

Actuation

How a robot moves!



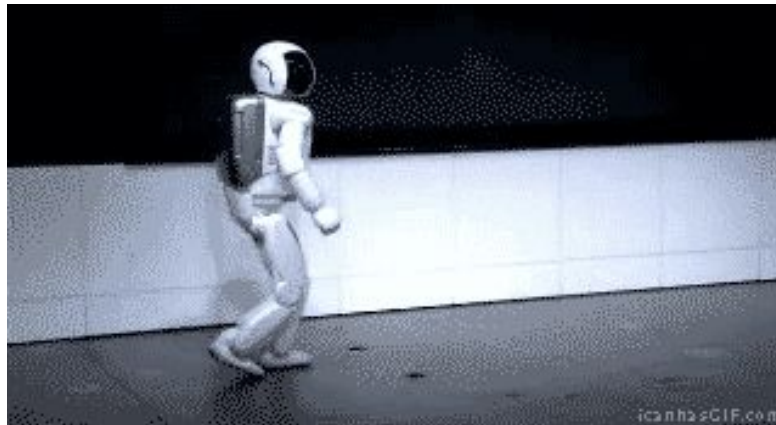
How robots move

The science of how robots move is called 'Actuation'

One important quality that we want robots to have is they must be able to move!

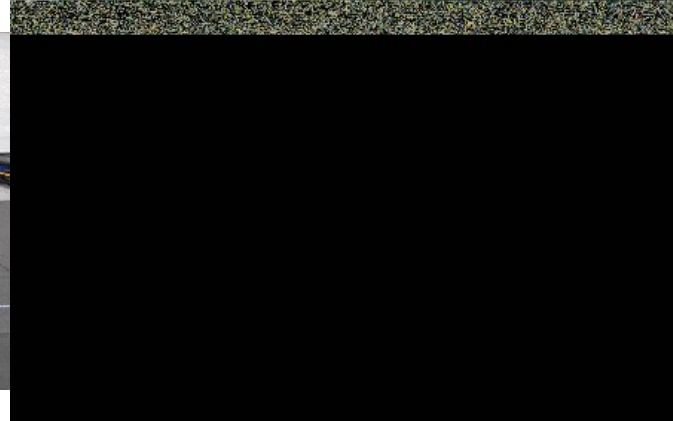
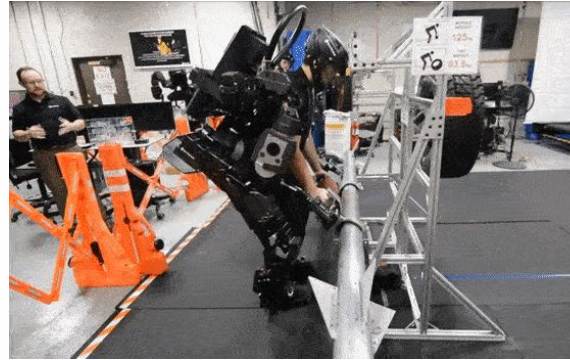
We humans take this for granted, but it is one of the most difficult parts of robotics.

Our bodies can move easily, but it is not as easy for robots.



Why do we need robots to move?

- To do work for us
- To help the elderly
- To be useful at many different locations



How do humans move?

Just like other areas of robotics (such as Artificial Intelligence), we look to the human body for inspiration.

What do humans need to move?



What do humans need to move?

1. Energy

We cannot move without some kind of energy source.

Where do we get our energy?



What do humans need to move?

1. Energy

Human get our energy from food!

Food contains **calories**, which our bodies use as energy.

A **calorie** is a unit of energy that comes from food.



Calories

You can look at the back of food containers to see how many **calories** a food has.

The more **calories**, the more energy it will give you!

Your body uses **calories** when it moves. The more you move, the more calories it will need.

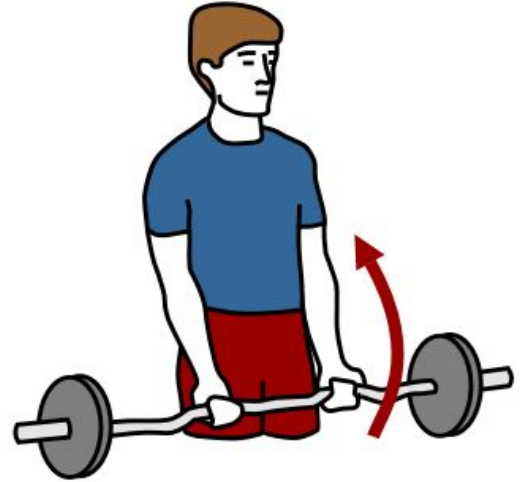


What do humans need to move?

2. Force Generator

We have our energy from food, now we need something to turn that energy into a force.

What is a force?

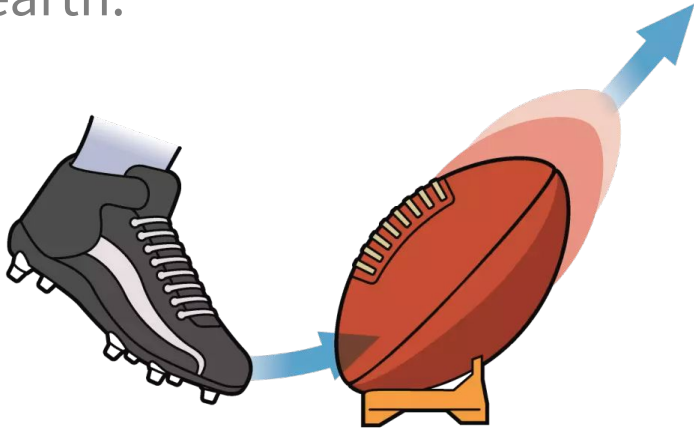


Force

In science, a **force** is anything that makes something move.

For instance, the foot kicking the ball is a **force**.

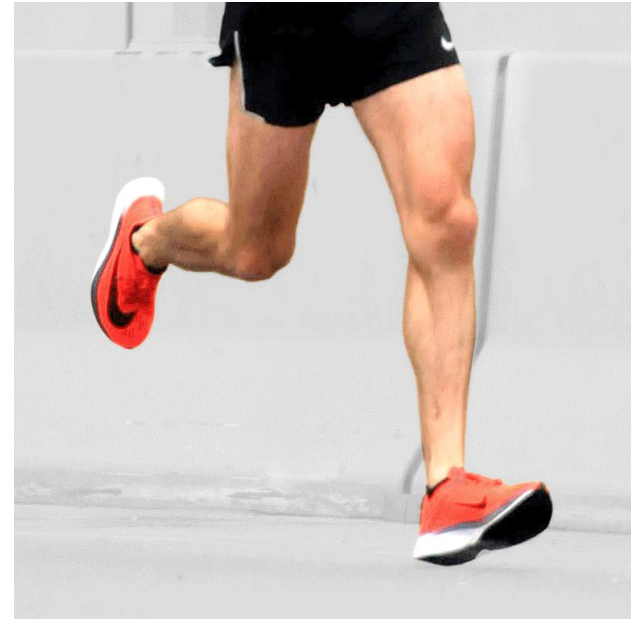
Another example is gravitational force, which makes things fall towards the earth.



