$$\vec{F} = k\frac{q_1 q_2}{r^2}\hat{u}_r = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}\hat{u}_r$$

$$\vec{E} = \frac{\vec{F}}{q} \qquad \vec{p} = Q\vec{d}$$

$$d\vec{E} = k\frac{dq}{r^2}\hat{u}_r \quad \vec{E} = k\int\frac{dq}{r^2}\hat{u}_r$$

$$E = \frac{\sigma}{\varepsilon_0}$$

$$\Phi_E = \oint_A \vec{E}\cdot d\vec{A} = \frac{Q}{\varepsilon_0} = \frac{1}{\varepsilon_0}\sum q_i$$

$$Q = \sum q_i = \oint_V \rho\, dV$$

$$\nabla\cdot\vec{E} = \frac{\rho}{\varepsilon_0} \qquad \vec{E} = \frac{\sigma}{\varepsilon_0}\hat{n}$$

$$\vec{E} = -\nabla V \quad \vec{E}\cdot d\vec{r} = -dV$$

$$V(P_1) - V(P_2) = \int_{P_1}^{P_2}\vec{E}\cdot d\vec{r} \qquad V(r) = \frac{q}{4\pi\varepsilon_0}\frac{1}{r}$$

$$V(P) = \frac{1}{4\pi\varepsilon_0}\sum_i\frac{q_i}{r_i} \qquad V(P) = \frac{1}{4\pi\varepsilon_0}\int\frac{dq}{r}$$

$$\vec{E} = -\hat{i}E_x - \hat{j}E_y - \hat{k}E_z = -\hat{i}\frac{\partial V}{\partial x} - \hat{j}\frac{\partial V}{\partial y} - \hat{k}\frac{\partial V}{\partial z}$$

$$\vec{M} = q\vec{d}\times\vec{E} = \vec{p}\times\vec{E}$$

$$U = -qdE\cos\theta = -\vec{p}\cdot\vec{E} \qquad U = \vec{p}\cdot\nabla V$$

$$\frac{q_1}{r_1} = \frac{q_2}{r_2} \qquad \frac{E_1}{E_2} = \frac{\sigma_1}{\sigma_2} = \frac{r_2}{r_1}$$

$$C = \frac{Q}{\Delta V} = \frac{\varepsilon_0 A}{d}$$

$$C = C_1 + C_2 + \dots + C_n$$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}$$

$$U = \frac{1}{2}V_1 q_1 + \frac{1}{2}V_2 q_2 + \dots + \frac{1}{2}V_n q_n$$

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\varepsilon_0 E^2 Ad \qquad u_E = \frac{1}{2}\varepsilon_0 E^2$$

$$\vec{E} = \frac{1}{\kappa}\vec{E}_{fri} \qquad C = \kappa C_0 = \kappa\frac{\varepsilon_0 A}{d} \qquad \vec{E} = \vec{E}_f + \vec{E}_b$$

$$\vec{P} = \frac{\Delta\vec{p}}{\Delta V} \qquad Q_b = PA\cos\theta = \vec{P}\cdot\vec{A}$$

$$\sigma_b = \frac{Q_b}{A} = \vec{P}\cdot\vec{n} \qquad \rho_b = -\nabla\cdot\vec{P}$$

$$\vec{D} = \varepsilon_0\vec{E} + \vec{P} \qquad \oint_A\vec{D}\cdot d\vec{A} = Q_f$$

$$\nabla\cdot\vec{D} = \rho_f \qquad \vec{P} = \varepsilon_0\chi_e\vec{E}$$

$$\vec{D} = \varepsilon_0\vec{E} + \vec{P} = \varepsilon_0\vec{E} + \varepsilon_0\chi_e\vec{E}$$

$$= \varepsilon_0(1+\chi_e)\vec{E} = \varepsilon_0\kappa\vec{E} = \varepsilon\vec{E}$$

$$I = \frac{dQ}{dt} = nqAv_d \qquad J = \frac{I}{A}$$

$$\vec{J} = nq\vec{v}_d \qquad V = RI$$

$$\vec{J} = \sigma\vec{E} \qquad \rho = \frac{1}{\sigma} \qquad R = \rho\frac{l}{A}$$

