$$\gamma \equiv \frac{1}{\sqrt{1-(v/c)^2}} \qquad \beta \equiv \frac{v}{c}$$

$$\Delta t = \gamma \, \Delta\tau$$

$$L = L_p/\gamma$$

$$\begin{aligned} ct' &= \gamma\,(ct) - \gamma\beta\,x \\ x' &= -\gamma\beta\,(c\,t) + \gamma\,x \\ y' &= y \\ z' &= z \end{aligned}$$

$$\begin{aligned} t' &= t \\ x' &= x - vt \\ y' &= y \\ z' &= z \end{aligned}$$

$$(\Delta x')^2 - (c\Delta t')^2 = (\Delta x)^2 - (c\Delta t)^2 \qquad (1)$$

$$u'_x = \frac{u_x - v}{1 - u_x v/c^2} \qquad (2)$$

$$u'_y = \frac{u_y}{\gamma(1 - u_x v/c^2)} \qquad (3)$$

$$u'_z = \frac{u_z}{\gamma(1 - u_y v/c^2)} \qquad (4)$$

$$f = f_o \sqrt{\frac{1+v/c}{1-v/c}}$$

$$f(x) = f(x_o) + f'(x_o)\,\Delta x + \frac{1}{2!} f''(x_o)\,\Delta x^2 + \dots$$

$$(1+x)^\alpha \approx 1 + \alpha x + \frac{\alpha(\alpha-1)}{2!}\,x^2 + \dots \qquad (5)$$

$$\frac{1}{1-x} = 1 + x + x^2 + x^3 + \dots \qquad (6)$$

$$\mathbf{p} \equiv \gamma m \mathbf{u} \quad \text{with} \quad \gamma \equiv \frac{1}{\sqrt{1-u^2/c^2}} \qquad (7)$$

$$E \equiv \gamma m c^2 \quad \text{with} \quad \gamma \equiv \frac{1}{\sqrt{1-u^2/c^2}} \qquad (8)$$

$$E_{\text{rest}} = mc^2 \qquad K = \gamma mc^2 - mc^2 \qquad (9)$$

$$E^2 = (cp)^2 + (mc^2)^2 \qquad \mathbf{u} = \frac{\mathbf{p}}{E} \qquad (10)$$

$$E' = \gamma\,E - \gamma\beta\,(cp_x) \qquad (11)$$

$$cp'_x = -\gamma\beta\,E + \gamma\,(cp_x) \qquad (12)$$

$$cp'_y = cp_y \qquad (13)$$

$$cp'_z = cp_z \qquad (14)$$

$$\frac{d\mathbf{p}}{dt} = \mathbf{F}$$

$$\frac{dp}{dt} = \frac{pv}{R} = \frac{\gamma m v^2}{R}$$

$$E = hf \qquad c\,p = E$$

$$I = \left\langle \frac{E}{A\Delta t} \right\rangle$$

$$I = hf \left\langle \frac{N}{A\Delta t} \right\rangle$$

$$I = \left\langle \frac{\mathcal{E} \times \mathcal{B}}{\mu_0} \right\rangle \qquad (15)$$

$$= \sqrt{\frac{\epsilon_o}{\mu_o}} \left\langle \mathcal{E}^2 \right\rangle \qquad (16)$$

$$E_e = hf - \phi$$

$$|e| V_s = E_e$$

$$2d\sin(\theta) = n\lambda \qquad n = 1, 2, 3, \dots \qquad (17)$$

$$\lambda' - \lambda = \frac{h}{m_e c}\,(1 - \cos\theta) \qquad (18)$$

$$\lambda_C = \frac{h}{m_e c} = 0.0024\text{nm}$$

$$\hbar = \frac{h}{2\pi} \qquad \lambda = \frac{\lambda}{2\pi}$$

$$a_0 = \frac{\hbar}{m_e c}\,\frac{1}{\alpha} = \frac{\hbar^2}{m_e k e^2} \simeq 0.5\mathring{A}$$

$$\alpha = \frac{ke^2}{\hbar c} \simeq \frac{1}{137}$$

$$L = m_e v r = n\hbar n = 1, 2, 3, \dots$$

$$
\begin{aligned}
L = m_e v r &= n\hbar \qquad n = 1, 2, 3\ldots && (19)\\
\frac{v_n}{c} &= Z\alpha \left[\frac{1}{n}\right] && (20)\\
E_n &= -\frac{1}{2} m_e c^2 (Z\alpha)^2 \left[\frac{1}{n^2}\right] && (21)\\
&= -\frac{ke^2}{2a_o} Z^2 \left[\frac{1}{n^2}\right] && (22)\\
&= -13.6\,\mathrm{eV}\, Z^2 \left[\frac{1}{n^2}\right] && (23)\\
r_n &= \frac{a_0}{Z}\left[n^2\right] && (24)\\
&= \frac{\hbar}{m_e c\, Z\alpha}\left[n^2\right] && (25)
\end{aligned}
$$

$$KE = -\frac{1}{2} PE \qquad \text{for Force} \propto 1/r^2$$

$$\frac{1}{2} m_e c^2 \alpha^2 = \frac{ke^2}{2a_0} = 13.6\,\mathrm{eV}$$