Chapter 4 Magnetic Field

4.1 Magnetic Field

4.2 The Biot - Savart Law

4.3 The Gauss's Law & The Ampere's Circuital Law

4.4 The Magnetic Forces on Current Conductors

4.5 The Motion of Charge in Magnetic Field

4.1 The Magnetic Field

Magnetism

- Ancient Greeks noticed that a piece of a mineral magnetite (an oxide of iron) had very special properties:
  - Could attract a piece of iron, but no effect on Au (gold), Ag (silver), Cu (copper), etc
  - Can attract or repel piece of magnetite depending on relative orientation

4.1 The Magnetic Field

Magnetism

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- By the 12th century people could build a magnetic compass.

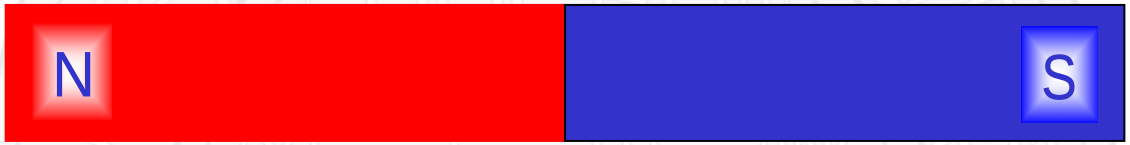
- A small magnetic needle is suspended so it can pivot around vertical axis.

- The needle will always come to rest with one end pointing North.

4.1 The Magnetic Field

Magnetism

- By definition we call that end “North” and the other “South”



- Like poles repel, unlike poles attract.
- North and South cannot be separated in a magnet.
- Magnetic forces can be pretty strong!

4.1 The Magnetic Field

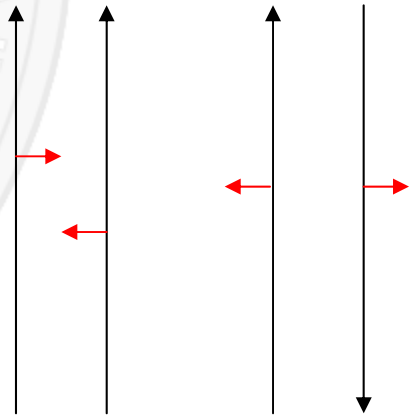
Magnetism

Show Ampere's Force

- The big step forward
- In 1820 Oersted realized that current flowing in a wire made the needle of a compass swing (rotating)
  - The direction depends on the direction of the current

BIG discovery: proves that Electricity and Magnetism are related!

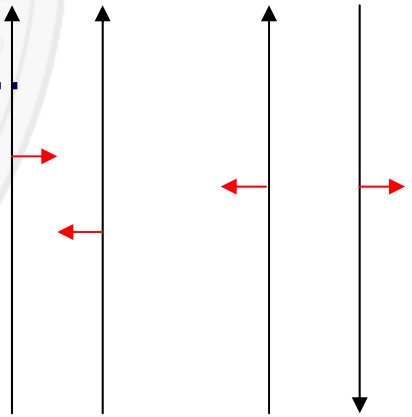
- Soon after, Ampere's experiment with parallel wires carrying current



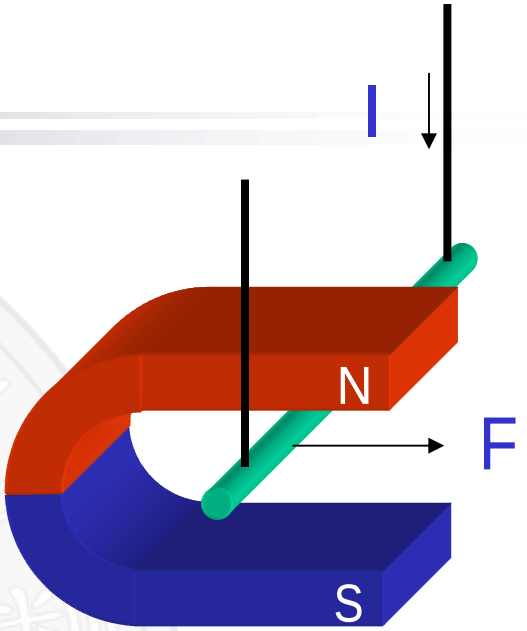
4.1 The Magnetic Field

Magnetism

- Soon after, Ampere's experiment with parallel wires carrying current
  - If currents are parallel, wires attract
  - If anti-parallel, wires repel
  - No force on a stationary charge nearby...
  - NB: wires are overall neutral!



