

$$\rho(\mathbf{r}) = \sum_{\alpha} q_{\alpha} \delta^{(3)}(\mathbf{r} - \mathbf{r}_{\alpha}) \quad (1)$$

$$\nabla \cdot \vec{j} + \frac{\partial \rho}{\partial t} = 0 \quad (2)$$

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$$

$$\mathbf{F} = \int \rho d^3 r (\mathbf{E} + \mathbf{v} \times \mathbf{B}) \quad (3)$$

$$= \int (\rho \mathbf{E} + \mathbf{j} \times \mathbf{B}) d^3 r$$

$$\mathbf{p} = \int_V \rho(\mathbf{r}) \mathbf{r} dV \quad (4)$$

$$\phi = \frac{1}{4\pi\epsilon_0} \int_V \frac{\rho(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} dV' \quad (5)$$

$$\phi = \frac{1}{4\pi\epsilon_0} \left[\frac{Q}{r} + \frac{\mathbf{r} \cdot \mathbf{p}}{r^3} + \frac{x_i D_{ij} x_j}{2r^5} \right] \quad (6)$$

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0} \int \frac{\rho(\mathbf{r}') d^3 r'}{|\mathbf{r} - \mathbf{r}'|} (\mathbf{r} - \mathbf{r}') \quad (7)$$

$$D_{ij} = \int \rho(\mathbf{r}) (3x_i x_j - \delta_{ij} r^2) dV$$

$$D_{ij} = \sum_{\alpha} q_{\alpha} (3x_i^{(\alpha)} x_j^{(\alpha)} - \delta_{ij} (r^{(\alpha)})^2); \quad \text{Tr } \hat{D} = 0 \quad (8)$$

$$\mathbf{E} = -\nabla \phi \quad (9)$$

$$\mathbf{j} = \rho \mathbf{v} \quad (10)$$

$$\mathbf{A}(\mathbf{r}) = \frac{\mu_0}{4\pi} \int \frac{\mathbf{j}(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} dV' \quad (11)$$

$$\mathbf{A}(\mathbf{r}) = \frac{\mu_0}{4\pi} \frac{\mathbf{m} \times \mathbf{r}}{r^3} \quad (12)$$

$$\mathbf{m}(\mathbf{r}) = \frac{1}{2} \int \mathbf{r} \times \mathbf{j}(\mathbf{r}) dV \quad (13)$$

$$\mathbf{B}(\mathbf{r}) = \nabla \times \mathbf{A} = \frac{\mu_0}{4\pi} \int \frac{\mathbf{j}(\mathbf{r}') \times (\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3} dV' \quad (14)$$

$$\mathbf{E} = -\frac{\partial \mathbf{A}}{\partial t} - \nabla \phi \quad (15)$$

$$\nabla \cdot \mathbf{A} + \frac{1}{c^2} \frac{\partial \phi}{\partial t} = 0$$

$$\nabla^2 \phi - \frac{1}{c^2} \frac{\partial^2 \phi}{\partial t^2} = -\frac{\rho}{\epsilon_0} \quad (16)$$

$$\nabla^2 \mathbf{A} - \frac{1}{c^2} \frac{\partial^2 \mathbf{A}}{\partial t^2} = -\mu_0 \mathbf{j}$$

$$\langle \rho \rangle = \frac{1}{T} \int_0^T \rho dt \quad (17)$$

$$D_{2n} - D_{1n} = \sigma$$

$$B_{2n} - B_{1n} = 0$$

$$P_{2n} - P_{1n} = -\sigma_{vez}$$

$$E_{2n} - E_{1n} = \frac{1}{\epsilon_0} \sigma \quad (18)$$

$$E_{2t} - E_{1t} = 0$$

$$\mathbf{n} \times (\mathbf{H}_2 - \mathbf{H}_1) = \mathbf{i}$$

$$M_{2t} - M_{1t} = \mathbf{i}_{vez} \times \mathbf{n}$$

$$\nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$

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

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \quad (19)$$

$$\nabla \times \mathbf{B} = \mu_0 \left(\mathbf{j} + \epsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right)$$

$$\nabla \cdot \vec{D} = \rho + \rho_{ext}$$

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

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \quad (20)$$

$$\nabla \times \mathbf{H} = \mathbf{j} + \mathbf{j}_{ext} + \frac{\partial \mathbf{D}}{\partial t}$$

