Electromagnetic Waves

Ampere's law $\oint \vec{B} \cdot d\vec{s} = m_0 I + m_0 e_0 \frac{d}{dt} \Phi_e$

and **Faraday**'s law $\oint \vec{E} \cdot d\vec{s} = -\frac{d}{dt} \Phi_m$

in vacuum can be combined to form two **wave equations**:

$$\frac{\partial^2 E_y}{\partial x^2} = m_0 e_0 \frac{\partial^2 E_y}{\partial t^2} \quad \text{and} \quad \frac{\partial^2 B_z}{\partial x^2} = m_0 e_0 \frac{\partial^2 B_z}{\partial t^2}$$

Therefore, the vacuum permits the propagation of electromagnetic waves.

Properties of electromagnetic waves

- The solutions to Maxwell's third and fourth equation (Ampere's Faraday's laws) are wavelike, where both ***E*** and ***B*** satisfy the same equation.
- Electromagnetic waves travel through empty space with the speed of light
- The electric and magnetic field components of plane EM waves are **perpendicular to each other** and also perpendicular to the direction of wave propagation. EM waves are **transverse waves**.
- The **relative magnitudes** of ***E*** and ***B*** in empty space are related by E/B=c.
- EM waves satisfy the **superposition principle**.