1. Tutorübung

Poynting-Vektor:

$$\underline{\boldsymbol{s}} = \underline{\boldsymbol{E}} \times \underline{\boldsymbol{H}} \tag{1}$$

$$[\underline{\boldsymbol{s}}] = \frac{J}{m^2 s} = \frac{W}{m^2} = \frac{N}{ms} \tag{2}$$

$$\int \underline{\boldsymbol{E}} d\underline{\boldsymbol{s}} = U \tag{3}$$

Durchfultungsgesetz:

$$\int\limits_{\partial A} \underline{\boldsymbol{H}} d\underline{\boldsymbol{s}} = J(A) = \iint\limits_{A} \underline{\boldsymbol{j}} d\underline{\boldsymbol{a}} \tag{4}$$

für Spulen

$$\int\limits_{\partial A} \underline{\boldsymbol{H}} ds = NJ \tag{5}$$

Materialgesetze

$$\underline{\boldsymbol{B}} = \underbrace{\mu_0 \mu_r}_{\mu} \underline{\boldsymbol{H}} \tag{6}$$

$$\underline{\boldsymbol{D}} = \underbrace{\epsilon_r \epsilon_0}_{\epsilon} \underline{\boldsymbol{E}} \tag{7}$$

lokales ohmsches Gesetz

$$\underline{\boldsymbol{j}} = \sigma \underline{\boldsymbol{E}} \tag{8}$$

Energiedichte

$$w_{mag} = \frac{1}{2} \underline{\boldsymbol{H}} \underline{\boldsymbol{B}} = \frac{1}{2\mu} \left| \underline{\boldsymbol{B}} \right|^2 \tag{9}$$

$$w_{el} = \frac{1}{2} \underline{\boldsymbol{E}} \underline{\boldsymbol{D}} = \frac{\epsilon}{2} \left| \underline{\boldsymbol{E}} \right|^2 \tag{10}$$

Bilanz

$$\underbrace{\frac{\partial x}{\partial t}}_{\text{zeitliche Veränderung}} + \underbrace{\operatorname{div} \underline{\boldsymbol{J}}_x(\underline{\boldsymbol{r}}, t)}_{\text{zu- oder abfluss}} = \underbrace{\pi}_{\text{Produktionsrate}} \tag{11}$$

2. Tutorübung

MWG:

$$\operatorname{div} \underline{\boldsymbol{D}} = \rho \qquad \text{Gaußsches Gesetz} \tag{12}$$

$$\operatorname{div} \underline{\boldsymbol{B}} = 0 \qquad \text{Quellenfreiheit des B-Feldes} \tag{13}$$

$$\operatorname{rot} \underline{\boldsymbol{H}} = \underline{\boldsymbol{j}} + \frac{\partial \underline{\boldsymbol{D}}}{\partial t} \qquad \text{Ampersches Durchflutungsgesetz} \tag{14}$$

$$\operatorname{rot} \underline{\boldsymbol{E}} = -\frac{\partial \underline{\boldsymbol{B}}}{\partial t} \qquad \text{Induktionsgestz} \tag{15}$$

Materialgleichungen:

$$\underline{\boldsymbol{D}} = \epsilon \underline{\boldsymbol{E}} \tag{16}$$

$$\underline{\boldsymbol{B}} = \mu \underline{\boldsymbol{H}} \tag{17}$$

$$\underline{\boldsymbol{j}} = \sigma \underline{\boldsymbol{E}} \tag{18}$$

$$\tag{19}$$

Poynting-Vektor:

$$\underline{\boldsymbol{s}} = \underline{\boldsymbol{E}} \times \underline{\boldsymbol{H}} \tag{20}$$

Potential stromdurchflossener Leiter:

$$\Phi(\underline{\boldsymbol{r}}) = -\frac{Q}{2\pi\epsilon l} \ln(\frac{r}{r_0}) + C \tag{21}$$

$$\underline{\boldsymbol{E}} = -\nabla\Phi \tag{22}$$

Elektromagnetisches Vektorpotential: $\underline{\boldsymbol{B}} = \operatorname{rot} \underline{\boldsymbol{A}}$
Skalares magnetisches Potential Φ: $\underline{\boldsymbol{E}} = -\nabla\Phi - \frac{\partial \underline{\boldsymbol{A}}}{\partial t}$
Eichfreiheit

$$\underline{\boldsymbol{A}}' = \underline{\boldsymbol{A}} - \nabla\chi \quad \Phi'_\chi = \Phi + \tfrac{\partial \chi}{\partial t} \tag{23}$$

$$A = \frac{Vs}{m} \qquad \Phi = V \tag{24}$$

Lorentz-Eichung: $\operatorname{div} \underline{\boldsymbol{A}} + \epsilon M \frac{\partial \Phi}{\partial t} = 0$
Coulomb-Eichung: $\operatorname{div} \underline{\boldsymbol{A}} = 0$

Zeitlicher Mittelwert: $\overline{x} = \frac{1}{T} \int_0^T x dt$