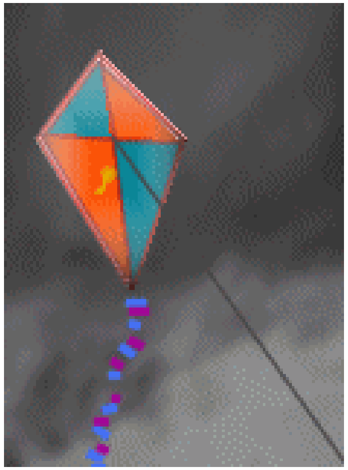
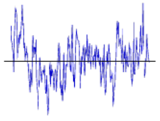


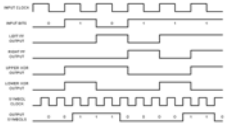
A practical introduction to electronics for anyone in any field of practice

Voltage, Current, Resistance, Power, & Diodes

Basic Electronics

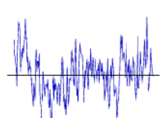
- What is considered to be a basic level of understanding for this important topic?
- We can look to many sources, but one that works well comes from industry – from Bell South, which is now part of AT&T.

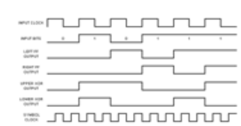




Bell South Test:
What Will We Address This Week?

- DC Circuits – most of this topic.
- AC Circuits – some of this.
- Transmission Lines – very little of this
- Electronics Fundamentals – some of this
- Applied Math – some of this
- Use of a Scientific Calculator – a little

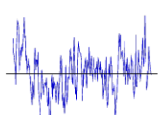


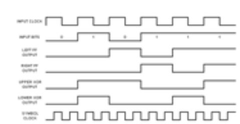


Bell South Test

- If you want to see how you are doing this week, you can take the practice test but don't expect to do well across the board.

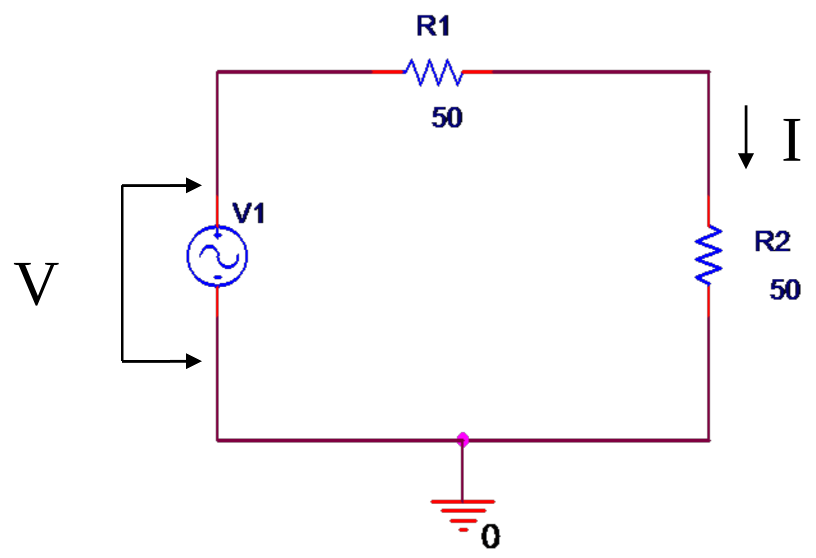
http://www.asisvcs.com/publications/pdf/710042.pdf





Voltage, Current, Power and Resistance

- Fundamental concepts
  - Voltage V volt
  - Current I amp
  - Power W watt
  - Resistance R ohm



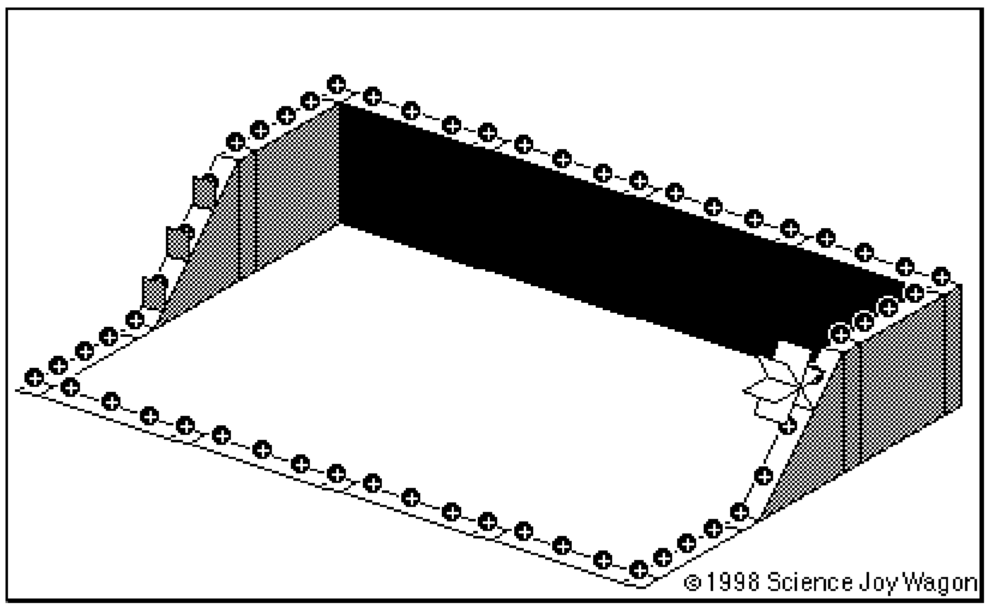
Voltage

- Voltage is defined as the amount of work done or the energy required (in joules) in moving a unit of positive charge (1 coulomb) from a lower potential to a higher potential. Voltage is also called potential difference (PD). When you measure voltage you must have two points to compare, one of them being the reference point. When measuring the voltage drop for a circuit component it is sometimes called measuring the potential across that component.

1 volt = 1 joule/coulomb

Voltage

- Voltage is analogous to pressure. A battery in an electrical circuit plays the same role as a pump in a water system.

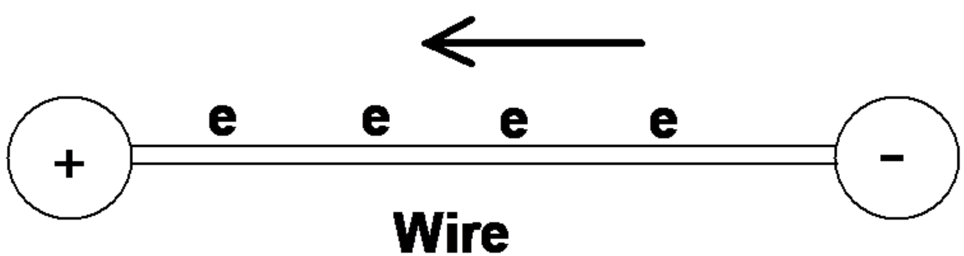


Current

- Current is the amount of electric charge (coulombs) flowing past a specific point in a conductor over an interval of one second.

