The main law of Einstein physics:

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

Dimension check:

$$\frac{d}{dt}(kg \cdot \frac{m}{s}) = kg \cdot \frac{m}{s^2} = N, \qquad q\vec{E}(A \cdot s \cdot V \cdot m^{-1}) = q\vec{E}(A \cdot s \cdot \frac{kg \cdot m^2}{A \cdot s^3} \cdot m^{-1})$$

Main logic:

$$\frac{d}{dt}\frac{m\vec{v}(t)}{\sqrt{1-\frac{v^2}{c^2}}} = q\vec{E} + q[\vec{v}(t) \times \vec{B}] \quad \Leftrightarrow$$

$$\frac{m\vec{v}(t+dt)}{\sqrt{1-\frac{v(t+dt)^2}{c^2}}} - \frac{m\vec{v}(t)}{\sqrt{1-\frac{v(t)^2}{c^2}}} = q(\vec{E} + [\vec{v}(t) \times \vec{B}])dt$$

$$\frac{\vec{v}(t+dt)}{\sqrt{1-\frac{v(t+dt)^2}{c^2}}} = \frac{q}{m}(\vec{E} + [\vec{v}(t) \times \vec{B}])\, dt + \frac{\vec{v}(t)}{\sqrt{1-\frac{v(t)^2}{c^2}}}$$

$$\vec{v}(t+dt) = \left(\frac{q}{m}(\vec{E} + [\vec{v}(t) \times \vec{B}])\, dt + \frac{\vec{v}(t)}{\sqrt{1-\frac{v(t)^2}{c^2}}}\right)\sqrt{1-\frac{v(t+dt)^2}{c^2}}$$

Denote:

$$\vec{A} = \frac{q(\vec{E}+[\vec{v}(t)\times\vec{B}])}{m}dt + \frac{\vec{v}(t)}{\sqrt{1-\frac{\vec{v}^2(t)}{c^2}}}$$

$$\vec{v}(t + dt) = \vec{A}\sqrt{1 - \frac{\vec{v}^2(t+dt)}{c^2}}$$

$$\vec{v}^2(t + dt) = \vec{A}^2(1 - \frac{\vec{v}^2(t+dt)}{c^2}) \Rightarrow \vec{v}^2(t + dt) + \vec{A}^2\frac{\vec{v}^2(t+dt)}{c^2} = \vec{A}^2$$

$$\vec{v}^2(t + dt)\left(1 + \frac{\vec{A}^2}{c^2}\right) = \vec{A}^2 \Rightarrow \vec{v}^2(t + dt) = \frac{\vec{A}^2}{1+\frac{\vec{A}^2}{c^2}}$$

$$\vec{v}(t + dt) = \frac{\vec{A}}{\sqrt{1+\frac{\vec{A}^2}{c^2}}}, \text{ where } v^2(t) = v_x^2(t) + v_y^2(t) + v_z^2(t)$$