answer Key

U3:L7 Electromagnetism #1

Prior to the 19th century, electricity and magnetism were generally thought to be separate and distinct phenomena. Yet many natural philosophers sought to discover a connection between electricity and magnetism. **Hans Christian Oersted** (1777-1851), professor of physics at Copenhagen University, believed for a long time in the unity of nature. Philosophically he felt there ought to be a connection between magnetism and electricity.

Everything is connected... ooo

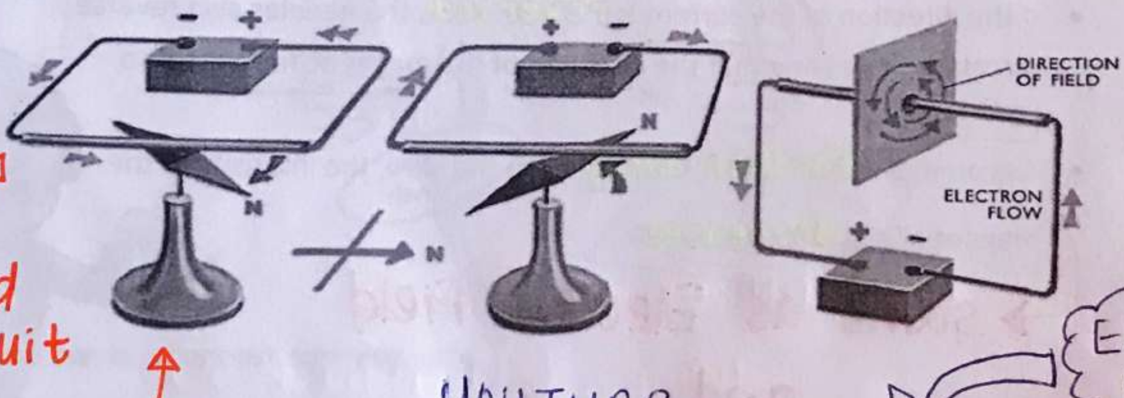
In 1820, Oersted delivered a lecture on electricity to some advanced students. By chance, a wire leading to a voltaic pile was nearly parallel to and above a compass that happened to be on a table along with other objects. When the circuit was closed, the needle swung around almost perpendicular to the current carrying wire as if gripped by a powerful magnet.

like a battery

"ON" (switch closed)

Oersted formulated the basic **principle of electromagnetism**:

that moving electric charges, (an electrical current) produce a magnetic field.

