Notes

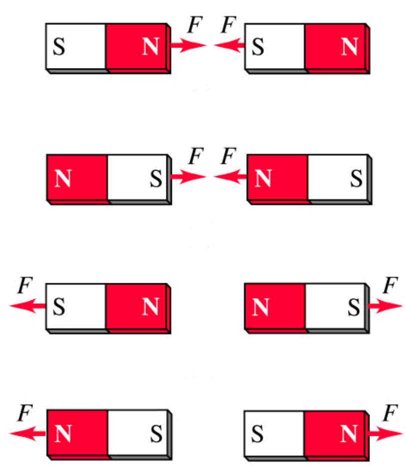
Physics Tool box

- **Law of Magnetic Poles** – Opposite magnetic poles attract. Similar magnetic poles repel.
- **Principle of Electromagnetism –** Moving electric charges produces a magnetic field.
- **Right-hand Rule for a Straight Conductor** – If a conductor is grasped in the right hand, with the thumb pointing in the direction of the current, the curled fingers point in the direction of the magnetic field lines.
- **Right-hand Rule for a Solenoid** – If a solenoid is grasped in the right hand, with the fingers curled in the direction of the electric current, the thumb points in the direction of the magnetic field lines in its core.
- A magnet is surrounded by a magnetic force field.
- **Domain Theory** – states that ferromagnetic substances are composed of a large number of tiny regions called magnetic domains, with each domain acting like a tiny bar magnet. These domains can be aligned by an external magnetic field.
- **Solenoid** – a coiled conductor used to produce a magnetic field.

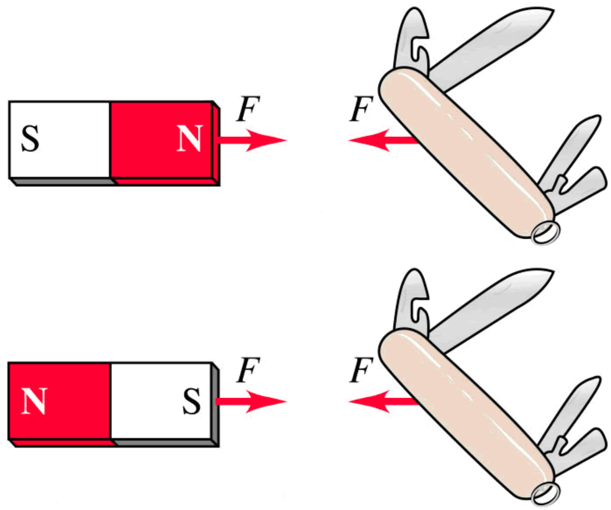
Magnetic phenomena were first observed at least 2500 years ago in fragments of magnetized iron ore found near the ancient city of Magnesia. These fragments were examples of what are now called permanent magnets. If a bar-shaped permanent magnet, or bar magnet, is free to rotate, one end points north. This end is called a north pole or N-pole; the other end is a south pole or s-pole.

Law of Magnetic Poles

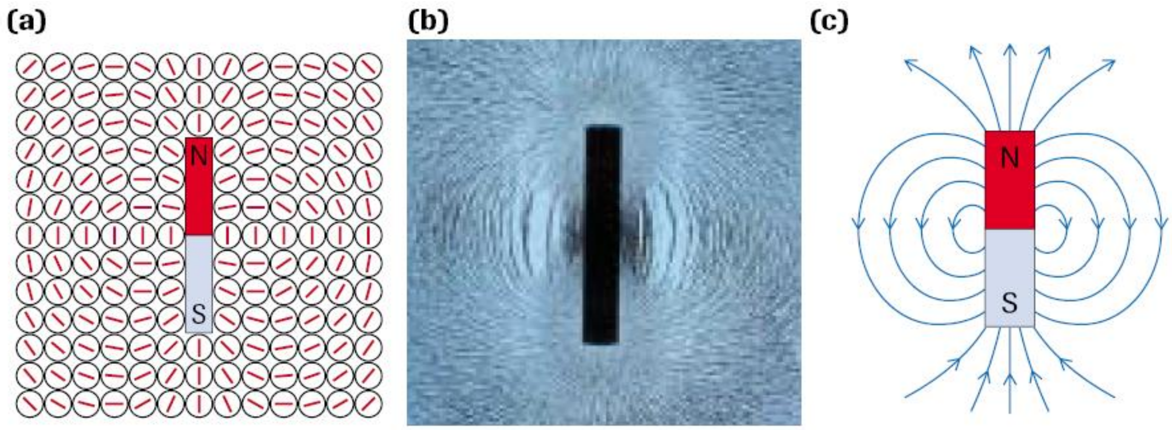
Opposite poles attract each other, and like poles repel