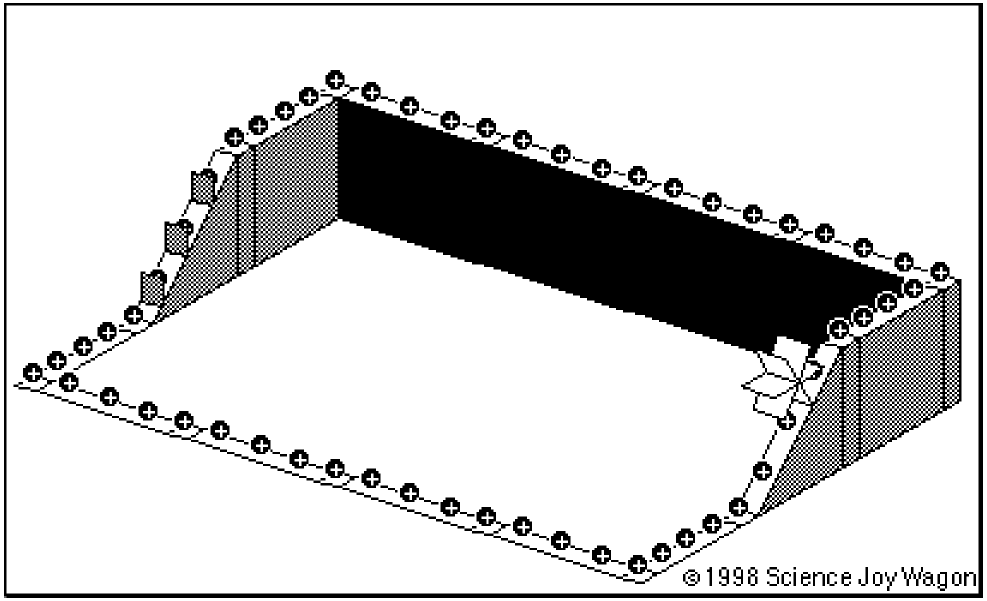
1 ampere = 1 coulomb/second

- Electron flow is from a lower potential (voltage) to a higher potential (voltage).



Current

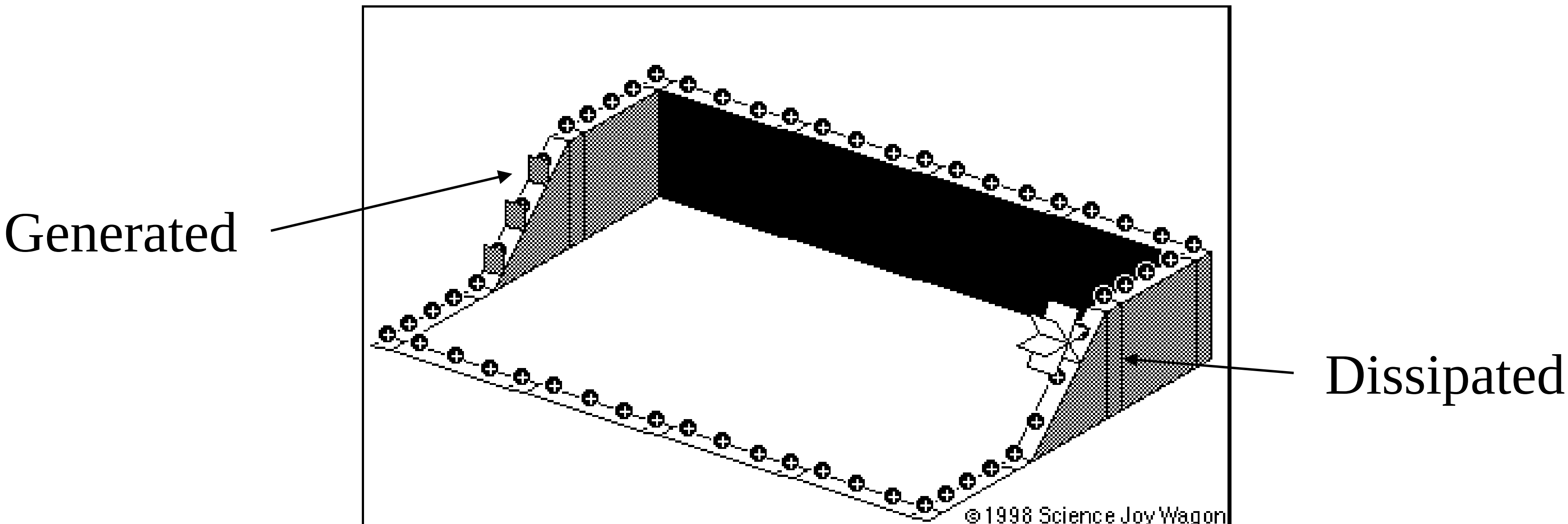
- For historical reasons, current is conventionally thought to flow from the positive to the negative potential in a circuit.



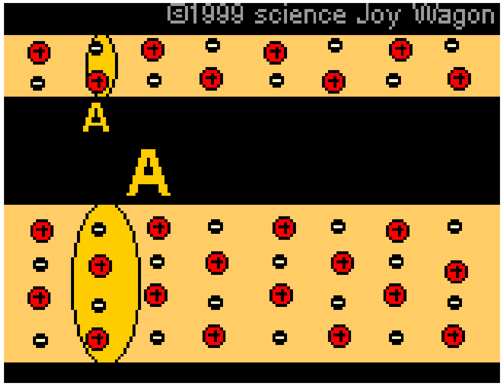
Power

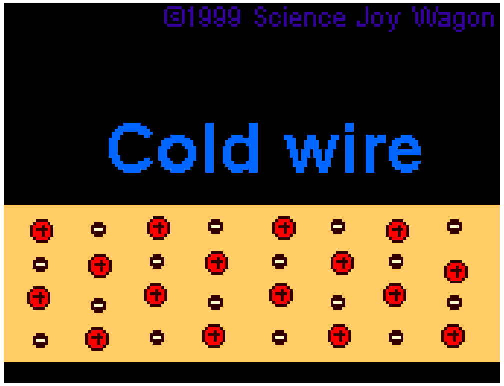
- Power is the rate at which energy is generated or dissipated in an electrical element.