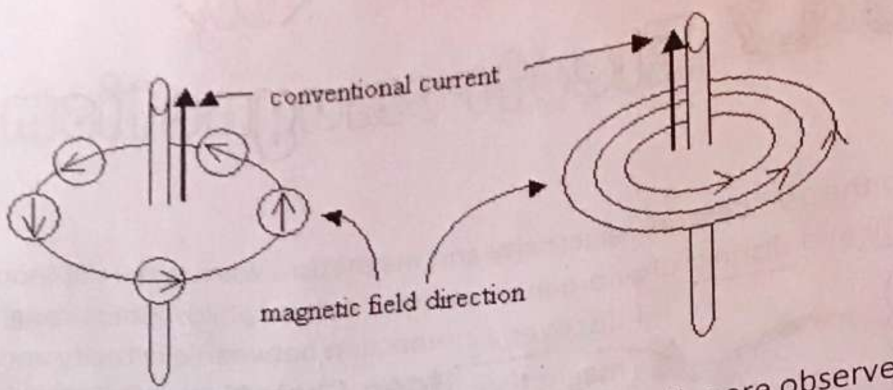


closed circuit

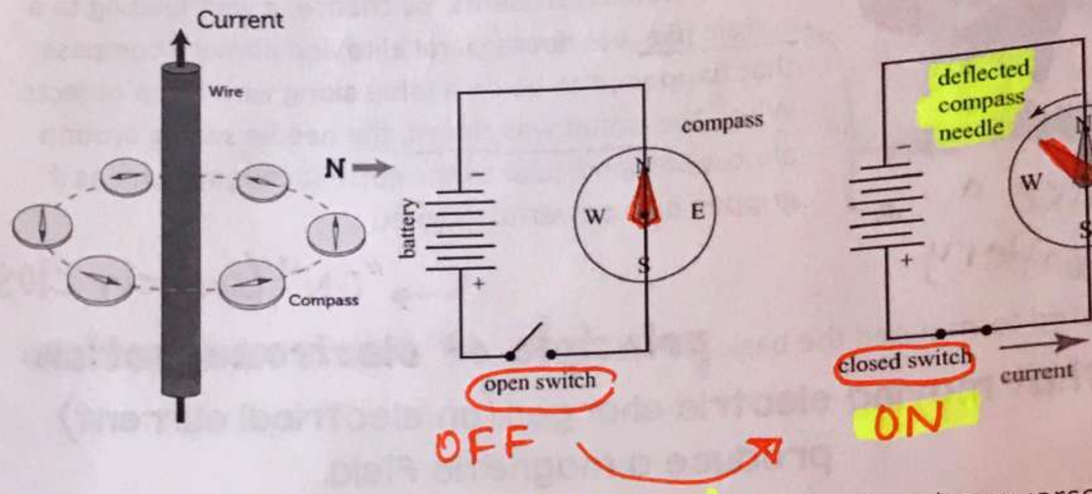
compass

YouTube "Electromagnetism 101" by National Geographic (3.19 mins)

EXTRA FUN STUFF

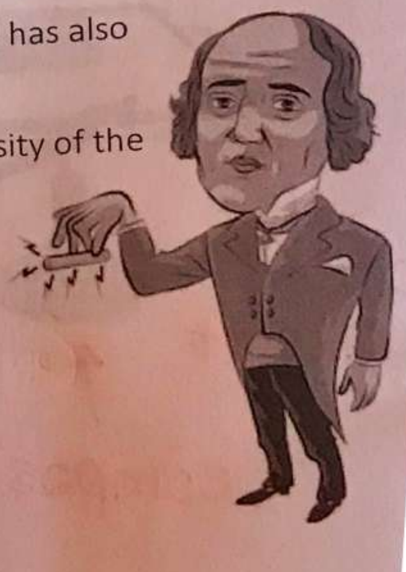


- When an electric current is present, the compass needles are observed to point in a **circular pattern** around the wire.
- The pattern indicates that the magnetic field lines produced by the current are circles **centered on the wire.**

