Key Points for Electromagnetic Waves (I)

1. **Electromagnetic Wave Equation:**
    - It is a partial differential equation that describes the propagation of electromagnetic waves through space or a medium.
    - Derived from Maxwell's equations, it relates electric and magnetic field vectors.
2. **Maxwell's Equations:**
    - The wave equation originates from Maxwell's equations, which govern the behaviour of electric and magnetic fields.
    - These include Gauss's laws for electricity and magnetism, Faraday's law of induction, and Ampère's law (with Maxwell's correction).
3. **Form of the Electromagnetic Wave Equation:**
    - In free space, it is given by:

$$\nabla^2\vec{E} - \mu_0\epsilon_0\frac{\partial^2\vec{E}}{\partial t^2} = 0$$

$$\nabla^2\vec{B} - \mu_0\epsilon_0\frac{\partial^2\vec{B}}{\partial t^2} = 0$$

4. **Wave Propagation:**
    - Electromagnetic waves propagate at the speed of light $c = \frac{1}{\sqrt{\mu_0\epsilon_0}}$ in a vacuum.
5. **Transverse Nature:**
    - Both electric and magnetic fields are perpendicular to the direction of wave propagation.
6. **Field Vectors Orientation:**
    - In an electromagnetic wave, the electric field vector ($\vec{E}$), magnetic field vector ($\vec{B}$) are mutually perpendicular.
7. **Hertzian Form of Solution:**
    - A plane wave solution can be expressed as: $\vec{E} = E_0\cos(\vec{k}\cdot\vec{r} - \omega t)\,\hat{n}$
8. **Poynting Vector:**
    - Represents the directional energy flux (power per unit area) of an electromagnetic wave: $\vec{S} = \vec{E}\times\vec{H}$
9. **Energy and Power Transmission:**
    - Electromagnetic waves carry energy and momentum, which are transported by the Poynting vector. **(Contd…)**