4.1 The Magnetic Field

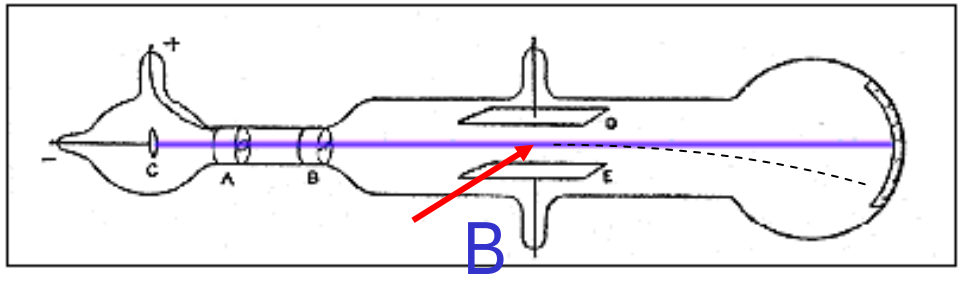


Magnetic Field

- Force on current by Magnet
  - If the direction of current changed, the direction of force changed
- Force on moving charge by Magnet
  - Move horizontally to right
  - Deflected down

Show Ampere's Force

Show Lorentz' s Force



4.1 The Magnetic Field

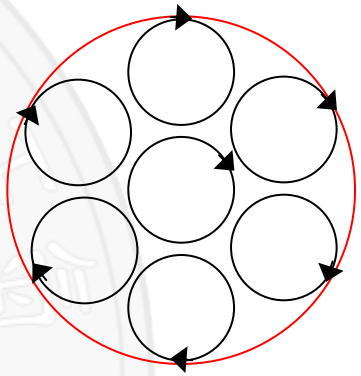
Magnetic Field

Magnet ⟷ Magnet

Magnet ⟷ Current

Current ⟷ Current

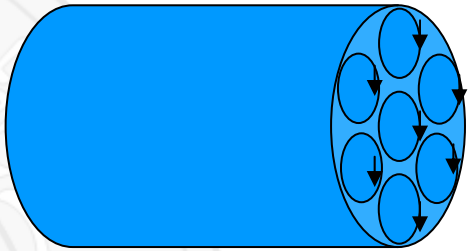
Magnet → Moving charge



4.1 The Magnetic Field

Magnetic Field

- Ampere hypothesis: All magnetic phenomena origined current

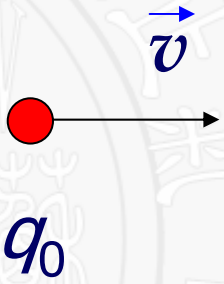


Magnetic field
From www.youtube.com

4.1 The Magnetic Field

The Definition of Magnetic Induction

- The force on moving charge depends on
  - The magnitude of $\vec{v}$
  - The direction of $\vec{v}$



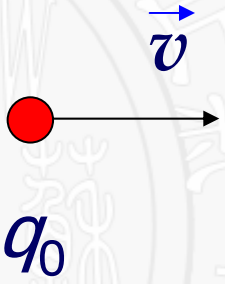
  - The direction of force is always perpendicular to the surface built by v and $\boldsymbol{B}$.
  - F_{max} will be maximum in a direction

