Magnetic Fields
What is magnetism?

- Magnetism is a *force* of attraction or repulsion that acts at a distance.
- It is a field force (A non-contact force.)
- It is caused by moving electrically charged particles.
- A magnet is an object that exhibits a strong magnetic field and will attract materials like iron to it.
- Magnets have two poles (dipoles) called the north (N) and south (S) poles.
- Two magnets will be attracted by their opposite poles, and each will repel the like pole of the other magnet.
Magnetic Flux Density ($B$): (magnetic field)

- A magnetic field can be visualized with field lines.
- The magnetic flux through some surface is proportional to the number of field lines passing through that surface.
- Note that the magnetic flux is the net number of field lines passing through that surface; that is, the number passing through in one direction minus the number passing through in the other direction. (It is a vector field)
- A magnetic field consists of imaginary lines of flux coming from moving or spinning electrically charged particles.

Examples: movement of electrons through a wire in an electric circuit or the spin of a proton

- Magnetic field are measured in units called "Tesla". The tesla (symbol T) is the SI derived unit of magnetic flux density.

\[(1 \text{ Gauss}) = 10^4 \text{T}\]
Naming the Poles of a Magnet

- Lines of magnetic flux flow from one end of the object to the other.
- The magnetic flux is defined as moving from N to S.
- By convention, we call one end of a magnetic object the N or North-seeking pole and the other the S or South-seeking pole, as related to the Earth's North and South magnetic poles.
Rules for Magnetic Field lines

1) Lines never cross
2) Lines move out of a North and into a South
3) Lines make complete paths
The North end of a magnet points to the North Pole. If the earth was a bar magnet where would you draw the north pole?

- The Earth's magnetic field appears to come from a giant bar magnet, but with its south pole located up near the Earth's north pole.

- The magnetic field lines come out of the Earth near Antarctica and enter near Canada.
• A schematic diagram of Earth's interior. The outer core is the source of the geomagnetic field.

• Earth's magnetic field comes from the liquid outer core or ocean of iron, which is an electrically conducting fluid in constant motion.
• Sitting atop the hot inner core, the liquid outer core seethes and roils like water in a pan on a hot stove.
• The outer core also has "hurricanes"--whirlpools powered by the Coriolis forces of Earth's rotation.
• The magnetic field waxes and wanes, poles drift and, occasionally, flip. Change is normal,
Earth's Magnetic Shield

https://www.youtube.com/watch?v=XXFVpwecixY
Red aurora borealis over Wrangell/St. Elias National Park in Alaska
Michael S. Quinton/National Geographic/Getty Images
Aurora

https://www.youtube.com/watch?v=Zz1HPLtecOg
Auroras are caused by charged particles, mainly electrons and protons, entering the atmosphere from above causing ionisation and excitation of atmospheric constituents, and consequent optical emissions.
Red: At the highest altitudes, excited atomic oxygen emits at 630.0 nm (red); low concentration of atoms and lower sensitivity of eyes at this wavelength make this colour visible only under more intense solar activity. The low amount of oxygen atoms and their gradually diminishing concentration is responsible for the faint appearance of the top parts of the "curtains".
**Green:** At lower altitudes the more frequent collisions suppress this mode and the 557.7 nm emission (green) dominates; fairly high concentration of atomic oxygen and higher eye sensitivity in green make green auroras the most common. The excited molecular nitrogen (atomic nitrogen being rare due to high stability of the N₂ molecule) plays its role here as well, as it can transfer energy by collision to an oxygen atom, which then radiates it away at the green wavelength. (Red and green can also mix together to produce pink or yellow hues.) The rapid decrease of concentration of atomic oxygen below about 100 km is responsible for the abrupt-looking end of the lower edges of the curtains.
Blue: At yet lower altitudes atomic oxygen is, uncommon, and ionized molecular nitrogen takes over in producing visible light emission; it radiates at a large number of wavelengths in both red and blue parts of the spectrum, with 428 nm (blue) being dominant. Blue and purple emissions, typically at the lower edges of the "curtains", show up at the highest levels of solar activity
Yellow and pink are a mix of red and green or blue.
1831- James Ross located the pole for the first time after an exhausting arctic journey during which his ship got stuck in the ice for four years.

1904 - Roald Amundsen found the pole again and discovered that it had moved--at least 50 km since the days of Ross.

The pole kept going during the 20th century, north at an average speed of 10 km per year, lately accelerating "to 40 km per year.

• There are no individual magnetic poles or magnetic charges (Called magnetic monopoles.)
• Electric charges can be separated, but magnetic poles always come in pairs - one north and one south.

• Opposite poles (N and S) attract and like poles (N and N, or S and S) repel.

• These bar magnets will remain "permanent" until something happens to eliminate the alignment of atomic magnets in the bar of iron, nickel, or cobalt.
What is the direction of the force on a magnetized object in a magnetic field?

a)

b)

c)
Force lines for two magnets with opposite poles aligned.

Force lines for two magnets with identical poles aligned.
Cutting a Magnet in Half

You can not create just one pole of a magnet by cutting a magnet into pieces. You just get smaller dipole magnets.
Magnetic and electric fields

Electric charges and magnetism similar

Just as the positive (+) and negative (−) electrical charges attract each other, the N and S poles of a magnet attract each other.

In electricity like charges repel, and in magnetism like poles repel.

Electric charges and magnetism different

The magnetic field is a dipole field. That means that every magnet must have two poles.

On the other hand, a positive (+) or negative (−) electrical charge can stand alone. Electrical charges are called monopoles, since they can exist without the opposite charge.
Detecting a magnetic field

• A compass can detect a magnetic field and show the direction of the field.

• Iron filings or moon dust (But not regular earth dust) can be used to show the shape of a magnetic field

• Gauss meters are used to measure the strength of a magnetic field using an electronic chip which generates a tiny electrical current when exposed to a magnetic field.
Assignment

Read p 5-14

Complete pages 28 and 29

and page 32 based on transparency page 31
The smell of Moon Dust

http://www.physics.sjsu.edu/becker/physics51/mag_field.htm

Build your own Gauss meter
http://my.execpc.com/~rhoadley/magmeter.htm