$$\rho = \rho_0\left[1 + \alpha(T - T_0)\right]$$

$$R = \sum_{i=1}^{n} R_i \qquad \frac{1}{R} = \sum_{i=1}^{n}\frac{1}{R_i}$$

$$P = \frac{dU}{dt} = \frac{V\,dQ}{dt} = VI = RI^2$$

$$I = \frac{dq}{dt}$$

$$\vec{F} = q\vec{v}\times\vec{B} \qquad R = \frac{mv}{qB}$$

$$\vec{F} = I\,\vec{l}\times\vec{B} \qquad \vec{F} = I\int\left(d\vec{l}\times\vec{B}\right) \qquad \vec{T} = I\vec{S}\times\vec{B}$$

$$\vec{m} = NI\vec{S} \qquad \vec{T} = \vec{m}\times\vec{B} \qquad \vec{F} = q\vec{E} + q\vec{v}\times\vec{B}$$

$$\omega = \frac{v}{R} = \frac{q}{m}B \qquad d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,d\vec{l}\times\hat{u}_r}{r^2}$$

$$\vec{B} = \int\frac{\mu_0}{4\pi}\frac{I\,d\vec{l}\times\hat{u}_r}{r^2}$$

$$\oint \vec{B}\cdot d\vec{r} = \mu_0 I_{Tot} = \mu_0 \sum I_i = \mu_0 \int_A \vec{J}\cdot d\vec{A}$$
$$\nabla\times\vec{B} = \mu_0 \vec{J}$$
$$\oint_A \vec{B}\cdot d\vec{A} = 0$$
$$\nabla\cdot\vec{B} = 0$$
$$\oint \vec{B}\cdot d\vec{r} = \mu_0\left(I + \frac{\partial \Phi_D}{\partial t}\right)$$
$$\nabla\times\vec{B} = \mu_0\left(\vec{J} + \frac{\partial \vec{D}}{\partial t}\right)$$

$$\varepsilon = -\frac{d\Phi_B}{dt}$$
$$\Phi_B = \int_A \vec{B}\cdot d\vec{A}$$
$$\varepsilon = -N\frac{d\Phi_B}{dt}$$
$$\varepsilon = \oint \vec{E}\cdot d\vec{l}$$
$$\oint \vec{E}\cdot d\vec{r} = \int_A \left(\nabla\times\vec{E}\right)\cdot d\vec{A} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}\int_A \vec{B}\cdot d\vec{A}$$
$$\nabla\times\vec{E} = -\frac{d\vec{B}}{dt}$$

$$\Phi_B = LI$$
$$\varepsilon_L = -\frac{d\Phi_B}{dt} = -L\frac{dI}{dt}$$
$$\tau = \frac{L}{R}$$
$$U = \int_0^I LI'\,dI' = \frac{1}{2}LI^2$$

$$u_B = \frac{B^2}{2\mu_0}$$
$$u = \frac{1}{2}\varepsilon E^2 + \frac{1}{2\mu}B^2$$
$$\varepsilon_{21} = -N_2\frac{d\Phi_{21}}{dt} = -M_{21}\frac{dI_1}{dt}$$
$$M_{21} = M_{12} = M$$

$$\vec{B} = \vec{B}_0 + \mu_0\vec{M}$$
$$\vec{B}_0 = \mu_0\vec{H}$$
$$\vec{B} = \mu_0\left(\vec{H} + \vec{M}\right)$$
$$\vec{M} = \chi_m\vec{H}$$
$$\mu = \mu_0\left(1 + \chi_m\right)$$
$$\oint \vec{H}\cdot d\vec{r} = \int \vec{J}_{fri}\cdot d\vec{A}$$
$$\vec{m}_L = \frac{-e}{2m_e}\vec{L} = g_L\vec{L}$$
$$m_L = \left(\frac{e}{2m_e}\hbar\right)l = m_B l$$
$$\vec{m}_S = g_S\vec{S} = -\frac{e}{m_e}\vec{S}$$
$$\frac{V_2}{V_1} = \frac{N_2}{N_1}$$
$$I_1V_1 = I_2V_2$$
$$\Delta U = \frac{e\hbar}{m_p}B$$

$$L\frac{dI}{dt} + \frac{q}{C} = 0$$
$$q = Q_m\cos(\omega_0 t + \varphi)$$
$$\omega_0^2 = \frac{1}{LC}$$
$$U_C = \frac{q^2}{2C}$$
$$U_L = \frac{LI^2}{2}$$
$$U_L + U_C = \frac{Q_0^2}{2C}$$