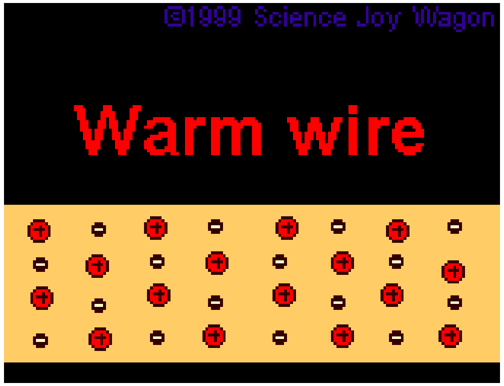
1 watt = 1 joule/sec



Resistance





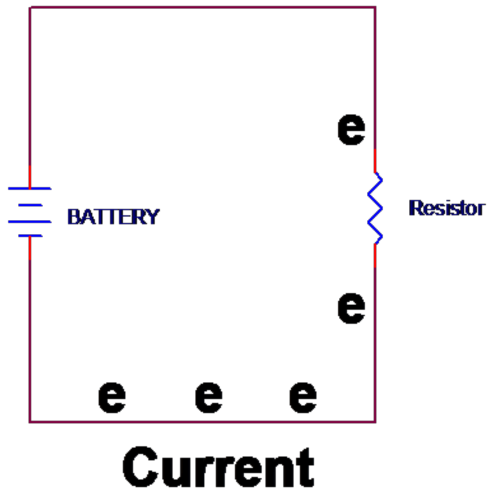


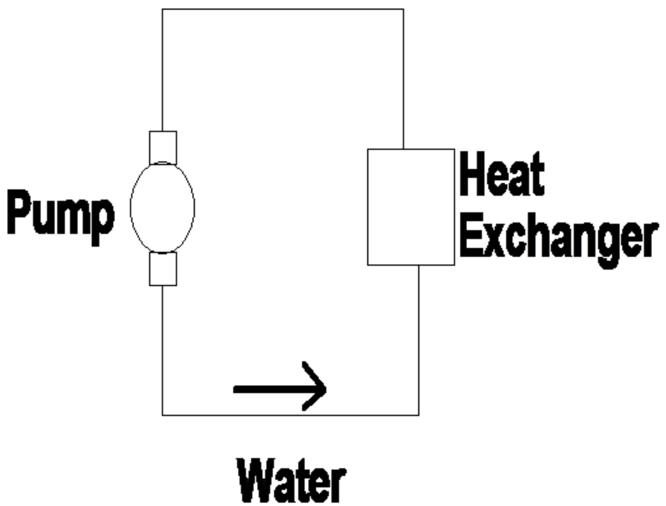
- Charges passing through any conducting medium collide with the material at an extremely high rate and, thus, experience friction.

$$R = \frac{\rho l}{A}$$

- The rate at which energy is lost depends on the wire thickness (area), length and physical parameters like density and temperature as reflected through the resistivity ρ

Circuit Diagram





- Water flow analogy is helpful, if not totally accurate

Basic Electrical Laws

- Ohm's Law

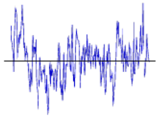
$$V = IR$$

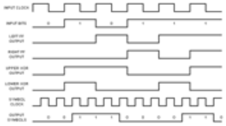
- Kirchoff's Voltage Law

$$\sum V = 0$$

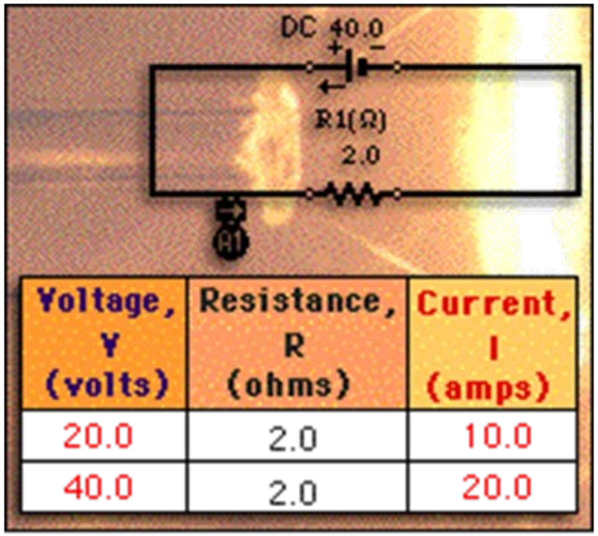
- Kirchoff's Current Law

$$\sum I = 0$$





Ohm's Law



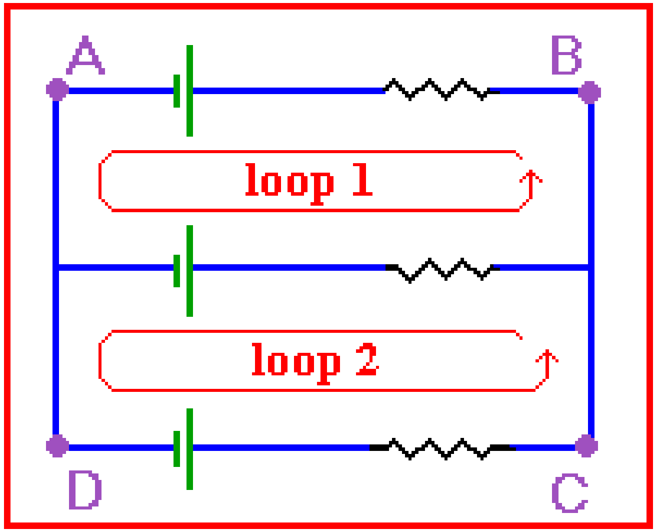
Voltage, V (volts)	Resistance, R (ohms)	Current, I (amps)
20.0	2.0	10.0
40.0	2.0	20.0

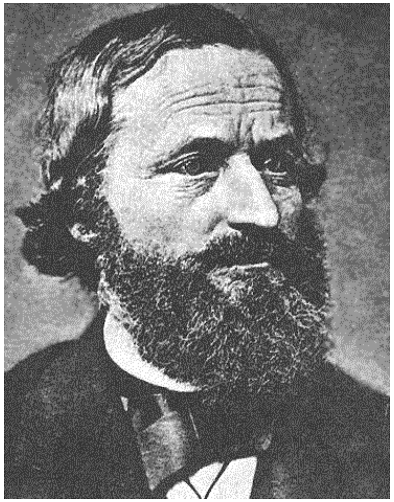
Georg Ohm

- There is a simple linear relationship between voltage, current and resistance.

$$V = IR$$

Kirchoff's Voltage Law (KVL)



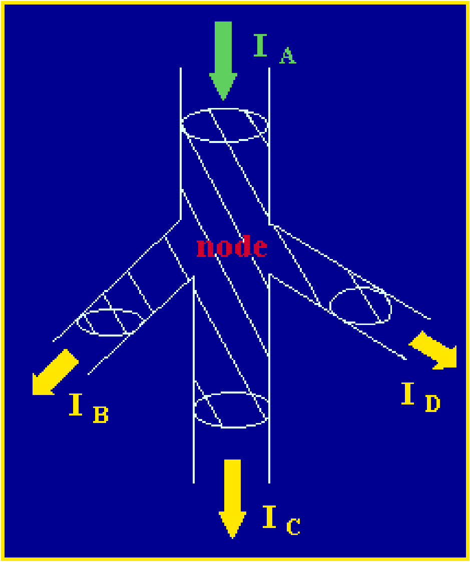


Gustav Kirchoff

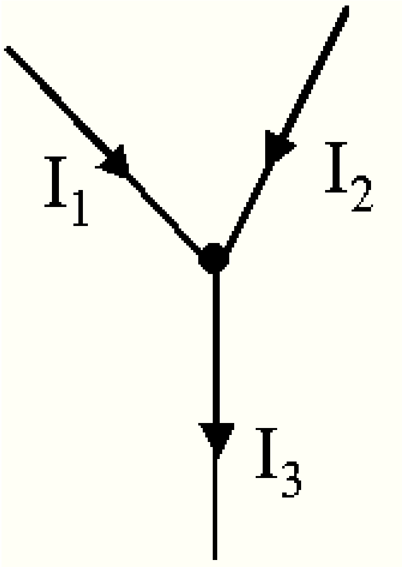
- The sum of the voltage differences around a circuit is equal to zero.

$$\sum V = 0$$

Kirchoff's Current Law (KCL)



Applying conservation of current.



