Chapter 36 & 37: Magnetism and Electromaagnetic Induction

What you will learn:

- You will relate magnetism to electric charge and electricity
- You will describe how electromagnetism is harnessed to produce mechanical work

Why it's important:

- Using electromagnetism in electric motors, you can convert electrical energy to mechanical energy
- Every day, you apply mechanical energy produced from electrical energy

State Standards Addressed

Electric and Magnetic Phenomena: *Electric and magnetic phenomena are related and have many practical applications. As a basis for understanding this concept:*

- *Students know* magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.
- *Students know* how to determine the direction of a magnetic field produced by a current flowing in a straight wire or in a coil.
- *Students know* changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.

I. Historical Background

A. The term _____ comes from region of Magnesia, a province in Greece, where certain stones (_____) had the unusual property of attracting pieces of iron

B. The _____ were first to fashion magnets into **compasses** in the 12th century

C._____ explores brought back knowledge in 1500's

D. In 16th century, _____ (Queen Elizabeth's physician) mad **artificial** _____ by rubbing pieces of iron against lodestone and suggested that a compass always points north and south because the _____ **has magnetic properties**.

E. In 1750, _____ in England found that magnetic poles obey the _____**,** and his results were confirmed by **Charles** _____**.**

F. Hans Christian _____ discovered that an electric current affects a magnetic compass. He saw that **magnetism was**

G. Shortly thereafter, the French physicist Andre-Marie **Ampere** proposed that _____ are the source of all **magnetic phenomena**.

II. Magnetic Properties

A. Magnetic Poles

1. A magnet is _____ (it has two ends)

a. North-seeking **pole-** points _____

b. South-seeking **pole-** points _____

c. Poles are located at the____ of the magnets

2. Like poles _____ and **unlike** _____ (just like forces between electric charges)

B. Magnetic Forces

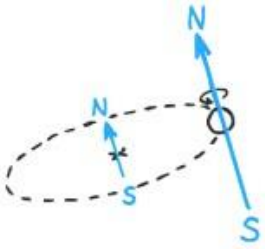
1. Are _____ to electric forces

a. Can both attract and repel

b. _____ of **magnetic interaction** depends on the **distance** between the two magnets

2. Whereas electric charges produce electric forces, regions called _____ give rise to magnetic forces

C. Permanent magnets



1. Caused by **motion of electrons** within the material (both _____ and _____)

a. Electrons spinning in _____ direction make up a **tiny magnet**.

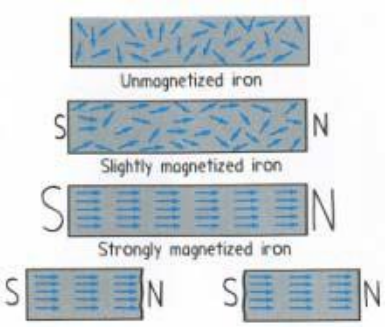
b. A pair of electrons **spinning in** _____ **directions** work against each other and **magnetic fields cancel**

2. In materials such as iron, each atom has four electrons whose **spin magnetism is** _____**.**

a. Each iron atom is tiny magnet

b. The magnetic fields from groups of atoms can add together. These are called _____ (10^{20} atoms)

c. When piece of iron is not in a magnetic field, the domains do not all point in same direction



d. When iron placed in **magnetic field**, **domains** tend to _____ with the **external field** producing a _____ **magnet**. After removing from field domains return to random arrangement.

e. In _____**magnets**, the iron has been **alloyed** with other substances (aluminum, cobalt, nickel) that keep domains aligned after external magnetic field is removed

D. Magnetic Fields

1. Magnetic forces can be described by existence of ***magnetic fields*** around the magnets

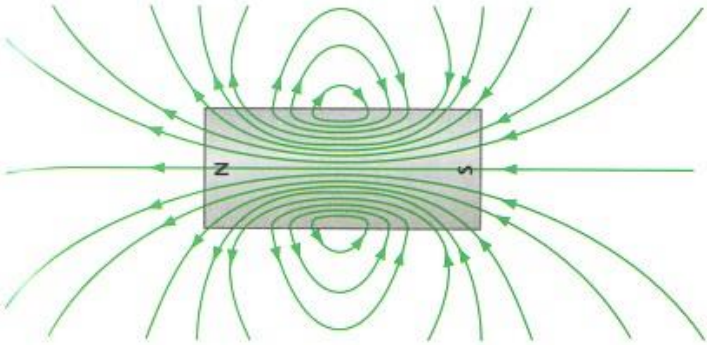
a. These lines are _____

b. Help **visualize** the field and provide _____

1). magnetic flux-
_____
_____

2). The____ **per unit area** is **proportional** to the_____ of the **magnetic field**

2. Field lines **come out N-pole** of magnet and **enter magnet at its S-pole**.



3. Field lines **continue through** the **inside** of the magnet.

4. Field lines always form _____

5. Magnetic fields exert forces on other magnets

a. __-pole of one magnet pushes N-pole of another magnet.

b. __-pole of one magnet attracts S-pole of another magnet.

