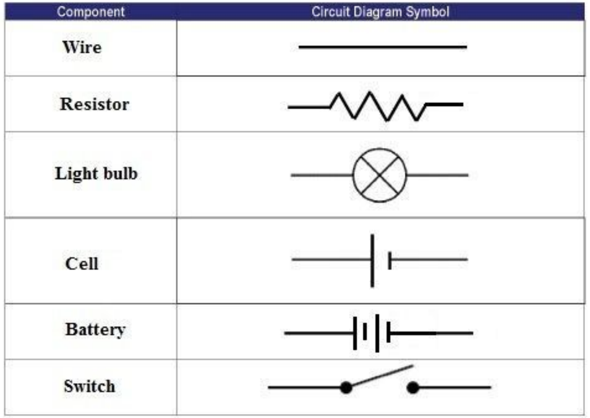
neurotechuoft

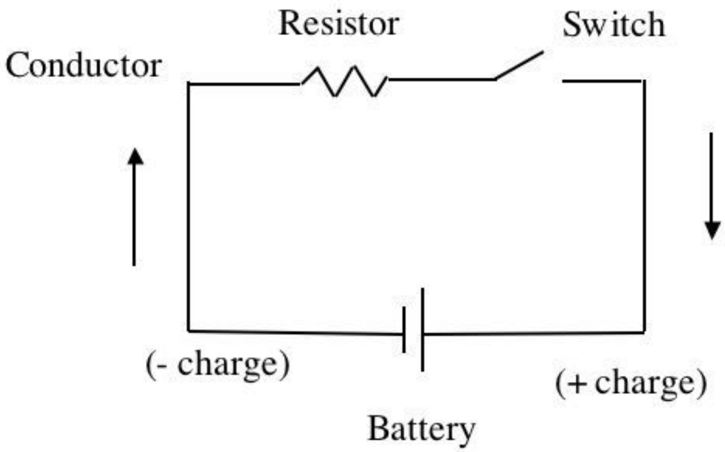
intro to

circuits

An electric circuit is a closed path along which electrons that are powered by an energy source can flow.

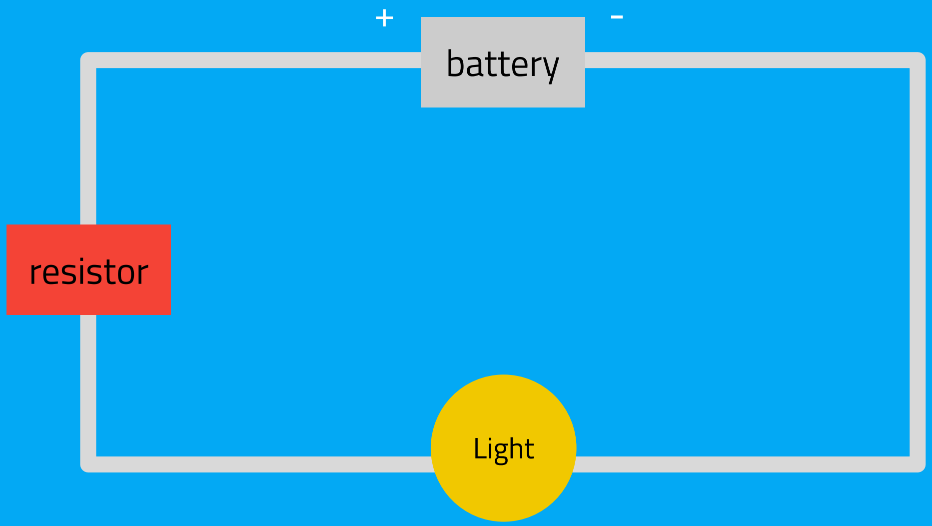


Component	Circuit Diagram Symbol
Wire	
Resistor	
Light bulb	
Cell	
Battery	
Switch	

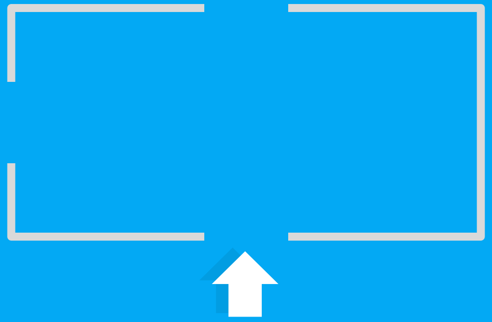


A basic circuit can include a battery, a load, a resistor, and a switch!

HOW TO MAKE A CIRCUIT!



Using wires, draw a path. Connect the components and make a circuit.

