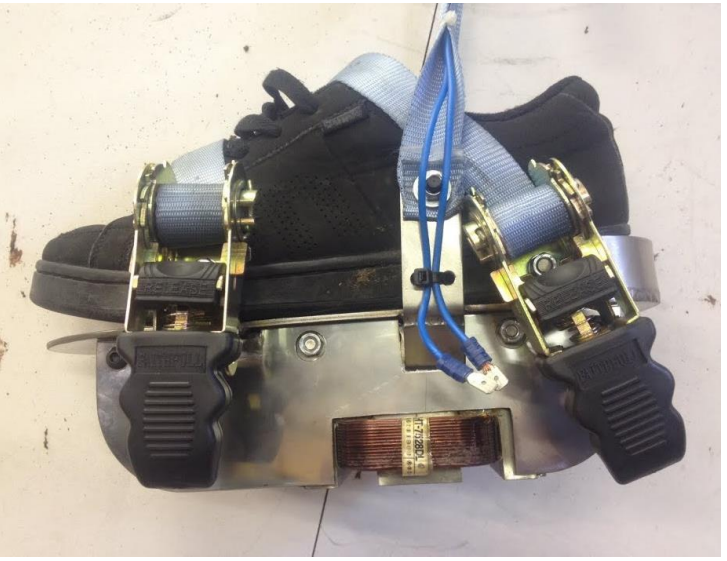
Magnetic Boots for working on Space X Starship

by Glenn Johnson with Josh Ange



Magnetic shoes don’t work on aluminum ships.

NASA has not needed magnetic boots for doing space walks on the outside of the Space Station because the Space Station and the majority of the space craft are made out of aluminum which is not magnetic. Now there may be a method of making magnetics for aluminum using eddie current effect but that would be pretty complicated and very power hungry—probably not worth the effort. NASA uses aluminum because it is lighter weight, corrosion resistant, easy to machine, and is fairly strong but it is not as strong as stainless steel and there are times that steel and titanium are used for specific applications for space.

Could NASA place steel ‘sidewalks’ on the outside of the space station to allow crew to use magnetic boots to walk to where they need to work? Maybe but may not be worth the work at this time in the Station’s life.

Space X Starship

- Space X is designing its Starship spacecraft that is much bigger than some of the other spacecraft and has chosen to use stainless steel because of the strength they need as well as the temperature ranges it can handle. Its also much cheaper than carbon fiber. There are several different types of stainless steel and they are used for a variety of different applications. Right now Space X is building the Starship out of 301 stainless steel and maybe shifting to 304L
  - Type 301 Stainless Steel is **non-magnetic in the annealed condition**, but becomes magnetic through cold work.
  - Alloy 304/304L is **non-magnetic in the annealed condition**, but can become slightly magnetic as a result of cold working or welding.
- NASA has awarded the Lunar Lander contract to Space X which is based off the Starship.
- Notice that the outside of the space craft is pretty smooth and there aren't any handrails—there probably will be some handrails on later versions. If astronauts need to do a space walk on their way to the moon or beyond, they will need a method for maneuvering around and working without floating away. They could still do it the tried and true way of floating around but how about something new—walking. Using feet for mobility and hands to hold things.
- It is also possible that there could be "magnetic sidewalks" on the outside of the ship where steel plates could be placed so that astronauts could walk in certain areas with their boots even though the rest of the ship might be made of aluminum.
- The Starship versions that are for Earth and Mars will need to have some kind of heat shielding on one side of the ship but the ones for landing on the moon may not have any external heat shielding.

Problem: If space craft are made out of ferromagnetic materials, could we come up with a magnetic boot that would allow astronauts to translate around and work on the outside of the ship instead of floating? This would allow astronauts to maneuver with their feet and carry things with their hands similar to what they do on Earth.

Objective:

Design and build a prototype of a magnetic boot that would allow astronauts to walk and work on the outside of a steel hulled ship.

Requirements--

Magnetic boots would only be good if

- Must be able to turn them on and off in some fashion to allow for walking
  - The switching mechanism is really what is going to be key to this. Its easy to get a strong magnet or electromagnet to stick to a piece of metal. The real question is can it be manipulated so some one could walk around easily.
- Turn on extra strength when working at a work site
- Turn them off when getting back inside or when the job is over
- Realistically, in zero-g the magnetic boots don't really need to hold your weight except when you are at a work site and pulling or pushing on something.
- Should hold at least 20 lbs. per shoe on common carbon steel.
- Where do the batteries go if they are needed?
- Are the switches in the boots or do they need to be in the hands?
  - Can the switching mechanism be done with toes or with ankle motion? Maybe motion of the arms so that you are still able to 'carry' things in your hands and arms?
  - If you adapt a specific type of walk, can your motions activate and deactivate—even if it looks funny?