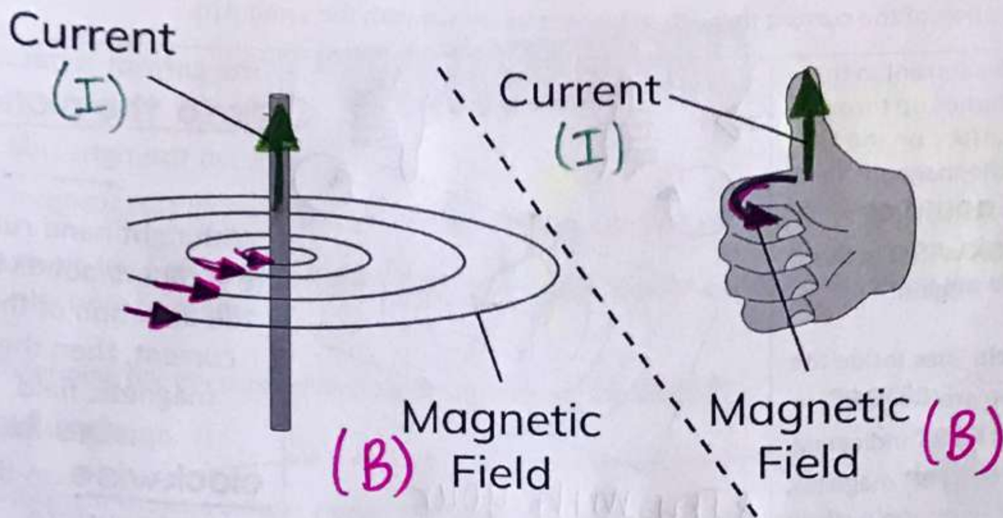


- If the direction of the current is **reversed**, the needles also reverse direction, indicating that the direction of the magnetic field has also reversed.
- As you move **farther away** from the wire, the intensity of the magnetic field **decreases.**

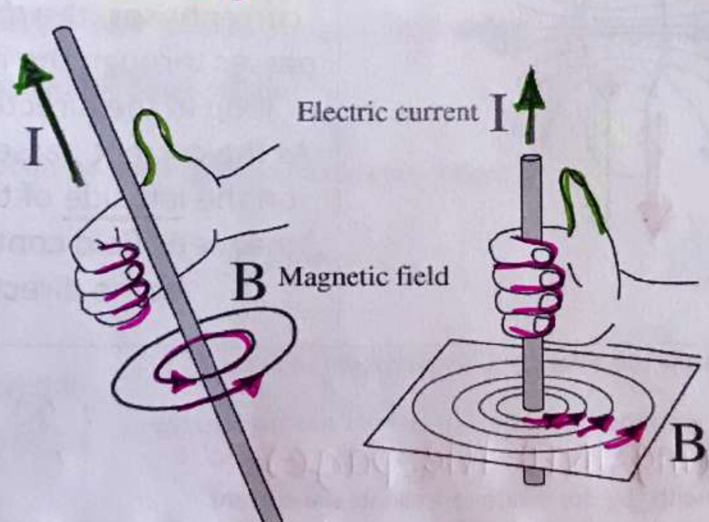
→ same as Electric Field and Magnetic Field



The direction of the magnetic field can be determined by the **right-hand rule** for a wire.



- Point the **thumb** in the direction of the conventional **current.** (I)
- Curl the fingers of the right hand into the shape of a half-circle.
- The tips of the **fingers** will point in the direction of the **magnetic field.** (B)



This bar is a current carrying wire

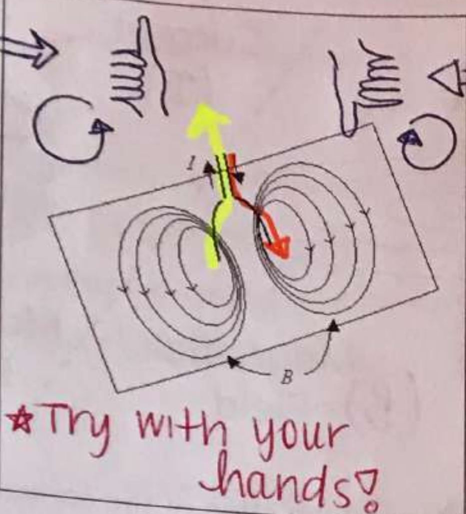
☆ try with your hand!

Magnetic Field of a Loop

When a straight wire is formed into a circular loop, its magnetic field will appear as shown below.
This diagram shows the top part of a loop above the surface of a plane.
The direction of the current through the loop is as shown with the symbol (I).

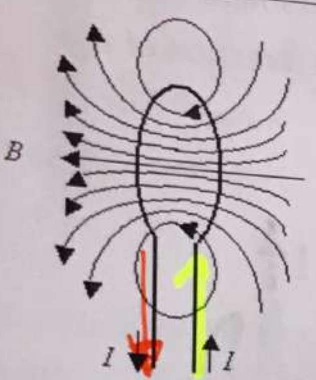
As the current in the wire comes up through the surface on the left side, the magnetic field is **counter-clockwise** in this region.

