1 Electromagnetic waves

Theorem 1.1 (Gauss' law). *Let ω be a solid and $\rho(\mathbf{r}) : \Omega \longrightarrow \mathbb{R}$ its charge density distribution. Then,*

$$\oint_{\partial\Omega} \langle \mathbf{E}, \mathrm{d}\mathbf{s} \rangle_I = \frac{1}{\epsilon} \int_{\Omega} \rho(\mathbf{r})\, \mathrm{d}v\,, \qquad \operatorname{div} \mathbf{E} = \frac{\rho(\mathbf{r})}{\epsilon}. \tag{1}$$

Definition 1.1.

$$\mathbf{D} = \epsilon_0 \mathbf{E} + \mathbf{P}. \tag{2}$$

Theorem 1.2 (Gauss' law in media). *Let Ω be a dipolar solid and $\rho_f(\mathbf{r}) : \Omega \longrightarrow \mathbb{R}$ its free charge density distribution. Then,*

$$\oint_{\partial\Omega} \langle \mathbf{D}, \mathrm{d}\mathbf{s} \rangle_I = \int_{\Omega} \rho_f(\mathbf{r})\, \mathrm{d}v\,, \qquad \operatorname{div} \mathbf{D} = \rho_f(\mathbf{r}). \tag{3}$$

Theorem 1.3 (Gauss' law for magnetism). *Let Ω be a solid. Then,*

$$\oint_{\partial\Omega} \langle \mathbf{B}, \mathrm{d}\mathbf{s} \rangle_I = 0, \qquad \operatorname{div} \mathbf{B} = 0. \tag{4}$$

Theorem 1.4 (Faraday's law for magnetism). *Let Σ be a surface formed by a circuit $\Gamma = \partial\Sigma$. Then,*

$$\oint_{\Gamma} \langle \mathbf{E}, \mathrm{d}\mathbf{r} \rangle_I = -\frac{\mathrm{d}}{\mathrm{d}t} \int_{\Sigma} \langle \mathbf{B}, \mathrm{d}\mathbf{s} \rangle_I, \qquad \operatorname{curl} \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}. \tag{5}$$

Theorem 1.5 (Ampère's law). *Let Σ be a surface formed by a circuit $\Gamma = \partial\Sigma$. Then,*

$$\oint_{\Gamma} \langle \mathbf{B}, \mathrm{d}\mathbf{r} \rangle_I = \mu_0 \int_{\Sigma} \langle \mathbf{J}, \mathrm{d}\mathbf{s} \rangle_I, \qquad \operatorname{curl} \mathbf{B} = \mu_0 \mathbf{J}. \tag{6}$$

Theorem 1.6 (Ampère's law for variables fields). *Let Σ be a surface formed by a circuit $\Gamma = \partial\Sigma$. Then,*

$$\operatorname{curl} \mathbf{B} = \mu_0 \left[\mathbf{J} + \epsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right] \tag{7}$$

Definition 1.2.

$$\mathbf{H} = \frac{1}{\mu_0} \mathbf{B} - \mathbf{M}. \tag{8}$$

Theorem 1.7 (Ampère's law in media). *Let Σ be a surface formed by a circuit $\Gamma = \partial\Sigma$ and $\mathbf{J}_f : \Sigma \longrightarrow \mathbb{R}^3$ its free current distribution. Then,*

$$\operatorname{curl} \mathbf{H} = \mathbf{J}_f + \frac{\partial \mathbf{D}}{\partial t}. \tag{9}$$

Proposition 1.8. *If $\mathbf{P}, \mathbf{M}$ ad $\mathbf{J}_f$ are linear, then the equations are linear and superposition principle holds.*

2 Extra

Definition 2.1. Physical constants

$$\begin{aligned} q_e &= 1{,}602 \times 10^{-19}\,\mathrm{C}, \\ h &= 6{,}62 \times 10^{-34}\,\mathrm{kg}, \\ \epsilon_0 &= 8{,}8542 \times 10^{-12}\,\mathrm{C}^2\,\mathrm{N}\,\mathrm{m}^2, \\ \mu_0 &= 4\pi \times 10^{-7} \mathrm{N}^2\,\mathrm{s}^2\,\mathrm{C}^{-2} \end{aligned}$$