Pointers—

- It seems like it would be valuable to have at least 2 magnets per shoe both for safety (redundancy) and also for mobility—one in the toe and one in the heal.
- It would be valuable if they aren't too big and bulky but operational is more important than size at the moment.
- Rather than walking, would it be possible to scoot, glide or shuffle across the surface?
- The shoes may be shaped different from normal shoes.
- Could be something that fits onto a regular shoe.
- There are at least 3 options—
  - solid magnetics—mechanical method of switching magnets to be "on/off"
  - Electromagnets—able to turn on and off by switches, uses batteries.
  - Hybrid—solid magnetics and electromagnets combination—solid magnets for walking and electro magnets for clamping on hard at the worksite—just thoughts for you to consider.

Science Fiction—sometimes but not always helpful

I don't have the purple magic rocks and those don't look like the magnetic fields I would expect from electromagnets.

Used in Star Trek Undiscovered Country

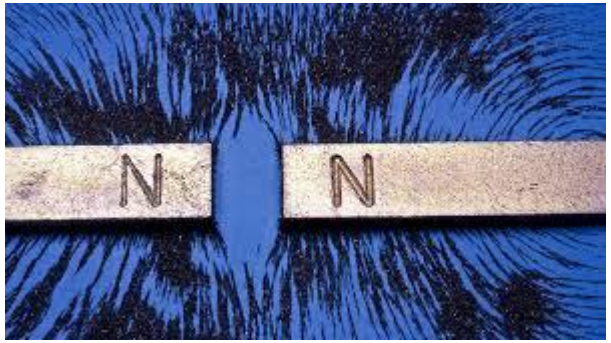
Wyle E. Kyotee may not be a successful hunter of the Road Runner but he is a decent engineer who goes through lots of ideas and has an amazing budget for cool gadgets.

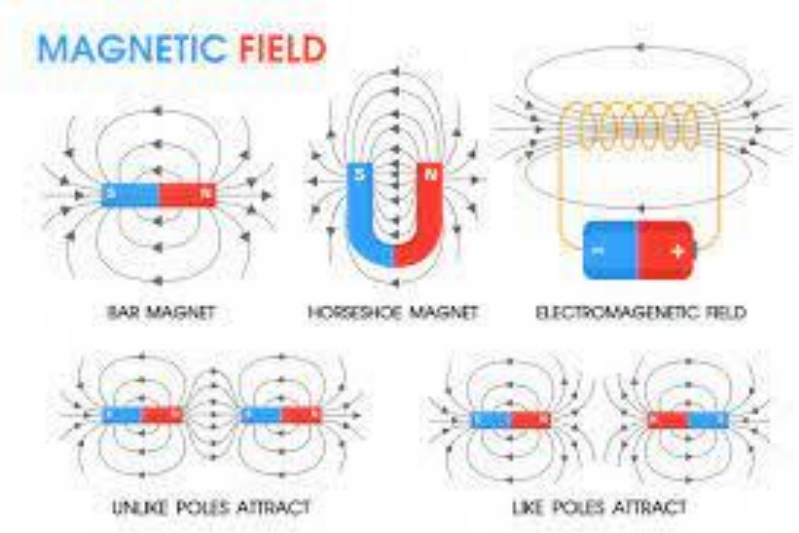
Magnetic prison boots for the movie Faceoff in 1997

Here are a few things for you to think about:

Magnetic field lines are described with lines that start on the North pole and end on the south pole of the magnet. The stronger the magnetic field the closer the lines are together. Magnetic field lines are pulled into ferro magnetic materials (stuff that sticks to magnets). Controlling magnetic fields are not rudimentary. Take some time to learn how to keep the magnetic field tight where you want it and weaker where you don't.

- Besides iron and steel (steel is an iron alloy that is mostly iron) how many other materials are affected by magnets?
- What are some of the rare earth magnets and what are they used for?
- Under what conditions are some rare earth magnets used but others are used for different purposes?
- How many alloys are affected by magnets?
- How expensive are these other materials?
- Are there reasons that some other more expensive materials might be important to be used?
- How do magnets affect electric currents?
- How do magnets affect electronics?---be specific here, it may be important.



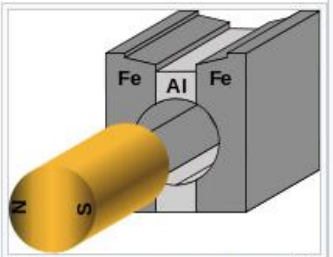


Solid magnetic boots?