The field lines inside the loop are **closer together** indicating a **stronger** magnetic field than on the outside of the loop.



The current is passing **into the plane** on the right side.

With right hand rule, the thumb points in the direction of this current, then the magnetic field appears **clockwise** on the plane surface.

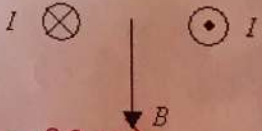


This diagram shows a loop in the **vertical position.**

On the ride side of the loop, as the current rises, the magnetic field passes through the interior of the loop in the direction shown. As the current passes downwards on the left side of the loop, the magnetic field continues in the same direction.

nother way to show this effect is to uses crosses and dots.

- The circle with the cross shows a current passing into the plane. (going INTO the page)
- The circle with the dot inside represents the current passing out of the plane. (coming OUT of the page)



nagine a loop passing into the page and then out of the page. Applying the right hand rule, we an see that the magnetic field direction will be down as shown.

Magnetic Field of a Solenoid

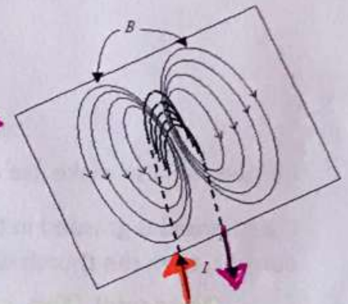
If a long conductor is wound into a coil with many loops, the coil is called a **solenoid**.

so if this solenoid has 15 loops you ADD all 15 Magnetic Fields

The magnetic field of a solenoid is the **sum** of the magnetic fields of **all its loops**.

As a result, the field inside the coil can be very strong, consisting of field lines there are straight and very close together.

To determine the direction of the magnetic field, use the **right hand rule**.

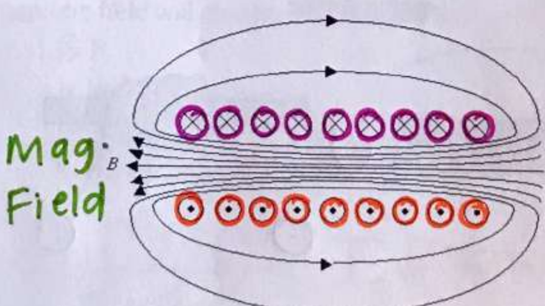


This diagram shows a current rising up through the plane on the left side. The current loops above and below the plane several times and descends through the plane on the right side.

This next diagram (hamburger dude) is another way to represent the magnetic field around a solenoid.

The current moves **into the plane** along the **top edge** of the solenoid and **out of the plane** along the **bottom edge**.

The magnetic field points to the **right** in the diagram below.



Remember...

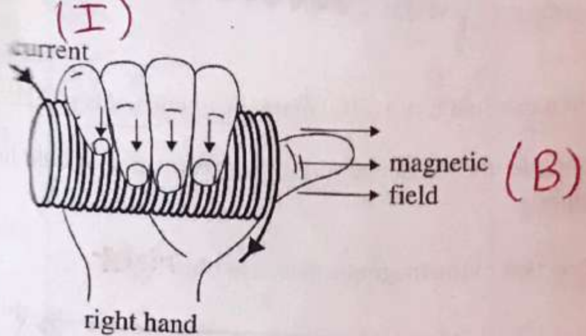
ⓧ = INTO page

⊙ = Out of page

Solenoid Right Hand Rule

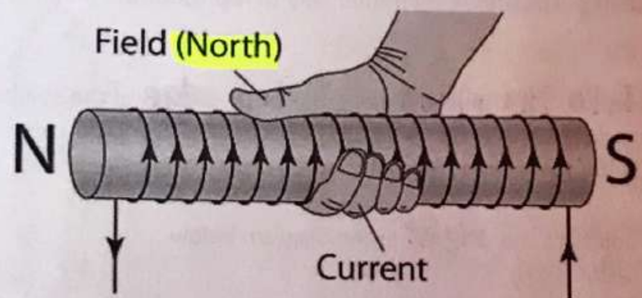
A solenoid has a magnetic field very similar to that of a bar magnet. In fact, a solenoid acts in many ways like a bar magnet, with the exception that the magnetic field can be turned off and on.

