



2024 - 25

Electromagnetic Waves

Recall what did you study in previous class

Four Maxwell's Equations

1. $\oint \vec{E} \cdot d\vec{s} = \frac{q}{\epsilon_0}$
2. $\oint \vec{B} \cdot d\vec{s} = 0$
3. $\oint \vec{E} \cdot d\vec{l} = -\frac{d}{dt} \phi_B = \frac{-d}{dt} \int \vec{B} \cdot d\vec{s}$
4. $\oint \vec{B} \cdot d\vec{l} = \mu_0 (I_C + I_D) = \mu_0 \left(I_C + \epsilon_0 \frac{d\phi_E}{dt} \right)$
5. Displacement current $I_D = \epsilon_0 \frac{d}{dt} \phi_E = \epsilon_0 \frac{d \oint \vec{E} \cdot d\vec{s}}{dt} = C \frac{dV}{dt}$

The electric and magnetic fields wave equations for an EM wave

- $\frac{\partial^2 E}{\partial x^2} = \mu_0 \epsilon_0 \frac{\partial^2 E}{\partial t^2}; \frac{\partial^2 B}{\partial x^2} = \mu_0 \epsilon_0 \frac{\partial^2 B}{\partial t^2}$
- $E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$
- $c_{\text{vacuum}} = \frac{1}{\sqrt{\mu_0 \epsilon_0}}; v_{\text{medium}} = \frac{1}{\sqrt{\mu_r \mu_0 \epsilon_r \epsilon_0}}$
- Refractive index of medium, $n = \sqrt{\mu_r \epsilon_r}$
- $\frac{E_0}{B_0} = \frac{E_{\text{RMS}}}{B_{\text{RMS}}} = \frac{E}{B} = c$
- Intensity, $I = \frac{\text{power}(P)}{\text{Area}(A)}$
- Average intensity of wave $I_{\text{av}} = (\text{average energy density}) \times (\text{speed of light}), I_{\text{av}} = U_{\text{av}} c = \frac{E_0 B_0}{2\mu_0} = \frac{E_0^2}{2c\mu_0} = \frac{cB_0^2}{2\mu_0}$
- Instantaneous energy density, $u = u_E + u_B$
- $u = \frac{1}{2} \epsilon_0 E^2 + \frac{B^2}{2\mu_0} = \epsilon_0 E^2 = \frac{B^2}{\mu_0}$
- Average energy density $u_{\text{av}} = \frac{1}{4} \epsilon_0 E_0^2 + \frac{B_0^2}{4\mu_0} = \frac{\epsilon_0 E_0^2}{2} = \frac{B_0^2}{2\mu_0}$
- Energy = (momentum). c or $U = Pc$
- Radiation pressure = $\frac{\text{Intensity}}{c}$
- (when the wave is completely absorbed)



- $= \frac{2 \text{ (Intensity)}}{c}$ (when the wave is completely reflected)
- Intensity of wave from a source at a distance r from it is proportional to $\frac{1}{r^2}$ (for a point source) $\frac{1}{r}$ (for a line source) For a plane source intensity is constant & independent of r .



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Library- <https://smart.link/sdfez8ejd80if>