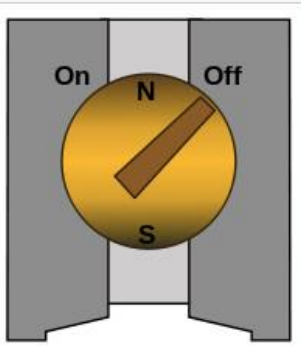
- This lady has a great design plan!!! But we need to be able to turn the shoes on and off as needed. If you can't walk in them, they aren't shoes but just clamps on the bottom of your feet.
- Also, there is much to be learned here about making the magnetic field stronger by using steel to control the field where it can be stronger without using more solid magnets. https://www.instructables.com/Prototyping-Magnetic-Boots/

Magnetic bases using solid magnets

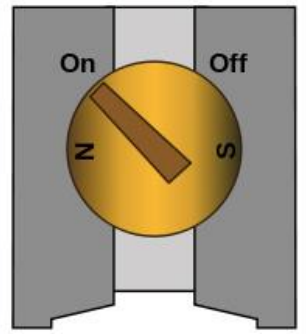
There are many magnet bases that have been used for many, many years that use positioning of the solid magnet to make the magnetic field stronger or weaker. They are used for tools that attach to steel hardware like mills and lathes. They are very strong and dependable. The most modern of these use neodymium magnets and can be much smaller and even stronger. Notice that when the selector is turned from off to the on position, the North and South poles come in contact with the iron pieces instead of the aluminum segment. The magnetic field is then concentrated into the iron and what ever iron/steel the base is in contact with.



Base and magnet assembly. Shown in the inverted position.

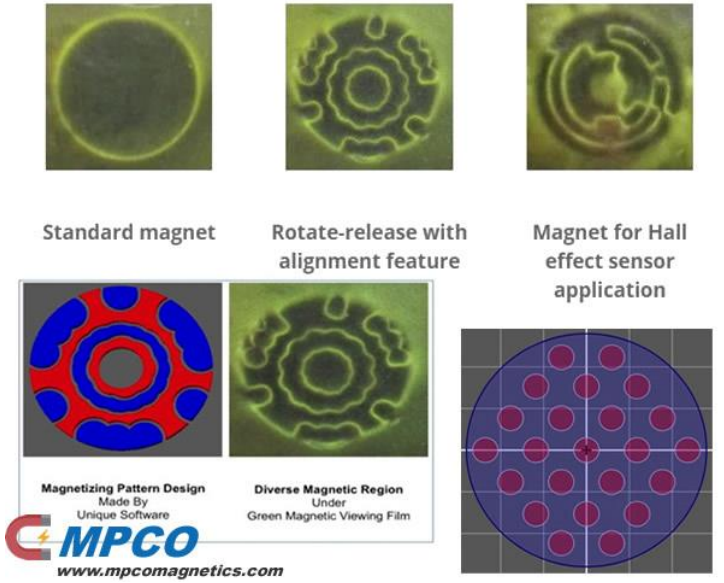


Magnet in *Off* position. Iron blocks act as keepers.

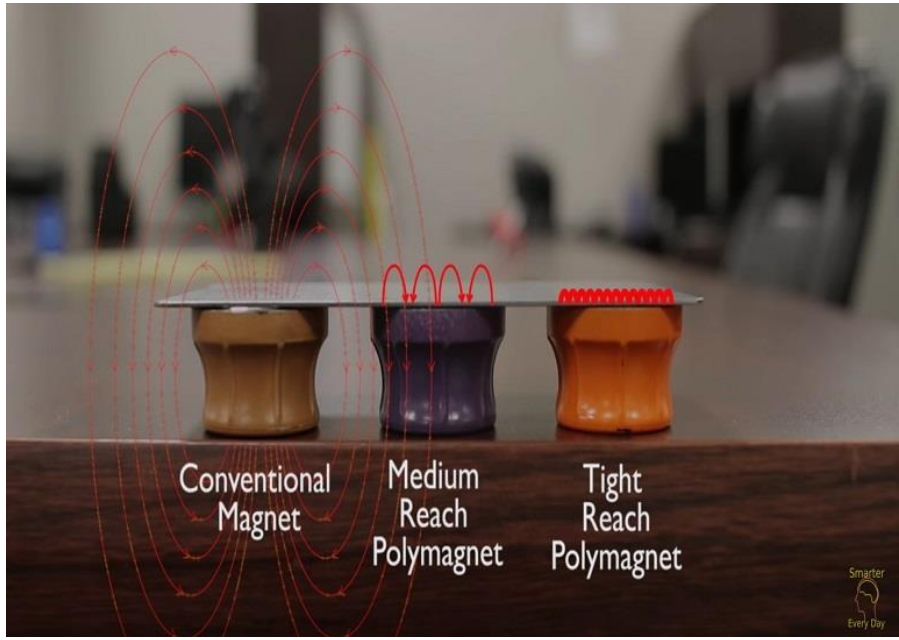


Magnet in *On* position. Iron blocks act as extension of magnet.