What do humans need to move?

2. Force Generator

Now that we know what a force is, what do humans use to generate force?



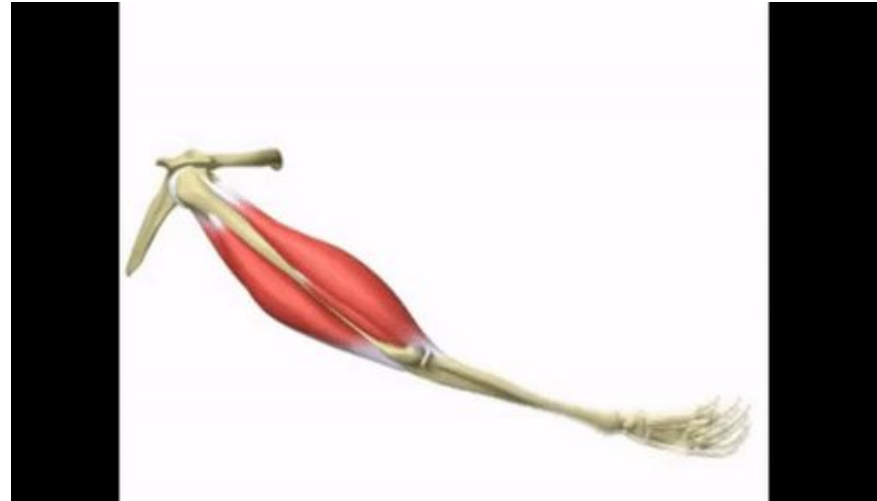
What do humans need to move?

2. Force Generator

Muscles!

Our muscles move our body.

They generate a **force** on our bodies.



What do humans need to move?

3. Movement Control

We need something to control how our muscles move.

How do we control our muscles?



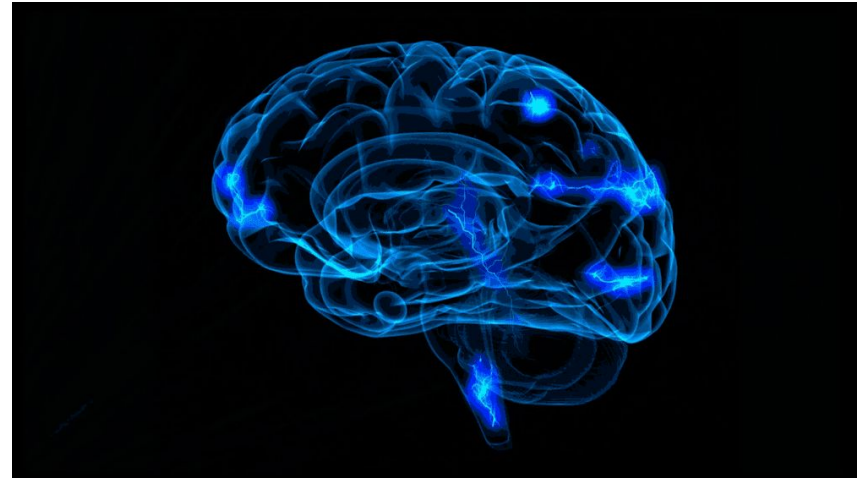
What do humans need to move?

3. Movement Control

We use our brain!

Our brain sends electrical signals to our muscles.

It is what controls our movement.



What do humans need to move?

1. Energy
2. Force Generator
3. Movement Control

Just like humans, robots need the above three things in order to be able to move.

Let's think about how we can add these things to a robot!

What do robots need to move?

1. Energy

Let's start off with energy.

Humans get our energy from food.

Where do robots get theirs?

Before this, we need to talk about the different types of energy.



What do robots need to move?

1. Energy

There are several different types of energy:

		Kinetic	Potential
	<i>Defining Principle:</i>	<i>Motion (of objects, atoms, waves, etc)</i>	<i>State / Stored</i>
Mechanical	<i>Large Objects</i>	Motion	Gravitational Elastic Magnetic
Internal?	<i>Atomic Sized</i>	Thermal Electrical Radiant -? Sound - ?	Nuclear Chemical Electrical

Types of Energy

There are two main families of energy: Kinetic and Potential.

Kinetic energy is energy that moves things.

Potential energy is energy that is stored in position (does not move).

Kinetic	Potential
<i>Motion (of objects, atoms, waves, etc)</i>	<i>State / Stored</i>

Types of Energy

Also, in each family of energy, there is energy that acts on large objects (called **mechanical energy**), and energy that acts on atomic, or very tiny objects (called **internal energy**)

		Kinetic	Potential
	<i>Defining Principle:</i>	<i>Motion (of objects, atoms, waves, etc)</i>	<i>State / Stored</i>
Mechanical	<i>Large Objects</i>	Motion	Gravitational Elastic Magnetic
Internal?	<i>Atomic Sized</i>	Thermal Electrical Radiant -? Sound - ?	Nuclear Chemical Electrical

Kinetic Energy

There are a few different types of Kinetic Energy:

- Motion: Whenever something with weight moves, it contains kinetic energy.



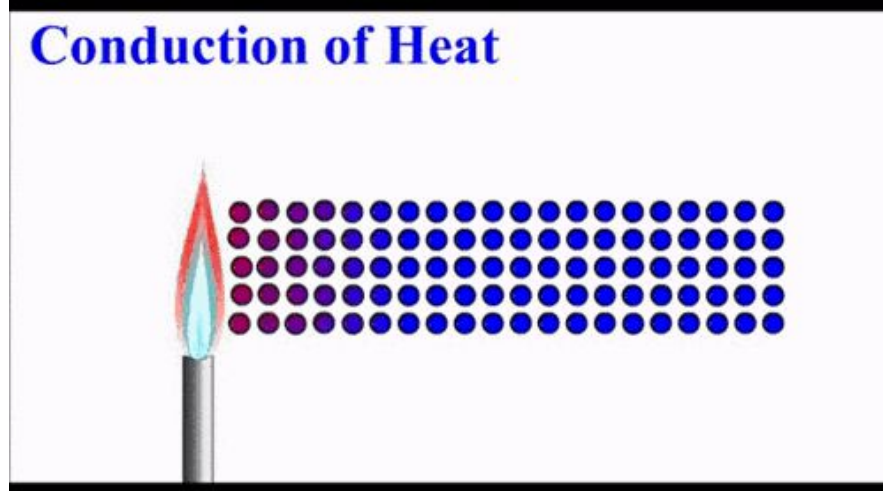
The wave contains kinetic energy because it's made up of moving water.