An object that contains iron but is not itself magnetized (shows no tendency to point north or south) is attracted by either pole of a permanent magnet. This is the attractions that the acts between a refrigerator door and a fridge magnet.

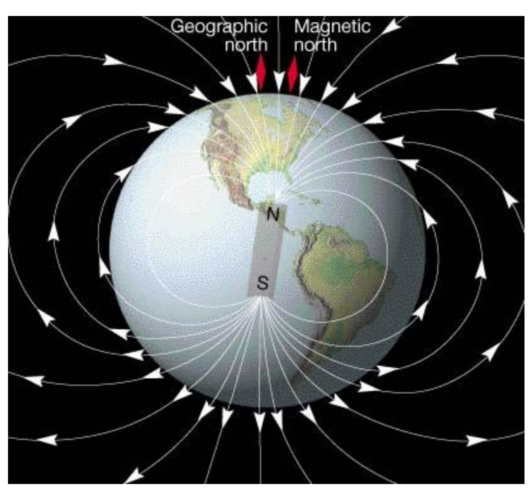


By analogy to electric interactions, we describe the interactions by saying that the bar magnetic sets up a magnetic field in the space around it and a second body responds to that field.

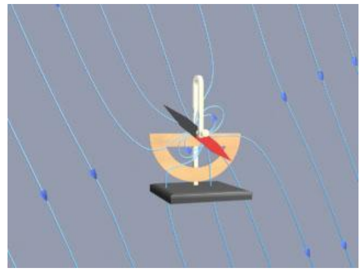


(a)The magnetic field of a single bar magnet is revealed by compasses placed around it.
(b) Iron filings clearly show the field but do not reveal the pole orientation.
(c) The field in one plane is represented by directed lines that (y convention) emerge from the N-pole and curve toward the S-pole

A freely turning magnet will rotate and point north-south because of its interaction with the magnetic field of Earth. The S-Pole of the Earth is in the northern hemisphere. This 3D field is always changing position (horizontally and vertically)

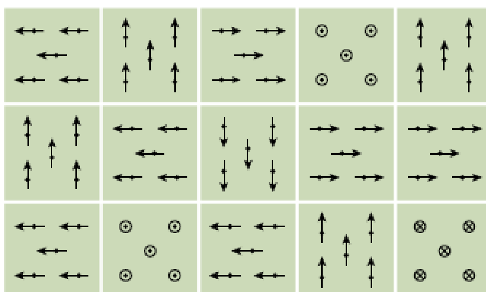


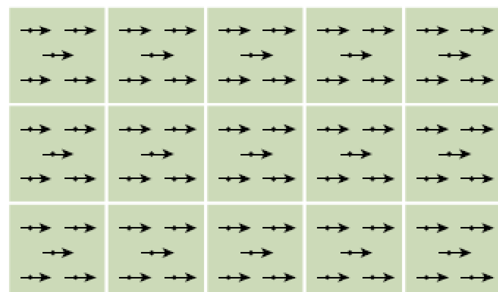
A normal compass only reveals the horizontal component. The angle between Earth's magnetic field, at any point, and the horizontal is called the magnetic inclination, or "dip" and is measured with a magnetic dipping needle. (Animation, Animation 2)



The Domain Theory of Magnetism

Although not normally magnetized, some ferromagnetic material, such as iron or nickel may become magnetized. The domain theory of magnetism best explains this.