Multiple N-S poles



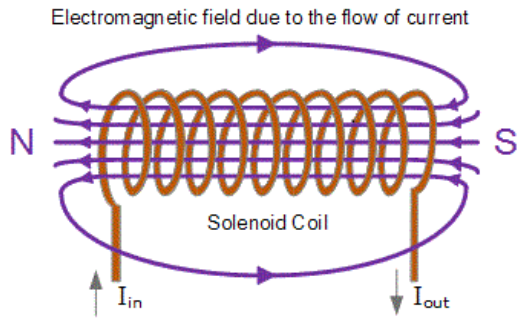
This company and others are doing some very interesting things with magnets and magnetic fields. I am not suggesting that you have to design and purchase magnets from these companies but it may be valuable to study their ideas.

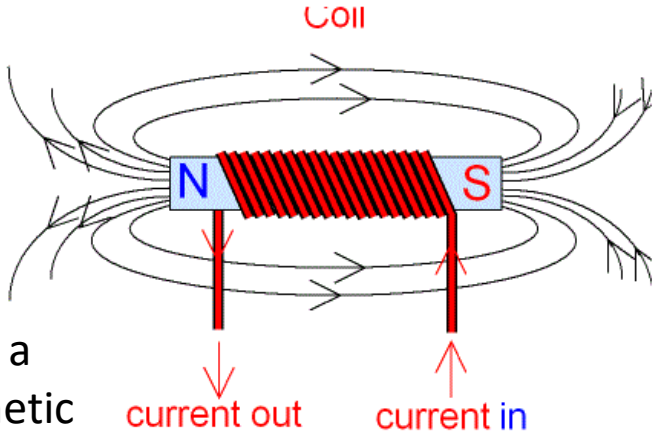


- https://www.youtube.com/watch?v=IANBoybVApQ

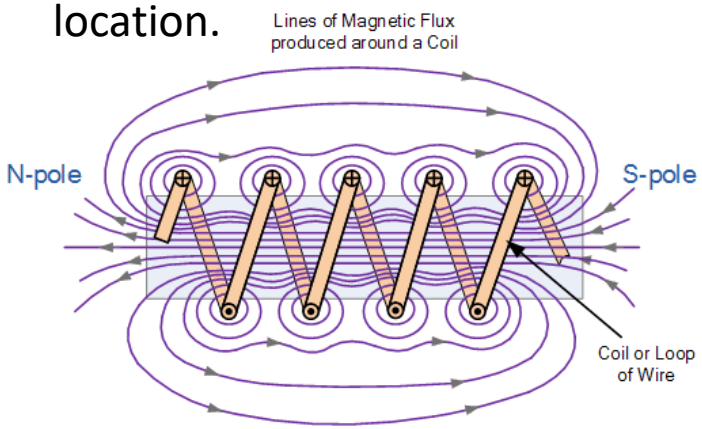
- Polymagnets
- http://www.polymagnet.com/polymagnets/
- https://www.youtube.com/watch?v=9T26k2iFyNM

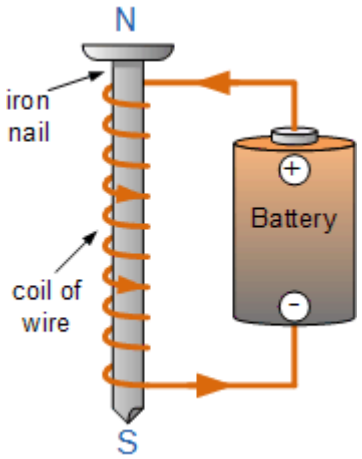
Electromagnets





Passing a current through a coil of wire makes a magnetic field but the field lines are spread out. Placing an iron core into a set of coils with electricity flowing through it makes the magnetic field tighter and stronger in that location.