The frisbee also contains kinetic energy because it's a moving piece of plastic.

Kinetic Energy

There are a few different types of Kinetic Energy:

- Thermal: Heat energy is caused by atoms rubbing together, so it is movement-based again.



Kinetic Energy

There are a few different types of Kinetic Energy:

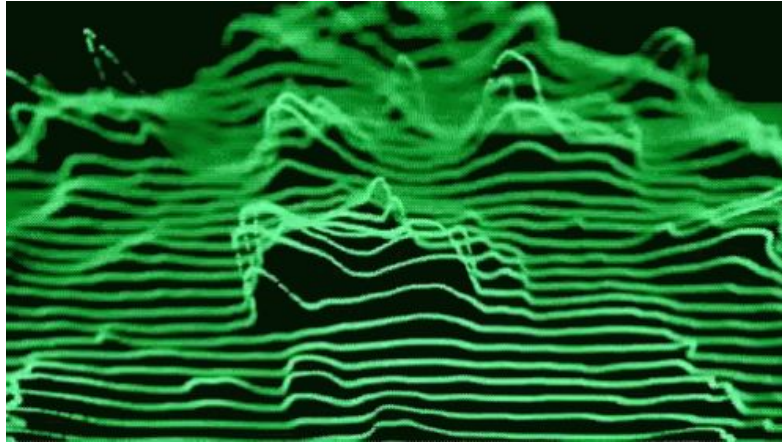
- Electrical: Electricity can move (like along a wire), so it also contains kinetic energy.



Kinetic Energy

There are a few different types of Kinetic Energy:

- Sound: Sound is caused by materials vibrating, so again, it's caused by movement.



Potential Energy

Potential energy is energy that is stored in a single position (does not move).

Like Kinetic energy, there are several different types of potential energy:

- Gravitational Energy
- Elastic Energy
- Magnetic Energy
- Nuclear Energy
- Chemical Energy

Potential Energy

- Gravitational Energy

This is the energy that comes from gravity.

It's what gives things weight and pulls them towards the Earth.

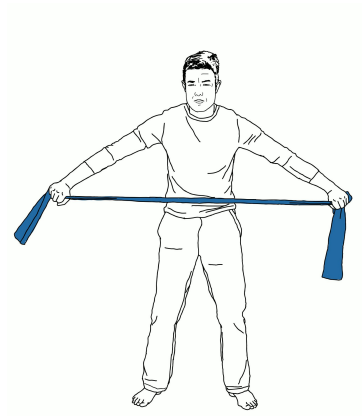
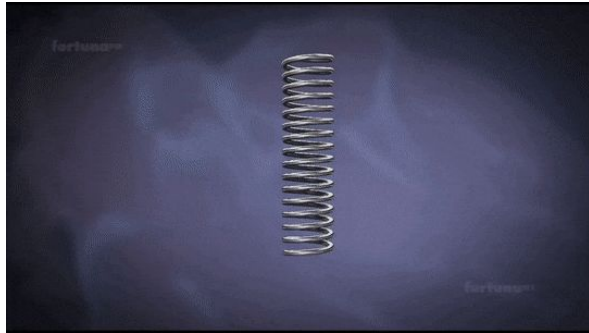


Potential Energy

- Elastic Energy

This is the energy that makes stretchy materials return to their original position.

For instance, elastic energy is what makes a spring or an elastic band act like they do.



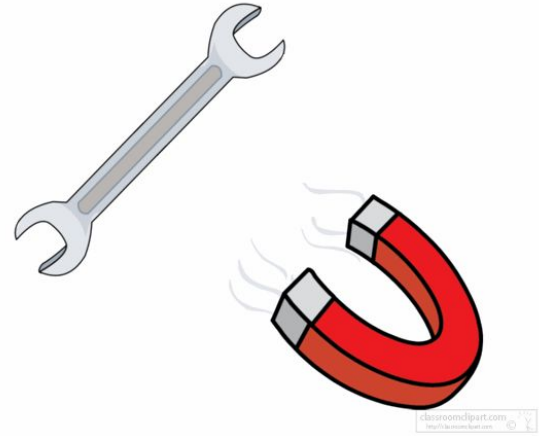
Potential Energy

- Magnetic Energy

This is the type of energy used by magnets.

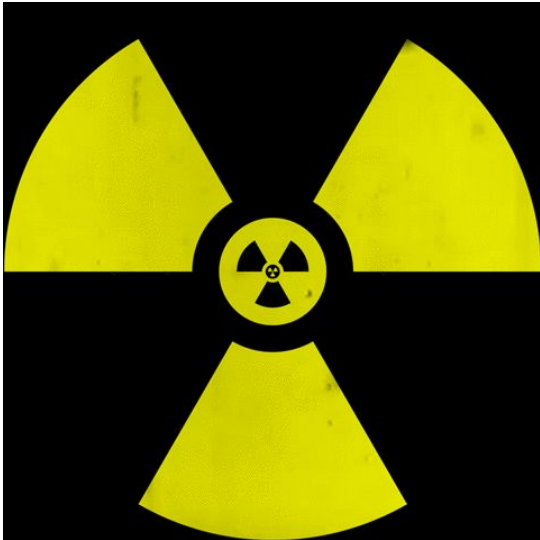
It is caused by magnetic fields.

Magnetic fields can affect certain materials (such as metals) and cause them to be repelled (pushed away) or attracted (pulled).



