proton charge: $e = 1.602 \times 10^{-19}\,\mathrm{C}$

electron charge: $-e$

electron mass: $m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$

proton mass: $m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$

$\varepsilon_0 = 8,854 \times 10^{-12}\,\mathrm{F\,m^{-1}}$

$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{T\,m\,A^{-1}}$

$F = ma$

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$A_{\text{surface cylinder}} = \pi r^2 L$

$A_{\text{surface sphere}} = 4\pi r^2$

$\varepsilon = -N\frac{d\Phi_B}{dt}$

$\oint_\Gamma \mathbf{E}\cdot\mathbf{dl} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}\int_S \mathbf{B}\cdot\mathbf{dS}$

$\varepsilon_{\text{ind}} = -L\frac{dI}{dt}$

$B_{\text{solen}} = \mu_0\frac{N}{l}I$

$U_{B_{\text{inductor}}} = \frac{1}{2}LI^2$

$L_{\text{solen}} = \mu_0\frac{N^2}{l}\pi R^2$

$\mu = \mu_0\mu_r$

$\chi_m = \mu_r - 1$

$\mathbf{B} = \mu_r\mathbf{B}_0 = \mu\mathbf{H}$

$\mathbf{M} = \frac{\mathbf{B}}{\mu_0} - \mathbf{H} = \frac{\mu_r\mu_0\mathbf{H}}{\mu_0} - \mathbf{H} = \underbrace{(\mu_r - 1)}_{\chi_m}\mathbf{H} = \chi_m\mathbf{H}$

$u_B = \frac{1}{2}\frac{B^2}{\mu} = \frac{1}{2}BH$

$u_B = \frac{U_B}{\text{volume}}$

$\oint \mathbf{E}\cdot\mathbf{dS} = \frac{q}{\varepsilon_0}$

$\oint \mathbf{B}\cdot\mathbf{dS} = 0$

$\oint_\Gamma \mathbf{E}\cdot\mathbf{dl} = -\frac{d}{dt}\int_S \mathbf{B}\cdot\mathbf{dS}$

$\oint_\Gamma \mathbf{B}\cdot\mathbf{dl} = \mu_0\int_S\left(\mathbf{j} + \varepsilon_0\frac{\partial\mathbf{E}}{\partial t}\right)\cdot\mathbf{dS} = \mu_0 I + \varepsilon_0\mu_0\frac{d}{dt}\int_S \mathbf{E}\cdot\mathbf{dS}$

$\nabla\cdot\mathbf{E} = \frac{\rho}{\varepsilon_0}$

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

$\text{rot}\,\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}$

$\text{rot}\,\mathbf{B} = \mu_0\mathbf{j} + \varepsilon_0\mu_0\frac{\partial\mathbf{E}}{\partial t}$

$$\mathbf{D} = \varepsilon\mathbf{E}, \quad \mathbf{B} = \mu\mathbf{H}$$

$\oint \mathbf{D}\cdot\mathbf{dS} = q$

$\oint \mathbf{B}\cdot\mathbf{dS} = 0$

$\oint_\Gamma \mathbf{E}\cdot\mathbf{dl} = -\frac{d}{dt}\int_S \mathbf{B}\cdot\mathbf{dS}$

$\oint_\Gamma \mathbf{H}\cdot\mathbf{dl} = I + \frac{d}{dt}\int_S \mathbf{D}\cdot\mathbf{dS}$

$\nabla\cdot\mathbf{D} = \rho$

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

$\text{rot}\,\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}$

$\text{rot}\,\mathbf{H} = \mathbf{j} + \frac{\partial\mathbf{D}}{\partial t}$

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

	Impedance $\widetilde{Z}$	Reactance χ
$V(t) = V_0 \cos(\omega t)$; $I_0 = \frac{V_0}{\lvert\widetilde{Z}\rvert}$		
R: $I(t) = \frac{V(t)}{R} = \frac{V_0}{R}\cos(\omega t)$	R	
L: $V(t) = L\frac{dI}{dt} \longrightarrow I = \frac{V_0}{\omega L}\sin(\omega t) = \frac{V_0}{\omega L}\cos\left(\omega t - \frac{\pi}{2}\right)$	$i\omega L$	ωL
C: $\begin{cases} V(t) = \frac{Q(t)}{C} \\ I = \frac{dQ(t)}{dt} \end{cases} \longrightarrow I = -\omega C V_0 \sin(\omega t) = \omega C V_0 \cos\left(\omega t + \frac{\pi}{2}\right)$	$\frac{1}{i\omega C} = -\frac{i}{\omega C}$	$\frac{1}{\omega C}$
Series: $\widetilde{Z} = \widetilde{Z}_1 + \widetilde{Z}_2 + \cdots$; Paralel: $\frac{1}{\widetilde{Z}} = \frac{1}{\widetilde{Z}_1} + \frac{1}{\widetilde{Z}_2} + \cdots$		
R+L+C: $\left\lvert\widetilde{Z}\right\rvert = \sqrt{R^2 + \left(-\frac{1}{\omega C} + \omega L\right)^2}$	$f_r = \frac{1}{2\pi\sqrt{LC}}$	
$\phi_{VI} = \arctan\frac{\mathrm{Im}\,\widetilde{Z}}{\mathrm{Re}\,\widetilde{Z}}$; $\phi_{IV} = -\phi_{VI}$		
R: $V_{\mathrm{rms}} = \frac{V_0}{\sqrt{2}}$; $I_{\mathrm{rms}} = \frac{I_0}{\sqrt{2}}$; $P_{\mathrm{average\_AC}} = RI^2_{\mathrm{rms}}$ $(P_{DC} = RI^2)$		