$$L\frac{dI}{dt} + IR + \frac{q}{C} = 0$$
$$q = Q_m e^{-\frac{t}{\tau}}\cos(\omega t + \phi)$$
$$\tau = \frac{2L}{R}$$
$$\omega = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2} = \sqrt{\omega_0^2 - \frac{1}{\tau^2}}$$

$$X_C = \frac{1}{\omega C}$$

$$X_L = \omega L$$

$$Z = \frac{V_m}{I_m} = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\tan\phi = \frac{X_L - X_C}{R}$$

$$I = I_m \sin(\omega t - \phi)$$

$$\overline{P} = \frac{1}{2} I_m^2 R = I_{rms}^2 R$$

$$\overline{P} = V_{rms} I_{rms} \cos\phi$$

$$\hat{Z} = X + iY = Ze^{i\varphi} = Z(\cos\varphi + i\sin\varphi)$$

$$Z = \sqrt{X^2 + Y^2}$$

$V = V_m \sin(\omega t)$ eller $V = V_m \cos(\omega t)$

$$\hat{V} = V_m e^{i\omega t}$$

$$L\frac{d\hat{I}}{dt} + R\hat{I} + \frac{\hat{q}}{C} = V_m \cos(\omega t) + iV_m \sin(\omega t)$$

$$\hat{I} = \frac{d\hat{q}}{dt}$$

$$L\frac{d^2\hat{I}}{dt^2} + R\frac{d\hat{I}}{dt} + \frac{\hat{I}}{C} = (i\omega)V_m e^{i\omega t}$$

$$\hat{I} = \hat{I}_m e^{i\omega t}$$

$$\hat{I}_m = \frac{V_m}{\left[R + i\left(\omega L - \frac{1}{\omega C}\right)\right]} = \frac{V_m}{R + i(X_L - X_C)}$$

$$\hat{Z} = R + iX = Ze^{i\varphi}$$

$$Z = \sqrt{R^2 + X^2}$$

$$\tan\varphi = \frac{X}{R} = \frac{X_L - X_C}{R}$$

$$\hat{I}_m = \frac{V_m}{\hat{Z}} = \frac{V_m}{Ze^{i\varphi}} = \frac{V_m}{Z} e^{-i\varphi}$$

$$I = \mathrm{Im}(\hat{I}) = I_m \sin(\omega t + \varphi)$$

eller $I = \mathrm{Re}(\hat{I}) = I_m \cos(\omega t + \varphi)$

$$I_m = \frac{V_m}{Z} = \frac{V_m}{\sqrt{R^2 + (X_L - X_C)^2}}$$

$$\hat{Z}_R = R$$

$$\hat{Z}_L = i\omega L$$

$$\hat{Z}_C = \frac{1}{i\omega C} = -\frac{i}{\omega C}$$

$$\hat{Z} = \hat{Z}_1 + \hat{Z}_2$$

$$\frac{1}{\hat{Z}} = \frac{1}{\hat{Z}_1} + \frac{1}{\hat{Z}_2}$$

$$\hat{V} = \hat{Z}\hat{I}$$

Maxwells ligninger m.m.:

$$\oint \vec{E} \cdot d\vec{r} = -\frac{d}{dt}\int_A \vec{B} \cdot d\vec{A} \qquad \nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\oint_A \vec{D} \cdot d\vec{A} = \int_V \rho \, dV \qquad \nabla \cdot \vec{D} = \rho$$

$$\oint \vec{H} \cdot d\vec{r} = \int_A \left(\vec{J} + \frac{\partial \vec{D}}{\partial t}\right) \cdot d\vec{A}$$

$$\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$$

$$\int_A \vec{B} \cdot \hat{n} \, dA = 0 \qquad \nabla \cdot \vec{B} = 0$$

$$\vec{D} = \varepsilon \vec{E} = \kappa \varepsilon_0 \vec{E}$$

$$\vec{B} = \mu \vec{H} = \kappa_M \mu_0 \vec{H}$$

$$E_{2t} = E_{1t}$$

$$D_{1n} = D_{2n}$$

$$\nabla^2 \vec{E} = \varepsilon_0 \mu_0 \frac{\partial^2 \vec{E}}{\partial t^2}$$