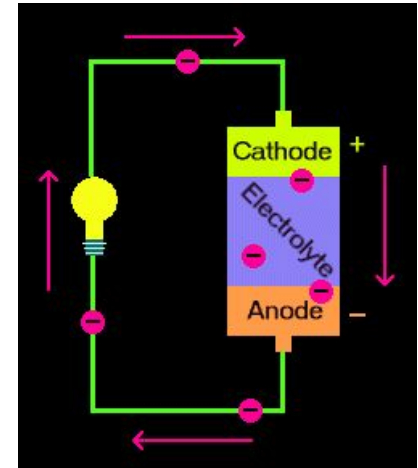
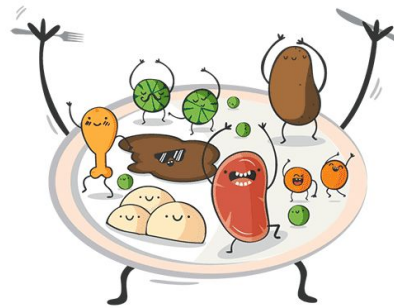
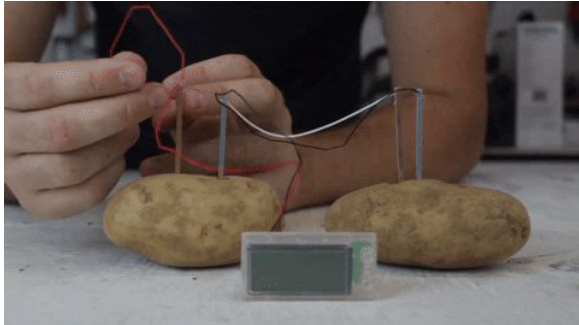
Potential Energy

- Nuclear Energy is the energy contained in radioactive materials, such as Uranium, Plutonium and Radium.



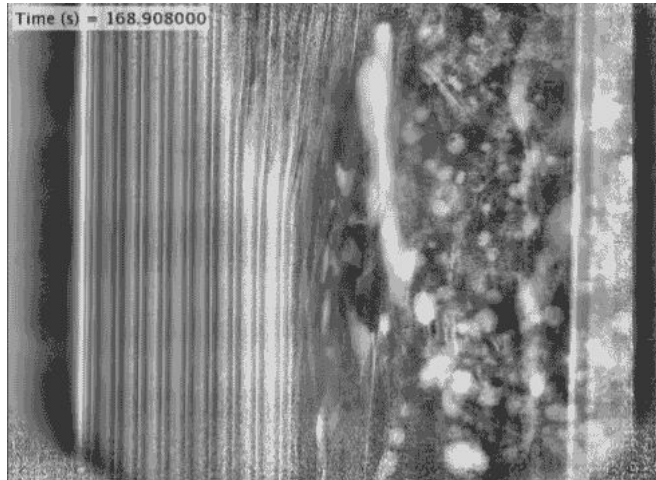
Potential Energy

- Chemical Energy is the energy that is stored in chemicals.
- It's the type of energy in batteries and in food.



Potential Energy

- This is an x-ray of what is inside a battery.
- As you can see, it is full of liquid, which contains chemicals.
- https://www.youtube.com/watch?v=ReS_SK5MnFY



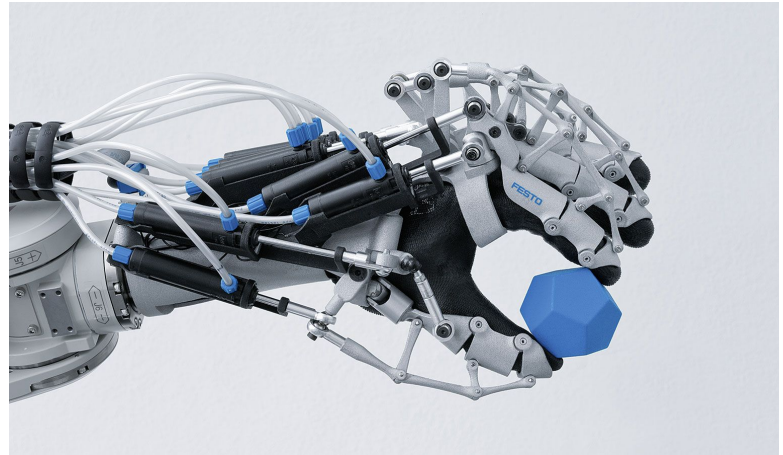
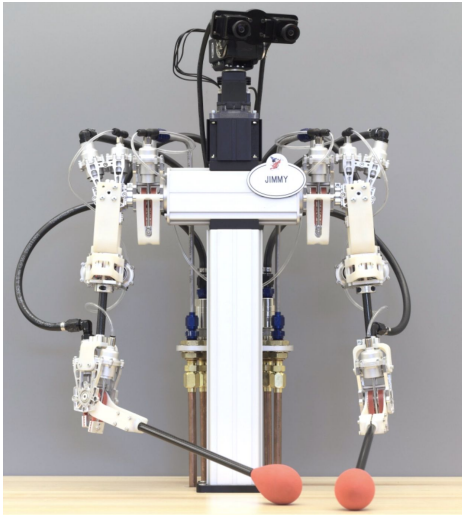
Actuators



Actuators

An actuator is the part of a robot that is responsible for moving it.

It needs a source of energy to work.



Types of Actuators

There are three main types of actuators:

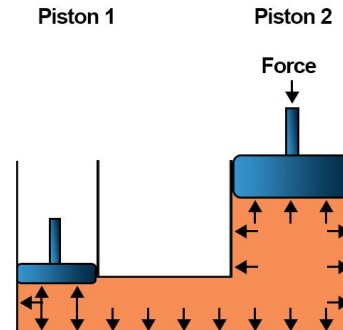
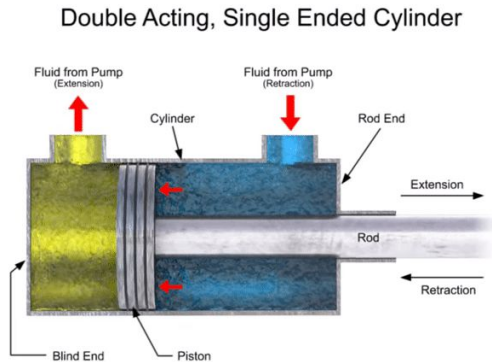
- Hydraulic Actuator
- Pneumatic Actuator
- Electric Actuator

Hydraulic Actuator

A hydraulic actuator uses liquids to create mechanical energy.