On the left image the atomic dipoles are lined up in each domain. The domains point in random directions (⊗ way from you, ⊙ toward you). The magnetic material is un-magnetized.

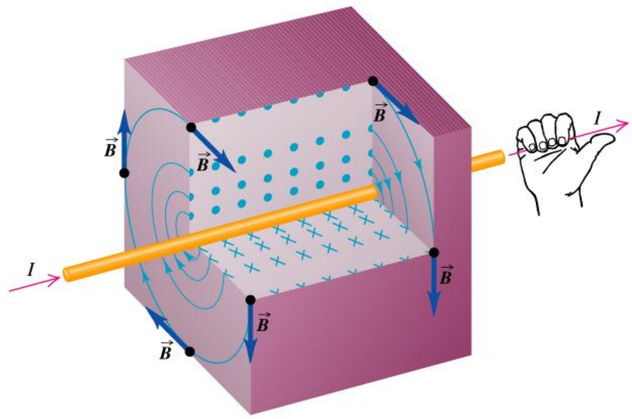
On the right image the atomic dipoles 9not the domains) turn so that all domains point in the direction of the magnetizing field. The magnetic material is fully magnetized

Ferromagnetic materials are transition elements that have atoms with unpaired electrons, and also large numbers of atoms are arranged in groups all facing the same way. These number in the tens of thousands, and form what could be called a minute magnet. They are called domains. In a piece of un-magnetized iron the domains are arranged randomly, but if the iron is put in a magnetic field then the domains begin to line up with the field, reinforcing. More and more domains line up as the external field is increased. When the external field is removed the iron retains some of the domain arrangement. Pure iron does not retain much of this induced magnetism and it is said to be magnetically soft. Impurities in the iron increase the retention of domain arrangement, and as steel retains most of the domains it is said to be magnetically hard.

The Principle of Electromagnetism

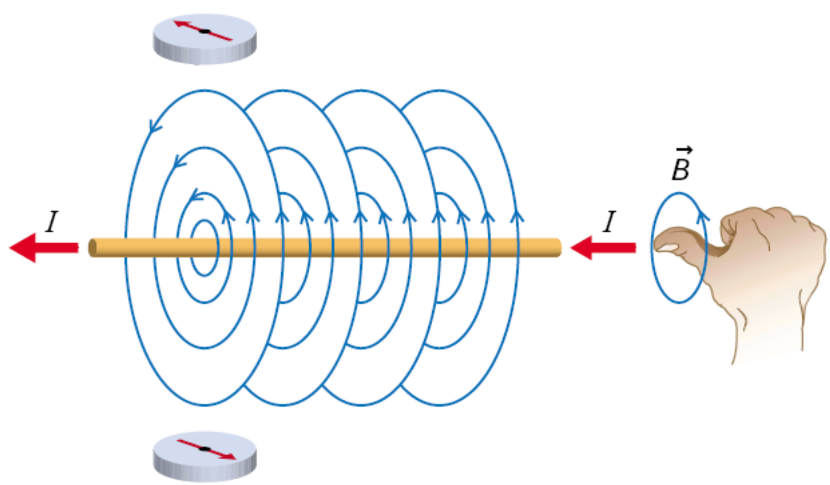
Moving electric charges produce a magnetic field

