Chapter 17 Notes

Section 17.1

**Electric Current and Magnetism**
Hans Christian Øersted (1819), a Danish physicist and chemist
- compass needle near a wire circuit and with current flowing through the wire,
  He noticed that the compass needle moved just as if the wire were a magnet.

When the switch is off, the compasses all point north

**Magnetism is created by moving charges.**

The compasses point in a circle as long as there is current in the wire.

The magnetic field of a straight wire
The direction of the field depends on the direction of the current in the wire.
The ___________________________ can be used to tell how the magnetic field lines point.
When your thumb is in the direction of the current, the fingers of your right hand wrap in the direction of the magnetic field.

**Field Strength – 2 Factors**
1. The strength is directly proportional to the current, so doubling the current doubles the strength of the field.
2. The field strength is inversely proportional to the distance from the wire.

The field gets stronger as you move ________________ to the wire.
Decreasing the distance to the wire by half, ________________ the strength of the field.
The magnetic field of loops and coils

2 ways to make strong magnetic fields from reasonable currents in small wires.
1. Parallel wires placed side-by-side can be ___________________.
   So 10 wires, each carrying 1 amp of current, create ________________ as strong a magnetic field.

2. A single wire can be looped into a ___________________, concentrating the magnetic field at the coil’s center.
   - The total magnetic field is the sum of the fields created by the current in each individual loop.
   - A coil with _____________ of wire carrying 1 amp creates the same magnetic field as a single-wire loop with _____________ of current.
   - Easier & SAFER to work with 1 amp vs. 50 amps.

Coils and solenoids
A coil concentrates the ___________________ at its center.
When a wire is bent into a circular loop, field lines on the inside of the loop squeeze together.
Field lines that are ___________________ indicate a higher magnetic field.
Field lines on the outside of the coil spread apart, average field strength is lower outside than inside.
A ________________ is an electromagnetic device is a coil with many turns.

Where coils are used
Solenoids and other coils are also used in speakers, electric motors, electric guitars.
Coils are the most efficient way to make a strong magnetic field with the least amount of current.

Magnetic forces and electric currents
The force between two coils
Two coils carrying electric current exert forces on each other, just like _____________ do
Section 17.2

Electric Motors
Permanent magnets and electromagnets work together to make electric motors and generators. _______________ convert electrical energy into mechanical energy.

Using magnets to spin a disk
Imagine a spinning disk with magnets
The magnet attracts one of the magnets in the disk and repels the next one. These attract and repel forces make the disk spin a little way around. The disk is called the ___________ because it can rotate.

How the electromagnets in a motor operate
In an electric motor, an electromagnet replaces the magnet you reversed with your fingers. The switch from north to south is done by reversing the _______________ in the electromagnet.

The _______________ is a kind of switch
As the rotor spins, the commutator _______________ the direction of the current in the electromagnet. This makes the electromagnet’s side facing the disk change from _______________, and then back again. The electromagnet attracts and repels the magnets in the rotor, and the motor turns.

3 Things
All types of electric motors must have three parts:
1. A rotating part (rotor) with magnets that alternate.
2. One or more fixed magnets around the rotor.
3. A commutator that switches the direction of current in the electromagnets back and forth in the right sequence to keep the rotor spinning.

AC motors
Motors that run on AC electricity are easier to make because the current switches __________ all by itself. Almost all household, industrial, and power tool motors are ___________ motors. These motors use electromagnets for both the ___________ & ___________ magnets.

The electromagnets are in the rotor, and they turn. The rotating part of the motor, including the electromagnets, is called the ___________ As the rotor spins, the three plates come into contact with the positive and negative ___________. Electric current passes through the brushes into the coils. As the motor turns, the plates rotate past the brushes, switching the electromagnets from north to south by reversing the positive and negative connections to the coils. The turning electromagnets are attracted and repelled by the permanent magnets and the motor turns.
Section 17.3

Electric Generators and Transformers

Motors transform electrical energy into mechanical energy.
Electric ______________________ transform mechanical energy into ____________________ energy.

Electromagnetic Induction

An electric current in a wire creates a _______________________.
Therefore, you can use a moving magnet to create electric current or voltage is called: _______________________.
A moving magnet induces ________________________ to flow in a circuit.

-When the magnet moves _________ the coil of wire, as the magnet is moving, electric current is induced in the coil and the meter swings (______).
  The current stops if the magnet stops moving.

-When the magnet is _______________ out again, as the magnet is moving, current is s induced in the opposite direction. The meter swings (______).
  The magnet stops moving, the current also stops.

The coil has to be close to the magnet for any current to be induced.
It has to be close enough that the _______________ from the magnet passes _____________ the coil.
The induced current depends on the _______________ of magnetic field actually passing through the coil.
Adding an iron core helps because iron amplifies the magnetic field and directs it through the coil.

-Current flows because a ________________________________ is created between the ends of the coil.
A moving magnet induces a voltage difference between the ends of the wires that make the coil.

Faraday’s Law - (Michael Faraday (1791-1867), an English physicist and chemist)
The induced voltage or current depends on how _______________ the magnetic field through the coil changes.

The voltage induced in a coil is proportional to the rate of change of the magnetic field through the coil.

= If the magnetic field does not change, no voltage is produced even if the field is very strong.