III. Electromagnetism

A. In 1820, Hans Christian **Oersted** discovered that _____

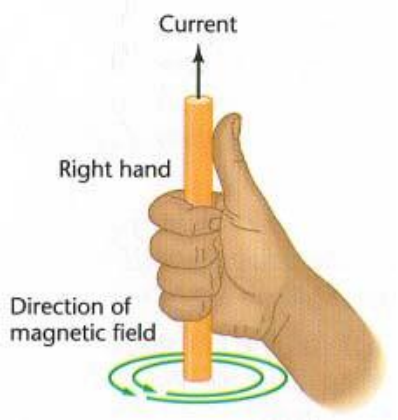
B. Magnetic field near a current-carrying wire

1. Force is _____ to direction of current in wire

2. Magnetic field lines form _____**circles** around the wire (closed loops)

a. Strength of magnetic field is **proportional** to the _____

b. Strength of field varies **inversely** with the _____ from the wire



3. First right-hand rule- *allows you to find the direction of the field around a wire*

a. Thumb points in **direction** of **conventional current (+ flow)**

b. Fingers of hand **circle** the wire and point in **direction of magnetic field**

C. Magnetic field near a coil

1. An electric current in a single circular loop of wire forms a magnetic field all around the loop

2. When wire looped several times to form a coil and current is allowed to flow- **field** around all the loops is always in _____

a. _____**-***long coil of wire with many loops*

b. Field of each loop adds to fields of other loops

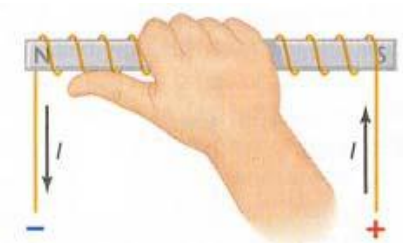
3. Electric current in a coil of wire has a **field** like that of a _____ (has N and S poles)

a. called an _____

b. Strength of **field** is **proportional** to **current** in coil

c. Can increase strength by placing an iron rod inside the coil. The field inside the coil magnetizes the core. These add together

4. **Direction** of **field** produced by electromagnet can be found using the ***second right-hand rule***



a. Imagine holding insulated coil with you right hand

b. Curl fingers around loops in the **direction** of the **conventional current** (+ flow)

c. Thumb points toward the N-pole of the electromagnet

IV. Forces Caused by Magnetic Fields

A. Forces on currents in magnetic fields

1. Michael _____ (mid 1800's) discovered that the **force** on a wire is at **right angles** to the **direction of the magnetic field.**

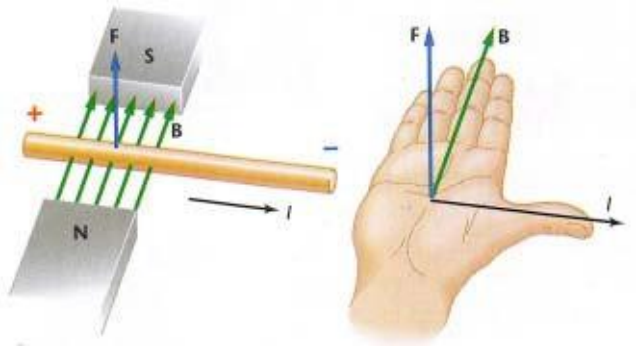
2. Force is also at _____ to the **direction** of the **current**

B. Use third right-hand rule to determine direction of force

1. Point _____ of right hand in **direction** of **magnetic field.**

2. Point _____in **direction** of **conventional (+) current**

3. _____ **of hand** points in **direction** of **force** acting on the wire



C. Magnitude of force (F) on wire is proportional to 3 factors

1. The strength of field *(B)*

2. The current *(I) in the wire*

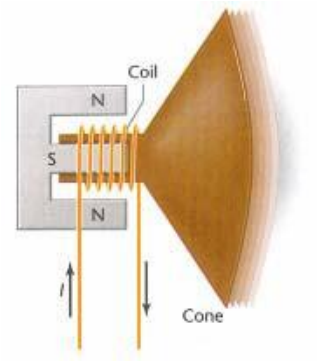
3. The length (L) of the wire that lies in the magnetic field

Equation:

Measured in ***teslas (T)*** ***1 T = 1 N/A·m***

V. Applications of Magnetic Force

A. Loudspeakers



1. Changes _____ energy into _____ energy

2. Uses a coil of fine wire mounted on a paper cone and placed in a magnetic field

3. Amplifier driving loudspeaker sends _____through the _____

4. The **current** _____ **direction** between 20 and 20,000 times each second, depending on the pitch of the tone it represents.