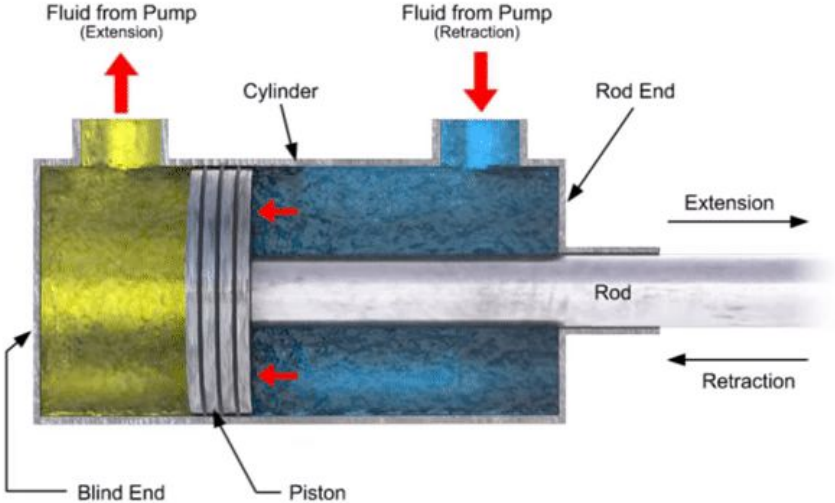
Liquids are nearly impossible to compress. Therefore, when you put a force on a liquid, it will push back very hard

They can generate enormous forces, but are not good for acceleration



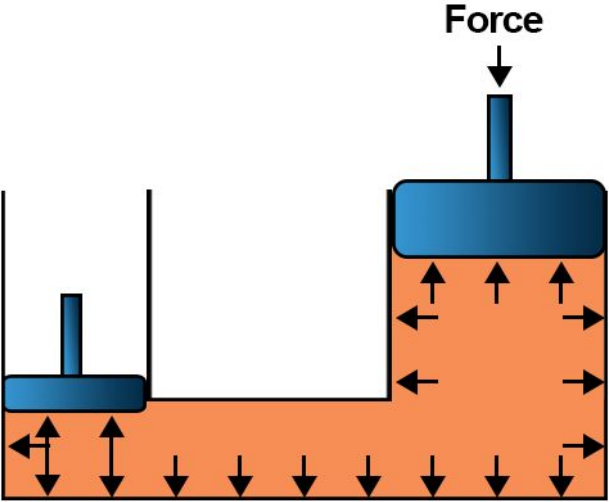
Hydraulic Actuator

Double Acting, Single Ended Cylinder



Piston 1

Piston 2



Hydraulic Actuator

These are used in 'low-rider' cars to make them bounce.



Hydraulic Actuator

Hydraulics are also used in planes to control the plane.

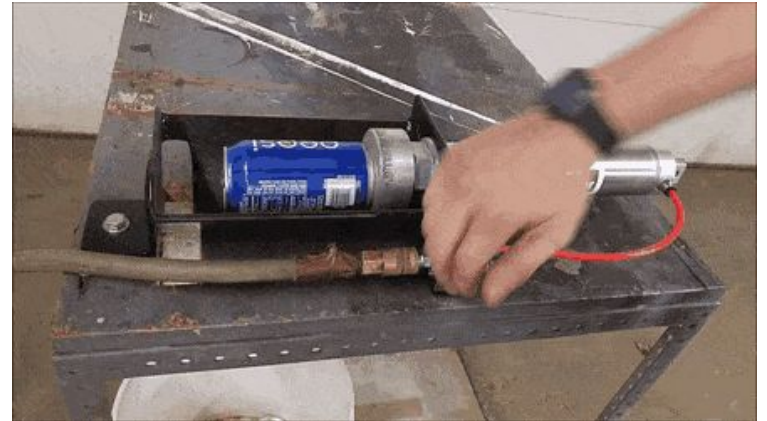
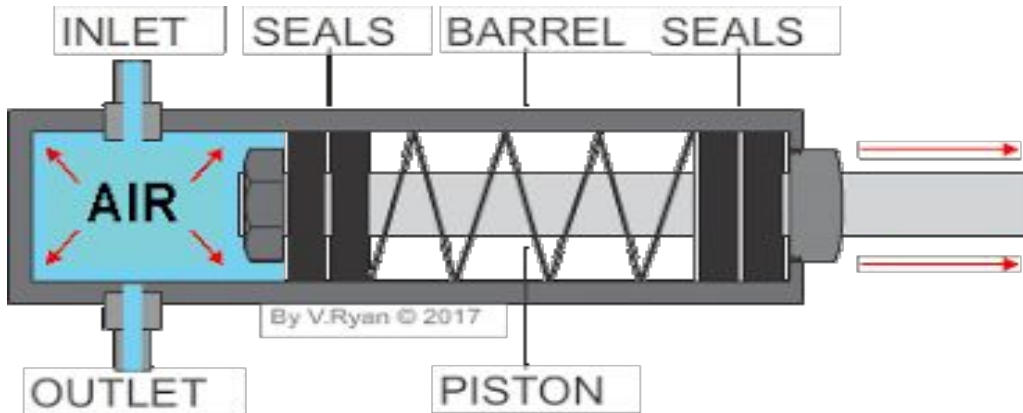
The plane hydraulics move the 'flaps' (which steer the plane), the landing gear, and the brakes.



Pneumatic Actuator

Pneumatic actuators are similar to Hydraulic actuators, but they use air instead of liquids.

Compressed air is pushed into a piston and it creates mechanical energy.



Pneumatic Actuator

These are used in jackhammers.

Jackhammers needs a special air compressor or pump work properly.

Notice the air hose connected to the jackhammers.

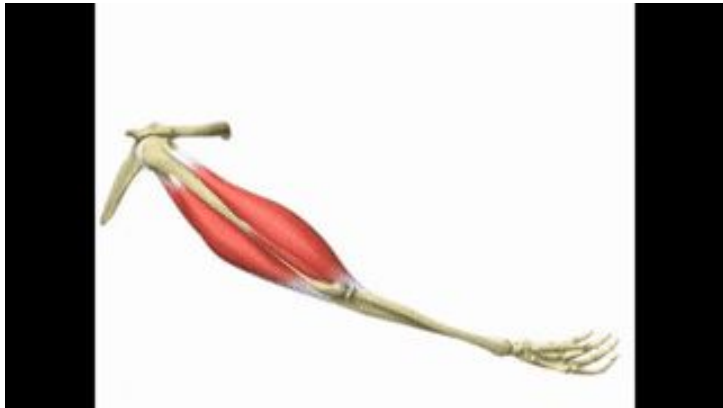


Pneumatic Actuator - Robot Muscles

Pneumatic Actuators are used in robot muscles.

Our muscles expand and contract due to electric signal from the brain.

Robot muscles work in the same way, except they become filled with air



Pneumatic Actuator - Robot Muscles



Electric Actuator

An electric actuator is a device used to convert electricity into mechanical energy.

The most well-known type of electric actuator is the electric motor.

Electric Motors are used in hoverboards, remote-control cars, and electric cars, among many other things.

