**Introduction to Electromagnetic Waves**

In this chapter, we explore the remarkable phenomenon of electromagnetic waves. These waves are a fundamental aspect of physics, and they play a crucial role in our understanding of the universe. Here are the key points:

1. **Maxwell’s Theory**: We begin by discussing James Clerk Maxwell’s theory, which led to the prediction of electromagnetic waves. Maxwell’s equations form the foundation for understanding these waves.
2. **What Are Electromagnetic Waves?**: Electromagnetic waves are waves radiated by accelerated or oscillatory charges. They exhibit a unique relationship between electric and magnetic fields: a varying magnetic field generates an electric field, and vice versa. These fields propagate perpendicular to each other and to the direction of wave travel.
3. **Transverse Nature**: Electromagnetic waves are transverse, meaning that their electric and magnetic fields oscillate perpendicular to the direction of propagation. Unlike longitudinal waves, they are not deflected by electric or magnetic fields.
4. **Phase Relationship**: The electric field (E) and magnetic field (B) in electromagnetic waves are in phase with each other. This synchronization ensures the wave’s stability and coherence.
5. **Speed of Electromagnetic Waves**: These waves travel at the speed of light in a vacuum, approximately 3 × 10^8 meters per second (m/s).
6. **Energy and Momentum**: The energy carried by an electromagnetic wave is equally distributed between its electric and magnetic fields. Additionally, the linear momentum delivered to a surface by these waves is given by (p = \frac{U}{c}), where (U) represents the total energy transmitted, and (c) is the speed of light.
7. **Electromagnetic Spectrum**: The electromagnetic spectrum encompasses a wide range of waves, from gamma rays (short wavelengths) to radio waves (long wavelengths). Each segment of the spectrum has unique properties and applications.
8. **Practical Applications**: Electromagnetic waves find applications in various fields, including communication (radio waves), medical diagnosis (X-rays), and cooking (microwaves).

Change in E produce magnetic field

`Int B\*dl = mu\_{0}epsilon\_{0}(dphi\_{E})/(dt)`

`Phi\_{e}` is the E through the area bounded by the closed path along which line integral of B calculated

Value of magnetic field at some point

`Int B\*dl = mu\_{0}i`

Direction of em wave is direction of `E xx B`

`Int B\*dl = mu\_{0}(i + i\_{d})`

`i\_{d} = epsilon\_{0}(dphi\_{E})/(dt) = C(dV)/(dt)`

`phi\_{E}` is flux due to E, `i\_{d}` is displacement current, V is the potential

current due to flow of charge is called conduction current so

`int B\*dl = mu\_{0}(i\_{c} + i\_{d})`

faradays law: change in magnetic field give rise to electric filed

`int E\*dl = (-dphi\_{B})/(dt)`

maxwells equation

`intE \*ds = q\_{text(enclosed)}/epsilon\_{0}`

`int B\*ds = 0`

`intE\*dl = (-dphi\_{B})/(dt)`

`int B\*dl = mu\_{0}(i\_{c} +i\_{d})`

during charging of capacitor

`i\_{d} = i\_{c}` (between plates)(`i\_{d}` cause change in E between plates)

electromagnetic waves

stationary charge only produces E

charge in uniform motion(or steady current) produce E and B

accelerated charges produce E, B and electromagnetic waves

oscillating charged particle is source of em wave

a charged particle oscillating with a frequency f produce oscillating E which becomes a source for oscillating B this becomes a source for oscillating E and so on

both E and B regenerate each other and electromagnetic wave propagates through space(same frequency of that of oscillating charge)

E, B and electromagnetic wave(velocity) perpendicular to each other

Eg: EM wave along z-direction

`E\_{x} = E\_{0}sin(omegat – kz)`

`B\_{y} = B\_{0}sin(omegat – kz)`

`k = (2pi)/lambdatext( )omega =2pif`

`c = omega/k = flambda = E\_{0}/B\_{0} = 1/(sqrt(epsilon\_{0}mu\_{0}))`

unlike mechanical waves EM waves don’t need a medium they are self sustaining

In medium : v depend on the electric and magnetic properties of medium

`v = (sqrt(epsilonmu))`

EM waves carries energy and momentum

`lambda A deg = 12400/(text(energy in eV))`

U = energy density

`U\_{E} = 1/2epsilonE^2`

`U\_{B} = B^2/(2mu\_{0})`

`U = U\_{E} + U\_{B}`

`E\_{rms} = E\_{0}/ sqrt(2)`

`B\_{rms} = B\_{0}/ sqrt(2)`

Missing

Intensity of EM wave

`I = U\_{av}c = (text(power))/(text(area))`

Momentum transported by EM wave

`P = U/c` (for complete absorption)

`P = (2U)/c` (for complete reflection)

Radiation pressure : Pressure exerted due to EM wave

`P\_{r} = I/c` (for complete absorption)

`P\_{r} = (2I)/c` (for complete reflection)

EM spectrum

`Lambda propto 1/gamma`

`Lambda` is least for gamma ray

`Lambda` highest for radio wave

[`((int\_0^T I^2dt)/(int\_0^T dt))^(1/2)`] = `I\_{rms}`

`(int\_0^T Idt)/(int\_0^T dt) = I\_{avg}`

Radio ---- rapid acceleration or deceleration of electron in aerials

Microwave ---- klystron valve or magneto valve

Infrared ----- vibration of atoms and molecules

Light ---- electrons in atoms emit light when they move to lower energylevel

UV ---- inner shell electrons in atome moving from one ernergylevel to lower energy level

X-rays --- X-ray tubes or inner shell electrons

Gamma rays ----- radioactive decay of the nucleus

Microwaves are used in radar, in oven(it is better than burners as direct food gets heated no vessel heating)

Infrared waves are called heat waves, green house effect

Visible light: violet = 400nm, red = 700nm

UV : LASIK eye surgery, ozone