5. A _____, exerted on the coil because it is in a magnetic field, **pushes** the coil either **into or out of the field**, depending on the **direction of the current**

6. The _____ of the **coil** causes the **cone to vibrate, creating sound waves in the air**

B. Galvanometer

1. Device used to _____

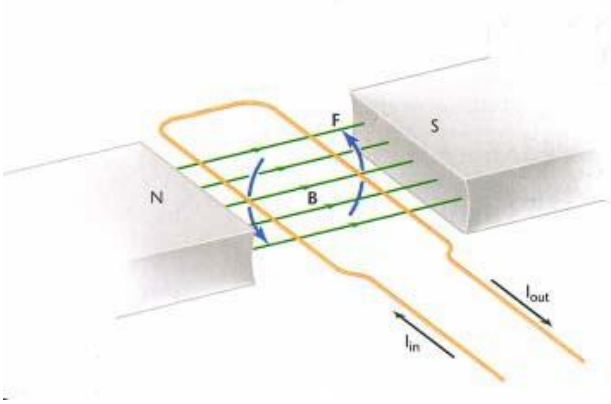
2. Used in **voltmeters and ammeters.**

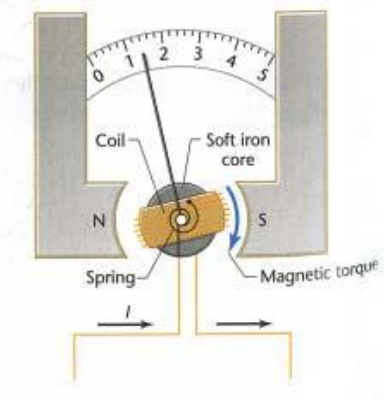
3. A small loop of current carrying wire is placed in a strong magnetic field

4. One side of loop forced down and the other side is forced up (third right-hand rule)

5. Magnitude of **torque** acting on the loop is proportional to the magnitude of the _____

6. A small spring in the galvanometer exerts a torque that opposes the torque resulting from the current; thus, the **amount of** _____ **is proportional to the current**





C. Electric Motor

1. Apparatus to convert _____ energy **to** _____ **energy**

2. Must rotate **360°**, therefore the **current** must _____direction just as the loop reaches its vertical position- allowing it to continue rotating.

a. To reverse direction, a **split-ring commutator** is used.

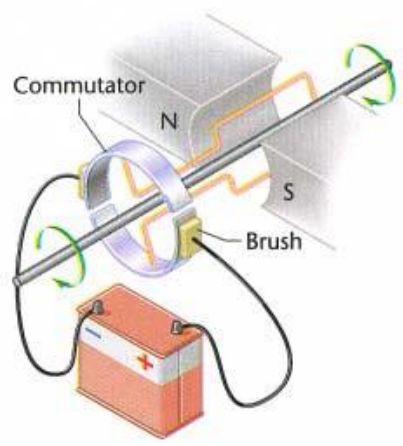
b. _____(pieces of graphite) make **contact** with the **commutator**, allowing current to flow into the loop

c. The split ring is arranged so that each half of the commutator changes brushes just as loop reaches vertical position.

d. Changing brushes _____ current in the loop- resulting in changing of forces acting on the loop- allowing loop to continue to rotate

e. _____**-** *many loops of wire mounted on a shaft in electric motor.* Total force proportional to ***nBIL***

*(**n** = total turns on armature, **B** is strength of magnetic field, **I** is the current, and **L** is length of wire in each turn that moves through the magnetic field)*



D. The Force on a Single Charged Particle

1. Charged particles do not have to be confined to a wire, but can move in any region as long as the air has been removed to prevent collisions with air molecules

2. The picture tube (or cathode ray tube) in a TV uses

electrons deflected by magnetic fields to form the pictures to be viewed.

a. In the tube, electrons are pulled off of atoms by electric fields at the negative electrode, or cathode.

b. Other electric fields gather, accelerate, and focus the electrons into a narrow beam.

c. Magnetic fields are used to deflect the beam back and forth and up and down across the screen of the tube.

d. The screen is coated with a phosphor and glows when struck by the electrons, producing the picture