$$\rho(\mathbf{r}) = \sum_{a} q_a \delta^{(3)}(\mathbf{r} - \mathbf{r}_{\alpha}) \tag{1}$$

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

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

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

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

$$\mathbf{p} = \int_{V} \rho(\mathbf{r}) \mathbf{r} dV \tag{4}$$

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

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

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

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

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

$$\mathbf{E} = -\nabla \phi \tag{9}$$

$$\mathbf{j} = \rho \mathbf{v} \tag{10}$$

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

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

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

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

$$\mathbf{E} = -\frac{\partial \mathbf{A}}{\partial t} - \nabla \phi \tag{15}$$

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

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

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

$$\langle \rho \rangle = \frac{1}{T} \int_{0}^{T} \rho dt \tag{17}$$

$$\nabla^2 \phi - \frac{1}{c^2} \frac{\partial^2 \phi}{\partial t^2} = -\frac{1}{\epsilon_0} \rho \tag{18}$$

$$\nabla^2 \mathbf{A} - \frac{1}{c^2} \frac{\partial^2 \mathbf{A}}{\partial t^2} = -\mu_0 \mathbf{j}$$
 (19)

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

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

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

$$E_{2n} - E_{1n} = \frac{1}{\epsilon_0} \sigma \tag{20}$$

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

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

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

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

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

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \tag{21}$$

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

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

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

$$\nabla \times \mathbf{E} = -\frac{\partial B}{\partial t} \tag{22}$$

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

$$q = UC = U\epsilon_0 \frac{S}{d} \tag{23}$$

$$\frac{d}{dt} \left(\sum_{n} \varepsilon_{n} + \underbrace{\int_{V} d^{3}r \left(\frac{1}{2} \mathbf{D} \cdot \mathbf{E} + \frac{1}{2} \mathbf{H} \cdot \mathbf{B} \right)}_{W_{em}} \right) \\
= - \oint_{\partial S} \mathbf{S}_{p} d\mathbf{S} \tag{24}$$

$$\frac{\mathrm{d}}{\mathrm{d}t}(\sum \varepsilon_n) = \int \mathrm{d}^3 r \, \mathbf{j} \cdot \mathbf{E}$$

$$\mathbf{S}_p = \mathbf{E} imes \mathbf{H}$$

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

$$\mathbf{L} = \int \mathbf{r} \times \mathbf{g} dV \tag{26}$$

(25)

(27)

(32)

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

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

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

$$V^{\mu} = \begin{pmatrix} \frac{c}{\sqrt{1 - \frac{v^2}{c^2}}} \\ \frac{\mathbf{v}}{\sqrt{1 - \frac{v^2}{c^2}}} \end{pmatrix}$$
 (28)

$$P^{\mu} = mV^{\mu} = \begin{pmatrix} \frac{E}{c} \\ \mathbf{p} \end{pmatrix} \tag{29}$$

$$\mathcal{A}^{\mu} = \frac{\mathrm{d}V^{\mu}}{\mathrm{d}\tau} = \begin{pmatrix} c\gamma \frac{\mathrm{d}\gamma}{\mathrm{d}t} \\ \gamma \frac{\mathrm{d}\gamma}{\mathrm{d}t} \mathbf{v} + \gamma^{2} \mathbf{a} \end{pmatrix}$$
(30)

$$\mathcal{F}^{\mu} = \begin{pmatrix} \frac{\mathbf{v} \cdot \mathbf{F}}{c\sqrt{1 - \frac{v^2}{c^2}}} \\ \frac{\mathbf{F}}{\sqrt{1 - \frac{v^2}{c^2}}} \end{pmatrix}$$
(31)

$$\mathbf{E'}_{\parallel} = \mathbf{R}_{\parallel}$$
 $\mathbf{E}_{\perp} + \mathbf{v} \times \mathbf{F}_{\parallel}$

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

$$\mathbf{B'}_{\parallel} = \mathbf{B}_{\parallel}$$
 $\mathbf{B'}_{\perp} = rac{\mathbf{B}_{\perp} - rac{1}{c^2}\mathbf{v} imes \mathbf{E}_{\perp}}{\sqrt{1 - rac{v^2}{2}}}$

$$\mathbf{E}' = \gamma (\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \frac{\gamma^2}{c^2 (1 + \gamma)} (\mathbf{v} \cdot \mathbf{E}) \mathbf{v}$$
(33)

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

$$\begin{pmatrix} x'^0 \\ x'^1 \\ x'^2 \\ x'^3 \end{pmatrix} = \underbrace{\begin{pmatrix} \gamma & -\beta\gamma & 0 & 0 \\ -\beta\gamma & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}}_{\Lambda^{\mu}} \begin{pmatrix} x^0 \\ x^1 \\ x^2 \\ x^3 \end{pmatrix}$$
(34)

$$g_{\mu\nu} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$$
 (35)

$$\frac{\partial}{\partial x^{\mu}} = \left(\frac{1}{c}\frac{\partial}{\partial t}, \nabla\right) \tag{36}$$

$$j^{\mu} = (c\rho, \mathbf{j} = \rho \mathbf{v}) \tag{37}$$

$$A^{\mu} = (\frac{\phi}{c}, \mathbf{A}) \tag{38}$$

$$\Box A^{\mu} = \mu_0 j^{\mu} \tag{39}$$

$$F^{\mu\nu} = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu} \tag{40}$$

$$F^{\mu\nu} = \begin{pmatrix} 0 & -\frac{E_x}{c} & -\frac{E_y}{c} & -\frac{E_z}{c} \\ \frac{E_x}{c} & 0 & -B_z & B_y \\ \frac{E_y}{c} & B_z & 0 & -B_x \\ \frac{E_z}{c} & -B_y & B_x & 0 \end{pmatrix}$$
(41)

$$F^{'\mu\nu} = (\Lambda F \Lambda^T)^{\mu\nu} \tag{42}$$

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

$$\frac{\mathrm{d}}{\mathrm{d}t} \underbrace{\left(\frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}}\right)}_{E} = \mathbf{v} \cdot \mathbf{F} = q\mathbf{v} \cdot \mathbf{E}$$
(43)

$$E^2 = c^2 p^2 + m^2 c^4 (44)$$

$$\frac{\mathrm{d}}{\mathrm{d}\tau} \left(\frac{\partial \tilde{L}}{\partial u^{\alpha}} \right) - \frac{\partial \tilde{L}}{\partial x^{\alpha}} = 0 \tag{45}$$

$$\frac{\partial u^{\mu}}{\partial u^{\alpha}} = \delta^{\mu}_{\alpha}
\frac{\partial u^{\mu}}{\partial u_{\alpha}} = g^{\mu\alpha}$$
(46)

$$S = \int (-mcds - qA^{\mu}dx_{\mu}) + S_{f}$$

$$ds = \sqrt{g_{\mu\nu}} \frac{dx^{\mu}}{d\tau} \frac{dx^{\nu}}{d\tau} d\tau$$

$$ds = cd\tau = c\sqrt{1 - \frac{v^{2}}{c^{2}}} dt$$
(47)

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

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