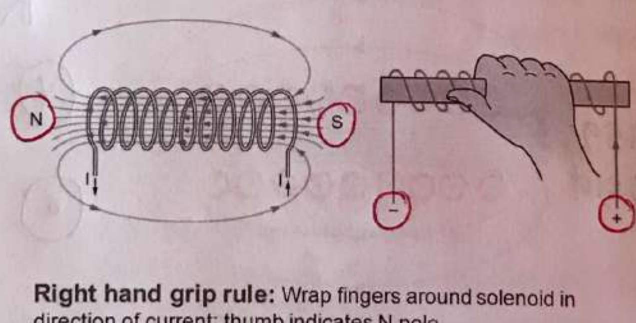
The right hand rule learned earlier can be applied to a solenoid to determine the direction of the magnetic field.



But we can also make use of a different kind of 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, then the thumb will point in the direction of the magnetic field lines in its core, and hence toward the north pole.





Right hand grip rule: Wrap fingers around solenoid in direction of current; thumb indicates N pole.

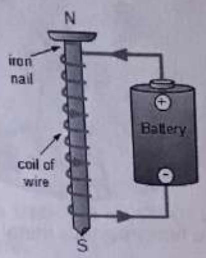
Electromagnets

An electromagnet is a current carrying coiled conductor. A solenoid is an example of an electromagnet.

There are several factors that can affect the strength of the magnetic field inside an electromagnet.

- The **type of material in the coil's center** is important. If a piece of **ferromagnetic material**, such as iron (or steel that contains iron), is placed in the core of a solenoid, the magnetic field becomes much **stronger**.

Remember, these are MAGNETIC materials



YOUTUBE

- If the **size of the coil** (diameter) is **smaller**, then the field strength is more concentrated and the magnetic field is **stronger**. vs
- If the **number of coils** or turns of wire is **increased**, then the magnetic field of the coil will also **increase**. vs
- If the amount of **electrical current** (I) flowing through the coil is **increased**, then the magnetic field (B) will also be **stronger**.

I↑ = Stronger B

I↓ = weaker B

The iron used in a solenoid core must be of a type called "soft." This does not mean physically soft like putty. It is of a type of iron that demagnetizes quickly when the current in the solenoid is shut off and the magnetic field drops to zero.

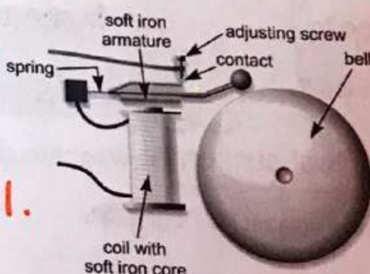
An iron core solenoid has many applications related to its ability to be a strong magnet that can be turned on and off.

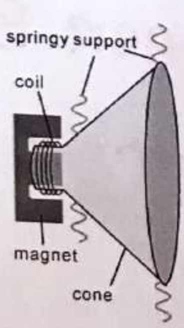
YouTube "Electro Lifting Magnets" (2.43 mins)

- Lifting electromagnets (used often in heavy duty mechanics) can **lift large ferromagnetic materials.**

- The electromagnet can attract a ferromagnetic metal to a contact point, and thus acts like a **switch**. Such a switch can be used to turn on high-currents circuits such as the bank of lighting in the Sky Dome in Toronto.
- In an electric bell, an electromagnet oscillates on and off causing a **bell to ring.**

like a school bell or ALARM or door bell.





- In magnetic speakers, a current is varied in a coil of wire in a magnetic field. The coil is attached to a speaker cone which moves back and forth **producing the sound.**