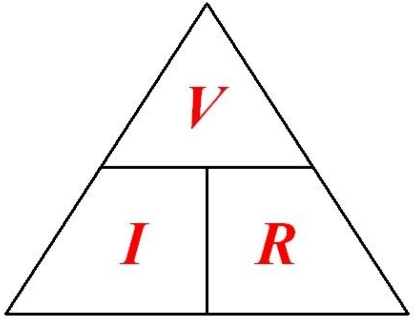


Your path should look like this!

the basics

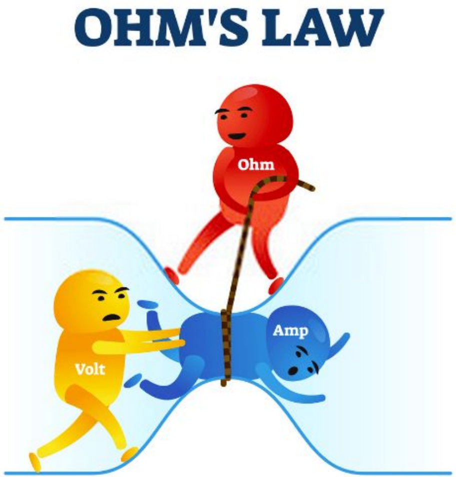
Ohm’s Law

$$V = I\,R$$



$$I = \frac{V}{R}$$

$$R = \frac{V}{I}$$



the basics

Current (I)

Unit = Ampere or Amp (A)

The type of electricity we'll be dealing with is **current electricity**. Current electricity is a constant flow of electrons. This flow is called the **electric current**.

Think of water flowing down a river:

- Water molecules = **Electrons**
- Amount of water flowing down the river = **Current**

the basics

voltage(V)

Unit = volts (v)

Voltage is the potential difference in charge between two points in an electrical field. It acts like a pressure from the power source (like a battery) that **pushes charged electrons through a circuit**.

Let's go back to the river analogy:

- Water flows down a river from an area of **higher elevation** to an area of **lower elevation**
- The difference in elevation is like the difference in potential energy (**voltage**) in a circuit

the basics

Resistance(R)

Unit = Ohms (Ω)

Resistance is the opposition that a substance offers to the flow of electric current. It is represented by the uppercase letter R. The standard unit of resistance is the ohm, sometimes written out as a word, and sometimes symbolized by the uppercase Greek letter omega

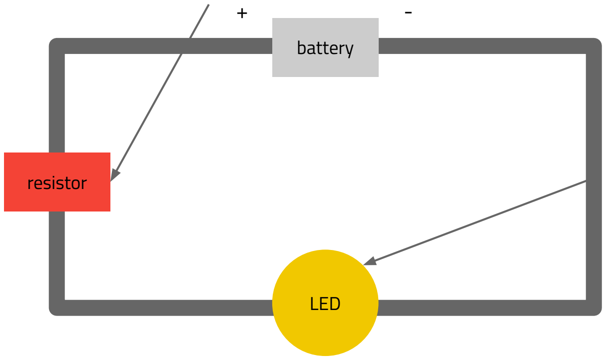
Let's go back to the river analogy:

- A net or or a dam slows down the flow of water in a river example one

how it works

Electricity does ‘work’ by flowing from a higher voltage to a lower voltage. In our circuit, the electricity flows from the + side of the battery to the - side by travelling along the conductive path (drawn with conductive ink!).

The resistor limits the flow of electrons through a circuit. If the current running through the load is too large, it may damage the load.

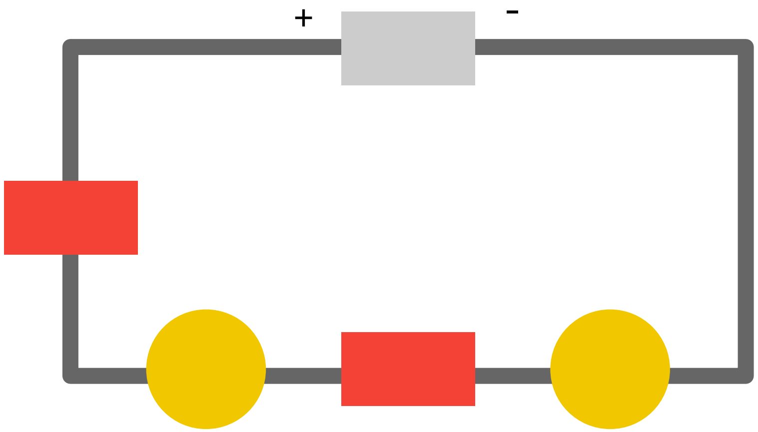


The load is the LED light. It makes use of electricity and prevents short circuits. A short circuit happens when there is nothing slowing down the current, which results in overheating and damage to the circuit.

