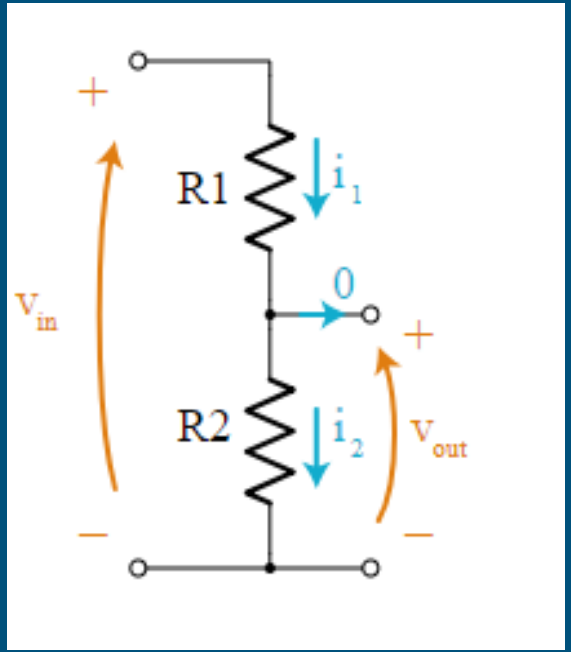
Note that the currents add together to 5A, the total current.


9 V
6 V
3 V
20 mA
20 mA
20 mA
20 mA
9 V
0 V
3 V
80 mA
3 V
20 mA
20 mA
20 mA
20 mA
0 V

VOLTAGE DIVIDER

A voltage divider is a simple series resistor circuit. It's output voltage is a fixed fraction of its input voltage. The divide-down ratio is determined by two resistors

Initially i1=i2 as circuit has no flow of current



VOLTAGE DIVIDER

$v = iR$ Ohm's Law

$$v_{in} = i\,(\mathrm{R1} + \mathrm{R2})$$

Rearranging to solve for i,

$$i = v_{in}\,\frac{1}{\mathrm{R1} + \mathrm{R2}}$$

We've solved for current i in terms of v_{in} and both resistors.

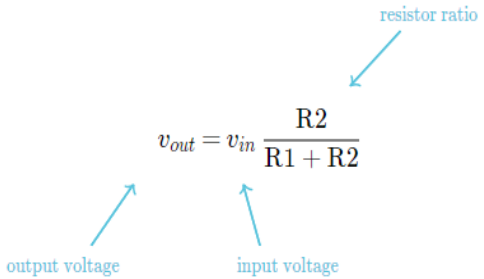
Next, we write an expression for v_{out} using Ohm's Law,

$$v_{out} = i\,\mathrm{R2}$$

We can substitute for i in the previous equation to get,

$$v_{out} = \left(v_{in}\,\frac{1}{\mathrm{R1} + \mathrm{R2}}\right)\mathrm{R2}$$

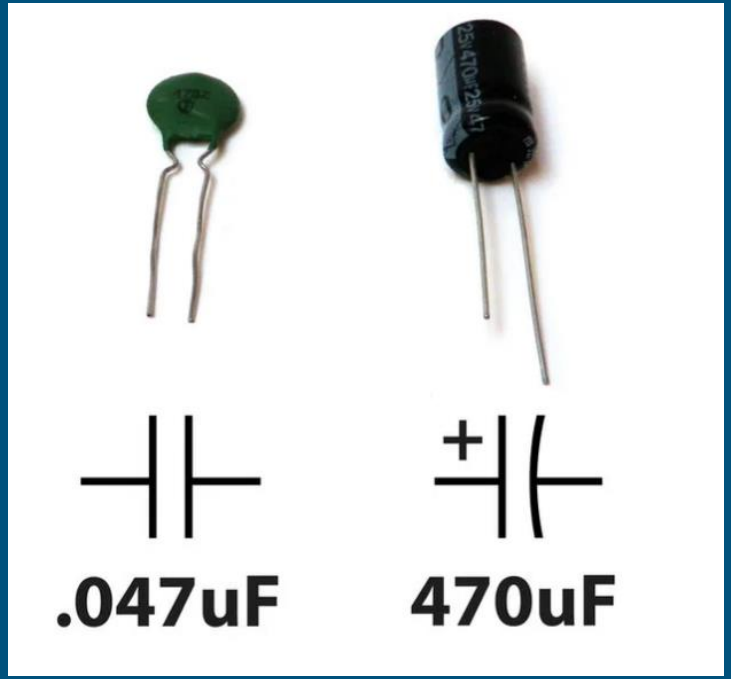
and we have derived the **voltage divider equation**:



