Magnetic Fields and Electromagnetism

Magnets have two different ends called poles, either as north pole (N) or south pole (S).

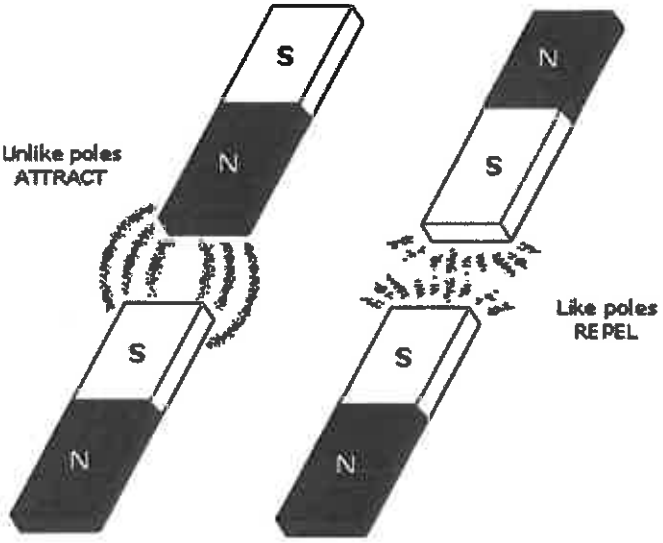
Just as opposite electric charges attract, opposite magnetic poles...

attract!

Just as like charges repel, like magnetic poles...

repel!

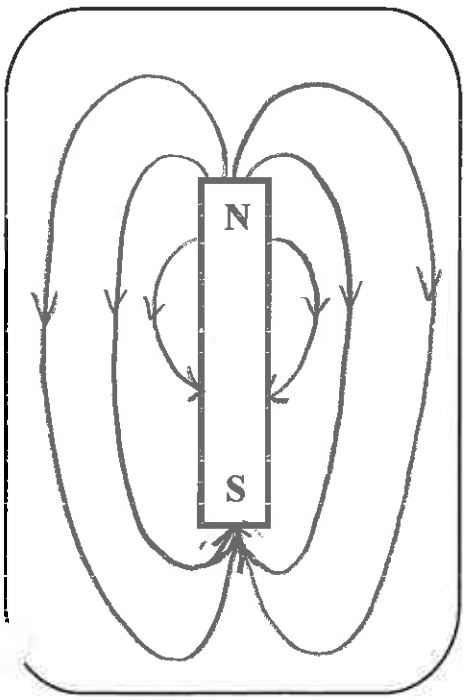
However, unlike electric charges which can be single charges (+ or -), magnetic poles only occur in pairs (N and S).