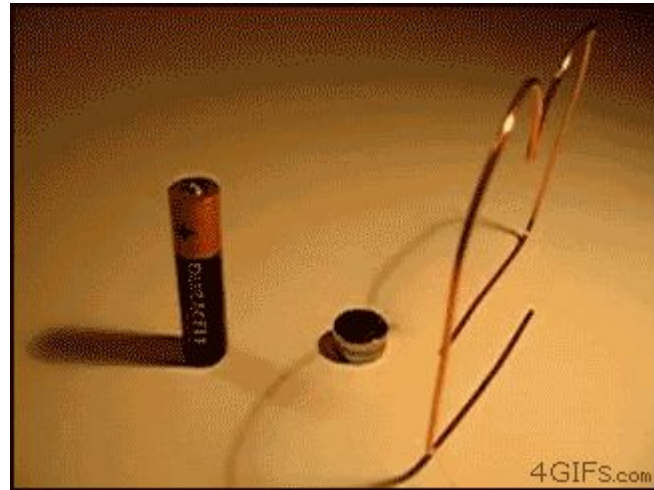
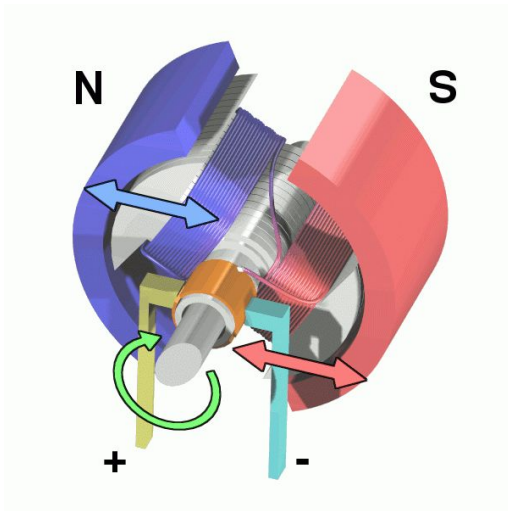


Electric Motors

An electric motor changes electrical energy into mechanical movement.

Electric motors work using magnets and electricity.

Let's explain in detail how electric motors work! But first, let's talk about magnets!



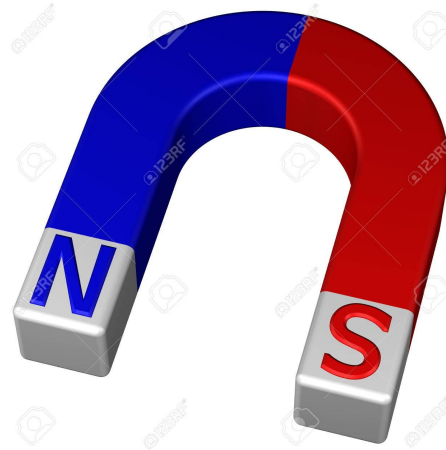
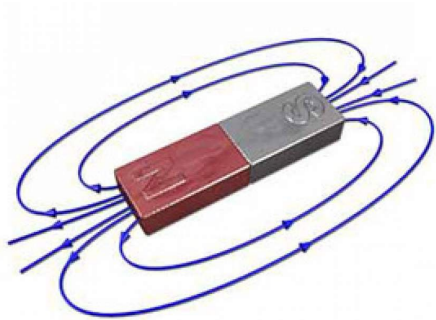
Magnets

There are two types of magnets:

- Permanent Magnets
- Electromagnets

Permanent Magnets are made from a magnetic material, and always act the same way.

They are your classic magnets.



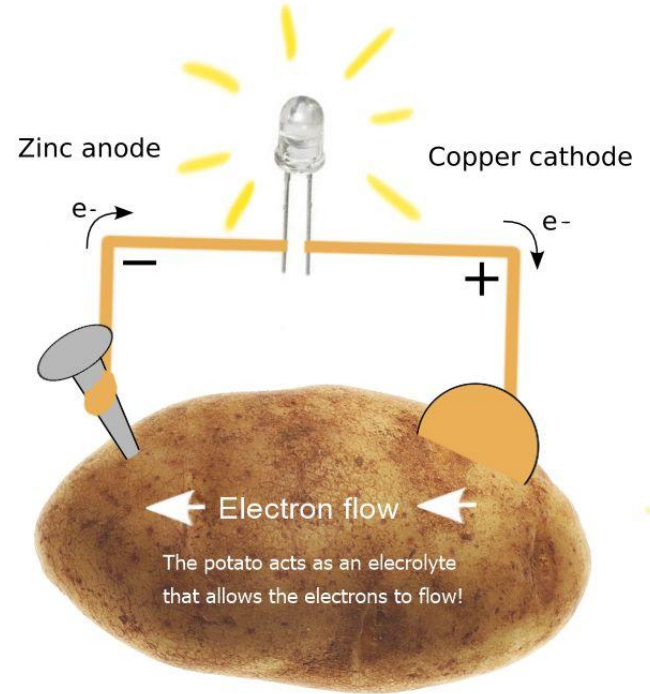
Magnets

Electromagnets are magnets that run on electricity.

When you create current electricity, it also creates a magnetic field.

Remember when we made our potato batteries.

We created an ELECTRIC CIRCUIT, which used CURRENT electricity.



Quick Question

What are the two different types of electricity?

Current and Static Electricity

What's the difference between them?

Current Electricity moves between two places.

Static Electricity stays in one place.

Quick Question

What are the two different types of electricity?

What's the difference between them?

Electric Currents and Magnets

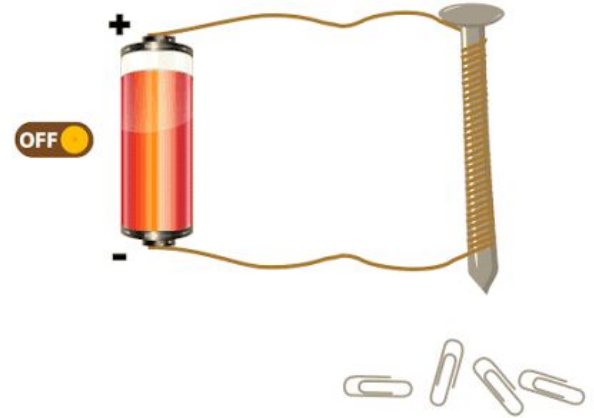
Every electric circuit uses current electricity.

Current Electricity produces a magnetic field.

Every electric circuit is also a magnet.

The more electricity passing through the circuit, the stronger the magnet.

These kinds of magnets are called
ELECTROMAGNETS.

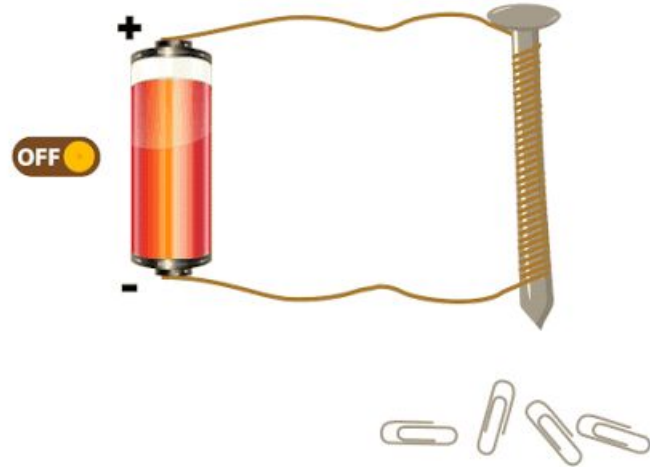


Electromagnet

This is a simple electromagnet.

