$$\tau = \int_0^t d\tau$$

$$\tau = \int_0^t \frac{dt}{\gamma} \ , \ \gamma = \frac{1}{\sqrt{1 - (\frac{v}{c})^2}}$$

$$\tau = \int_0^t \sqrt{1 - (\frac{v}{c})^2} \ dt$$

$$\tau = \int_0^t \sqrt{1 - (\frac{at}{c})^2} \ dt$$

$$\tau = \frac{at\sqrt{1 - (\frac{at}{c})^2} \ + \ csin^{-1}(\frac{at}{c})}{2a} \ |_0^{t_1}$$

$$\frac{1}{2}[t_1\sqrt{1 - (\frac{at_1}{c})^2} \ + \ \frac{c}{a}sin^{-1}(\frac{at_1}{c})]$$

$$\frac{1}{2}[t_1\gamma_{t_1} \ + \ \frac{c}{a}sin^{-1}(\frac{v_{t_1}}{c})]$$