VOLTAGE DIVIDER

Voltage dividers can be used to measure the resistance of the sensor. To form a voltage divider, the sensor is connected in series with a known resistance and known voltage is applied across the divider. The analog to digital converter of the microcontroller is connected to the center tap of the divider so that tap voltage can be measured. By using the known resistance, measured voltage sensor resistance can be calculated.

CAPACITORS

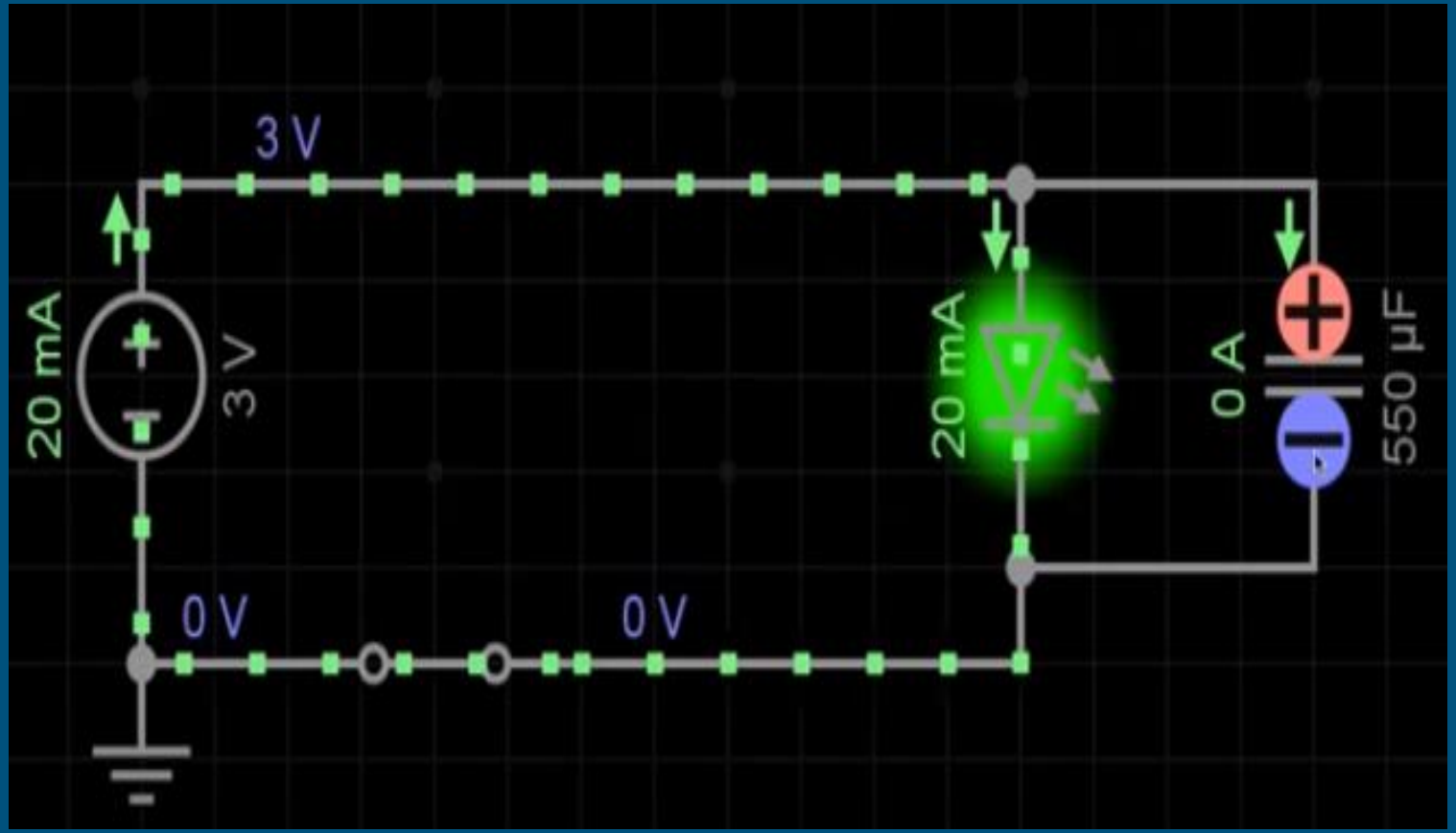


CAPACITORS CONT….

A capacitor is a component that stores electricity and then discharges it into the circuit when there is a drop in electricity

Capacitors are measured in Farads. The values that you will typically encounter in most capacitors are measured in picofarad (pF), nanofarad (nF), and microfarad (uF)

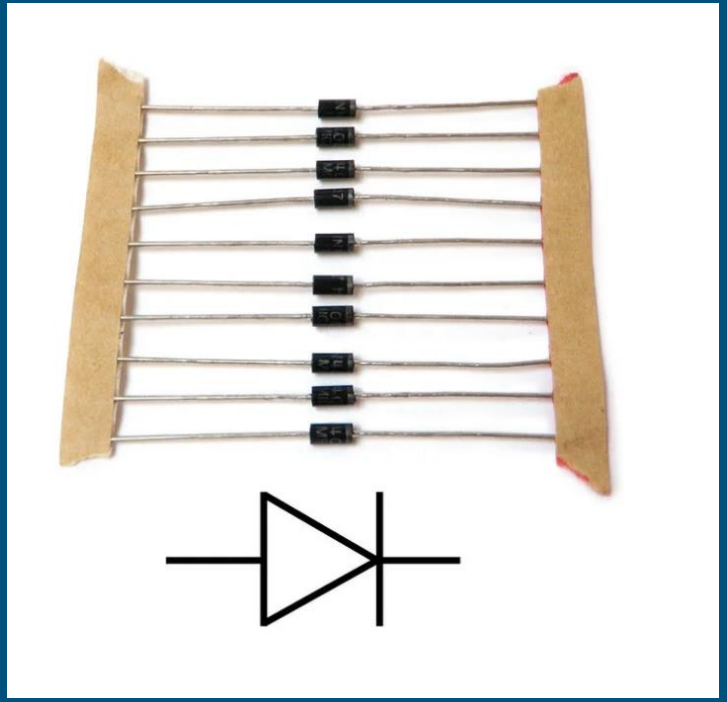
https://www.justradios.com/uFnFpF.html


3 V
20 mA
3 V
20 mA
0 A
550 µF
0 V
0 V

SEMICONDUCTORS

- Semiconductors are a bit different. They are composed of matter with atoms that have some space for electrons, but not enough to conduct electricity the way metals do. Silicon is such a material. Under some circumstances, silicon can act as a conductor. Under others, it acts as an insulator. By tweaking these circumstances, it's possible to control the flow of electrons.
- **doping** -- introducing certain kinds of material -- into silicon, they could control its conductivity. Impurities added to the silicon atom either be negatively charged or positively charged
- Negatively-charged material has an excess of electrons while positively charged material has an excess of **holes** -- places where electrons could fit. **n-type transistor**, which has a positively-charged substrate and p-type which has negatively charged substrate.