We have a battery and a circuit made up of a wire. The wire is wrapped around a zinc nail. Remember, zinc is an conductor.

What is a conductor?



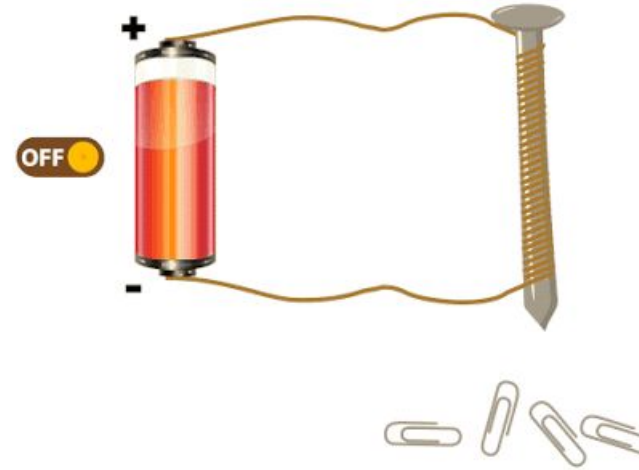
Electromagnet

This is a simple electromagnet.

We have a battery and a circuit made up of a wire. The wire is wrapped around a zinc nail. Remember, zinc is an conductor.

What is a conductor?

A conductor is a material that allows electricity to pass through it easily.

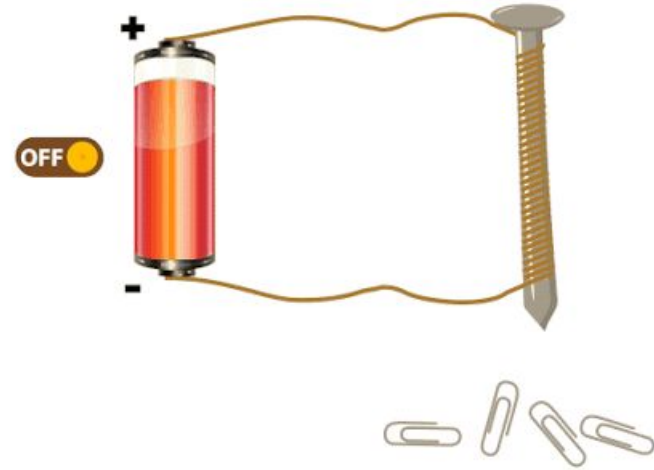


Electromagnet

Notice when we switch the circuit on, the nail becomes a magnet.

The paperclips then become attracted to the nail.

This is because of the electric current passing through the nail.

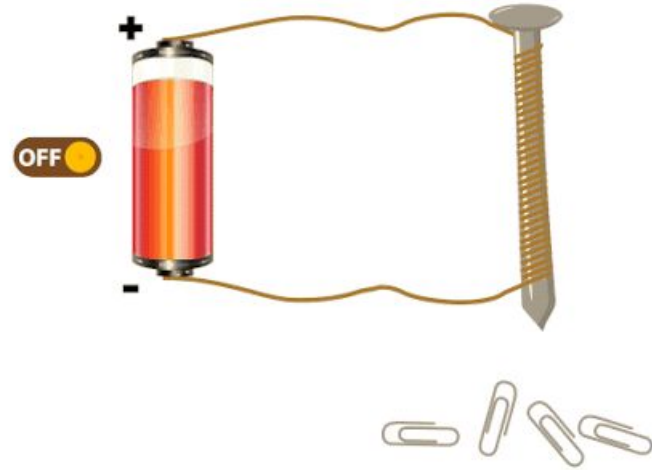


Electromagnet

Try this at home!

You can do this with any battery.

You just need a battery, nail, some copper wire and some paperclips.



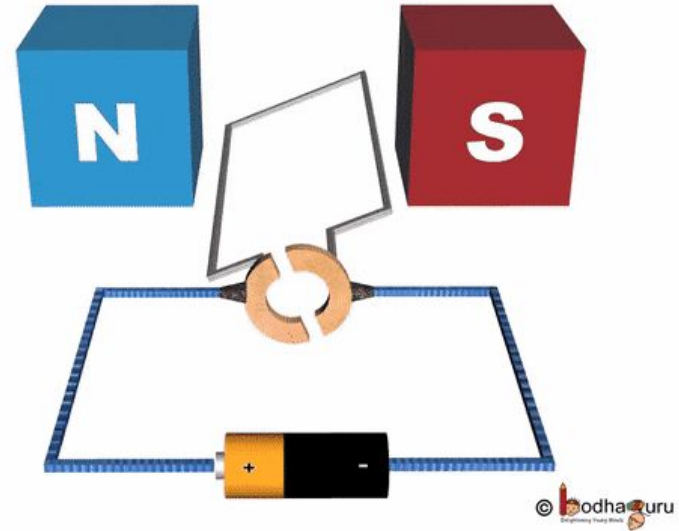
Back to Electric Motors

These use electromagnets and permanent magnets to work.

We need two permanent magnets, a copper wire and a source of electricity.

We bend the wire into a rectangular shape, then run an electric current through the wire.

This makes it into an electromagnet.



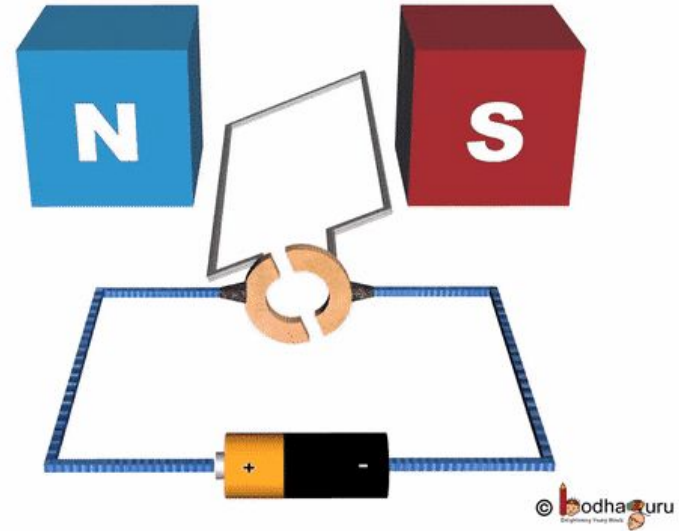
Back to Electric Motors

Now we put the bent wire (which is now an electromagnet) between the two permanent magnets.

