Chapter-8: Electromagnetic Waves

1. Displacement Current

$$I_d = \epsilon_0 \frac{d\varphi_E}{dt}$$

For a suitable uniform-field situation:

$$I_d = \epsilon_0 A \frac{dE}{dt}$$

2. For EM Wave, Direction of Oscillations and Propagation of wave

$$\vec{E} \times \vec{B} = \vec{v}$$

3. Electromagnetic Wave

In vacuum, the speed of electromagnetic waves

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$

For an electromagnetic wave travelling through vacuum,

$$E_0 = cB$$

Therefore,

$$c = \frac{E_0}{B_0}$$

4. Frequency and Wavelength

For every electromagnetic wave,

$$c = f\lambda$$

$$\lambda = \frac{c}{f}$$

And

$$f = \frac{c}{\lambda}$$

5. Frequency–Wavelength–Energy Relationship

Photon Energy

$$E = hf$$

$$E = \frac{hc}{\lambda}$$

6. Photon Momentum

$$p = \frac{E}{c}$$

$$p = \frac{hf}{c}$$

$$p = \frac{h}{\lambda}$$

7. Energy Transported by Electromagnetic Waves

Electric and Magnetic Energy Density

For the electric field:

$$u_E = \frac{1}{2}\epsilon_0 E^2$$

For the magnetic field:

$$u_B = \frac{1}{2}\left(\frac{B^2}{\mu_0}\right)$$

For an electromagnetic wave in vacuum:

$$u_E = u_B$$

8. Intensity

$$I = \frac{Energy}{Area \times time}$$

$$I \propto {E_0}^2$$

$$I \propto {B_0}^2$$

9. Radiation Pressure

For complete absorption:

$$P = \frac{I}{c}$$

For complete reflection,

$$P = \frac{2I}{c}$$

10. Poynting Vector

$$\vec{S} = \frac{1}{\mu_0}\left(\vec{E} \times \vec{B}\right)$$