Ch: Electromagnetic Waves

Class XII Physics

Chapter Notes

Top Concepts

1. Displacement current is due to time-varying electric field and is given by

$$i_d = \varepsilon_o \frac{d\phi_E}{dt}$$

Displacement current acts as a source of magnetic field in exactly the same way as conduction current.

2. Electromagnetic waves are produced only by charges that are accelerating, since acceleration is absolute, and not a relative phenomenon. An electric charge oscillating harmonically with frequency ν, produces electromagnetic waves of the same frequency ν.
An electric dipole is a basic source of electromagnetic waves.

3. Electromagnetic waves with wavelength of the order of a few metres were first produced and detected in the laboratory by Hertz in 1887. He thus verified a basic prediction of Maxwell's equations.

4. Electric and magnetic fields oscillate sinusoidally in space and time in an electromagnetic wave. The oscillating electric and magnetic fields, **E** and **B** are perpendicular to each other, and to the direction of propagation of the electromagnetic wave.

5. For a wave of frequency ν, wavelength λ, propagating along *z*-direction, we have

$$E = E_x(t) = E_o \sin(kz - \omega t)$$

$$= E_o \sin\left[2\pi\left(\frac{z}{\lambda} - \nu t\right)\right] = E_o \sin\left[2\pi\left(\frac{z}{\lambda} - \frac{t}{T}\right)\right]$$

$$B = B_y(t) = B_o \sin(kz - \omega t)$$

$$= B_o \sin\left[2\pi\left(\frac{z}{\lambda} - \nu t\right)\right] = B_o \sin\left[2\pi\left(\frac{z}{\lambda} - \frac{t}{T}\right)\right]$$

They are related by $E_o/B_o = c$

6. The speed *c* of electromagnetic wave in vacuum is related to μ_0 and ε_0 (the free space permeability and permittivity constants) as follows:

$$c = 1/\sqrt{\mu_o \varepsilon_o}$$

The value of *c* equals the speed of light obtained from optical measurements. Light is an electromagnetic wave; c is, therefore, also the speed of light. Electromagnetic waves other than light also have the same velocity c in free space.
The speed of light, or of electromagnetic waves in a material medium is given by $v = 1/\sqrt{\mu\varepsilon}$
where μ is the permeability of the medium and ε its permittivity.

7. Electromagnetic waves carry energy as they travel through space and this energy is shared equally by the electric and magnetic fields.

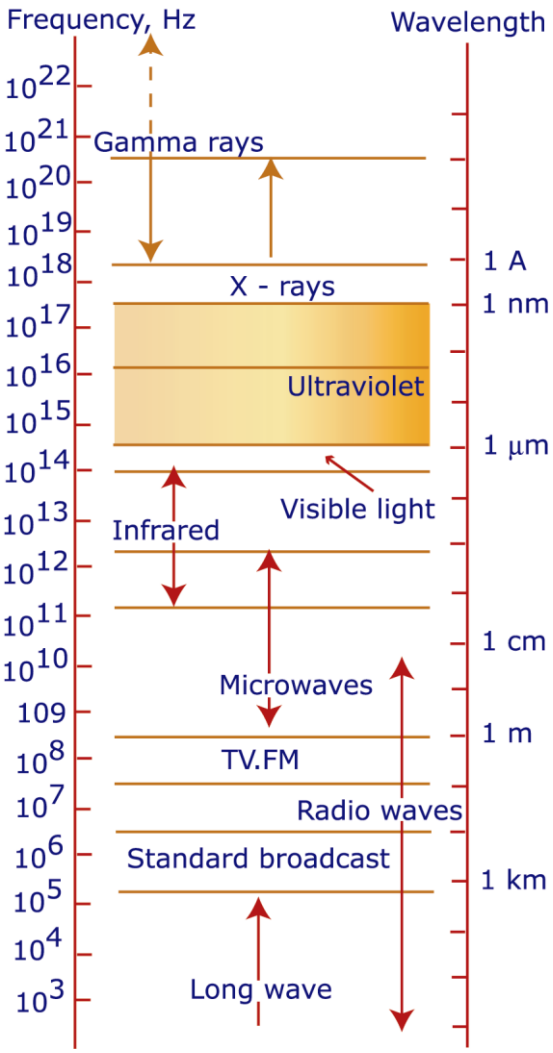
8. If in a region of space in which there exist electric and magnetic fields $\vec{\mathbf{E}}$ and $\vec{\mathbf{B}}$, there exists Energy Density (Energy per unit volume) associated with these fields given by

$$U = \frac{\varepsilon_0}{2}\vec{\mathbf{E}}^2 + \frac{1}{2\mu_0}\vec{\mathbf{B}}^2 \qquad (0.1)$$

where we are assuming that the concerned space consists of vacuum only.

9. Electromagnetic waves transport momentum as well. When these waves strike a surface, a pressure is exerted on the surface. If total energy transferred to a surface in time t is U, total momentum delivered to this surface is $p = U/c$.

10. The spectrum of electromagnetic waves stretches, in principle, over an infinite range of wavelengths. The classification of electromagnetic waves according to frequency is the electromagnetic spectrum. There is no sharp division between one kind of wave and the next. The classification has more to do with the way these waves are produced and detected. Different regions are known by different names; γ-rays, X-rays, ultraviolet rays, visible rays, infrared rays, microwaves and radio waves in order of increasing wavelength from 10^{-2} Å or 10^{-12} m to 10^{6} m.



11.

(a) Radio Waves: Produced by accelerated motion of charges in wires. They are used in radio and television communication systems. They are generally in the frequency range from 500 kHz to about 1000 MHz.

(b) Microwaves: These are short wavelength radio waves with frequencies in the gigahertz range. Due to their short wavelengths, they are suitable for radar systems used in aircraft navigation. Microwave ovens use them for cooking.

(c) Infrared Waves: These are produced by hot bodies and molecules. They lie in the low frequency or long wavelength end of the visible spectrum.

(d) Visible Light: The spectrum runs from about $4\times10^{14}Hz$ to about $7\times10^{14}Hz$. Our eyes are sensitive to this range of wavelengths.

(e) Ultraviolet light: It covers wavelengths ranging from 400 nm to 0.6 nm. The sun is an important source of UV rays.

(f) X-rays: These cover the range 10 nm to about 10^{-4} nm.

(g) Gamma Rays: These lie in the upper frequency range of the spectrum, and have wavelengths in the range $10^{-10}-10^{-14}$ m.