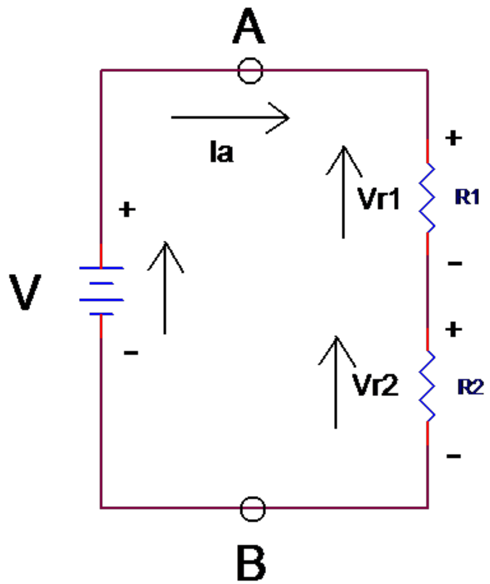
- The sum of all the currents entering or exiting a node is equal to zero.

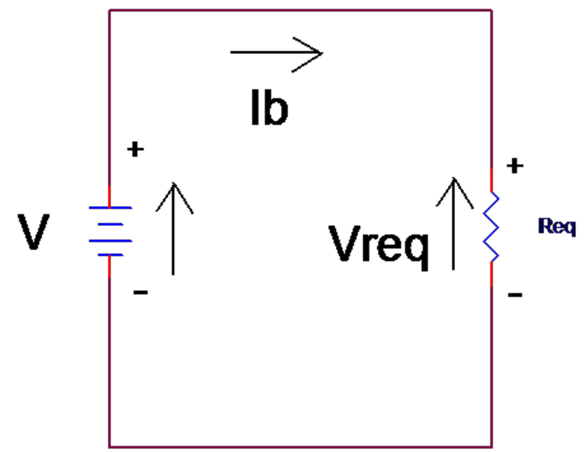
$$\sum I = 0$$

Conservation Laws

- Both the KVL and KCL are based on conservation laws.
  - KVL conserves voltage
  - KCL conserves current
- Other conservation laws we know about
  - Conservation of energy
  - Conservation of momentum
- A key to understanding any system is identifying the relevant conservation laws

Series Combination of Resistors

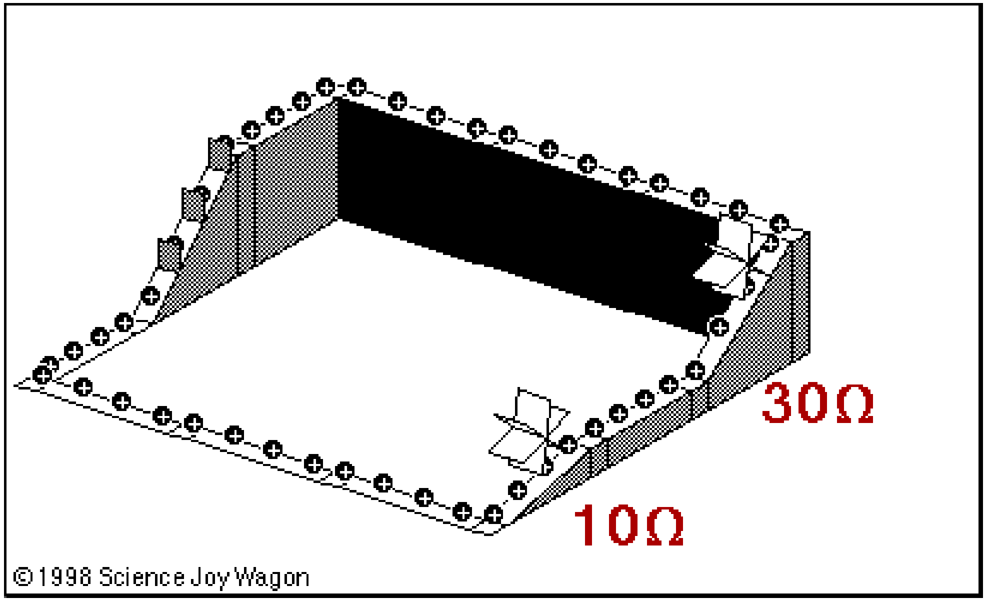


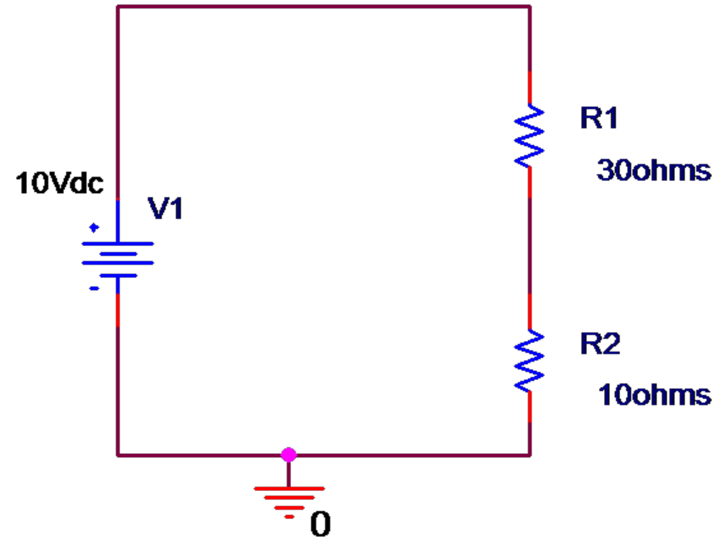


- Resistors add in series

$$R_{EQ} = R_1 + R_2 + \ldots + R_N$$

Series Combination of Resistors

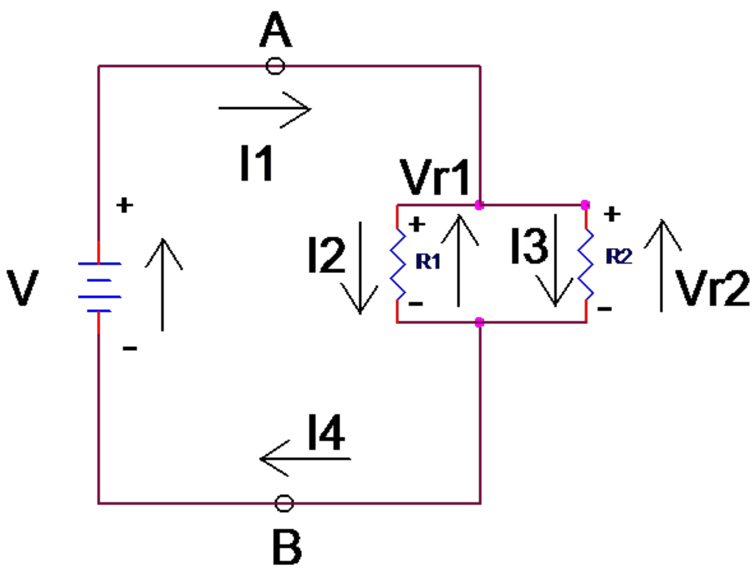


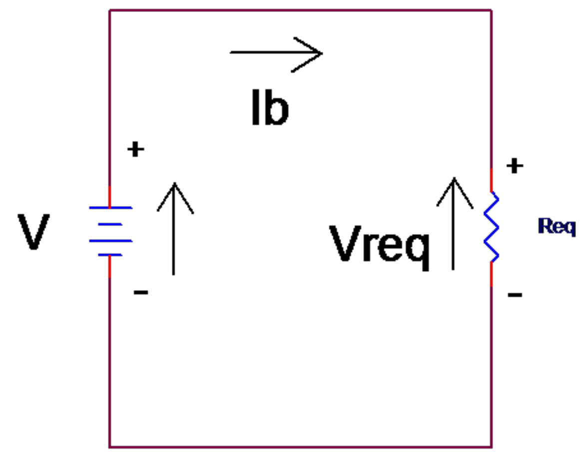


- The effect of resistors in series is additive. There is a corresponding voltage drop across each resistor.

