

Maxwell's equations

Integral form

Gauss's law

$$\int_{\text{CLOSED}} \vec{E} \cdot d\vec{A} = \frac{Q_{\text{ENCL}}}{\epsilon_0}$$

No magnetic monopoles

$$\int_{\text{CLOSED}} \vec{B} \cdot d\vec{A} = 0$$

Faraday's law

$$\oint \vec{E} \cdot d\vec{\ell} = -\frac{d}{dt} \int \vec{B} \cdot d\vec{A}$$

Ampère's law

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 (I_{\text{THREAD}} + I_D)$$

$$I_D := \epsilon_0 \frac{d}{dt} \int \vec{E} \cdot d\vec{A}$$

Differential form

Gauss's law

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$

No magnetic monopoles

$$\vec{\nabla} \cdot \vec{B} = 0$$

Faraday's law

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

Ampère's law

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \vec{J}_D$$

$$\vec{J}_D := \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

Electromagnetic waves

We can use Maxwell's equations in differential form to obtain

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

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

E-M waves propagate with speed

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3.00 \times 10^8 \text{ m/s}$$