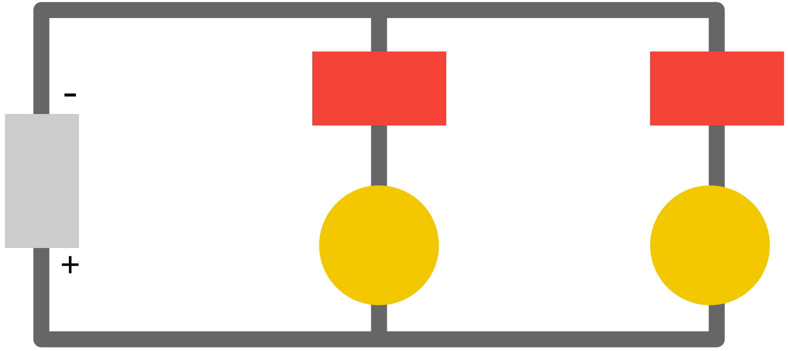
example two

series vs parallel

There are two common types of circuits: series and parallel. Try making your own! What do you notice?



Series Circuit



Parallel Circuit

voltage, current, and resistance in

series and parallel

Ohm's Law states that in a conductor (like our circuit), **voltage** is equal to the **current** multiplied by the **resistance**: **V** = **IR**.

	Series Circuit	Parallel Circuit
Voltage (V)	The voltage of the circuit is equal to the sum of all the potential differences across its loads V(T) = V(1) + V(2) + V(3)	The voltage of the circuit is equal across all of the potential differences across its loads V(T) = V(1) = V(2) = V(3)
Resistance (R)	The resistance of the circuit is equal to the sum of the resistances of all the loads R(T) = R(1) + R(2) + R(3)	The resistance of the circuit is equal to the inverse of the sum of all inverse resistances $\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_{N-1}} + \frac{1}{R_N}$

Axon as an Electric Cable

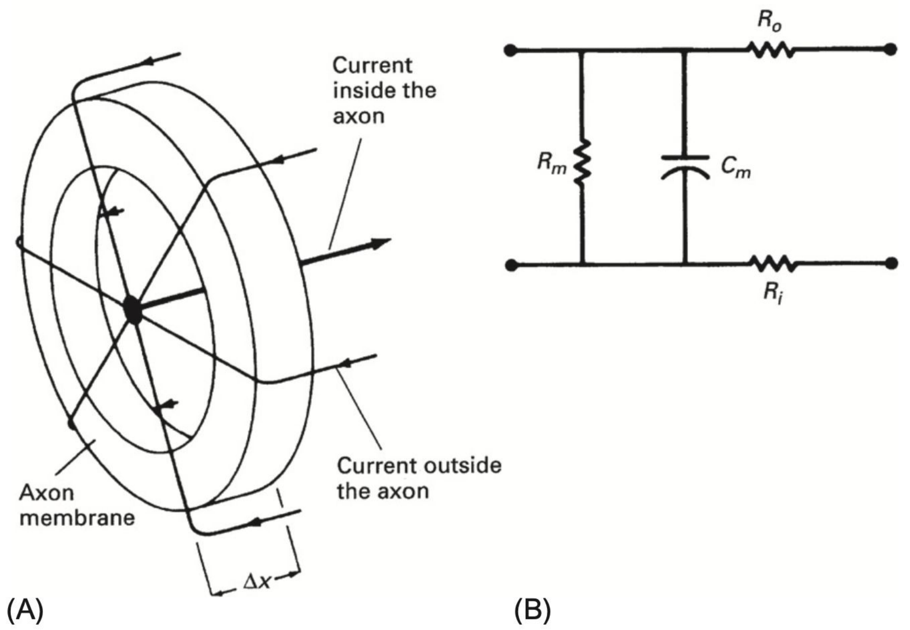


FIGURE 13.6 (A) Currents flowing through a small section of the axon. (B) Electrical circuit representing a small section of the axon.