$$R_{EQ} = R_1 + R_2 + \ldots + R_N$$

Parallel Combination of Resistors

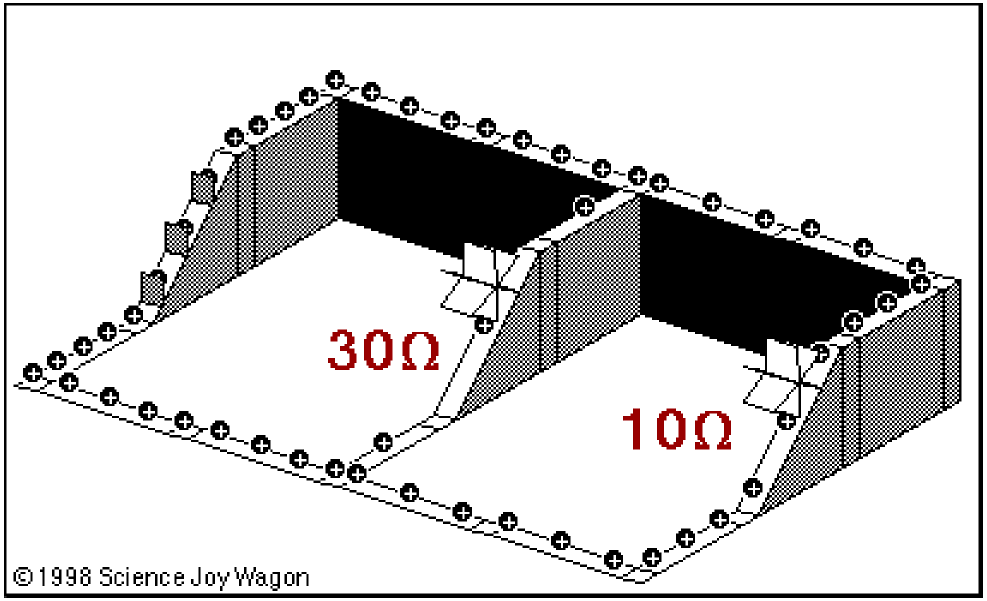


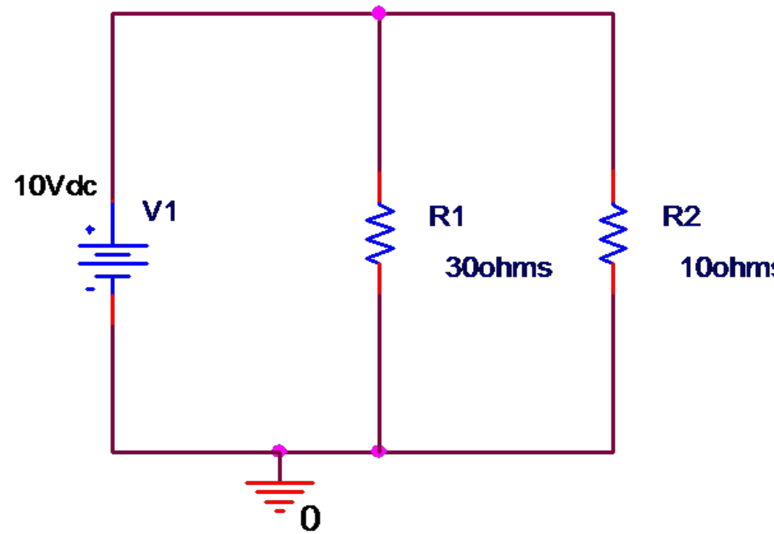


- The reciprocal or inverse of resistors add in parallel.

$$\frac{1}{R_{EQ}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_N}$$

Parallel Combination of Resistors

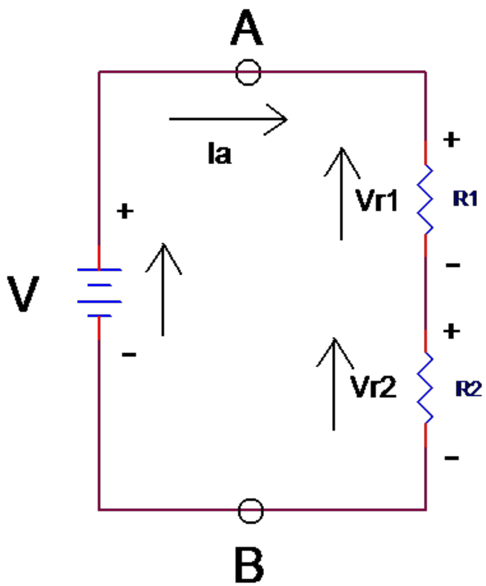


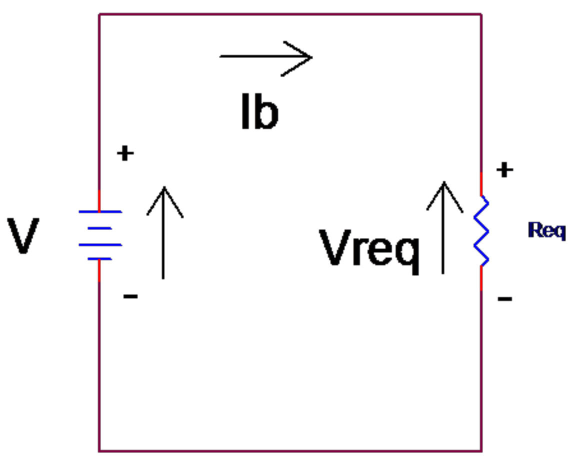


- For resistors in parallel, the same voltage occurs across each resistor and more than one path exists for the current, which lowers the net resistance.

