Unit Six: Waves and Modern Physics

4 Fundamental Forces

Strong - Acts between things made of quarks → Responsible for attraction between protons & neutrons. Force carrier is Gluon

EM - Acts between charged particles. Force carrier is photon → caused by accelerated charge

Weak - Responsible for radioactive decay

Gravity - attraction between mass

EM force > Gravitational force (Gravity is always attractive)

Types of Particles

Quark Matter.
- Hadrons
  - Baryons
  - Mesons

Leptons: electrons, muons. No strong force

Boson: Force carriers

Rules: Quarks make Stable particles with zero or whole # charge

Annihilation occurs when a particle and corresponding antiparticle meet. $E = mc^2$

Waves transfer energy NOT mass

- Mechanical waves → require a medium, energy related to amplitude. Can be transverse e.g. or longitudinal
  - Ex - Sound (Longitudinal) Speed up with density
- EM waves - caused by acceleration of charged particle. Move through a vacuum at 3×10^8 m/s. Slow down with increase in "n". All transverse. Energy related to frequency

Pulse = a single disturbance in a wave

Periodic wave - repeating cycle

Transverse (⊥) | Longitudinal (//)

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reciprocal

$\lambda = \frac{\text{meters}}{\text{cycle}}$ $f = \frac{\text{cycles}}{\text{second}}$ $T = \frac{\text{seconds}}{\text{cycle}}$

$V = f\lambda = \frac{\text{cycles}}{\text{second}} \cdot \frac{\text{meters}}{\text{cycle}} = \frac{\text{meters}}{\text{second}}$

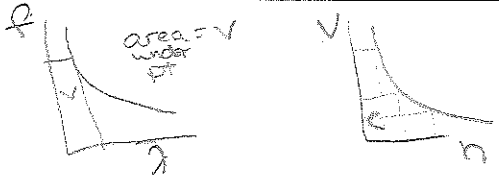
- V of sound wave in air = 331 m/s
- V of EM spectrum in vacuum or air (radio, light, microwave, etc) = 3×10^8 m/s

$n = \frac{c}{v}$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$ (all angles measured to normal)

if n ↑; λ, f, v ↓ & vice versa

$\frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$



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Wave Phenomena

Reflection $\theta_i = \theta_r$ (same medium)

happens to waves & particles

Refraction $n = \frac{c}{v}$ — bending of wave due to change in "n"

Reflection & Refraction usually happen together

θ is relative to normal line

Diffraction

Bending of a wave due to obstruction

→ does it change unless medium changes

amount of curving is greatest when a larger λ tries to pass through small opening

Interference, Standing waves, Resonance

Superposition

Constructive interference

involves "building larger"

0° or 360° phase difference

→ results in antinodes

destructive interference

involves cancelling of waves

180° phase difference

→ results in nodes

Standing waves

Result from Interference & reflection

Resonance — involves the matching of frequency from the environment to an object

Doppler Effect

Relative motion between observer and source

toward → increasing f, decreasing λ, blue shift

away → decreasing f, increasing λ, red shift

if acceleration occurs constant change

Energy and Mass are conserved in atomic events → the mass defect (change) is converted to energy

Equations

$E = mc^2$ → mass in kg use $c = 3 \times 10^8$ m/s

mass in "u" $1u = 931 \times 10^6$ MeV

$E_{photon} = \frac{hc}{\lambda} = hf$ → $h = 6.63 \times 10^{-34}$ J/s

Number of possible frequencies from energy diagram is the sum of levels below Ex: for n = 5 (4+3+2+1 = 10)

Steps for Energy diagram to EM spectrum (or reverse to go from EM to Energy diagrams)

1. find ΔE in eVs
2. convert to Joules
3. use $E = hf$ or $E = \frac{hc}{\lambda}$
4. Find on EM spectrum

Evidence of wave behavior

Diffraction, Interference, Double slit

Doppler effect

Particle Behavior

Photoelectric effect, photon momentum