$$q = UC = U\epsilon_0 \frac{S}{d} \quad (21)$$

$$\frac{d}{dt} \left(\sum_n \epsilon_n + \underbrace{\int_V d^3 r \left(\frac{1}{2} \mathbf{D} \cdot \mathbf{E} + \frac{1}{2} \mathbf{H} \cdot \mathbf{B} \right)}_{W_{em}} \right) \quad (22)$$

$$= - \oint_{\partial S} \mathbf{S}_p d\mathbf{S}$$

$$\frac{d}{dt} (\sum_n \epsilon_n) = \int d^3 r \mathbf{j} \cdot \mathbf{E}$$

$$\mathbf{S}_p = \mathbf{E} \times \mathbf{H} \quad (23)$$

$$\mathbf{g} = \frac{\mathbf{S}_p}{c^2} \quad \text{- gustina impulsa}$$

$$\mathbf{L} = \int \mathbf{r} \times \mathbf{g} dV \quad (24)$$

$$\frac{d}{dt} \left[\sum_{\alpha} \mathbf{p}_{\alpha} + \int d^3 r (\mathbf{D} \times \mathbf{B}) \right]$$

$$- \frac{1}{2} \int d^3 r (\epsilon_0 \mathbf{E}^2 \nabla \epsilon_r + \mu_0 \mathbf{H}^2 \nabla \mu_r) = \oint_S \hat{T} d\mathbf{S} \quad (25)$$

$$\hat{T} = |\mathbf{E}\rangle\langle\mathbf{D}| + |\mathbf{H}\rangle\langle\mathbf{B}| - \frac{1}{2}(\mathbf{E} \cdot \mathbf{D} + \mathbf{H} \cdot \mathbf{B})\hat{I}$$

$$V^{\mu} = \left(\frac{\frac{c}{\sqrt{1-\frac{v^2}{c^2}}}}{\frac{\mathbf{v}}{\sqrt{1-\frac{v^2}{c^2}}}} \right) \quad (26)$$

$$P^{\mu} = mV^{\mu} = \left(\frac{E}{\mathbf{p}} \right) \quad (27)$$

$$\mathcal{A}^{\mu} = \frac{dV^{\mu}}{d\tau} = \left(\gamma \frac{d\gamma}{dt} \mathbf{v} + \gamma^2 \mathbf{a} \right) \quad (28)$$

$$\mathcal{F}^{\mu} = \left(\frac{\frac{\mathbf{v} \cdot \mathbf{F}}{c\sqrt{1-\frac{v^2}{c^2}}}}{\frac{\mathbf{F}}{\sqrt{1-\frac{v^2}{c^2}}}} \right) \quad (29)$$

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

$$\mathbf{E}'_{\perp} = \frac{\mathbf{E}_{\perp} + \mathbf{v} \times \mathbf{B}_{\perp}}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (30)$$

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

$$\mathbf{B}'_{\perp} = \frac{\mathbf{B}_{\perp} - \frac{1}{c^2} \mathbf{v} \times \mathbf{E}_{\perp}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\mathbf{E}' = \gamma(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \frac{\gamma^2}{c^2(1+\gamma)}(\mathbf{v} \cdot \mathbf{E})\mathbf{v} \quad (31)$$

$$\mathbf{B}' = \gamma(\mathbf{B} - \frac{1}{c^2} \mathbf{v} \times \mathbf{E}) - \frac{\gamma^2}{c^2(1+\gamma)}(\mathbf{v} \cdot \mathbf{B})\mathbf{v}$$

$$\begin{pmatrix} x'^0 \\ x'^1 \\ x'^2 \\ x'^3 \end{pmatrix} = \underbrace{\begin{pmatrix} \gamma & -\beta\gamma & 0 & 0 \\ -\beta\gamma & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}}_{\Lambda^{\mu}_{\nu}} \begin{pmatrix} x^0 \\ x^1 \\ x^2 \\ x^3 \end{pmatrix} \quad (32)$$

$$g_{\mu\nu} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix} \quad (33)$$

$$\frac{\partial}{\partial x^{\mu}} = \left(\frac{1}{c} \frac{\partial}{\partial t}, \nabla \right) \quad (34)$$

