

Maybe Useful Equations

Boundary conditions (for linear media):

$$\begin{aligned}\vec{E}_{in}^{\parallel} &= \vec{E}_{out}^{\parallel} \\ \epsilon_{out} \vec{E}_{out}^{\perp} - \epsilon_{in} \vec{E}_{in}^{\perp} &= \sigma_f \\ \frac{\vec{B}_{out}^{\parallel}}{\mu_{out}} - \frac{\vec{B}_{in}^{\parallel}}{\mu_{in}} &= \vec{K}_f \times \hat{n} \\ B_{out}^{\perp} &= B_{in}^{\perp}\end{aligned}$$

Reflection and transmission of EM waves polarized in the incidence plane (e.g. xz plane):

$$\begin{aligned}\frac{E_{R0}}{E_{I0}} &= \frac{\alpha - \beta}{\alpha + \beta} \\ \frac{E_{T0}}{E_{I0}} &= \frac{2}{\alpha + \beta} \\ (\alpha &= \frac{\cos\theta_T}{\cos\theta_I}, \beta = \frac{n_2}{n_1})\end{aligned}$$

Reflection and transmission of EM waves polarized in the direction normal to the incident plane (e.g., y direction):

$$\begin{aligned}\frac{E_{R0}}{E_{I0}} &= \frac{1 - \alpha\beta}{1 + \alpha\beta} \\ \frac{E_{T0}}{E_{I0}} &= \frac{2}{1 + \alpha\beta} \\ (\alpha &= \frac{\cos\theta_T}{\cos\theta_I}, \beta = \frac{n_2}{n_1})\end{aligned}$$

Wave vector in conductors:

$$k = k_+ + ik_-$$

$$k_{\pm} = \omega \sqrt{\epsilon \mu} \sqrt{\frac{\sqrt{1 + \left(\frac{\sigma}{\epsilon \omega}\right)^2} \pm 1}{2}}$$

Electric dipole radiation:

$$\vec{E} = \frac{\mu_0}{4\pi r} \left[\hat{r} \times (\hat{r} \times \ddot{\vec{p}}) \right]$$

Magnetic dipole radiation:

$$\vec{E} = \frac{\mu_0}{4\pi cr} (\hat{r} \times \ddot{\vec{m}})$$

Radiation by point charge:

$$\vec{E} = \frac{q}{4\pi\epsilon_0} \frac{1}{\bar{r}^2} \frac{(1 - \beta^2)(\hat{i} - \vec{\beta})}{(1 - \hat{i} \cdot \vec{\beta})^3} + \frac{q}{4\pi\epsilon_0 c^2} \frac{1}{\bar{r}} \frac{\hat{i} \times [(\hat{i} - \vec{\beta}) \times \vec{a}]}{(1 - \hat{i} \cdot \vec{\beta})^3}$$

$$(\bar{r} = \vec{r} - \vec{r}')$$

$$\frac{dP}{d\Omega} = \frac{\mu_0 q^2}{16\pi^2 c} \frac{|\hat{i} \times [(\hat{i} - \vec{\beta}) \times \vec{a}]|^2}{(1 - \hat{i} \cdot \vec{\beta})^5}$$

$$\frac{dP_{\parallel}}{d\Omega} = \frac{\mu_0 q^2 a^2}{16\pi^2 c} \frac{\sin^2 \theta}{(1 - \beta \cos \theta)^5}$$

$$\frac{dP_{\perp}}{d\Omega} = \frac{\mu_0 q^2 a^2}{16\pi^2 c} \frac{[(1 - \beta \cos \theta)^2 - (1 - \beta^2) \sin^2 \theta \cos^2 \phi]}{(1 - \beta \cos \theta)^5}$$

$$P_{\parallel} = \frac{\mu_0 q^2 a^2 \gamma^6}{6\pi c}$$

$$P_{\perp} = \frac{\mu_0 q^2 a^2 \gamma^4}{6\pi c}$$

Lorentz transformation:

$$x'^{\mu} = \Lambda x^{\mu}, \eta'^{\mu} = \Lambda \eta^{\mu}, p'^{\mu} = \Lambda p^{\mu}$$

$$\Lambda = \begin{bmatrix} \gamma & -\gamma\beta & 0 & 0 \\ -\gamma\beta & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Transformation of electromagnetic fields:

$$E'_{\parallel} = E_{\parallel}$$

$$B'_{\parallel} = B_{\parallel}$$

$$\vec{E}'_{\perp} = \gamma(\vec{E}_{\perp} + \vec{v} \times \vec{B})$$

$$\vec{B}'_{\perp} = \gamma\left(\vec{B}_{\perp} - \frac{1}{c^2} \vec{v} \times \vec{E}\right)$$