4.1 The Magnetic Field

The Definition of Magnetic Induction

- The Definition of Magnetic Induction

$$B = \frac{F_{\max}}{q_0 v}$$



When B and v are at right angle, the force will be maximum

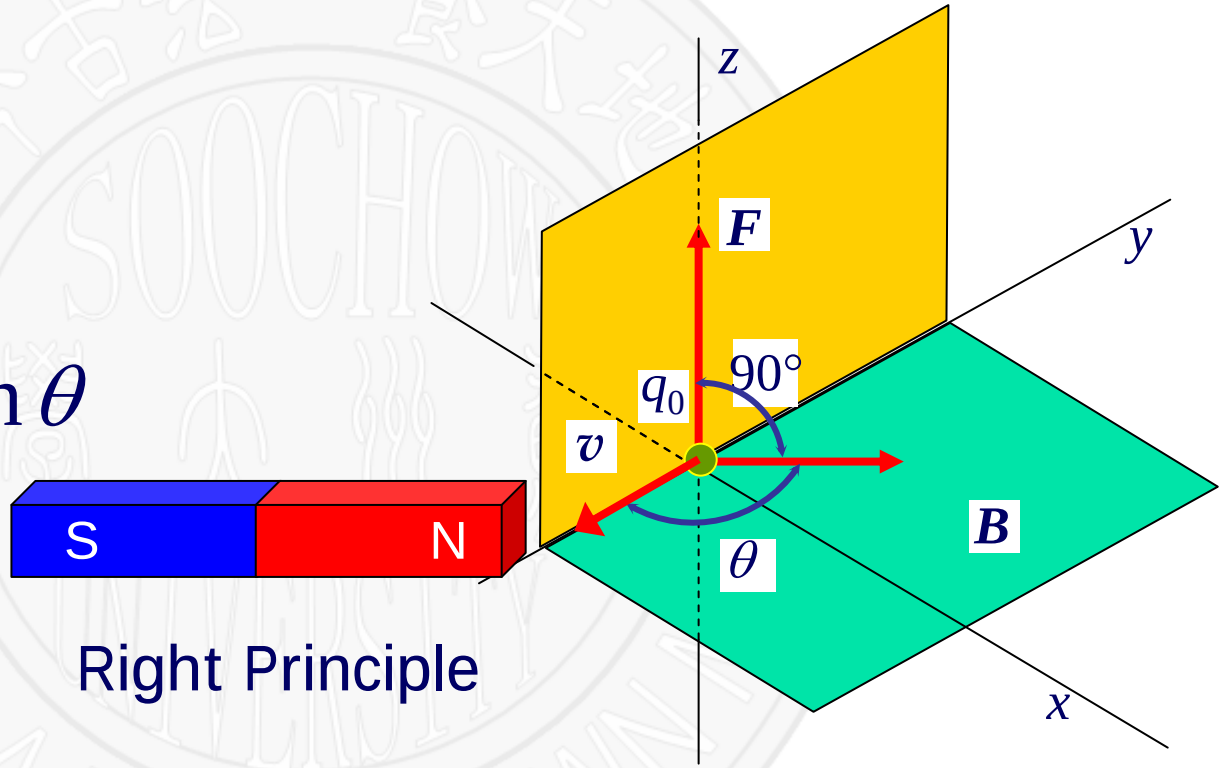
4.1 The Magnetic Field

The Definition of Magnetic Induction

- Lorentz Force

$$\vec{\mathbf{F}} = q\vec{v} \times \vec{\mathbf{B}}$$

$$F = qvB\sin\theta$$



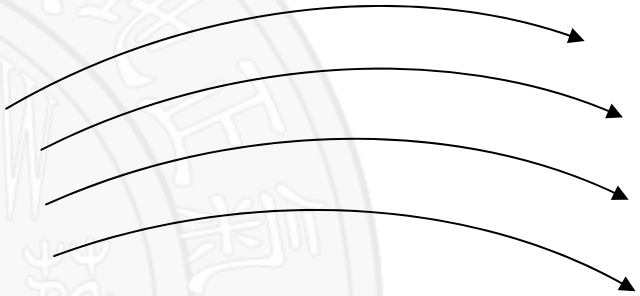
Right Principle

SI unit:1 tesla =1 weber/meter^2
= 1 Newton /(Ampere·meter)

4.1 The Magnetic Field

Lines of Magnetic Field (Lines of Induction)

- Properties of Induction Lines:



- The tangent to a line of induction gives *the direction of* ***B***
- The closer of the lines, the stronger of the field
- Lines of induction is closed
- Lines of induction never cross

Show B' lines

Show B' lines of solenoid

Magnetic field

From www.youtube.com

4.1 The Magnetic Field

Example 4.1 A uniform magnetic field ***B*** points horizontally *f*rom south to north; its magnitude is 1.5T. If a 5.0MeV proton moves vertically downward through this field, what force will *act on* it!

Solution: At first, let calculate the velocity of the proton

$$E_k = \frac{1}{2}mv^2 = 5.0\times10^6 \times 1.6\times10^{-19} = 8.0\times10^{-13}(J)$$

$$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2\times8.0\times10^{-13}}{1.7\times10^{-27}}} = 3.07\times10^7\, m/s$$

4.1 The Magnetic Field

According to the equation of Lorentz force

$$F = qvB\sin\theta = 1.6\times10^{-19}\times3.07\times10^{7}\times1.5$$

$$= 7.4\times10^{-12}(N)$$

Magnetite is a ferrimagnetic mineral with chemical formula **Fe3O4**, one of several iron oxides and a member of the spinel group. The chemical IUPAC name is **iron(II,III) oxide** and the common chemical name **ferrous-ferric oxide**. The formula for magnetite may also be written as FeO·Fe2O3, which is one part wüstite (FeO) and one part hematite (Fe2O3). This refers to the different oxidation states of the iron in one structure, not a solid solution.
The Curie temperature of magnetite is 858 K. Magnetite is the most magnetic of all the naturally occurring minerals on Earth, and these magnetic properties led to lodestone being used as an early form of magnetic compass. Magnetite typically carries the dominant magnetic signature in rocks, and so it has been a critical tool in paleomagnetism, a science important in discovering and understanding plate tectonics.

