Electromagnetism

Cause of Magnetism

Mag. Field: $\vec{B}$

A stationary electric charge . . . is surrounded by an electric field

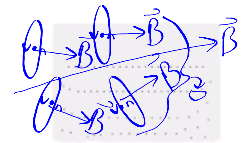
A moving electric charge . . . generates a magnetic field as well

What causes magnetism? motion of charged particles – spin and rotation of electrons

Non-magnetic material

Examples: wood, plastic, aluminum, other metals

Reason: individual B fields of atoms cannot be made to align to produce an overall magnetic field

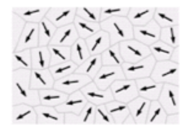


Non-magnetic material

Magnetic material

Examples: iron, nickel, cobalt

Reason: composed of domains

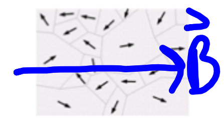


Unmagnetized magnetic material

Domain: small group of atoms whose magnetic fields are aligned

Magnetized material

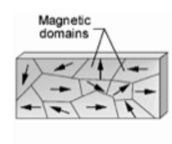
Reason: many domains have been aligned to produce an overall magnetic field



Magnetized magnetic material

Induced Magnetism:

a magnetic material is magnetized by the application of an external magnetic field causing many of its domains to align

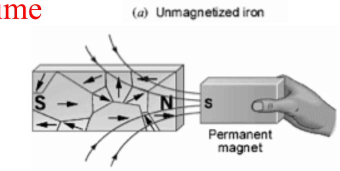


(a) Unmagnetized iron

1. What does the strength of a magnet depend on?

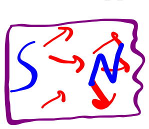
Hard (permanent) magnet: domains remain aligned for a long time
ferro magnet

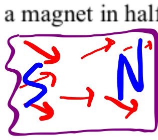
Soft (temporary) magnet: domains return to random state quickly after being magnetized
paramagnet



(b) Induced magnetism

2. How does a magnet become weak or lose its magnetism? disrupt the alignment of the domains
   i) vibrations-dropping, hitting
   ii) heat
   iii) other B fields
   iv) over time sitting still-Earth's B field
3. What will happen if you break a magnet in half?

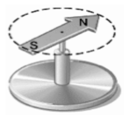




2 smaller magnets

Magnetic Fields

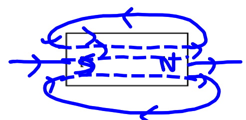
The Compass

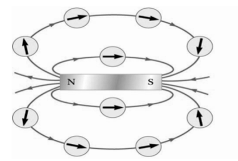


1. a small magnet free to rotate
2. responds to the Earth's magnetic field - responds to all magnetic fields
3. can be used to "map" magnetic

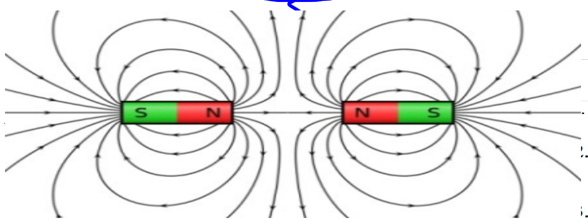
Sketch in the magnetic field lines below.

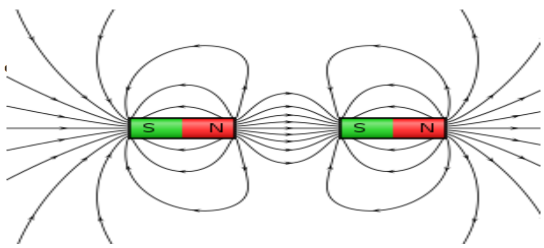
a)





Mapping magnetic field lines using a compass





Magnetic Field Lines

test fields with a small compass

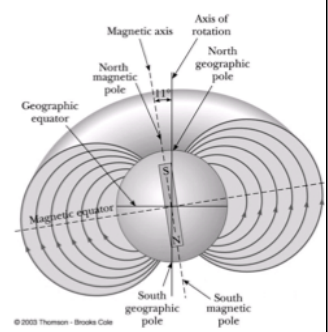
2. Field lines point out of N, into S
3. Field lines never cross
4. B Field most intense where field lines most dense
5. Direction of B tangent to field lines

Why does the Earth have a magnetic field?

spinning of iron-rich molten outer core

The north magnetic pole of the Earth acts like . . .

the south pole of a bar magnet



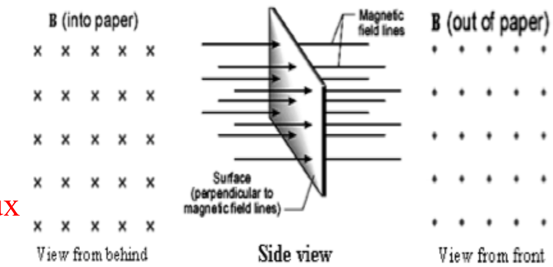
Magnetic Fields in Three Dimensions

Magnetic Flux:
lines of the magnetic field

Magnetic Field Strength, Magnetic Field Intensity, Magnetic Flux Density:
strength of the magnetic field

measured by the density of the magnetic flux

Symbol: $\vec{B}$ Units: $\left[\frac{N}{C \cdot m/s}\right] = [T]$ Type:



1. In 1819, Danish physicist and chemist Hans Christian Oersted was the first to notice
a connection between electricity and magnetism.


Hans Christian Oersted (Denmark, 1777 – 1851)

2. He noticed that
an electric current in a wire deflected a nearby compass needle.

3. This demonstrated the principle that
current generates its own magnetic field.

Not only was this astounding and unexpected, but further investigation showed that the magnetic field produced by the current in the wire had an unusual shape.

