Physics Principles

The Basic Unit of Magnetism

Magnetic Fields

Magnetism is About Lining Up

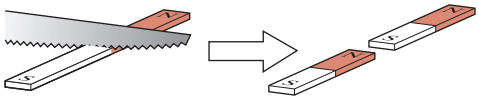
Magnetization & How It Works

Why Do Magnets Stick to Things?

Magnets Exert Forces on Currents

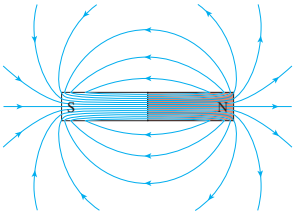
Changing Magnetic Fields Induce Electric Currents

The basic unit of magnetism is the dipole.



Magnetic Fields Are Circles

North is where they come out.
South is where they go in.

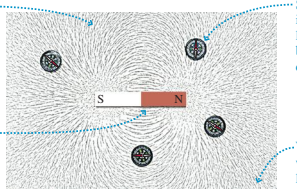


Dipoles Line Up With The Field

Magnetism is liney uppy, not forcey.

Each iron filing acts like a tiny compass needle and rotates to point in the direction of the magnetic field.

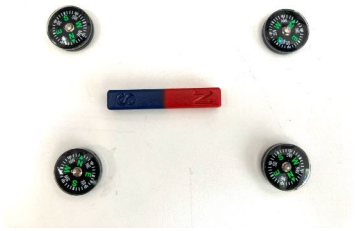
Where the field is strong, the torque easily lines up the filings.



Since the poles of the iron filings are not labeled, a compass can be used to check the direction of the field.

Where the field is weak, the torque barely lines up the filings.

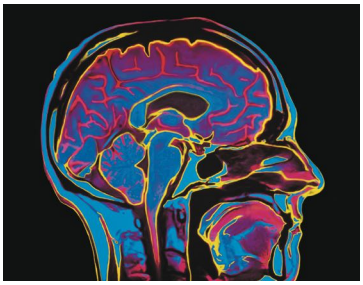
Bar Magnets & Compasses



Electrons, Protons, Neutrons, and Lots of Atoms Are Magnetic Dipoles.

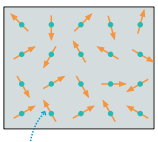
The arrow represents the inherent magnetic moment of the electron.

That's how an MRI works.



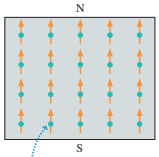
Magnetic Materials Have Dipoles That Want to Line Up

Not Magnetic



The atomic magnetic moments due to unpaired electrons point in random directions. The sample has no net magnetic moment.

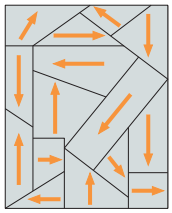
Magnetic



The atomic magnetic moments are aligned. The sample has north and south magnetic poles.

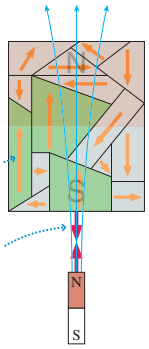
It's All About the Domains

Unmagnetized piece of iron



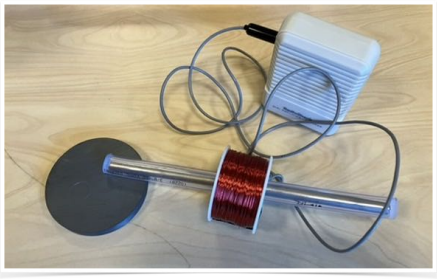
Magnetic, but not magnetized.

Favorable Domains Grow, Unfavorable Ones Shrink.



Magnetized!

The Barkhausen Effect



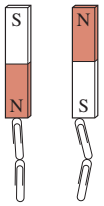
The Curie Point

Material	Curie temperature (K)	°C	°F
Iron (Fe)	1043-1,664	770	1418
Cobalt (Co)	1400	1130	2060
Nickel (Ni)	627	354	669
Gadolinium (Gd)	292	19	66

Making and Breaking Magnets

Lined up is lower energy.

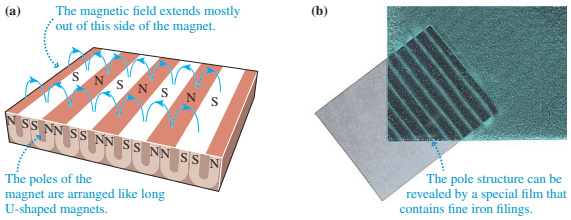
There is a force toward a lower energy state.
That's why things are attracted to magnets.



MagNuts

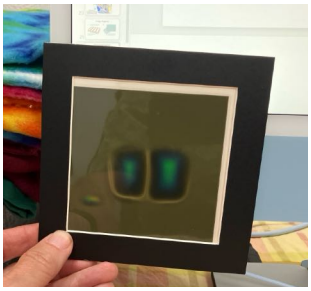
Strong doesn't necessarily mean sticky. For stickiness, you want a strong change in field.

Fridge Magnets



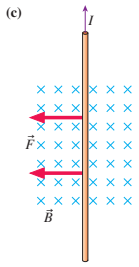
Where are there magnets?

What do you notice about the locations?

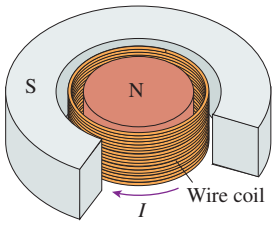


Magnetic fields exert forces on electric currents.

The force is perpendicular to the field and to the current.

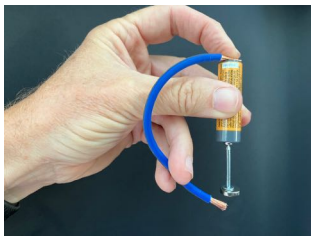


That's why speakers have magnets in them.



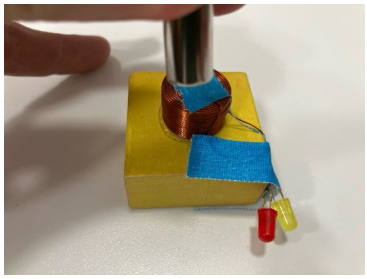
The world's simplest motor.

Notice that the force doesn't just attract the wire to the magnet….
It makes things spin!



Changing magnetic fields induce electric fields.

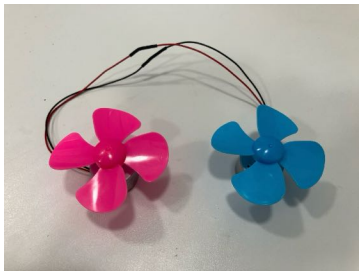
And those electric fields can make currents flow.



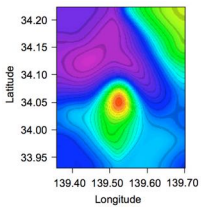
This is how most electricity is generated.

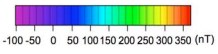
Motors are generators and generators are motors.

We'll talk about this later.



Shark Shoal at a Seamount





Magnetic field anomaly

The sharks' electric field sense lets them sense changes in the magnetic field.

All kinds of devices use this principle.

Inducing music As you can see in the photo, the pickups on an electric guitar have small disk-shaped magnets that magnetize the nearby steel strings. What you can't see are the small coils below each magnet. As the magnetized strings vibrate, the flux they create in the coils changes rapidly, inducing a changing emf in the coils. When amplified, this emf can drive a loudspeaker, which converts the strings' motion to sound.