$$\frac{1}{R_{EQ}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_N}$$

Series Combination of Resistors





- KVL: $V = V_{r1} + V_{r2}$
- Ohm's Law: $V = I_a R_1 + I_a R_2$

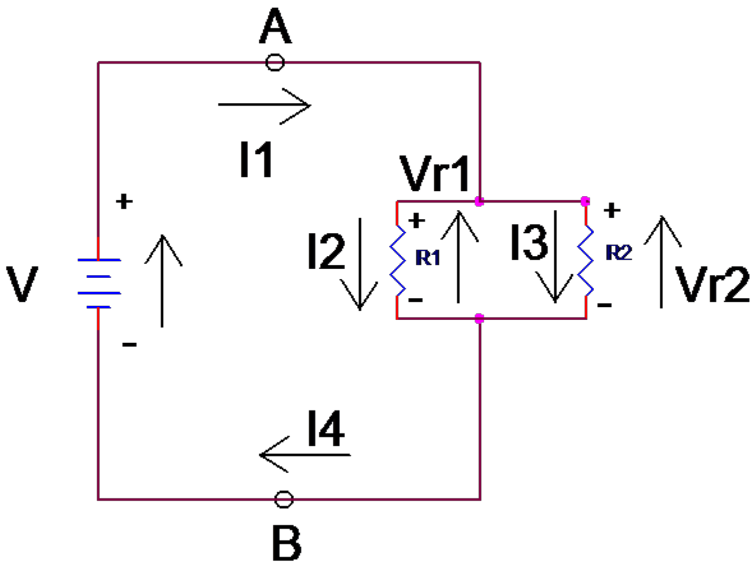
$$V = I_a (R_1 + R_2) = I_a (R_{eq})$$

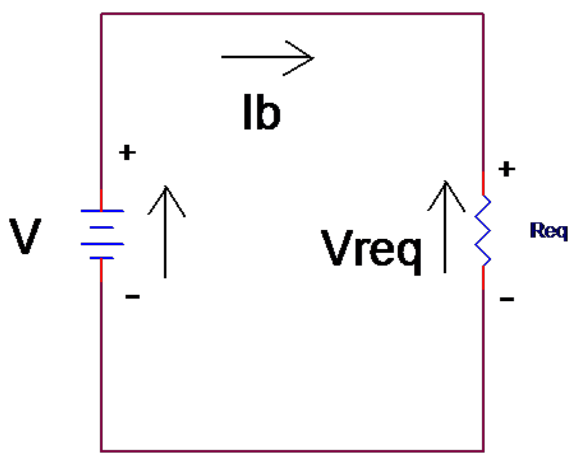
$$R_{eq} = R_1 + R_2$$

In General

$$R_{EQ} = R_1 + R_2 + \ldots + R_N$$

Parallel Combination of Resistors





- KCL:

$$I_1 = I_2 + I_3$$

- Ohm's Law:

$$I_1 = \frac{V}{R_1} + \frac{V}{R_2} = V\left(\frac{1}{R_{EQ}}\right)$$

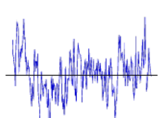
- We can say:

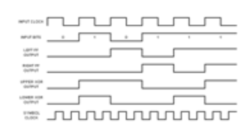
$$\frac{1}{R_{EQ}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_N}$$

Combination of Resistors

- Series $R_{EQ} = R_1 + R_2 + \ldots + R_N$
- Parallel $\dfrac{1}{R_{EQ}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots + \dfrac{1}{R_N}$
- For two resistors, the second expression can be written as

$$R_{EQ} = \frac{R_1 R_2}{R_1 + R_2}$$

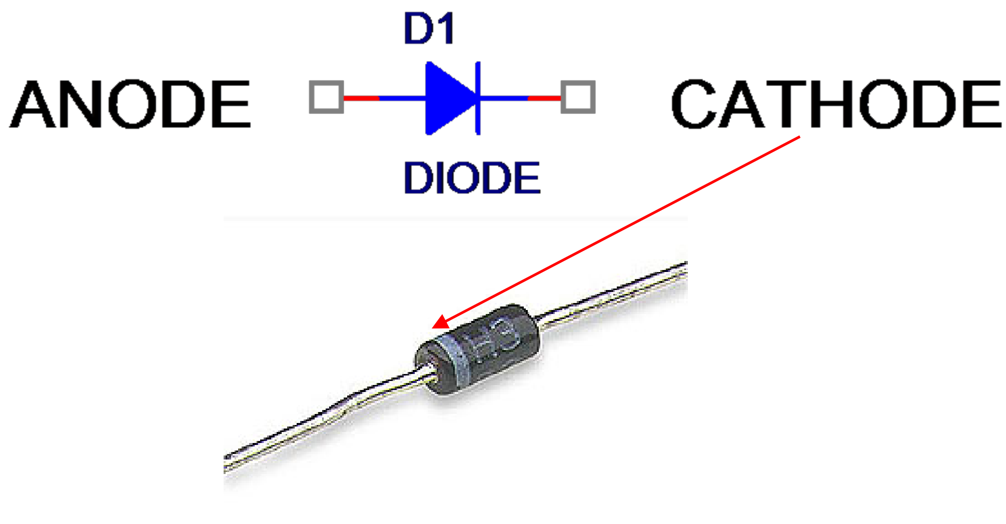




Combination of Resistors

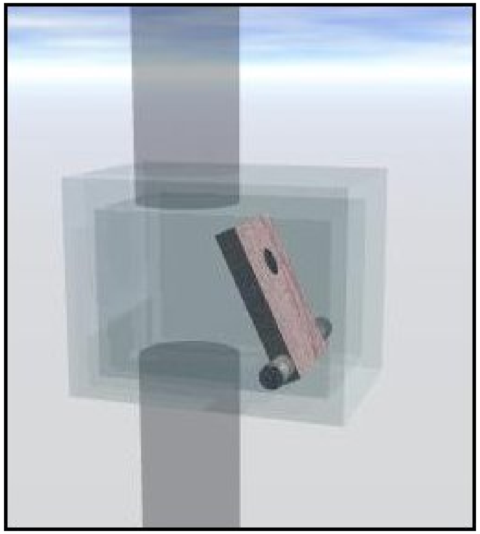
- Adding resistors in series always results in a larger resistance than any of the individual resistors
- Adding resistors in parallel always results in a smaller resistance than any of the individual resistors

Diodes



- A diode can be considered to be an electrical one-way valve.
- They are made from a large variety of materials including silicon, germanium, gallium arsenide, silicon carbide …

Diodes



- In effect, diodes act like a flapper valve
  - Note: this is the simplest possible model of a diode

Diodes

- For the flapper valve, a small positive pressure is required to open.
- Likewise, for a diode, a small positive voltage is required to turn it on. This voltage is like the voltage required to power some electrical device. It is used up turning the device on so the voltages at the two ends of the diode will differ.
  - The voltage required to turn on a standard diode is typically around 0.6-0.8 volt for a standard silicon diode and a few volts for a light emitting diode (LED)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Light emitting diodes, commonly called LEDs, are real unsung heroes in the electronics world. They do dozens of different jobs and are found in all kinds of devices. Among other things, they form the numbers on digital clocks, transmit information from remote controls, light up watches and tell you when your appliances are turned on. Collected together, they can form images on a jumbo television screen or illuminate a traffic light.
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How Light Emitting Diodes Work