Circuit model of Axons

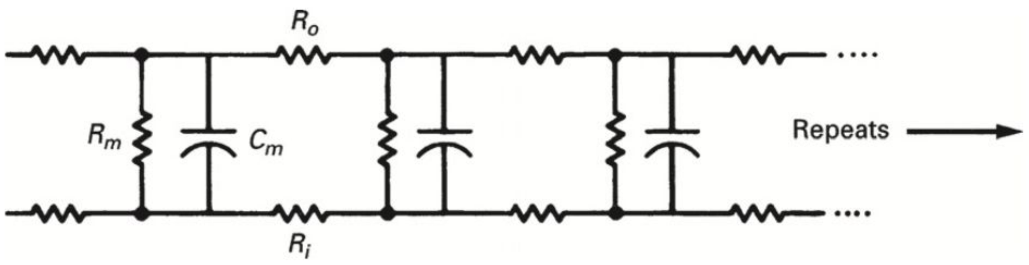


FIGURE 13.7 The axon represented as an electrical cable.

Electrical constants of Axons

TABLE 13.1 Properties of Sample Axons

Property	Nonmyelinated axon	Myelinated axon
Axon radius	5×10^{-6}m	5×10^{-6} m
Resistance per unit length of fluid both inside and outside axon (r)	6.37×10^{9} Ω/m	6.37×10^{9} Ω/m
Conductivity per unit length of axon membrane (gm)	1.25×10^{-4} mho/m	3×10^{-7} mho/m
Capacitance per unit length of axon (c)	3×10^{-7} F/m	8×10^{-10} F/m

Analysis of the Axon Circuit

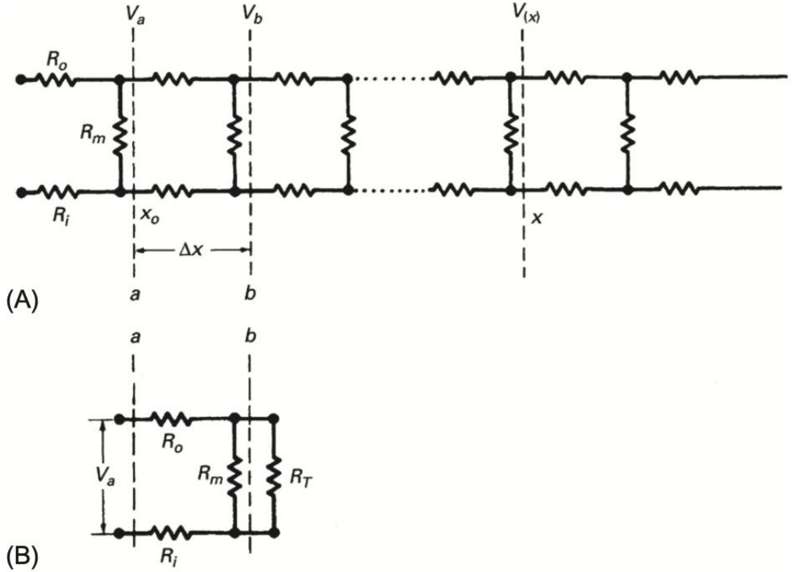
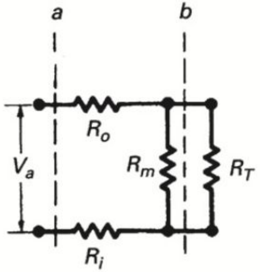


FIGURE 13.9 (A) Approximation to the circuit in Fig. 13.7 with the capacitances neglected. (B) The resistances to the right of line b replaced by the equivalent resistor R_T.

Exercise

Find is R_T in terms of all other variables and use the simulation to create the circuit and verify your answer for the values given below.
(Given that the axon is infinitely long, you can assume the resistance to the right of 'a' is R_T)

$R_o = R_i = R = 6.37\Omega$
$R_m = 10\Omega$



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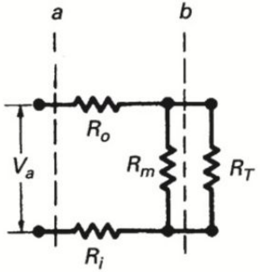

$R_o = R_i = R = 6.37\Omega$
$R_m = 10\Omega$

$$R_T = R_o + R_i + \frac{R_T R_m}{R_T + R_m}$$

$$R_T = 2R + \frac{R_T R_m}{R_T + R_m}$$

$$R_T = R + \left[R^2 + 2RR_m\right]^{1/2}$$

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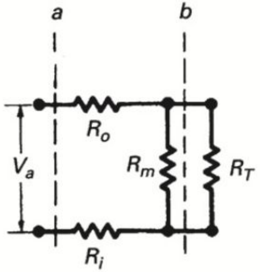

$R_T = 6.37 + (6.37^2 + 2(6.37)(10))^{0.5}$

$R_T = 19.3\Omega$