$p = \frac{F}{A}$

$$p = Z\frac{u \text{ or } S}{c} \begin{cases} Z = 1 & \text{totally absorbed} \\ Z = 2 & \text{totally reflected} \\ 1 < Z < 2 & \text{intermediate case} \end{cases}$$

$\mathbf{S} = \mathbf{E} \times \mathbf{H}$

$S = \frac{Pot}{A}$

$F = \frac{P}{t}$, P is linear momentum

$$\longrightarrow P = Z\frac{\overbrace{\boxed{SAt}}^{U}}{c} = Z\frac{U}{c}$$

Volumetric density of the linear momentum of the electromagnetic field : $\varepsilon_0 \mathbf{E} \times \mathbf{B} = \varepsilon_0 \mathbf{E} \times (\mu_0 \mathbf{H}) = \varepsilon_0 \mu_0 \mathbf{S}$

linear momentum of the electromagnetic field in a volume V : $\int_V \varepsilon_0 \mathbf{E} \times \mathbf{B}\, \mathrm{d}V = \int_V \varepsilon_0 \mu_0 \mathbf{S}\, \mathrm{d}V$

Poynting's theorem: $-\frac{d}{dt}\left[\int_V \left(\frac{\varepsilon E^2}{2} + \frac{B^2}{2\mu}\right) dV\right] = \int_V \mathbf{j} \cdot \mathbf{E}\, dV + \oint_S (\mathbf{E} \times \mathbf{H}) \cdot d\mathbf{S}$

$\mathbf{B} = \nabla \times \mathbf{A}$

$\Phi_B = \int_S \mathbf{B} \cdot d\mathbf{S} = \int_S (\nabla \times \mathbf{A}) \cdot d\mathbf{S} = \oint_\Gamma \mathbf{A} \cdot d\mathbf{l}$

$\mathbf{E} = -\nabla\varphi - \frac{\partial \mathbf{A}}{\partial t}$

$\xi(x,t) = \xi_0 \sin[k(x - vt) + \varphi_0]$

$k = \frac{2\pi}{\lambda}$; $v = \frac{\lambda}{T} = \lambda f$

$v = \frac{\omega}{k}$; $\omega = 2\pi f$

$\nabla^2 \mathbf{B} = \mu\sigma\frac{\partial \mathbf{B}}{\partial t} + \varepsilon\mu\frac{\partial^2 \mathbf{B}}{\partial t^2}$

$Q = \frac{\omega\varepsilon}{\sigma}$

$$v = \frac{\omega}{\omega\sqrt{\frac{\varepsilon\mu}{2}}\left(\sqrt{1+\frac{1}{Q^2}}+1\right)^{1/2}} = \left(\frac{2}{\sqrt{1+\frac{1}{Q^2}}+1}\right)^{1/2}\frac{1}{\sqrt{\varepsilon\mu}}$$

$\xi(x,t) = \xi_0 \sin(kx - \omega t + \varphi_0)$

$\xi(\mathbf{r},t) = \xi_0 \sin(\mathbf{k} \cdot \mathbf{r} - \omega t + \varphi_0)$

$\bar{S} = \frac{E_0 B_0}{2\mu}$; $E_0 = cB_0$

$\nabla^2 \mathbf{E} = \mu\sigma\frac{\partial \mathbf{E}}{\partial t} + \varepsilon\mu\frac{\partial^2 \mathbf{E}}{\partial t^2}$

$$\Delta = \frac{1}{\omega\sqrt{\frac{\varepsilon\mu}{2}}\left(\sqrt{1+\frac{1}{Q^2}}-1\right)^{1/2}}$$

$$\Omega = \arctan\left(\sqrt{Q^2+1} - Q\right) = \arctan\frac{1}{\sqrt{Q^2+1}+Q}$$