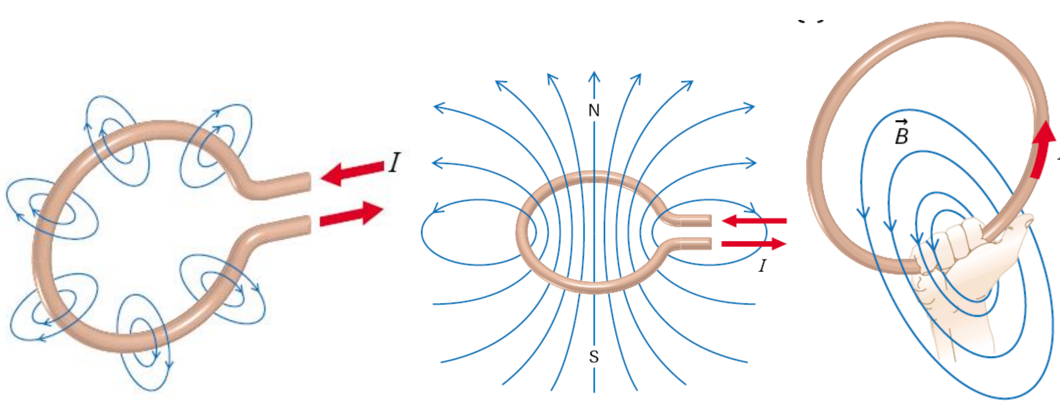
When an electric current flows through a straight conductor, it induces a magnetic field which consists of field lines that are concentric circles, centered on the conductor.



The direction of these field lines (as indicated by the N-pole of a small compass) is calculated by the right hand rule.

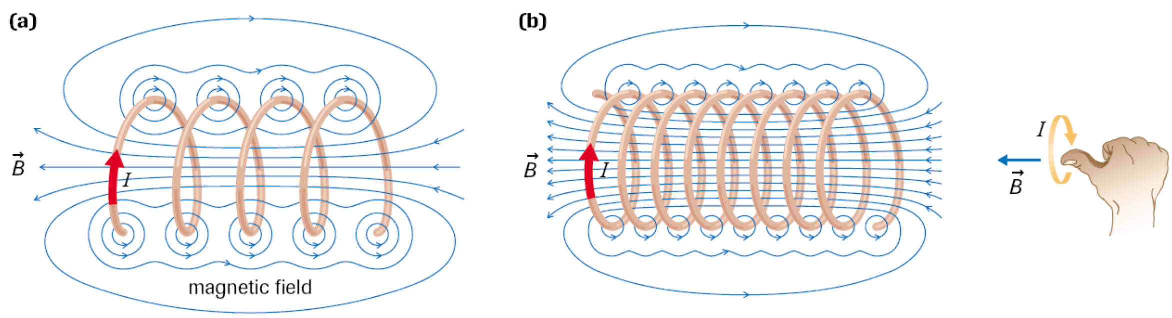
Right-hand Rule for a Straight Conductor – If a conductor is grasped in the right hand, with the thumb pointing in the direction of the current, the curled fingers point in the direction of the magnetic field lines.





Magnetic field of a coil or Solenoid

A solenoid is a long conductor wound into a coil of many loops. When a current is passed through the wire, a magnetic field is produced inside the coil.

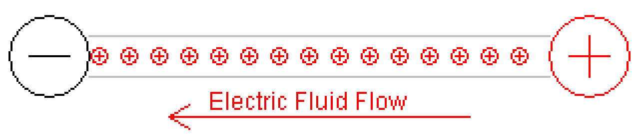


Right hand Rule for a Solenoid

If a solenoid is grasped in the right hand, with the fingers curled in the direction of the electric current, the thumb points in the direction of the magnetic field lines in the core.

Current direction

When scientists were first working with electricity, they didn't know about the structure of an atom. with electrons moving around the outside and protons stuck in the middle. They did figure out that something, which they called "electric fluid," was moving from one place to another, but they didn't know what this "fluid" really was. They decided it would help to be able to talk about which direction this stuff was moving. They picked one side and called it "positive," saying that it had a lot of "electric fluid." They called the other side "negative," saying that it had less "electric fluid." Then they set about trying to measure the flow of this "fluid" from "positive" to "negative."



Eventually, they learned that what was really moving was electrons, which were moving from the side that had been named "negative" to the side that had been named "positive." Oops! It would be a nuisance to change all the names, so they just kept it the way it was. "Current" replaced "electric fluid" as the name for stuff that flows from positive to negative, and the electrons kept on going from negative to positive, just as they had been doing before we knew anything about them.

Extra Notes and Comments