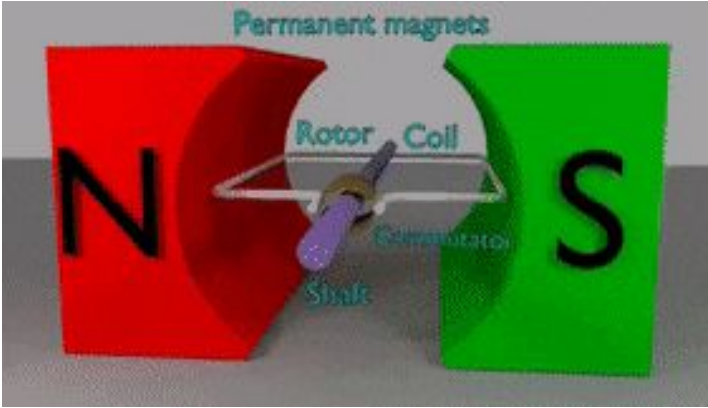
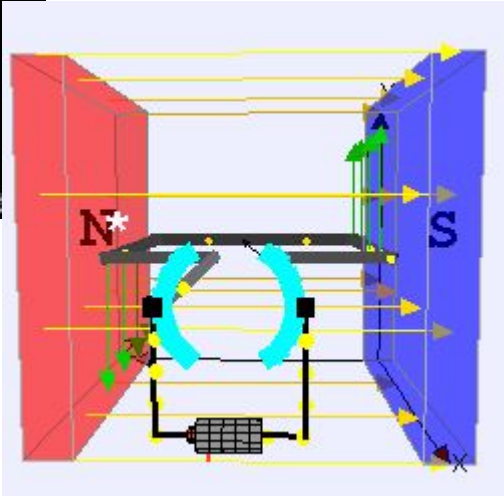
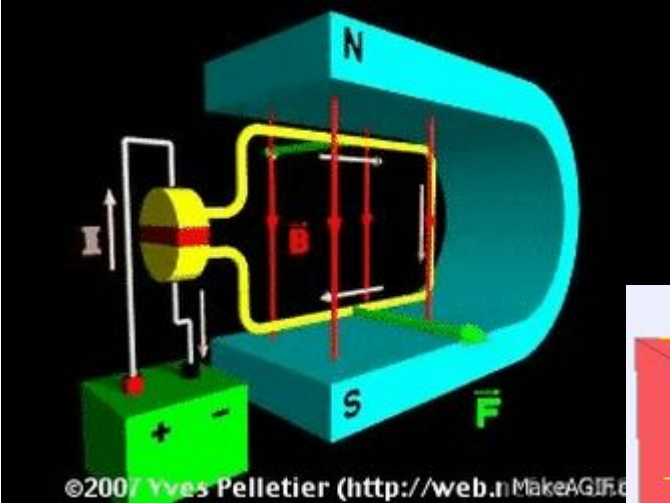
The magnets will both repel and attract the wire, causing it to spin.

We're turning electricity into motion.

This is how an electric motor works.



Electric Motors



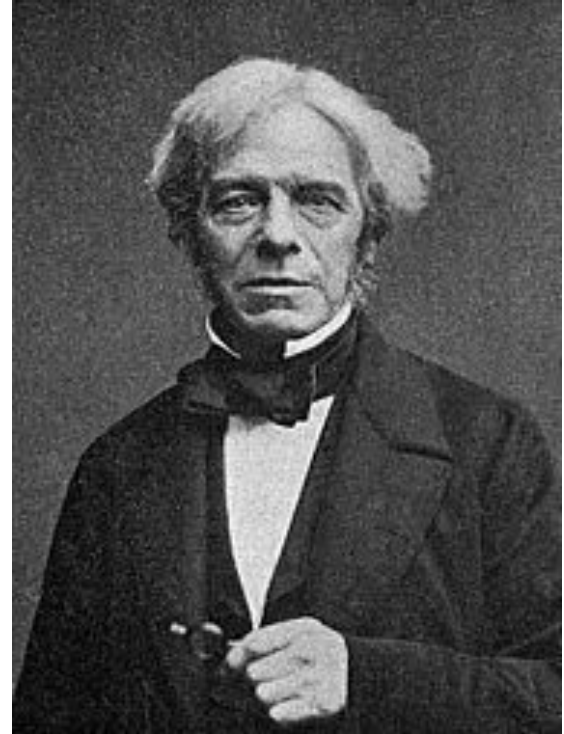
The First Motor

Michael Faraday invented the electric motor in 1821.

He made an electromagnet by wrapping a wire around a nail and connecting it to a battery, making a circuit.

He then used it to spin a wire around a pool of mercury (which is a better conductor).

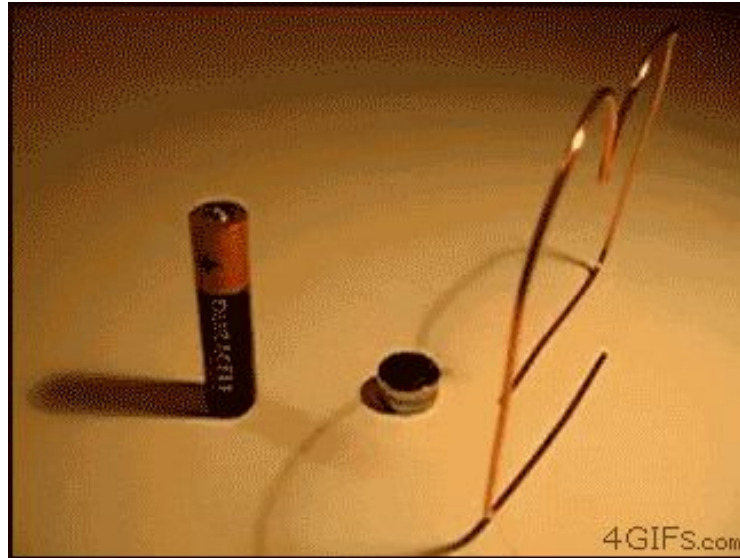
<https://nationalmaglab.org/education/magnet-academy/watch-play/interactive/faraday-motor>



Simple Electric Motor

Here is a real-life simple electric motor.

Using a battery, magnet and bent copper wire, you can create an electric motor.



Electromagnet

Try this at home!

You can do this with any battery.

You just need a battery, nail, some copper wire and some paperclips.

