Operace s Nablou

Gradient	Divergence	Rotace
$\vec{\nabla} f = \left(\frac{\partial f}{\partial x}; \frac{\partial f}{\partial y}; \frac{\partial f}{\partial z}\right)$	$\vec{\nabla} \cdot \vec{F} = \frac{\partial F_x}{\partial x} + \frac{\partial F_y}{\partial y} + \frac{\partial F_z}{\partial z}$	$\vec{\nabla} \times \vec{F} = \left(\frac{\partial F_z}{\partial y} - \frac{\partial F_y}{\partial z}; \frac{\partial F_x}{\partial z} - \frac{\partial F_z}{\partial x}; \frac{\partial F_y}{\partial x} - \frac{\partial F_x}{\partial y}\right)$

Vektorové identity

$\vec{\nabla}(\vec{\nabla} \times \vec{F}) = 0$	$\vec{\nabla} \times \vec{\nabla} \times \vec{F} = \vec{\nabla}(\vec{\nabla}\vec{F}) - \Delta\vec{F}$	$\vec{\nabla}(\vec{A} \times \vec{B}) = \vec{B}(\vec{\nabla} \times \vec{A}) - \vec{A}(\vec{\nabla} \times \vec{B})$

Maxwellovy rovnice

$\vec{\nabla} \cdot \vec{D} = q$	$\vec{\nabla} \cdot \vec{B} = 0$	$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$	$\vec{\nabla} \times \vec{H} = \vec{j} + \frac{\partial \vec{D}}{\partial t}$

Vakuum

$\vec{\nabla} \cdot \vec{E} = 0$	$\vec{\nabla} \cdot \vec{B} = 0$	$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$	$\vec{\nabla} \times \vec{B} = \varepsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t}$

Vodič

$\vec{\nabla} \cdot \vec{E} = 0$	$\vec{\nabla} \cdot \vec{B} = 0$	$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$	$\vec{\nabla} \times \vec{B} = \mu\sigma\vec{E} + \varepsilon\mu \frac{\partial \vec{E}}{\partial t}$

Vlnění

$$\psi(t, \vec{x}) = A\,(t, \vec{x}) e^{i\varphi(t,\vec{x})}$$

$\vec{k} = \vec{\nabla}\varphi$	$\vec{k} = const \to k = \frac{2\pi}{\lambda}$	$\omega = -\frac{\partial \varphi}{\partial t}$	$\omega = const \to \omega = \frac{2\pi}{T}$

Rovinná vlna

$\psi(t, \vec{x}) = A\, e^{i(\vec{k}\cdot\vec{x} - \omega t)}$	$\psi(\vec{x}) = A\, e^{i(\vec{k}\cdot\vec{x})}$

Vlnová rovnice

$$\Delta\psi - \frac{1}{v^2}\frac{\partial^2 \psi}{\partial t^2} = 0 \to \left(\Delta - \frac{1}{v^2}\frac{\partial^2}{\partial t^2}\right)\psi = 0 \to \Box\psi = 0$$

Disperzní relace

$$\phi(\omega, \vec{k}) = 0$$

$\omega = \omega(\vec{k})$	$\vec{k} = \vec{k}(\omega)$
Fázová rychlost	Grupová rychlost
$v_f = \frac{\omega}{k}$	$v_g = \frac{\partial \omega}{\partial k}$

Fourierova transformace

$\frac{\partial}{\partial t} \to -i\omega$	$\vec{\nabla} \to i\vec{k}$
$\frac{\partial}{\partial x} \to ik_x$	$(\vec{\nabla})^2 = \Delta \to -k^2$

Disperzní relace z elektromagnetické vlny ve vakuu

$$\vec{\nabla} \times \vec{B} = \varepsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t} \to \vec{\nabla} \times \vec{\nabla} \times \vec{B} = \varepsilon_0 \mu_0 \frac{\partial \vec{\nabla} \times \vec{E}}{\partial t} \to -\Delta\vec{B} = -\varepsilon_0 \mu_0 \frac{\partial^2 \vec{B}}{\partial t^2} \to (\Delta - \varepsilon_0 \mu_0 \frac{\partial^2}{\partial t^2})\vec{B} = 0$$

$$-k^2 - \frac{1}{c^2}(-\omega^2) = 0 \to \omega = ck$$

$$v_f = \frac{\omega}{k} = c; v_g = \frac{\partial \omega}{\partial k} = c \to v_f \cdot v_g = c^2$$

Dopplerův Jev	
Nerelativisticky	Relativisticky
$f = f_0(1 \pm \frac{v}{c})$	$f = \gamma(1 \pm \frac{v}{c})f_0$

Relativita			
$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$	$\beta = \frac{v}{c}$	$\tilde{t} = \gamma\left(t - \frac{vx}{c^2}\right)$	$\tilde{x} = \gamma(x - vt)$

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

Čtyř-vektory (Objekty, které lze transformovat Lorentzovou maticí)			
Událost	Čtyř-tok	Čtyř-potenciál	Čtyř-rychlost
$\begin{pmatrix} ct \\ x \\ y \\ z \end{pmatrix}$	$\begin{pmatrix} c\rho \\ j_x \\ j_y \\ j_z \end{pmatrix}$	$\begin{pmatrix} \frac{\phi}{c} \\ A_x \\ A_y \\ A_z \end{pmatrix}$	$\gamma\begin{pmatrix} c \\ v_x \\ v_y \\ v_z \end{pmatrix}$

Transformace	
$\tilde{S} = \Lambda S$	$S = \Lambda^{-1}\tilde{S}$
$\begin{pmatrix} c\tilde{t} \\ \tilde{x} \\ \tilde{y} \\ \tilde{z} \end{pmatrix} = \begin{pmatrix} \gamma & -\gamma\beta & 0 & 0 \\ -\gamma\beta & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} ct \\ x \\ y \\ z \end{pmatrix}$	$\begin{pmatrix} ct \\ x \\ y \\ z \end{pmatrix} = \begin{pmatrix} \gamma & \gamma\beta & 0 & 0 \\ \gamma\beta & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} c\tilde{t} \\ \tilde{x} \\ \tilde{y} \\ \tilde{z} \end{pmatrix}$
Kontrakce délek	Dilatace času
$\Delta x = \frac{\Delta\tilde{x}}{\gamma}$	$\Delta \mathrm{t} = \gamma\Delta\tilde{t}$

Energie			
Celková energie	Kinetická energie	Klidová energie	Pythagorova věta o energii
$E = \gamma m_0 c^2$	$E = (\gamma - 1)m_0 c^2$	$E = m_0 c^2$	$E^2 = p^2c^2 + m_0^2c^4$