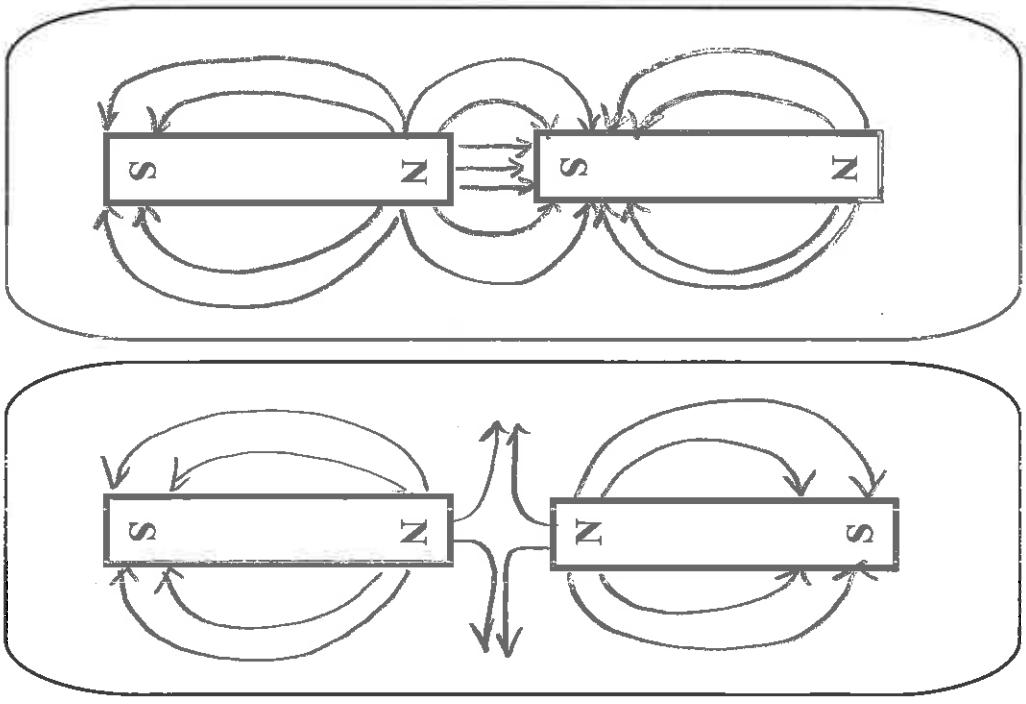


Magnets, like electric and gravity forces, also exert forces on each other from a distance, meaning that they are surrounded by... magnetic fields

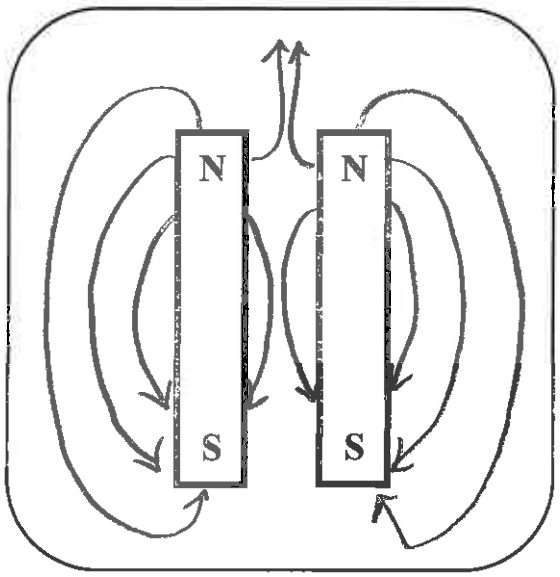
It is important to note that magnetic fields are vectors and therefore we need to represent the field lines as arrows.

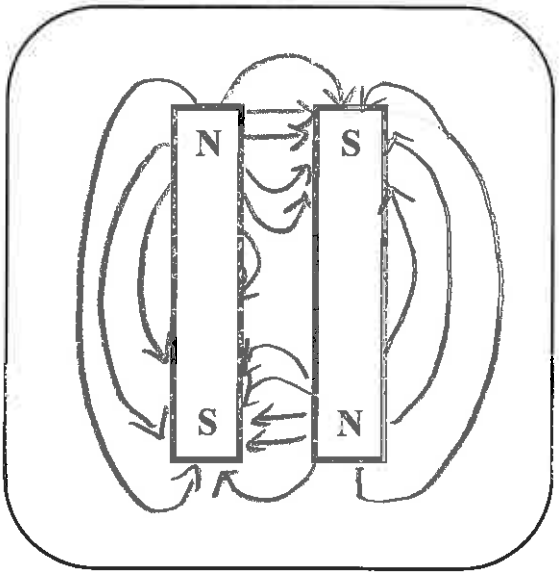
Magnetic field lines move outward from the north pole and inward toward the south pole. Therefore...





Note that magnetic field lines always form closed loops.





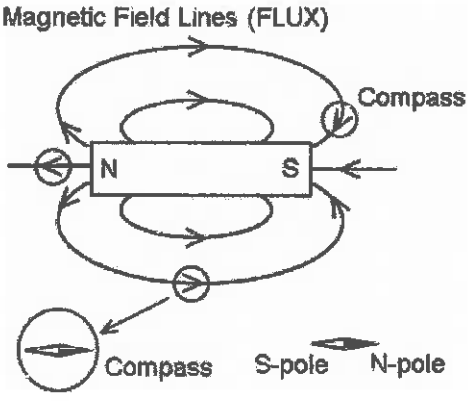
Compasses and Earth's Magnetic Field

The largest magnet on Earth is... Earth!

And its magnetic field resembles that of... a bar magnet

Earth has two geographic poles, the north pole and the south pole, and Earth (like every other magnet) has two magnetic poles.

