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ENGINEERING PHYSICS

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ENGINEERING PHYSICS

Unit I : Review of concepts leading to Quantum Mechanics

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Week #1

- Review of Electric and magnetic fields
- EM Wave equation
- ***Energy transported by EM Waves***
- Max Planck's Black Body Radiation equation

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Unit I : Review of concepts leading to Quantum Mechanics

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Class #3

- *Energy in an electric field*
- *Energy in a magnetic field*
- *Energy transported by Electric and Magnetic waves*
- *Total Energy of the EM wave*
- *Poynting Vector and average energy transported*
- *Polarization of EM waves*

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Unit I : Review of concepts leading to Quantum Mechanics

- ***Suggested Reading***
  1. ***Fundamentals of Physics, Halliday, Resnik, Chapter 34***
  2. ***NCERT Physics Book I grade 12 – Chapter 8***

- ***Reference Videos***
  1. ***https://nptel.ac.in/courses/108/106/108106073/***
  2. ***UE20PH101_week1_class2***

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Energy in an electric field

The energy of a capacitor charged to a potential V

$$Energy = \frac{1}{2}CV^2 = \frac{1}{2}\frac{\varepsilon_o A}{d}V^2 = \frac{1}{2}\varepsilon_o Ad.E^2$$

The energy stored per unit volume of the capacitor

$$Energy\ per\ unit\ volume = \frac{1}{2}\varepsilon_o E^2$$

The energy per unit volume in an electric field is dependent only on the strength of the field !

Energy in a magnetic field

The energy of an inductor L with current I flowing

$$Energy \quad = \frac{1}{2}LI^2$$

$$= \frac{1}{2}\frac{N^2\mu_o A}{l}.\frac{B^2 l^2}{\mu_o{}^2 N^2} = \frac{1}{2}\frac{B^2 A.l}{\mu_o}$$

The energy stored per unit volume of the inductor

$$Energy\ per\ unit\ volume = \frac{1}{2}\frac{B^2}{\mu_o}$$

The energy per unit volume in a magnetic field !

Energy in an electromagnetic field

- *Energy content in a EM field =>*
- $\frac{1}{2}\varepsilon_o {E_x}^2 + \frac{1}{2}\frac{{B_y}^2}{\mu_o}$

$$= \frac{1}{2}\varepsilon_o {E_x}^2 + \frac{1}{2}\frac{{E_x}^2}{c^2\mu_o}$$

$$= \varepsilon_o {E_x}^2$$

- *Energy transported in the z direction*

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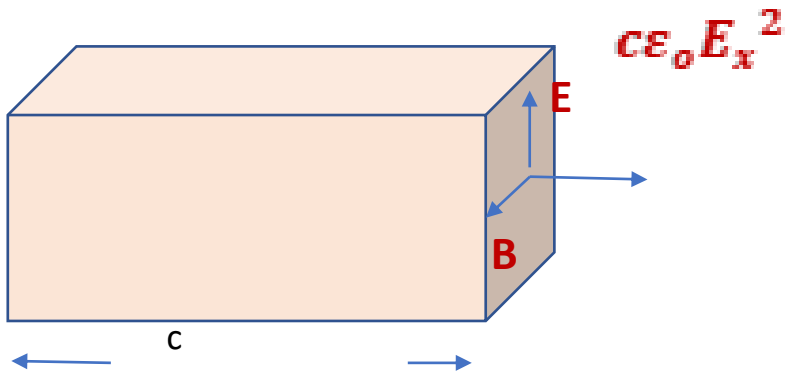
Energy in an electromagnetic field

- ***Energy transported per unit volume per unit time - Poynting Vector***
- $\boldsymbol{s \equiv \frac{1}{\mu_o} E \times B = c\varepsilon_o E \times B}$

A beam of electromagnetic waves with unit area of cross section travelling in free space



Energy in an electromagnetic field

- Average energy transported by an electromagnetic wave – energy transported in one cycle

- $\langle Energy \rangle = \frac{c\varepsilon_o}{T}\int_0^T {E_x}^2 \, dt$

$$= \frac{c\varepsilon_o}{T}\int_0^T {E_{ox}}^2 \sin^2(\omega t + kz)\, dt$$

$$= \frac{1}{2}\varepsilon_o c {E_{ox}}^2$$

$$= \frac{1}{2} c \frac{{B_{oy}}^2}{\mu_o}$$

$$= \frac{1}{2}\frac{E_{ox}B_{oy}}{\mu_o}$$

Energy in an electromagnetic field

- Energy transported is dependent on the amplitude of the electric and magnetic waves
- Energy is independent of the wavelength or frequency of the waves!!

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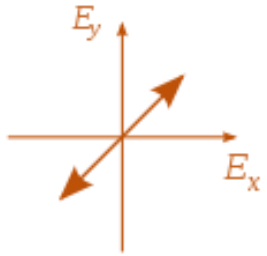
Polarisation of electromagnetic waves

- Polarization of radiation / electromagnetic waves
- Polarization of the electric wave

Plane polarized EM wave -
two waves in phase



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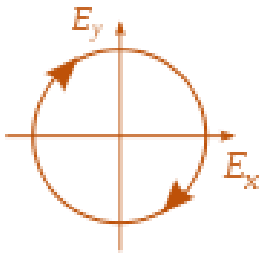
Polarization of electromagnetic waves

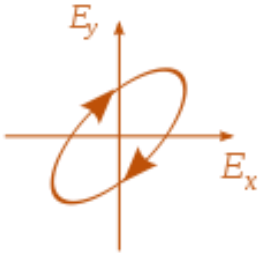
Circularly polarized EM wave –

two waves of equal amplitudes and out of phase by 90°



Elliptically polarized EM wave –

two waves of unequal amplitudes and out of phase <> 90°



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Class#3…….. Quiz….

The concepts which apply to electromagnetic waves….

1. Electric waves in free space are longitudinal
2. Magnetic waves in free space are transverse
3. The curl of a magnetic field is uniformly zero
4. The divergence of a magnetic field can be non zero
5. The curl of an electric field is always linked to a time varying magnetic field
6. The divergence of a vector field is a scalar
7. Two waves out of phase by 90^{o} and unequal amplitude form a circularly polarized wave

THANK YOU

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