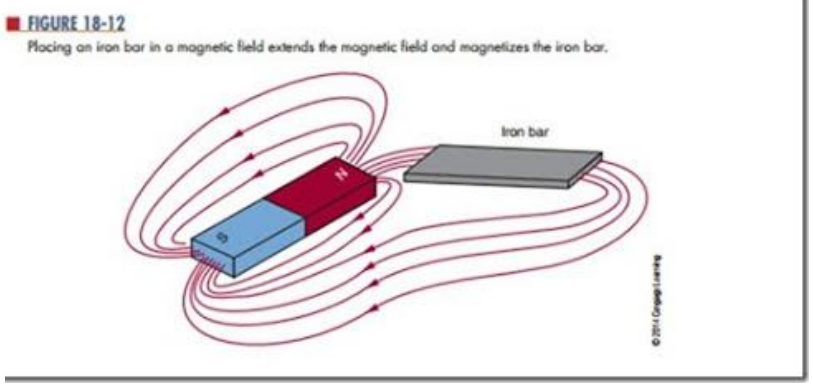


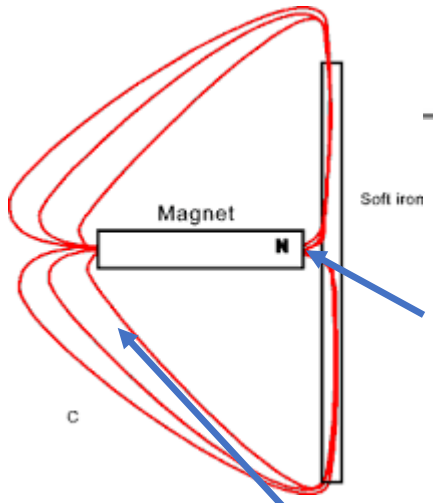
This is a drill with an electromagnet base. It is helpful when drilling into big plates of steel

Making an electromagnetic vice
https://www.youtube.com/watch?v=orsmjiCMotM

Controlling your magnetic field

- Magnetic field lines are used to describe the strength of a magnet in an area. The more field lines, the stronger the magnet in that area.
- Ferro magnetic materials are metals that are attracted to magnets and include iron, cobalt, nickel, europium and gadolinium. The cheapest and most common is iron. Steel is an alloy of iron. When larger percentages of other metals are added to the iron (chromium, vanadium,…) to make stainless steel, the steel is no longer magnetic.
- Ferro magnetic materials draw in and concentrate magnetic field lines and can be used to increase the strength of the magnet in a specific area.