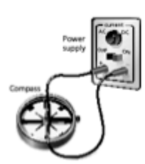
Current off

Oersted placed a compass beneath a wire with no current.

Direction of Compass Needle:

||

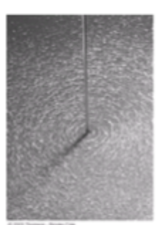
Current on

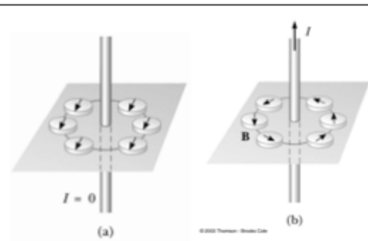


When the current was turned on, the compass needle deflected.

Direction of Compass Needle:

⊥


Iron filings sprinkled around a wire with current show a very different magnetic field from those of bar magnets.



Current off **Current on**

Direction of Compass Needle when current is on:

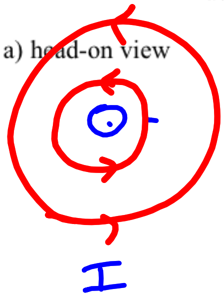
⊥ to wire, tangent to circle around wire

Direction of magnetic field around wire:

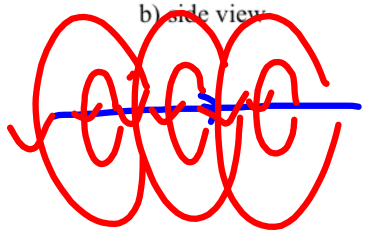
concentric circles around wire

Draw the magnetic field lines around a current bearing wire:

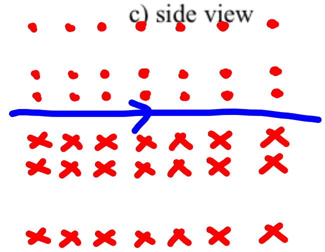
a) head-on view



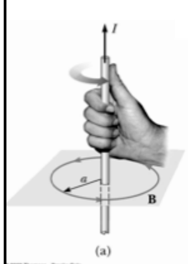
b) side view



c) side view



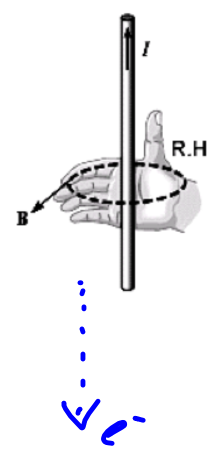
Right Hand Rule: Magnetic Field around a Wire



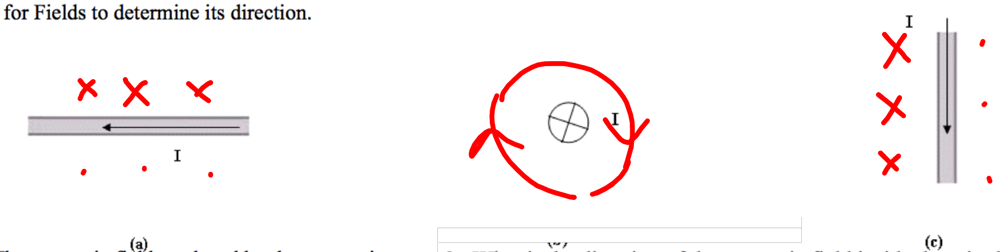
The direction of the curl of these field lines (clockwise or counterclockwise) can be determined by a **Curled Hand** right hand rule.

Thumb: direction of positive charge

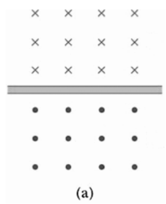
Fingertips: curl in direction of **B** field

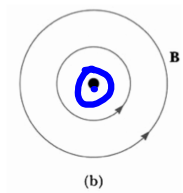


1. Draw the magnetic field around the wire in each case below. Use the Right Hand Rule for Fields to determine its direction.

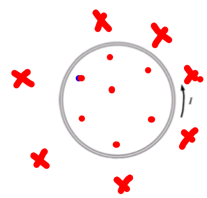


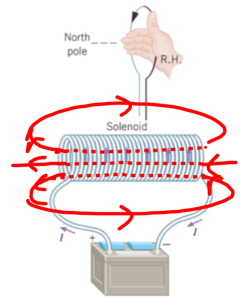
2. The magnetic field produced by the current is shown in each case. Use the Right Hand Rule for Fields to determine the direction of the current flow in each wire shown below.





3. What is the direction of the magnetic field inside the wire loop shown below? The Solenoid?





Eqn **B = $\frac{\mu_0 I}{2\pi r}$

B =

B =

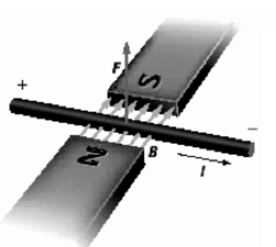
Force on a Wire

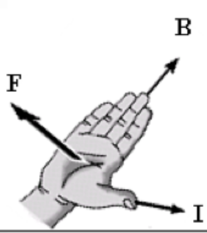
If a wire with current flowing through it is placed in an external magnetic field, it will experience a force. Why?

Two magnetic fields – around wire and from external magnet – will either attract or repel

Right Hand Rule: Magnetic Force on a Wire

The direction of the force exerted on a wire bearing current when placed in an external magnetic field can be determined by a **Flat Hand** right hand rule.





Flat Hand:

Fingers:

Thumb:

Palm:

Maximum force occurs when:

No force occurs when:

Use the right hand rule for forces to confirm the direction of the force in each case.