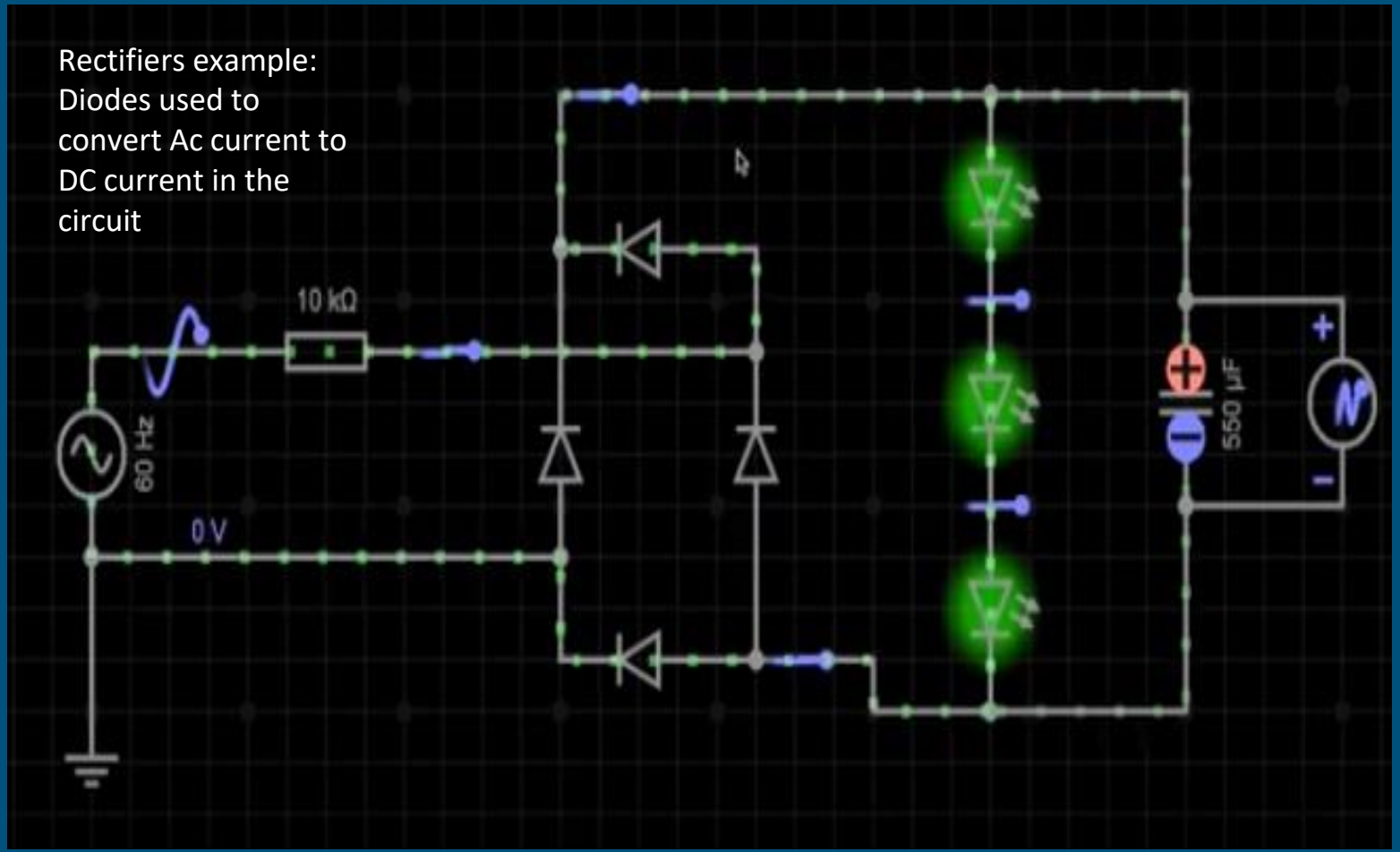
DIODES



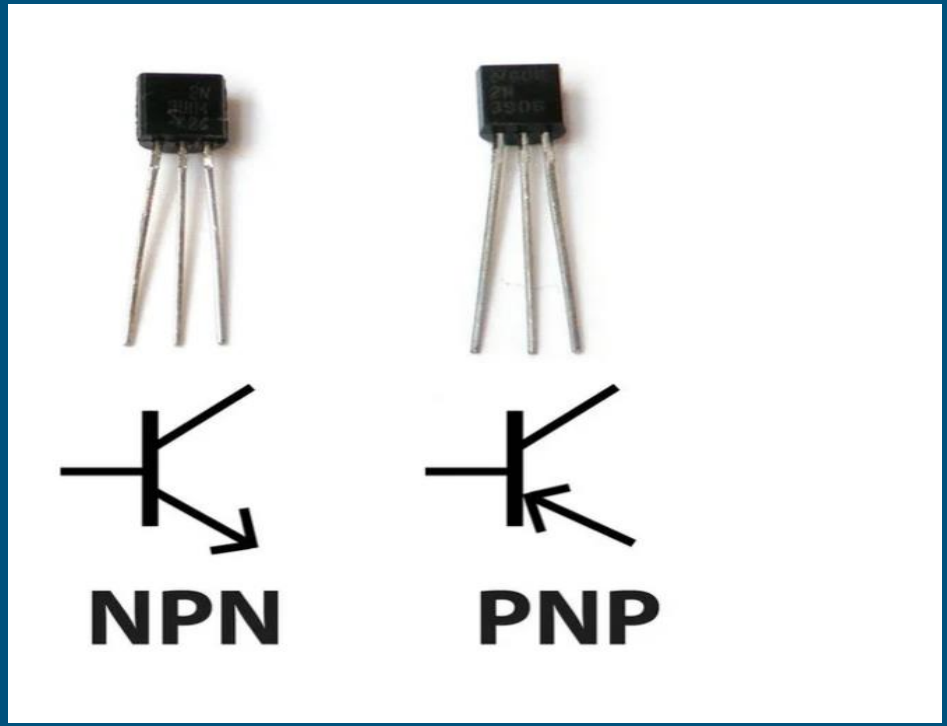
DIODES CONT..

- Diodes are components which are polarized
- They only allow electrical current to pass through them in one direction
- This is useful in that it can be placed in a circuit to prevent electricity from flowing in the wrong direction
- it requires energy to pass through a diode and this results in a drop of voltage. This is typically a loss of about 0.7V
- Note: The ring found on one end of the diode indicates the side of the diode which connects to ground. This is the cathode. It then follows that the other side connects to power. This side is the anode.