Induced current/voltage, work, and energy

As a magnet is pushed through a coil of wire, current is induced to flow and voltage develops.
The induced current in the coil makes its own magnetic field that tries to push your magnet back out again.
You have to push the magnet in or out, doing work, to supply the energy that makes current flow.
Again, Conservation of ________________________________.
Generating Electricity
A ______________________converts mechanical energy into _______________________________.

When a north pole is approaching, the current is in one direction.
After the north pole passes and a south pole approaches, the current is in the ________________________.
As long as the disk is spinning, there is a changing magnetic field through the coil and electric current is created. The generator shown above makes ___________________________.

It is impossible to make a situation where the _____________________________ keeps increasing (becoming more north) forever. Eventually the field must stop increasing and start decreasing.

Energy for generators
You must keep the rotating coil (or magnetic disk) turning to create electricity.
In hydroelectric generator, ________________________turns a turbine. Windmills do the same.
Power plants use ______________________________to heat water to high temperatures & high pressures.
The steam then spins turbines.

Electric Power Transformers
Electricity is transmitted at high voltage ~ __________________volts in high tension wires.
The voltage in your wall outlet is 120 volts.

A transformer can take one amp at 13,800 volts from the power lines outside and convert it.
The total electrical power _________________________ because 13,800 V × 1 A = 120 V × 115 A.

Transformers operate on electromagnetic induction
The two coils are called the __________________________________. The input to the transformer is connected to the primary coil. The output of the transformer is connected to the secondary coil. The two coils are wound around an iron core. The core concentrates the magnetic field lines through the centers of the coils.

How a transformer works
Consider the transformer between the outside power lines and your house:
1. The primary coil is connected to outside power lines.
   Current in the primary coil creates a magnetic field through the secondary coil.
2. The current in the primary coil changes constantly because it is alternating current.
3. As the current changes, so does the strength and direction of the magnetic field through the secondary coil.
4. The changing magnetic field through the secondary coil induces current in the secondary coil.
   The secondary coil connects to your home’s wiring.
The number of turns determines:
1. The strength of an electromagnet’s magnetic field
2. Induced voltage
3. Induced current

Transformers work because there are a different number of turns in the primary and secondary coils. Eg. In the same changing magnetic field, a coil with 100 turns produces ten times the induced voltage or current as a coil with 10 turns.

Voltage and current
Stepped Down – primary coil has more turns than the secondary coil - _______________________ voltage.
Stepped Up - secondary coil has more turns than the primary coil - _________________________ voltage.

Because of energy conservation, the power (voltage \times current) is the same for both coils.

Problems:
1. When you plug in a cell phone, a transformer on the plug changes the outlet’s 120 V to the 6 V needed by the battery. If the primary coil has 240 turns, how many turns must the secondary coil have?

2. A transformer has 20 turns on the secondary coil and 200 turns on the primary. What is the secondary voltage if the primary voltage is 120 volts?

3. How many turns must the primary coil have if it steps down 13,800 volts to 120 volts with 112 turns?
Computers
Almost every piece of electronic equipment, from VCRs to cell phones, to microwave ovens, has at a tiny computer called a microcontroller. Computers have a memory that allows them to store information. Computer memory and quick access to the information in memory are part of why computers are so useful.

It’s all about information
The working of a computer can be broken down into 3 basic steps
1. putting information in
2. processing information
3. sending information back out.
Today there are many ways to input information: the mouse and keyboard, digital cameras, scanners, microphones, touch screens, and bar code readers.

The long and the short of it
The two basic types of computer memory are: 1) short-term and 2) long term.
Short-term memory is erased when the power is turned off.
Long-term memory retains its information even with no power.
Programs use various languages such as C++ or Java to create complex lists of instructions that tell the computer what to do with the information in its memory.
Short-term memory is thousands of times faster than long term memory, but also much smaller.

1-0-1-0-1-0
Almost all computers use magnetic disk drives (hard drives) for __________ term memory.
A hard drive is actually one or more circular plates made of glass or metal covered with a fine layer of __________. The Read/Write Head uses a miniature coil to “write” information on the disk as a sequence of magnetic north and south poles. When electricity is passed through the coil, a magnetic field is produced. This magnetic field causes the magnetic film on the surface of the disk to “record” the polarity of the field. Since each spot on the disk can only be north or south, all information must be represented as on or off, like a switch. Schematically, a north pole means “on” while a south pole means “off”.

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When you activate a program, the computer loads the program from long term memory into short term memory where information can be used quickly. When the program is done, the computer erases it (and its data) from short term memory, freeing up this faster memory for other programs.

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The on-or-off language is called __________. Like a switch that can be turned “on” and “off,” there are only two digits in the language: 0 and 1. In computer terms the word bit stands for “binary digit.” The binary language is used by all computers to store information. Eight bits form a __________. A code represents each letter or number as a different one byte sequence of 0s and 1s. The diagram shows how the word ‘face’ is represented by 4 bytes or 32 bits. The binary code language used here is called the ASCII Code.
To read information, the changing magnetic poles on the disk induce tiny voltages on the coil in the read/write head as the disk spins. The voltages are amplified and turned into digital ones and zeros that are stored in short term memory (RAM).

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The future of computer memory
Words and numbers are relatively compact in terms of storage. A single digitized picture can take up 5 MB, or 50 x more memory. Scientists are investigating the possibility of storing information on a protein found in a bacterium. Different twisting forms of the protein are used to record digital ones and zeros. Since proteins are so small it may be possible to get 100 or 1,000 times as much information into the same space used by a conventional hard drive today.