Unit 2: Magnetism and Electromagnetism

by Leah M. Akins

based on Electrical Motor Control Systems by Patrick and Fardo

Magnets vs. Electromagnets

- **Magnets:**
  - **→are made from special materials which retain their magnetism**
  - **→provide a constant magnetic field**
- **Electromagnets:**
  - **→magnetism is controlled by an electric field**
  - **→provides a variable magnetic field**

Magnetic Theory

- **A *magnetic field* can be:**
  - **→produced between magnetic north and south poles.**
  - **→Induced by an electric field.**
- **The magnetic field is made up of lines of *magnetic flux (ƒ)* in the direction from North to South.**
- **When flux lines are close together, the magnetic field is strong.**

Magnetic Theory

- **Magnetism Law - parallel to law of electric charges**
  - **➔Like poles repel**
  - **➔Unlike poles attract**
- **Magnetic flux lines come out of the north pole.**
- **Magnetic flux lines enter at the south pole.**

Magnetic Theory

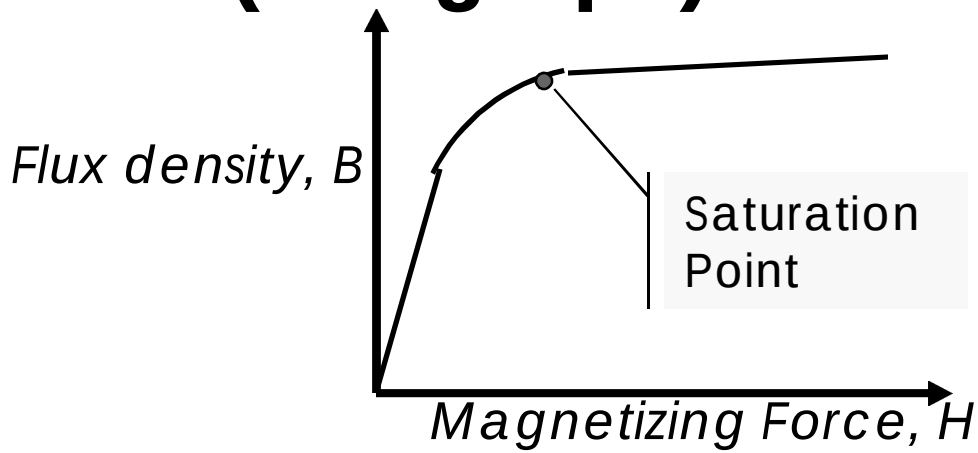
- ***Domain Theory of Magnetism***
  - **➔Explains the magnetic properties of materials.**
  - **➔A *domain* is a group of atoms (about 10^{15} atoms).**
  - **➔Within a domain, electrons are believed to spin in the same direction thus creating a small magnetic field.**
  - **➔Figure 5-12 shows the arrangement of domains in varying materials.**

Magnetic Properties

- ***Permeability (μ)*** **- the ability of a magnetic material to transfer magnetic flux.**
  - **➔A material with high permeability can be easily magnetized (and demagnetized).**
  - **➔Example: soft iron.**
  - **➔*Relative permeability (μ_r)* - comparison of the permeability to that of air.**

Magnetic Properties

- ***Retentivity*** **- the ability of a material to retain a magnetic flux after the magnetizing force is removed.**
- ***Magnetic Saturation*** **- describes when maximum alignment of domains takes place in a material. (see graph)**



Permanent Magnets

- **Each end of the magnet is a *pole*.**
- **Made from iron, cobalt, nickel, or mixture of these (called an *alloy*).**
  - **➔These materials have a high retentivity.**
  - **➔Can lose magnetism through jarring and heat.**
  - **➔Should be stored with a *keeper* which provides an easy flux path between poles.**
- **See Fig. 5-1 for field lines of a bar magnet.**
- **What do you think the magnetic field lines of the horseshoe magnet look like?**

Magnetic Fields and Current

- **Current-carrying conductors produce a magnetic field.**
- **Conductors in the presence of a changing magnetic field, produces a current.**
  - **➔Faraday's Law: When a coil of wire moves across the lines of force of a magnetic field, electrons flow through the wire in one direction.**
  - **➔The operation of electrical generators depends on *electromagnetic induction* (induced current in conductors moving across a magnetic field).**

Current and Field Directions

- **The *left-hand rule of magnetic flux*:**
  - **➔When holding the conductor in the left hand with the thumb pointing in the direction of electron current flow, the fingers are in the direction of the magnetic field.**
  - **➔When wrapping the fingers of your left hand around a wire coil in the direction of electron current, the thumb points in the direction of the north pole.**
- **Flux lines in a coil?**

Electromagnets and Electromagnetism

- **Electromagnets are made from a coil of wire around a magnetic core material.**
- **The magnetic strength is directly proportional to three factors:**
  - **→the amount of current applied**
  - **→the number of turns in the coil**
  - **→the permeability of core material (affects flux density)**
- **Magnetic Strength = *I* X *N***

Relays

- **Electrical devices that rely on magnetism to operate.**
- **Used to control other equipment by using a small amount of electrical current to control a larger current, such as the current through a motor.**
- **See Figure 5-14.**

Current Ratings for Relays

- ***Pickup Current*** **- the minimum current required to energize the relay.**
- ***Dropout Current*** **- the minimum current that will keep the relay energized.**
- ***Contact Current*** **- the maximum current that can safely flow through the contact circuit.**

Solenoids

- **Functions as a relay, but instead of moving a contact, a plunger is moved.**
  - **➔When the solenoid is energized, it moves the plunger in the center.**
  - **➔When the solenoid is de-energized, a spring pulls the plunger back.**
- **See Figure 5-16.**

The End

- **Activity**
  - **➔Exploratory Learning Activity on Motors**
- **Homework**
  - **➔Read Chapter 5**
  - **➔Chapter 5: All review questions, p. 102**