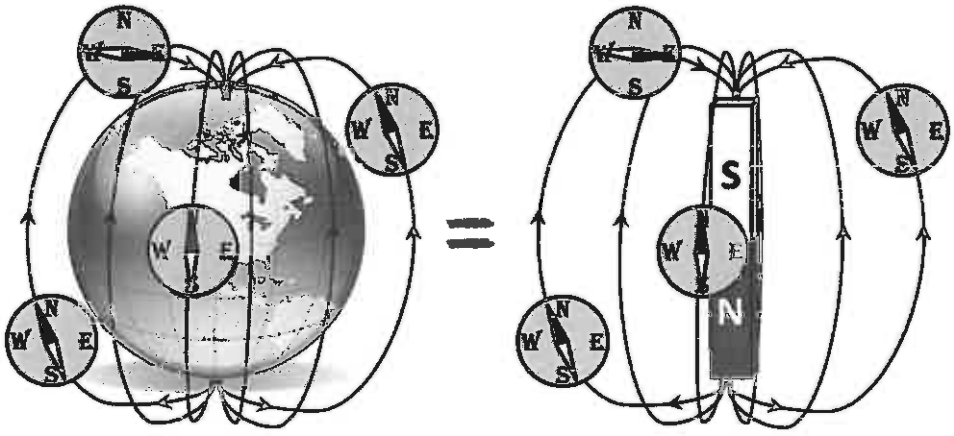
The geographic and magnetic poles are not in exactly the same location but they are close enough to say that a compass needle (really just a magnet) always points to Earth's north geographic pole.



But why you ask?

The north pole of a compass will... line up with Earth's magnetic field lines

Shocker: Magnetic "North" is actually Earth's south magnetic pole!



Bigger Shock: Earth's magnetic poles actually move (albeit) slowly from day to day and year to year.

They have even reversed directions many times in history (the last one was ~80, 000 years ago.

What causes Earth's magnetic field you ask?

Earth's solid iron core is surrounded by a fluid ocean of hot, liquid metal. The flow of liquid iron in Earth's core creates moving electric charges (called currents), which in turn creates the magnetic field.

So...this means that electric currents create a magnetic field...? You bet! This is called:
Principle of Electromagnetism

Electromagnetism

A current carrying wire in a straight conductor will have a very regular magnetic field around it as predicted by the: 1st Right Hand Rule

1) place right

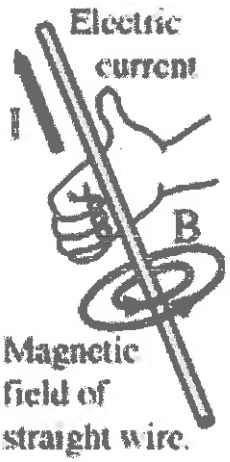
Figure 3

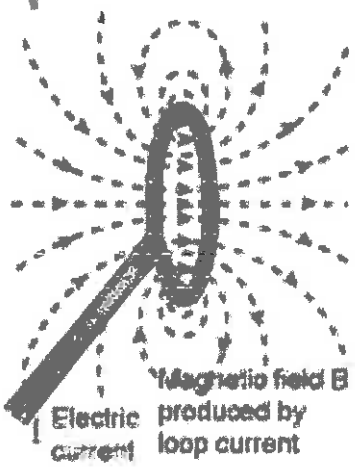
Thumb: current

Fingers: magnetic field

* note: field is stronger closer to the wire

If the wire is placed in a circular loop, the right hand rule still works:



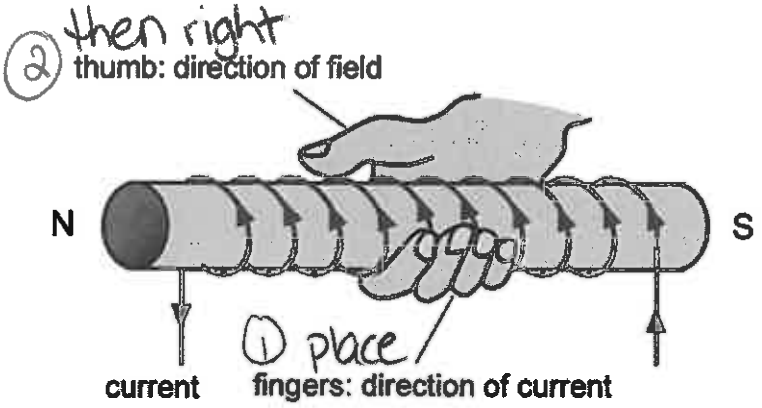


* magnetic field is stronger in the center of the coil as the field lines are closer

If the wire is wound into a coil (called a solenoid or an electromagnet), the magnetic field is composed of the combined fields of all its loops.

To determine the direction of the magnetic field in a solenoid we use the ...

2nd Right-Hand Rule



Fingers: direction of current

Thumb: points N

The many loops of wire each carry current, therefore.... the field reinforces

This results in a concentrated uniform magnetic field in the center and a weak, non-uniform field outside.

In this way, the magnetic field produced by electric current in a solenoid is similar to that of bar magnet.