$$j^{\mu} = (c\rho, \mathbf{j} = \rho\mathbf{v}) \quad (35)$$

$$A^{\mu} = \left(\frac{\phi}{c}, \mathbf{A} \right) \quad (36)$$

$$\square A^{\mu} = \mu_0 j^{\mu} \quad (37)$$

$$F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \quad (38)$$

$$F^{\mu\nu} = \begin{pmatrix} 0 & -\frac{E_x}{c} & -\frac{E_y}{c} & -\frac{E_z}{c} \\ \frac{E_x}{c} & 0 & -B_z & B_y \\ \frac{E_y}{c} & B_z & 0 & -B_x \\ \frac{E_z}{c} & -B_y & B_x & 0 \end{pmatrix} \quad (39)$$

$$F'^{\mu\nu} = (\Lambda F \Lambda^T)^{\mu\nu} \quad (40)$$

$$\frac{d\mathbf{p}}{dt} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$$

$$\frac{d}{dt} \left(\underbrace{\frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}}}_E \right) = \mathbf{v} \cdot \mathbf{F} = q\mathbf{v} \cdot \mathbf{E} \quad (41)$$

$$E^2 = c^2 p^2 + m^2 c^4 \quad (42)$$

$$\frac{d}{d\tau} \left(\frac{\partial \tilde{L}}{\partial u^{\alpha}} \right) - \frac{\partial \tilde{L}}{\partial x^{\alpha}} = 0 \quad (43)$$

$$\frac{\partial u^{\mu}}{\partial u^{\alpha}} = \delta^{\mu}_{\alpha}$$

$$\frac{\partial u^{\mu}}{\partial u_{\alpha}} = g^{\mu\alpha} \quad (44)$$

$$S = \int (-mc ds - q A^{\mu} dx_{\mu}) + S_f$$

$$ds = \sqrt{g_{\mu\nu} \frac{dx^{\mu}}{d\tau} \frac{dx^{\nu}}{d\tau}} d\tau \quad (45)$$

$$ds = c d\tau = c \sqrt{1 - \frac{v^2}{c^2}} dt$$

$$A^{\mu} dx_{\mu} = (\phi - \mathbf{A} \cdot \mathbf{v}) dt$$

$$\sin(\alpha \pm \beta) = \sin \alpha \cos \beta \pm \cos \alpha \sin \beta$$

$$\cos(\alpha \pm \beta) = \cos \alpha \cos \beta \mp \sin \alpha \sin \beta$$

$$\tan(\alpha \pm \beta) = \frac{\tan \alpha \pm \tan \beta}{1 \mp \tan \alpha \tan \beta} \quad (46)$$

$$\cot(\alpha \pm \beta) = \frac{\cot \alpha \cot \beta \mp 1}{\cot \beta \pm \cot \alpha}$$

$$\sin(2\alpha) = 2 \sin \alpha \cos \alpha$$

$$\cos(2\alpha) = \cos^2 \alpha - \sin^2 \alpha$$

$$\tan(2\alpha) = \frac{2 \tan \alpha}{1 - \tan^2 \alpha} \quad (47)$$

$$\cot(2\alpha) = \frac{\cot^2 \alpha - 1}{2 \cot \alpha}$$

$$\sin \alpha \pm \sin \beta = 2 \sin \frac{\alpha \pm \beta}{2} \cos \frac{\alpha \mp \beta}{2}$$

$$\cos \alpha + \cos \beta = 2 \cos \frac{\alpha + \beta}{2} \cos \frac{\alpha - \beta}{2}$$

$$\cos \alpha - \cos \beta = -2 \sin \frac{\alpha + \beta}{2} \sin \frac{\alpha - \beta}{2}$$

$$\tan \alpha \pm \tan \beta = \frac{\sin(\alpha \pm \beta)}{\cos \alpha \cos \beta} \quad (48)$$

$$\cot \alpha \pm \cot \beta = \frac{\sin(\alpha \pm \beta)}{\sin \alpha \sin \beta}$$

$$\sin \alpha \cos \beta = \frac{1}{2} (\sin(\alpha + \beta) + \sin(\alpha - \beta))$$

$$\cos \alpha \cos \beta = \frac{1}{2} (\cos(\alpha + \beta) + \cos(\alpha - \beta))$$

$$\sin \alpha \sin \beta = -\frac{1}{2} (\cos(\alpha + \beta) - \cos(\alpha - \beta))$$

$$\sin \frac{\alpha}{2} = \pm \sqrt{\frac{1 - \cos \alpha}{2}}$$

$$\cos \frac{\alpha}{2} = \pm \sqrt{\frac{1 + \cos \alpha}{2}} \quad (49)$$

$$\tan \frac{\alpha}{2} = \pm \sqrt{\frac{1 - \cos \alpha}{1 + \cos \alpha}}$$