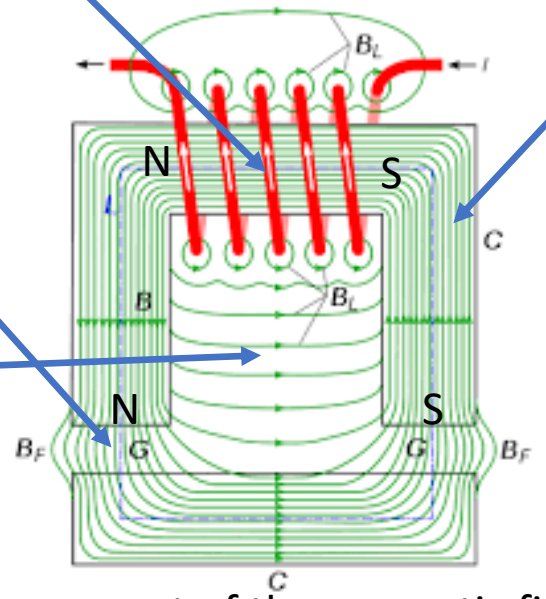


Strong magnetic field

Weak magnetic field

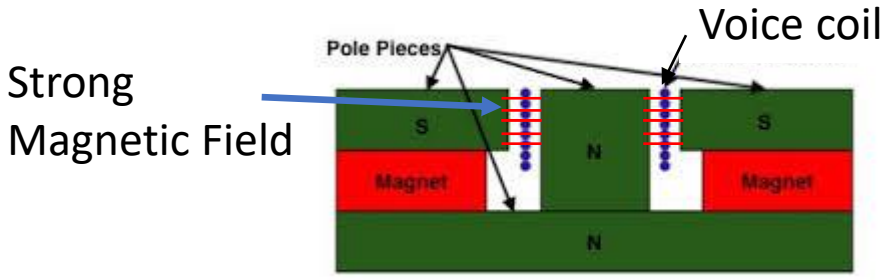
Electromagnet

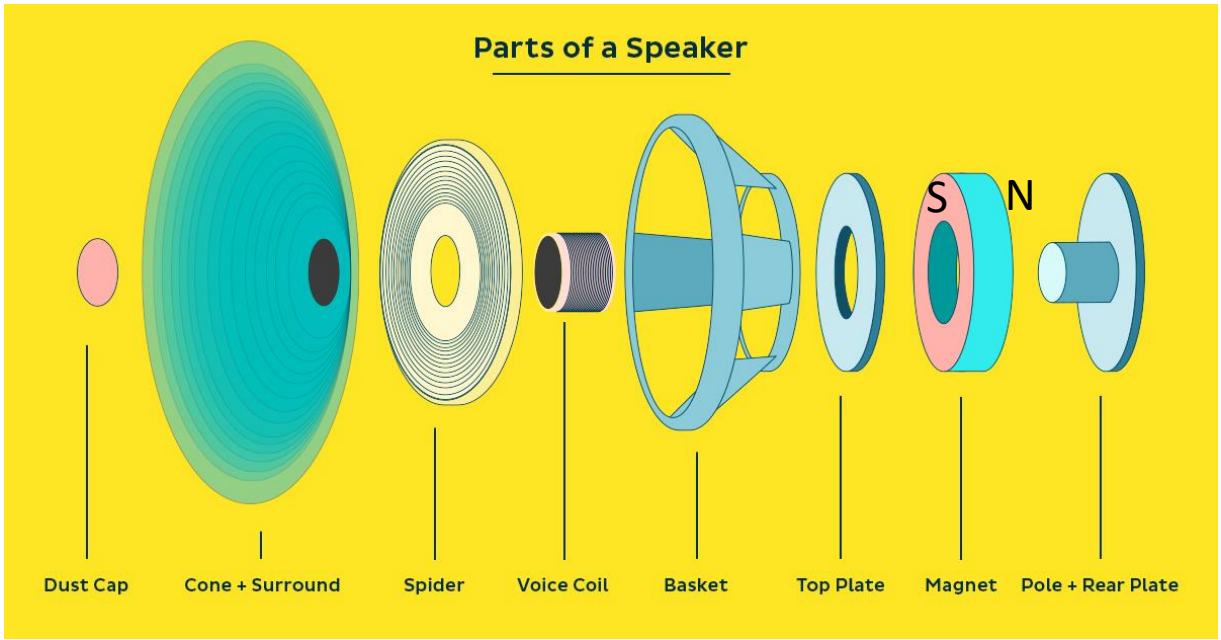
Iron core for electromagnet



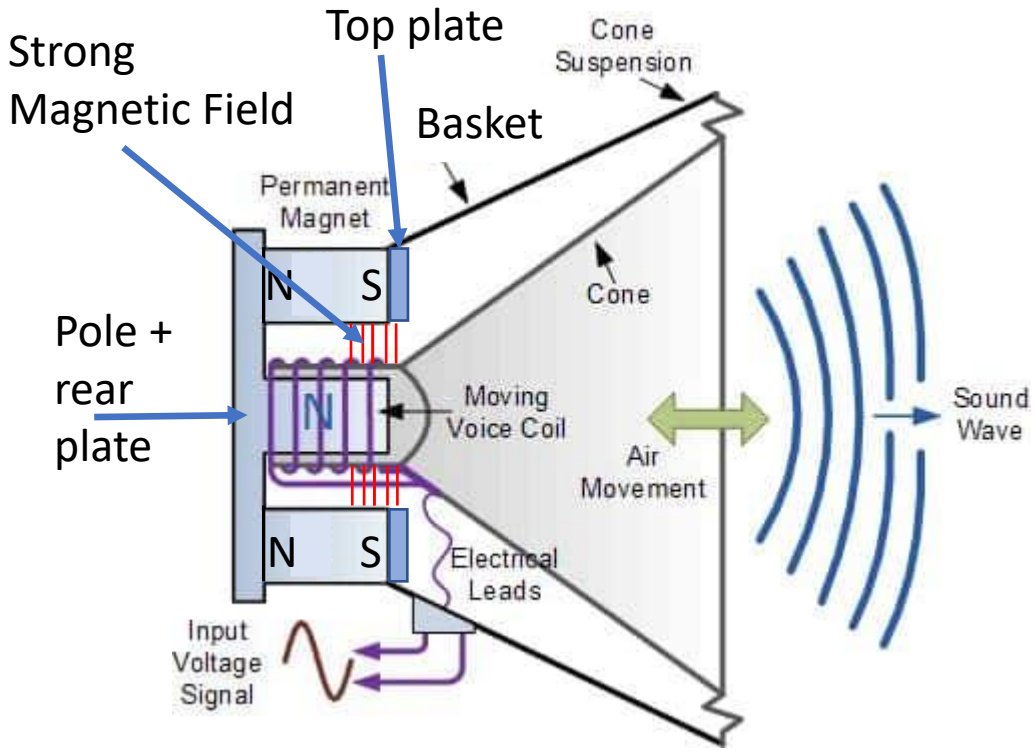
The iron core keeps most of the magnetic field contained within the horseshoe shape and the horizontal bar at the bottom. The open space area between the two iron pieces has a very strong magnetic field.

Speakers and microphones use iron pieces to concentrate magnetic field lines in specific areas. This allows them to use weaker, cheaper magnets to get a good sound with low power.



