

Chapter 6: Electricity & Magnetism

Outline:

I. Electricity

1. Static Electricity
2. current, voltage, power
3. Conductors, Semi-conductors, Insulators, Superconductors

II. Magnetism

1. Permanent magnets, Electromagnets, Earth
2. Electric Generator
3. Transformers

III. Household Electricity

I. Electricity

I. 1. Static Electricity

- Rubbing certain materials against each other makes them charged
- Force between charges gets weaker with distance, like gravity. However, it's much stronger.

I. 2. Current, voltage, power

- current:
 - moving charges are called "current", measured in "Amps". Tells us how much charge is moving through a wire per second.
- voltage:
 - energy per charge is the "voltage", measured in "Volts".
- both can be either constant (DC) or always changing (AC).
- power: $\text{power} = \text{voltage} \times \text{current}$, or in units: $\text{Watts} = \text{Volts} \times \text{Amps}$, so for high power, both voltage and current have to be high
- dangerous: high power is dangerous, while high voltage by itself is not. However in our homes we want to transform to low voltage because the power we get is at a dangerous level (which is why you shouldn't touch a socket) and if we had all this power with high voltage, then sparks would fly from the socket to you, which is dangerous.

I. 3. Conductors, Semi-conductors, Insulators, Superconductors

- resistance is the friction between the material and the moving charges, it tells us how hard it is to make charges move in the wire
- we can categorize materials by their resistance
- Conductors (also called metals): low resistance, good for moving charges, we use them for wires.
- Insulators: high resistance, good for insulating against current, because it cannot flow in the material

- Semi-conductors: can sometimes be a conductor, sometimes an insulator, depending on temperature and other things
- Superconductors: no resistance at all, current can flow completely uninhibitedly, only work at very low temperatures (4K)
- High temperature superconductors: the same but they work at higher temperature (150K)

II. Magnetism

II. 1. Permanent magnets, Electromagnets, Earth

- all magnetism is created by moving charges
- in electromagnets the magnetism is created by charges moving in the form of a current (Amps) through a wire.
- in permanent magnets it is created by electrons spinning around their own axis, and all of them spin in the same direction. In normal materials electrons spin as well but all in different directions so all the magnetism cancels. Above a certain temperature (Curie temperature) a permanent magnet loses its magnetism
- Earth is a magnet whose magnetism comes from liquid iron flowing in the core, acting as a kind of dynamo. Earth's magnetic poles flip every 1 million years or so.
- rare earth magnets are very small, light and strong magnets which made possible small earphones.

II. 3. Electric Generator

- in general: a generator produces electricity in a wire by moving it past a magnet.
- special case: a dynamo is a generator which moves the wire past an electromagnet which is powered by the electricity that the dynamo itself produces

II. 4. Transformers

- in general: transforms voltages from high to low or vice versa, but only if it is AC electricity.
- special case: Tesla coil is a transformer that transforms to very high voltages

III. Household Electricity

- we use high voltage in power lines because it means less current for the same power. Less current means less heating of the wires and therefore less energy lost to heat
- but since it's fairly high power, high voltage would be dangerous in the house because sparks could fly from sockets and shock you with the same power as if you would touch the socket
- so we use the transformers to reduce voltage to 110 Volts, alternating at 60 Hz