- https://www.toppr.com/bytes/principles-of-led/

Rectifiers example: Diodes used to convert Ac current to DC current in the circuit



TRANSISTORS



TRANSISTORS CONT….

A transistor takes in a small electrical current at its base pin and amplifies it such that a much larger current can pass between its collector and emitter pins

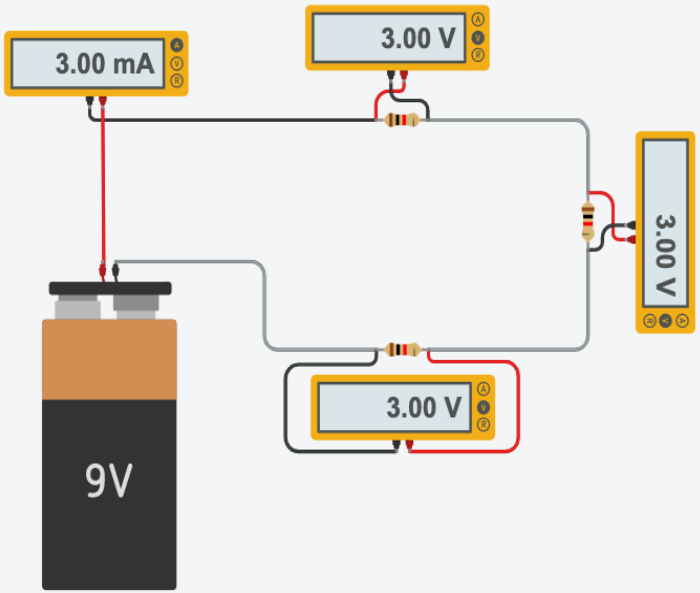
There are two basic types of transistors, which are NPN and PNP.

NPN transistors allow electricity to pass from the collector pin to the emitter pin

PNP transistors allow electricity to pass from the emitter pin to the collector pin

Used to make gates, switches …….

PRACTICE: OHM'S LAW



THANK YOU