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

$$\nabla^2 \vec{B} = \varepsilon_0 \mu_0 \frac{\partial^2 \vec{B}}{\partial t^2}$$

$$\vec{E} = \vec{E}_0 \sin(kz - \omega t)$$

$$B_0 = \frac{kE_0}{\omega} = \frac{E_0}{c}$$

$$v = \frac{1}{\sqrt{\kappa \varepsilon_0 \mu_0}} = \frac{c}{\sqrt{\kappa}} = \frac{c}{n}$$

$$u = u_E + u_B = 2u_E = \varepsilon_0 E^2$$

$$I = \frac{\delta E}{A\delta t} = \frac{c\delta E}{A\delta x} = \frac{c\delta E}{\delta V} = cu$$

$$I = \frac{1}{\mu_0}EB$$

$$\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B}$$

$$p = \frac{S}{c}$$

$$p = \frac{2S}{c}$$

$$I = I_0\cos^2\theta$$

$$\vec{E} = \hat{i}E_x\cos(kz-\omega t) + \hat{j}E_y\cos(kz-\omega t+\varphi)$$

$$E_1 + E_r = E_2$$

$$S_1 = S_r + S_2$$

$$S = \frac{1}{\mu_0}EB = \frac{n}{\mu_0 c}E^2$$

$$\frac{S_r}{S_1} = \left(\frac{n_1-n_2}{n_1+n_2}\right)^2$$

$$\frac{S_2}{S_1} = \frac{4n_1^2}{(n_1+n_2)^2}$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$\frac{1}{s}+\frac{1}{s'}\approx\frac{2}{R}$$

$$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$$

$$\frac{n_1}{s}+\frac{n_2}{s'}\approx\frac{n_2-n_1}{R}$$

$$\frac{n_1}{f} = (n_2-n_1)\left(\frac{1}{R_a}-\frac{1}{R_b}\right)$$

$$m = -\frac{s'}{s}$$

$$M = \frac{25}{f(\mathrm{cm})}$$

$$\phi = 2\pi\frac{l}{\lambda} = 2\pi\frac{d\sin\theta}{\lambda}$$

$$\phi = \pm m(2\pi) \quad \text{eller} \quad d\sin\theta_m = \pm m\lambda$$

$$d\sin\theta_{m'} = \pm\left(m'+\frac{1}{2}\right)\lambda$$

$$E_T = \left[2E_0\cos\left(\frac{\phi}{2}\right)\right]\sin\left(\omega t+\frac{\phi}{2}\right)$$

$$I_T = 4I_0\cos^2\left(\frac{\phi}{2}\right) = 4I_0\cos^2\left(\frac{\pi d\sin\theta}{\lambda}\right)$$

$$I_T = 4I_0\cos^2\left[\left(\frac{\pi d}{\lambda L}\right)x\right]$$

$$E_T = E_0\sum_{n=0}^{N-1}\sin(\omega t+n\phi)$$

$$E_T = \left[\frac{\sin(N\phi/2)}{\sin(\phi/2)}\right]E_0\sin\left\{\omega t+(N-1)\frac{\phi}{2}\right\}$$

$$I_T = I_0\left[\frac{\sin(N\phi/2)}{\sin(\phi/2)}\right]^2$$

$$\Delta\phi_{1/2} = 2\pi/N$$

$$d\sin\theta_m = \pm m\lambda \quad m = 0,1,2,....$$

$$\Delta\theta_{1/2} = \frac{1}{N\sqrt{(d/\lambda)^2-m^2}}$$

$$D = \frac{m}{d\cos\theta_m}$$

$$\Delta\lambda > \frac{\lambda}{Nm}$$

$$\beta = \frac{\pi a\sin\theta}{\lambda}$$

$$I = I_0N^2\frac{\sin^2\beta}{\beta^2}$$

$$I = I_M\frac{\sin^2\beta}{\beta^2}$$

$$I_T = 4I_M\frac{\sin^2\beta}{\beta^2}\cos^2\left[\left(\frac{\pi d}{\lambda L}\right)x\right]$$

$$\Delta\theta > \frac{\lambda}{D}$$

$$x \propto \frac{1}{\omega_0^2-\omega^2}\cos(\omega t)$$

$$\frac{1}{n^2} = 1 - \frac{K}{\omega_0^2 - \omega^2}$$