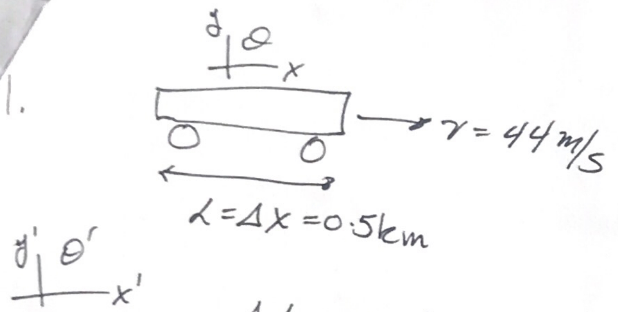
PH253 S19
HW1

1.



$\Delta t = 0$ for stationary observer - simultaneous

$$\Delta t' = \gamma\left(\Delta t - \frac{v\Delta x}{c^2}\right) = -\frac{\gamma v L}{c^2} \simeq \underline{-2.4\times10^{-13}\,s}$$

$\Delta x = x_{front} - x_{back}$ $\quad \Delta t = t_{front} - t_{back}$

$\Delta t' < 0 \Rightarrow$ strikes the front first

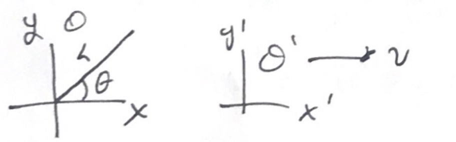
2. in pion frame O, $\Delta t_p = 1.8\times10^{-8}\,s$

$v = 0.8c \Rightarrow \gamma = 5/3$

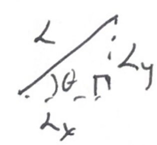
Classical: $\Delta t'_{lab} = \Delta t_p$, $\Delta x' = v\Delta t' \simeq \underline{4.3\,m}$

rel.: $\Delta t'_{lab} = \gamma\Delta t_p$, $\Delta x' = \gamma v \Delta t_p \simeq \underline{7.2\,m}$

3.

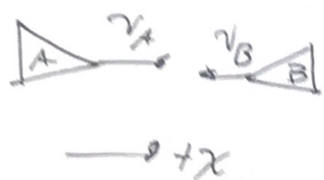


$\tan\theta = \frac{L_y}{L_x}$



in O', $L_y' = L_y$, $L_x' = L_x/\gamma$ contracted along dir of motion

$$\tan\theta' = \frac{L_y'}{L_x'} = \gamma\frac{L_y}{L_x} = \gamma\tan\theta \qquad \underline{\theta' = \tan^{-1}(\gamma\tan\theta)}$$

4. 

$v_A = 0.8c \quad v_B = -0.6c$

should <u>subtract</u>

$$v_{a\,rel\,b} = \frac{v_b - v_a}{1 - \frac{v_a v_b}{c^2}} = \frac{-0.6c - 0.8c}{1 - \frac{(0.8c)(-0.6c)}{c^2}} \approx \underline{0.95c}$$

5. $p_{rel} = 2p_{cl} \Rightarrow \gamma m v = 2mv$ or $\gamma = 2$

$$\gamma = 2 = \frac{1}{\sqrt{1 - v^2/c^2}} \qquad 1 - \frac{v^2}{c^2} = \frac{1}{4} \qquad \underline{\frac{v}{c} = \frac{\sqrt{3}}{2} \approx 0.866c}$$

6. change in PE of $\Delta U = q\Delta V = e\Delta V$
equal change in KE $= (\gamma - 1)mc^2$ starting from rest

$KE = \Delta U = (\gamma - 1)mc^2 = e\Delta V$

with $v = 0.98c$, $\gamma \approx 5.025$

electron: $mc^2 = 511\ keV$

$$\Delta V = \frac{(\gamma - 1)mc^2}{e} \simeq 2.06 \times 10^6\ V$$

$K = \Delta U = e\Delta V \simeq 0.33\ pJ = 2.06\ MeV$

$$P = \frac{q^2 a^2}{6\pi \epsilon_0 c^3}\ , \quad a = g,\ q = -e \quad \text{(ignoring radiation reaction force)}$$

in time t, falls from rest $\Delta y = \frac{1}{2} g t^2 = 1\text{cm}$ (given)

$$\Rightarrow \quad t = \sqrt{\frac{2\Delta y}{g}} \simeq 0.045\ s$$

$$\Delta E = P t = \frac{e^2 g^2}{6\pi \epsilon_0 c^3} \sqrt{\frac{2\Delta y}{g}} \simeq 7.76 \times 10^{-53}\ J \quad \text{negligible!}$$

$$U = mg\Delta y \Rightarrow \frac{\Delta E}{U} \simeq 9 \cdot 10^{-22} \text{ fractional change}$$

8. $\lambda = 641\text{nm}$ $\quad T_2 = 1200K,\ T_1 = 1500K$

$$I(\lambda, T) = \frac{8\pi h c^2}{\lambda^5} \left(e^{hc/\lambda k T} - 1 \right)^{-1}$$

$$\frac{I(\lambda, T_1)}{I(\lambda, T_2)} \simeq 42$$