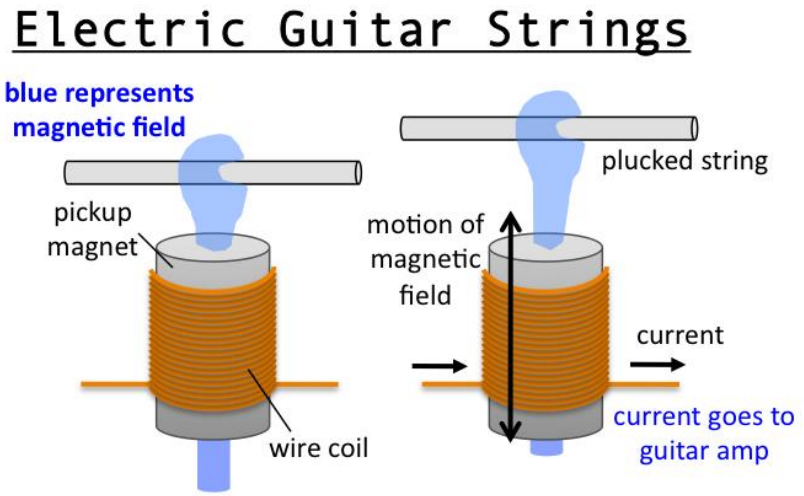


This speaker design uses a Pole + rear plate made of iron to bring the magnetic field lines of the North of the magnet through the center of the magnet so that it is close to the South pole of the magnet. The top plate brings more of the magnetic field lines of the South pole close to the North pole---very strong magnetic area in the circle between the plug of the rear plate and the hole of the top plate.

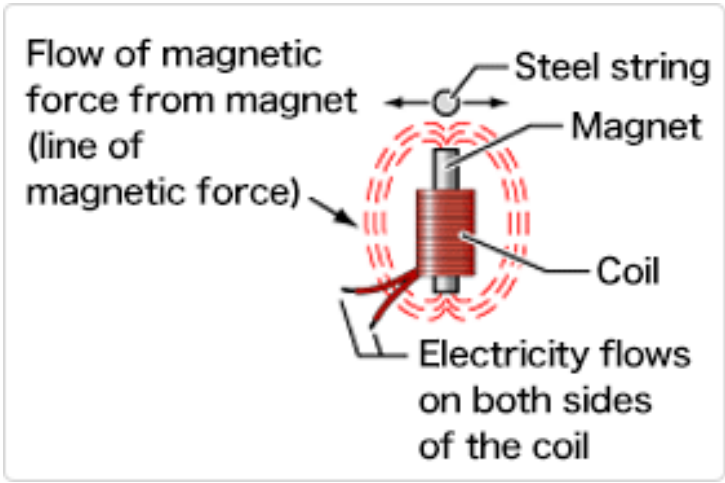


A speaker or a microphone uses iron pieces to control the magnetic field of a solid magnet to produce a very strong field

