Ohanian Solutions 3.

8.a) $t = \frac{40 \times 10^3 \text{ m}}{0.9?3 \times 10^8 \text{ m/s}} = 133\ \mu s \qquad e^{-t/\tau} = e^{-133/2.2} = 5.5 \times 10^{-27}$ ~ ZERO.

b) $\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} = 7.1 \qquad \tau_{eff} = 15.6\ \mu s. \qquad e^{-t/\tau'} = 2 \times 10^{-4} = 0.02\%.$

9) a) $\gamma\tau = t = \frac{x}{v}$ solve for v: $v^2\gamma^2 = \frac{x^2}{\tau^2} = \frac{v^2}{1 - v^2/c^2}$

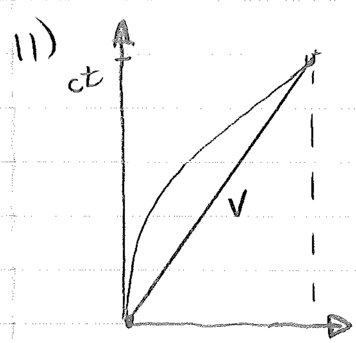
so $\frac{x^2}{\tau^2}\left(1 - \frac{v^2}{c^2}\right) = v^2$

$\frac{x^2}{\tau^2} = v^2\left(1 + \frac{x^2}{(c\tau)^2}\right) \qquad v = \frac{x/\tau}{\sqrt{1 + x^2/(c\tau)^2}} = \frac{2500c}{\sqrt{1 + 2500^2}} =$

$= 0.9999992\ c$

b) 25,000 + 0.002 yrs.

11)



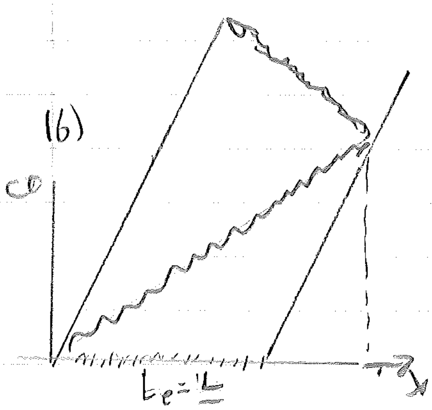
Straight worldline $\tau = \frac{t}{\gamma_0} = \sqrt{1 - \frac{v^2}{c^2}}\ t$

Accelerating worldline $v = at$

$d\tau = \frac{dt}{\gamma} = \sqrt{1 - v^2/c^2}\ dt$

$\tau = \int_0^t \sqrt{1 - (at)^2/c^2}\ dt = \frac{1}{2} t \sqrt{1 - \frac{a^2t^2}{c^2}} + \frac{\sin^{-1}\left(\frac{at}{c}\right)}{\left(\frac{2a}{c}\right)}$

16)



Forward

$ct = L_e + vt \qquad t = L_e/c - v$

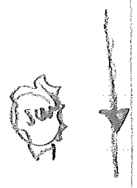
Backward

$ct = L_e - vt \qquad t = L_e/c + v.$

$t_{tot} = \frac{2cL_e}{(c - v)(c + v)} = \frac{2L}{\gamma c} \cdot \frac{1}{1 - v^2/c^2} = 2\gamma\frac{L}{c}$

19. Doppler twice. so $\nu' = \frac{1+v/c}{1-v/c}$.

21. Far away, approaching, shorter λ. $\lambda' = \sqrt{\frac{1-v/c}{1+v/c}}\,\lambda = 0.33\lambda$
$= 183$ nm UV



Abeam. Sun's clock runs slowly, so light is longer λ.

$$\lambda' = \gamma\lambda = 1.66\lambda = 917 \text{ nm. near IR.}$$

Receding: $\lambda' = \sqrt{\frac{1+v/c}{1-v/c}}\,\lambda = 3\lambda = 1650$ nm.