by Tom Harris

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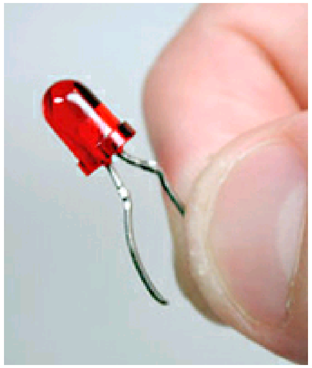
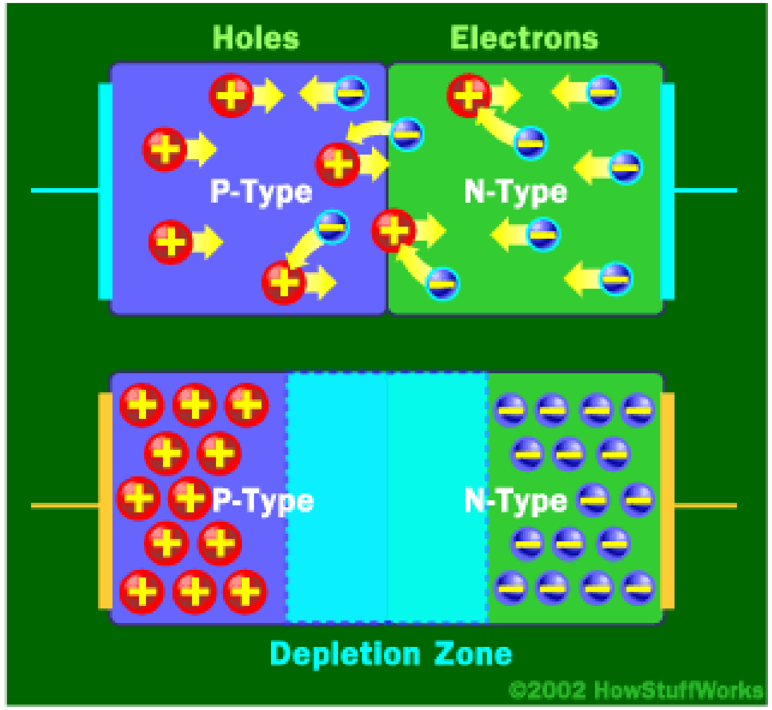
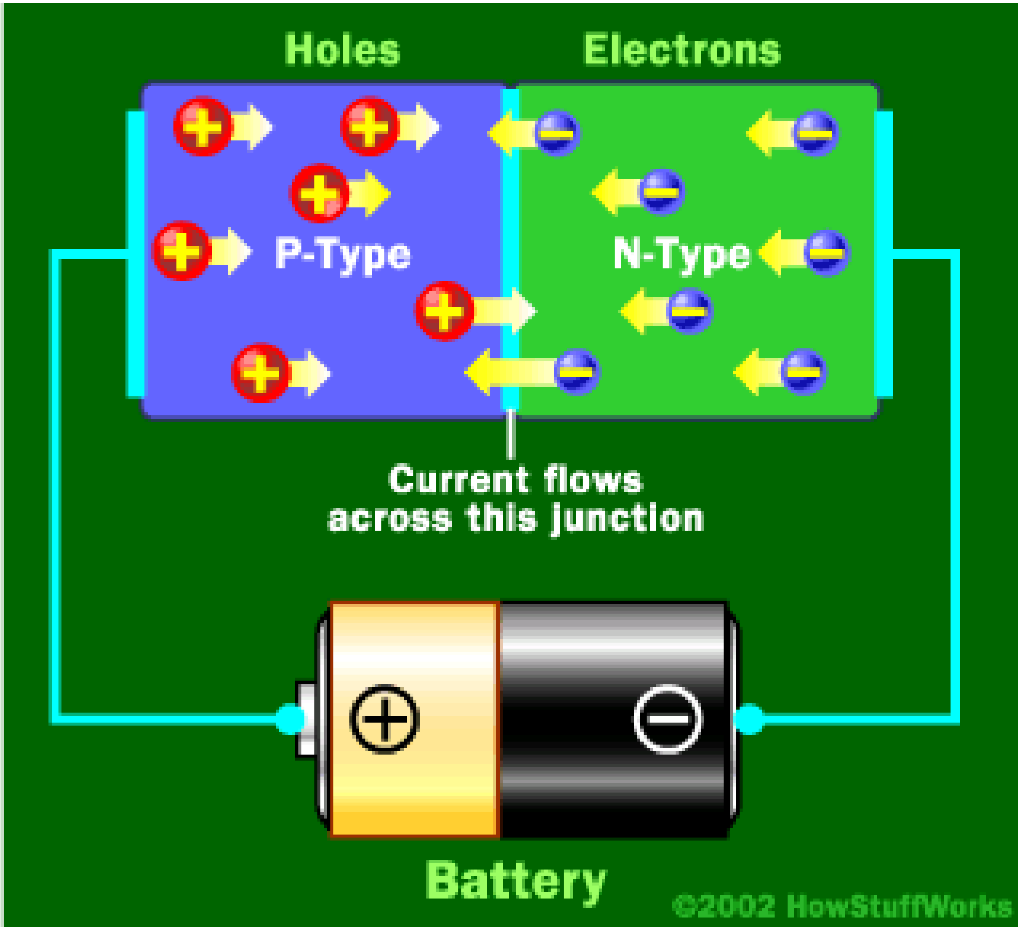


Light emitting diodes, commonly called LEDs, are real unsung heroes in the electronics world. They do dozens of different jobs and are found in all kinds of devices. Among other things, they form the numbers on digital clocks, transmit information from remote controls, light up watches and tell you when your appliances are turned on. Collected together, they can form images on a jumbo television screen or illuminate a traffic light.

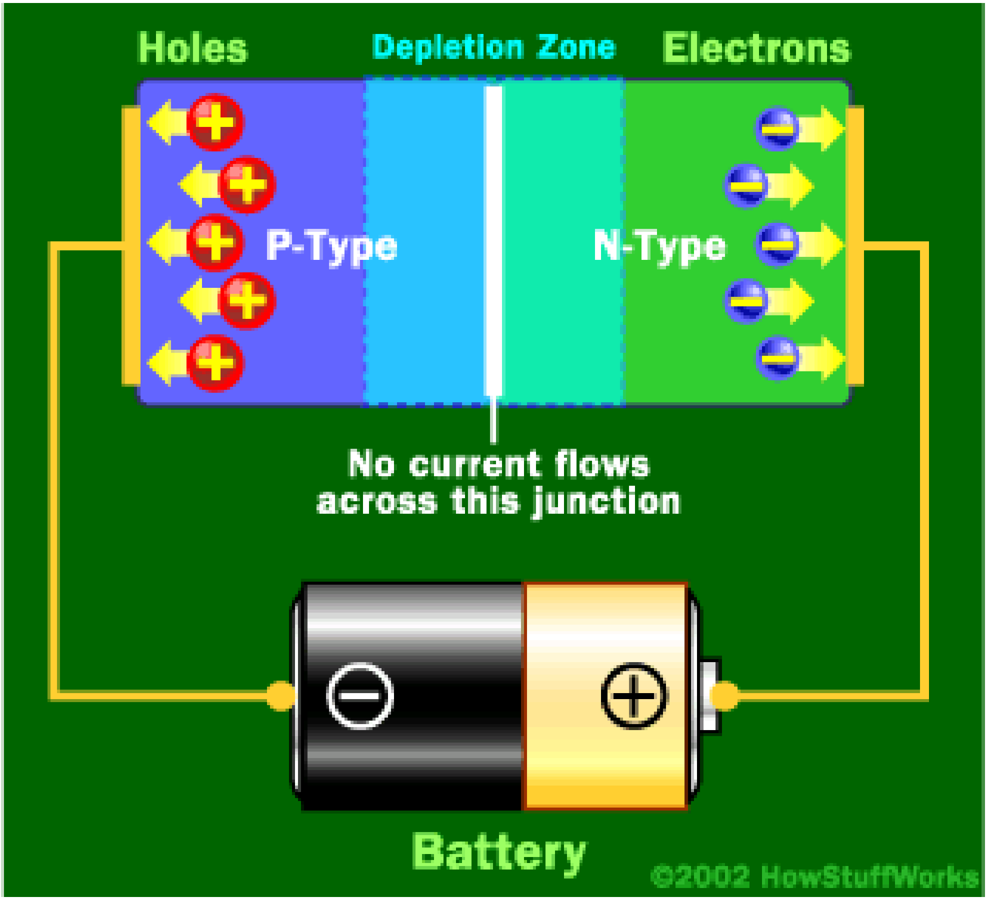
Basically, LEDs are just tiny light bulbs that fit easily into an electrical circuit. But unlike ordinary incandescent bulbs, they don't have a filament that will burn out, and they don't get especially hot. They are illuminated solely by the movement of electrons in a semiconductor material, and they last just as long as a standard transistor.



