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

$$\vec{p} = m\vec{v} = \frac{m_0\vec{v}}{\sqrt{1 - v^2 / c^2}} \quad (1.1)$$

$$E = mc^2 = \frac{m_0 c^2}{\sqrt{1 - v^2 / c^2}} = T + m_0 c^2 \quad (1.2)$$

КШФ 11.2.3

$$F_x = \frac{d}{dt}\frac{mv}{\sqrt{1 - v^2 / c^2}} \quad (1.3)$$

$$\int F dt = \int d\frac{mv}{\sqrt{1 - v^2 / c^2}}$$

$$Ft = \left.\frac{mv}{\sqrt{1 - v^2 / c^2}}\right|_0^v = \frac{mv}{\sqrt{1 - v^2 / c^2}} \quad (1.4)$$

$$1 - \frac{v^2}{c^2} = \frac{m^2 v^2}{F^2 t^2}$$

$$v = \frac{1}{\sqrt{\frac{1}{c^2} + \frac{m^2}{F^2 t^2}}} = \frac{cFt}{\sqrt{F^2 t^2 + m^2 c^2}} \approx \frac{Ft}{m} = at \quad (1.5)$$

$$v = \frac{ds}{dt} = \frac{cFt}{\sqrt{F^2 t^2 + m^2 c^2}} \quad (1.6)$$

$$\int_0^s ds = \int_0^t \frac{cFt}{\sqrt{F^2 t^2 + m^2 c^2}} dt \quad (1.7)$$

$$\alpha = F^2 t^2 + m^2 c^2$$

$$d\alpha = F^2 2t dt \quad (1.8)$$

$$s = \frac{c}{2F}\int_{m^2c^2}^{\alpha} \frac{d\alpha}{\sqrt{\alpha}} = \frac{c}{F}\sqrt{\alpha}\Big|_{m^2c^2}^{\alpha} = \frac{c}{F}\sqrt{F^2 t^2 + m^2 c^2}\Big|_0^t = \frac{c}{F}\left(\sqrt{\alpha} - mc\right) =$$

$$= \frac{c}{F}\left(\sqrt{F^2 t^2 + m^2 c^2} - mc\right) \quad (1.9)$$

Не релятивістський випадок:

$$s = \frac{c}{F}\left(\sqrt{F^2 t^2 + m^2 c^2} - mc\right) = \frac{c}{F}\left(mc\sqrt{1 + \frac{F^2 t^2}{m^2 c^2}} - mc\right) \approx$$

$$\approx \frac{c}{F}\left(mc\left(1 + \frac{1}{2}\frac{F^2 t^2}{m^2 c^2}\right) - mc\right) = \frac{c}{F}\frac{mc}{2}\frac{F^2 t^2}{m^2 c^2} = \frac{Ft^2}{2m} = \frac{at^2}{2} \quad (1.10)$$

КШФ 11.2.7

$$E^2 - p^2c^2 = const \tag{1.11}$$

$$\left(T + mc^2 + mc^2\right)^2 - (\vec{p}_1)^2 c^2 = E'^2 - \vec{p}'^2 c^2 = M^2 c^4 \tag{1.12}$$

$$\begin{aligned}
&\left(T + mc^2 + mc^2\right)^2 - (\vec{p}_1)^2 c^2 = M^2 c^4 \\
&\left(E_1 + mc^2\right)^2 - (\vec{p}_1)^2 c^2 = M^2 c^4 \\
&E_1^2 + 2E_1 mc^2 + m^2c^4 - p_1^2 c^2 = m^2c^4 + 2E_1 mc^2 + m^2c^4 = \\
&= 2m^2c^4 + 2(T + mc^2)mc^2 = 2Tmc^2 + 4m^2c^4 = M^2c^4
\end{aligned} \tag{1.13}$$

$$M = \sqrt{\frac{2Tmc^2 + 4m^2c^4}{c^4}} = \sqrt{\frac{2Tm}{c^2} + 4m^2} \tag{1.14}$$