Lecture 5
Electricity and Magnetism

2 Aspects of the Same Force

Wave Motion:

Wave motion is different from projectile motion. (mechanics)

A wave is a disturbance that travels through a medium, and that transfers energy without transferring matter.

Electric Charge Described:

- can be negative(-) or positive(+)
- is carried by subatomic particles (pieces that make up atoms)
- is determined by the # of <u>electrons</u>

  excess negative, deficit positive
- Electricity can flow or be static

(A current is a flow of electrons & static electricity is a cloud.)

Maxwell’s Equations summarize Electromagnetism

In 1861 James Clerk Maxwell published 4 postulates (laws)

He built on what others had already begun to establish

1st Equation (Charles Coulomb's work) Describes the nature & magnitude of electric force

- Like charges repel each other; unlike charges attract.

- Between any two charged objects is a force proportional to the size of the two charges, divided by the square of the distance between them.

(1st law)

Electric Force (F_e) resembles gravitational force:

F_e is proportional to

$$\frac{(q_1) \times (q_2)}{d^2}$$

Charge of object one

Charge of object two

where : q_1 & q_2 are the charges and d is the distance between them

The 2nd law describes magnets.

- There are no isolated magnetic poles. (Unlike electric charge which can exist as a negative or a positive charge alone.)

- Magnetic poles react to other poles the way charges react to each other : like repel like & opposites attract.

3rd law states the link:

- Moving electric charge creates magnetic fields.

(Where you have electricity you will have magnetism as well as the reverse)

Where electrical current flows there is a perpendicular magnetic field.

If you reverse the current you reverse the poles of the field.

The more coils of electrical conducting wire, the stronger the magnetic field created.

4th Law Magnetic effects can accelerate electrical charge.

(electromagnetic induction)
If you change the magnetic field in the region of an electrical wire, electrons flow. You can generate electric current or induce magnetism

Electricity

- Positively or negatively charged particles that flow can be called an electrical current, though in everyday life it refers to electrons (negative charges) flowing in a circuit: electricity.
- Circuit: continuous path of material through which electrical current can flow. (copper wires, for example)
- Amp (ampere) is the unit of flow, how many charges go by a point in a second
- Electrical potential (volts) : the amount (pressure) of electrons that can be pushed through a wire
- Circuits can conduct the electrical current, but a source is needed to push the electrons (generator or a battery)

The 3rd and 4th law reveal electromagnetic radiation (spectrum of light waves)

- The nature of light is sometimes a particle and sometimes a wave because of this relationship
- Energy waves radiate out from a source and can be differentiated

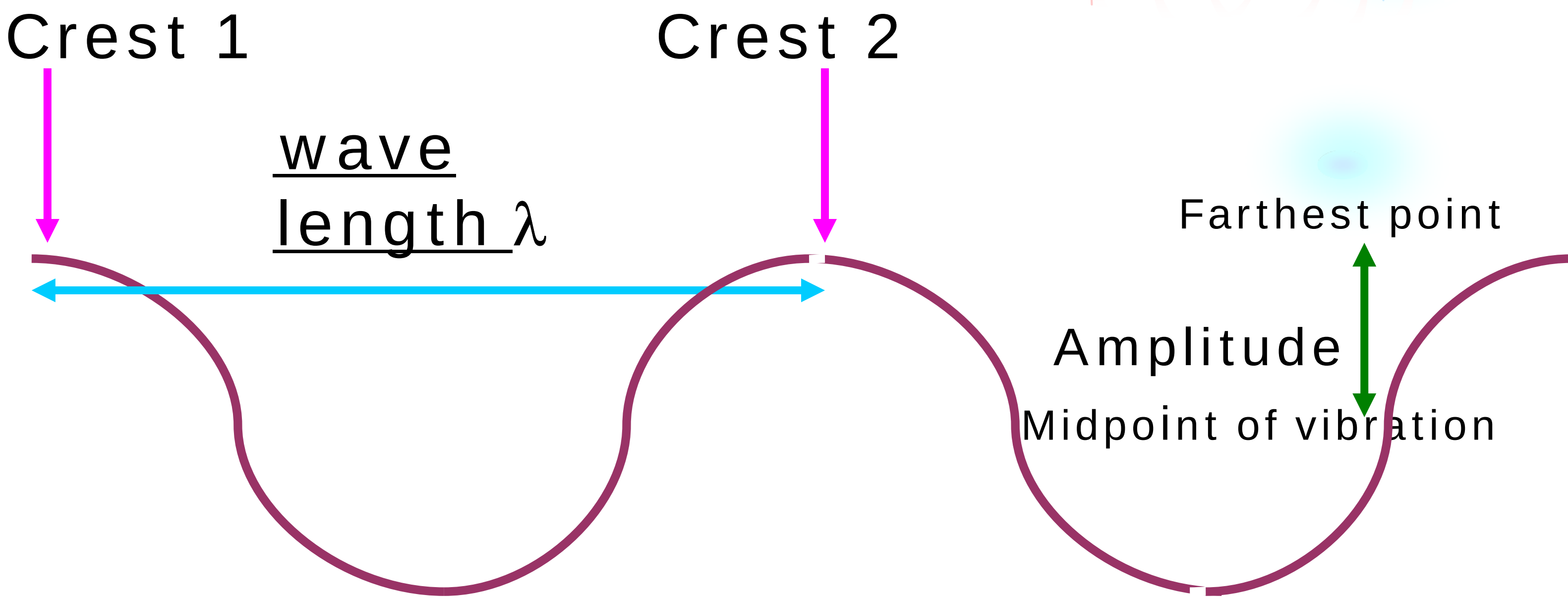
Electromagnetic waves are characterized by speed, $\upsilon = f \lambda$

wave length (λ) : distance from crest to crest

frequency (f) : how many crests pass a point in a second or vibration per second (equal to source frequency: Hertz: one crest a second)

amplitude: width of vibration

speed (υ) : movement defined by $\upsilon = f \lambda$
speed at which the disturbance moves through the medium


Crest 1
Crest 2
wave length λ
Farthest point
Amplitude
Midpoint of vibration

Frequency and energy are linked; size and frequency are linked.

Electromagnetic waves travel at the speed of light:

1.86×10^5 miles per second

(3.0×10^5 kilometers/second)

All are produced by moving electromagnetic fields.

- <u>Radio Waves</u>

λ= yards to thousands of miles, not absorbed by air, ideal for communication

- <u>Microwaves</u>

λ= 0.1”-1 foot, communications television broadcasts via satellite, fine tuned, radar

- <u>Infrared</u>

λ= 1.0 x 10^{-6} to 0.1” Heat energy: vibration of molecules we perceive, it is absorbed by air, all objects absorb and emit infrared radiation

- Visible light

λ= ~16-32 millionths of an inch long, usually expressed in nanometers (nm)
(1nm = 10^{-9}m, one billionth of a meter)

This is light that we see, literally divided into the colors of the rainbow:
(ROYGBIV) red, orange, yellow, green, blue, indigo, violet

of visible light: Violet is the shortest λ, highest frequency and energy, red the longest λ , lowest frequency and energy

- Ultraviolet

  λ= less than about a millionth of an inch in length, black light, so energetic and small it can split apart molecules

  kill cells, used to sterilize items, causes sunburns

- X-rays

  λ = the size of an atom, can pass through solid matter

- Gamma rays

  λ= are much smaller than individual atoms, smallest and most energetic, created by atomic decay and are produced in stars

White light