Electric Guitar pickups

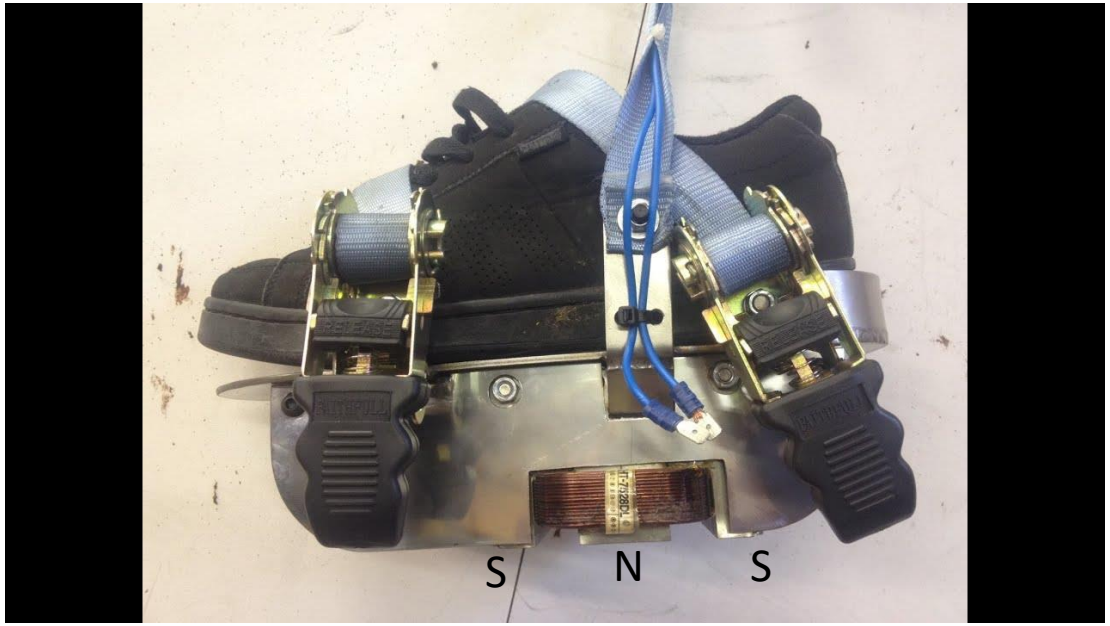


Electric guitar pickups are made of solid magnet cores for each guitar string with copper wire coils wrapped around the cores. When a steel guitar string vibrates, it changes the magnetic field and induces a current in the wire coil that is sent to the amplifier. There may be some value to looking at this construction and design to look for things that could be helpful in your design



Magnetic shoes

This guy has actually developed some functional shoes!!!! This guy is smart and has a working prototype which is better than I have seen anywhere!!! He uses an electro magnet (probably from a microwave) in the center of the shoe. Notice that there are blue wires coming off his shoes and he is using car batteries to run the electromagnets. I don't think we need to be able to hold all of your weight since we are expecting to be in zero-g. His controls are cables with handles and buttons to his hands. Once you have something functional, the next step is to make it better. Can you do it?
https://www.youtube.com/watch?v=uRKHCRR9-C4



Power Requirements for Electromagnets

- Astronauts on a space walk may need to be attached for 6 to 8 hours but there isn't a need to demonstrate that yet. If you can demonstrate the ability to walk and clamp down at a worksite for a total of 5 minutes, that is a good enough demonstration to show your idea. Since we are in zero-g, we don't need to hold your weight like Colin Furze. Being able to hold 20lbs on a common carbon steel is a good enough demonstration.
- In general NASA uses 28V or less for safety reasons. That varies a little depending on the application but that would be a good safety standard for students.
- You can use car batteries like Colin Furze if you like but those can be expensive and are pretty big. I would expect that using some batteries used for battery powered drills would be good enough for your demonstrations and testing. Remember to allow your batteries to cool off between charging and discharging.
- Could there be any value to turning your electromagnet on and off several times per second to save power without losing significant grip on the steel? Could this be done with an Arduino or Raspberry Pi?

Gliding

The SpaceX Starship has a very smooth looking surface. Is there a way to be connected to the smooth surface without having to walk? Would the wheels have to be magnetized or could there be magnets on the bottom of the shoes (close to the steel surface) that are pulling the shoes to the steel and loading ‘magnetic weight’ onto the wheels?

When using roller skates, one foot is pushing sideways with the wheels and the other foot is rolling forward. This allows for very controlled movements both slow and fast.

There use to be roller skating waitresses at drive up restaurants that would take your order and bring food out to the car, all on roller skates. They also had to be able to walk or side step at times to deal with inconsistencies in the road or to get close to the cars.

Although I think Heelys are really cool (I might have to get me a pair) and there may be some good options, I’m not sure they have as much control as roller skates since you run and then glide. With roller skates, you control both speed and stopping with the wheels.

New Thoughts on shoes

Is there value to a rounded bottom shoe to allow for some mechanical advantage for attachment and release as you roll your step? Should there be a flat spot in the middle?

Magnetic Roofing shoe

This shoe is made in Australia for steel roof workers. It has magnets in the sole for working on steel roofs. Adds extra friction for walking on smooth sheet metal roofing.

There will still be floating.

- The purpose of these boots is to allow the astronaut to translate outside on the fairly smooth, steel surface of the SpaceX Starliner and still be able to carry their tools and equipment for the work. Once they get to the worksite they may need to remove a panel and work under the surface of the space craft. The suit does not allow for as much dexterity as you might have in your jeans or even a jumpsuit. This means that the astronaut will have to release the boots from the surface and then attach a lanyard to the spaceship and float like astronauts do today. Not all work has to be done with the boots attached to the surface. The magnetic boots are there to give astronauts another tool for control when they are doing Extra Vehicular Activities (EVAs).

Other applications

- Could these boots be valuable to metal workers on high rise buildings. Instead of depending solely on a person's balance or a tether, could people use magnetic boots to make walking around an open steel structure safer.
- Could these boots be valuable to underwater working trying to weld or work on steel structures under--- hold yourself to the work site.
- These boots may also be valuable if people visit M-Class asteroids like Psyche 16. Where the gravity is around 1% of Earth's gravity but the asteroid is 80% iron and nickel—Ferromagnetic. Robotic and human minors might move around on the surface with magnetic wheels and shoes to keep from floating away from their work.