At the junction, free electrons from the N-type material fill holes from the P-type material. This creates an insulating layer in the middle of the diode called the depletion zone.



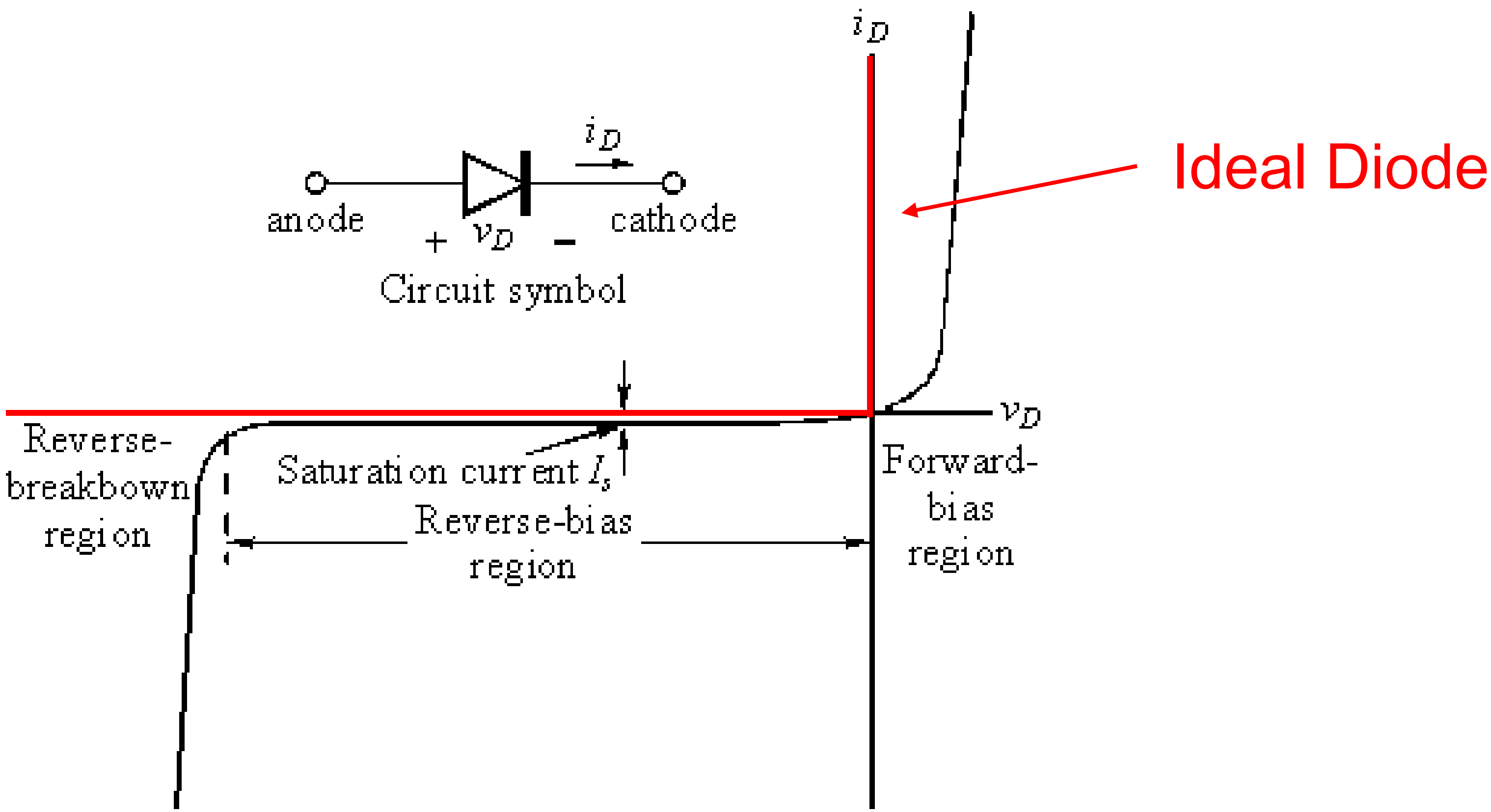
When the negative end of the circuit is hooked up to the N-type layer and the positive end is hooked up to P-type layer, electrons and holes start moving and the depletion zone disappears.

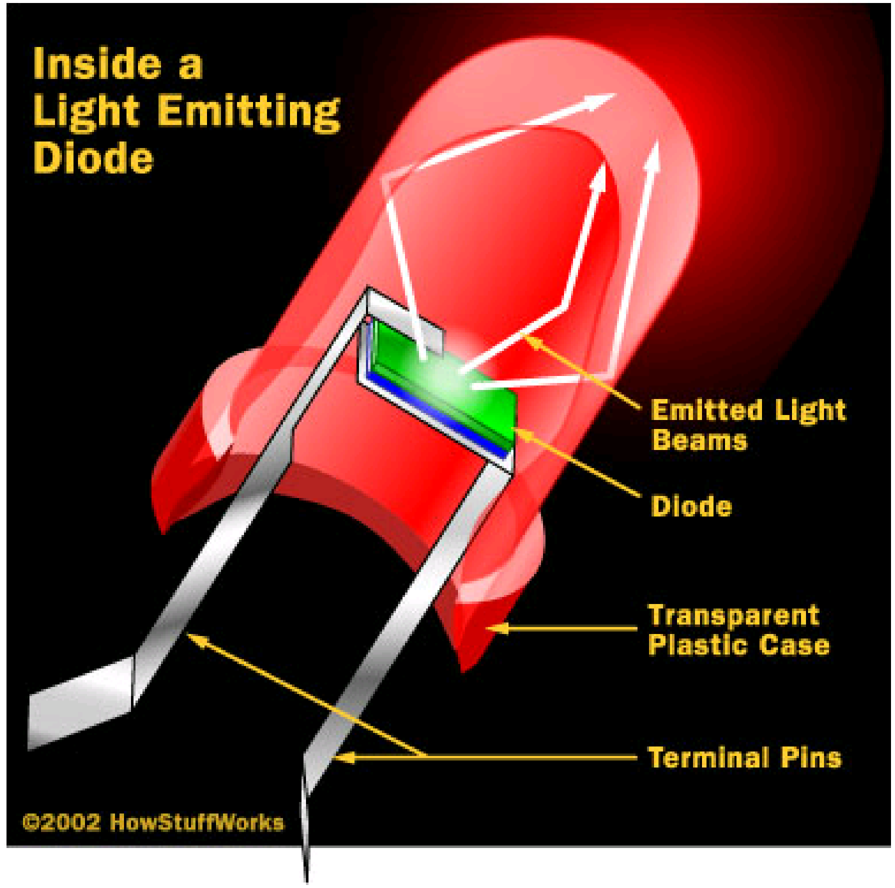


When the negative end of the circuit is hooked up to the N-type layer and the positive end is hooked up to the P-type layer, free electrons collect on one end of the diode and holes collect on the other. The depletion zone gets bigger.

Diode V-I Characteristic

- For ideal diode, current flows only one way
- Real diode is close to ideal





LEDs have several advantages over conventional incandescent lamps. For one thing, they don't have a filament that will burn out, so they last much longer. Additionally, their small plastic bulb makes them a lot more durable. They also fit more easily into modern electronic circuits.