4.1 The Magnetic Field

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Magnesia (Greek: Μαγνησία, Magnisía, IPA: [maɣni□sia]), deriving from the tribe name Magnetes, is the name of the southeastern area of Thessaly in central Greece. The modern prefecture was created in 1947 out of the Larissa prefecture. About 70% of the population live in the Greater Volos area which is the second-largest city in Thessaly and the third busiest commercial port in Greece. Much of the population lives near the Pagasetic Gulf and in the eastern part.

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4.1 The Magnetic Field

The capital of Magnesia prefecture is the metropolitan city of Volos one of the most scenic and developed urban areas in Greece. Magnesia is located only half way between Athens and Thessaloniki. According to the most recent census carried out (2001), the population stands at 207,000. The capital of the prefecture is a metropolitan city consisting of three municipalities, the municipality of Volos with a population of around 95,000 (2001), the municipality of Nea Ionia with approximately 45,000 permanent and temporary citizens, and the municipality of Iolkos with around 3,500 citizens. Mount Pelion, the mountain of the Centaurs, generously offers natural beauty and spectacular views to its visitors. The peaks and the slopes of the mountain are decorated with small churches dedicated to saints and the Virgin Mary. In this quaint churches one can admire precious relics and post-Byzantine icons. The prefecture of Magnesia is as well proud of the Northern Sporades group of islands located at the East of mainland Magnesia. Skiathos island, famous tourist resort of the Mediterranean sea worldwide, along with the greenest island of the Mediterranean Skopelos, the ecological Alonissos with the national park of Mediterranean Monk Seals or Monachus monachus, and smaller islets comprises the summer paradise for over 2,000,000 million tourists every year.

Magnesia is represented in the Greek Parliament by five members.

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4.1 The Magnetic Field

In Greek mythology, the Trojan War was waged against the city of Troy by the Achaeans after Paris of Troy stole Helen from her husband Menelaus, the king of Sparta. The war is among the most important events in Greek mythology, and was narrated in many works of Greek literature, including the Iliad and the Odyssey by Homer. The Iliad relates a part of the last year of the siege of Troy, while the Odyssey describes the journey home of Odysseus, one of the Achaean leaders. Other parts of the war were told in a cycle of epic poems, which has only survived in fragments. Episodes from the war provided material for Greek tragedy and other works of Greek literature, and for Roman poets like Virgil and Ovid.

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4.1 The Magnetic Field

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4.1 The Magnetic Field

The war originated from a quarrel between the goddesses Athena, Hera and Aphrodite, after Eris, the goddess of strife and discord, gave them a golden apple, sometimes known as the Apple of Discord, marked "for the fairest". The goddesses went to Paris, who judged that Aphrodite, as the "fairest", should receive the apple. In exchange, Aphrodite made Helen, the most beautiful of all women, fall in love with Paris, who took her to Troy. Agamemnon, king of Mycenae and the brother of Helen's husband Menelaus, led an expedition of Achaean troops to Troy and besieged the city for ten years. After the deaths of many heroes, including the Achaeans Achilles and Ajax, and the Trojans Hector and Paris, the city fell to the ruse of the Trojan Horse. The Achaeans slaughtered the Trojans and desecrated the temples, thus earning the gods' wrath. Few of the Achaeans returned safely to their homes and many founded colonies in distant shores. The Romans later traced their origin to Aeneas, one of the Trojans, who was said to have led the surviving Trojans to modern day Italy.

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4.1 The Magnetic Field

The Ancient Greeks thought the Trojan War was a historical event that had taken place in the 13th or 12th century BC, and believed that Troy was located in modern day Turkey near the Dardanelles. By modern times both the war and the city were widely believed to be non-historical. In 1870, however, the German archaeologist Heinrich Schliemann excavated a site in this area which he identified as Troy; this claim is now accepted by most scholars.[1][citation needed] Whether there is any historical reality behind the Trojan War is an open question. Many scholars believe that there is a historical core to the tale, though this may simply mean that the Homeric stories are a fusion of various tales of sieges and expeditions by Mycenaean Greeks during the Bronze Age. Those who believe that the stories of the Trojan War derive from a specific historical conflict usually date it to the 12th or 11th centuries BC, often preferring the dates given by Eratosthenes, 1194–1184 BC, which roughly corresponds with archaeological evidence of a catastrophic burning of Troy VIIa

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