HW 9/6

1.10) Lorentz transformation: $t' = \frac{t + \frac{v}{c^2}x}{\sqrt{1 - \frac{v^2}{c^2}}}$ $\quad x' = \frac{vt + x}{\sqrt{1 - \frac{v^2}{c^2}}}$

$$t' = \frac{(4s) + \frac{(8 m/s)}{c^2}(3m)}{\sqrt{1 - \frac{(8 m/s)^2}{c^2}}} = 4.000\,000\,000\,000\,0017\ s$$

$$x' = \frac{(8 m/s)(4s) + (3m)}{\sqrt{1 - \frac{(8 m/s)^2}{c^2}}} = 35.000\,000\,000\,000\,012\ m$$

The results using the Lorentz transformation and from the Galilean transformation have a very small difference. This is expected since the velocity is much smaller than the speed of light.

1.11) bike's frame of reference

$ct_n = c\left(\frac{40}{9}\ ns\right)n = \left(\frac{4}{3}m\right)n$ $\quad x_n = 0$

$\beta = \frac{v}{c} = \frac{0.6c}{c} = 0.6 = \frac{3}{5}$ $\quad \gamma = \frac{1}{\sqrt{1 - 0.36}} = \frac{1}{0.8} = \frac{5}{4}$

$$\begin{bmatrix} ct_n' \\ x_n' \end{bmatrix} = \begin{bmatrix} \gamma & \gamma\beta \\ \gamma\beta & \gamma \end{bmatrix}\begin{bmatrix} ct_n \\ x_n \end{bmatrix} = \begin{bmatrix} \frac{5}{4} & \frac{5}{4}\cdot\frac{3}{5} \\ \frac{5}{4}\cdot\frac{3}{5} & \frac{5}{4} \end{bmatrix}\begin{bmatrix} n\left(\frac{4}{3}m\right) \\ 0m \end{bmatrix} = \begin{bmatrix} n\left(\frac{5}{3}m\right) \\ n(1m) \end{bmatrix}$$

$x_n' = n(1m)$, so the drops each occur 1m apart.

First 2 columns are given

1.13)

Event	Ship ct	Ship x	Mom ct'	Mom x'
grin	0	0	0	0
flush	18	0	30	24
open	0	45	60	75

• all units in [m]

a)

$v = 0.8c$

$\beta = 0.8 = \frac{4}{5}$

$\gamma = \frac{1}{\sqrt{1-0.8^2}} = \frac{5}{3}$

Grin $\begin{bmatrix} ct_1' \\ x_1' \end{bmatrix} = \begin{bmatrix} \gamma & \gamma\beta \\ \gamma\beta & \gamma \end{bmatrix} \begin{bmatrix} ct \\ x \end{bmatrix} = \begin{bmatrix} \frac{5}{3} & \frac{5}{3}\cdot\frac{4}{5} \\ \frac{5}{3}\cdot\frac{4}{5} & \frac{5}{3} \end{bmatrix} \begin{bmatrix} 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 0\,m \\ 0\,m \end{bmatrix}$

Flush $\begin{bmatrix} ct_2' \\ x_2' \end{bmatrix} = \begin{bmatrix} \frac{5}{3} & \frac{5}{3}\cdot\frac{4}{5} \\ \frac{5}{3}\cdot\frac{4}{5} & \frac{5}{3} \end{bmatrix} \begin{bmatrix} 18 \\ 0 \end{bmatrix} = \begin{bmatrix} 30\,m \\ 24\,m \end{bmatrix}$

Open Drawer $\begin{bmatrix} ct_3' \\ x_3' \end{bmatrix} = \begin{bmatrix} \frac{5}{3} & \frac{5}{3}\cdot\frac{4}{5} \\ \frac{5}{3}\cdot\frac{4}{5} & \frac{5}{3} \end{bmatrix} \begin{bmatrix} 0 \\ 45 \end{bmatrix} = \begin{bmatrix} 60\,m \\ 75\,m \end{bmatrix}$

b) From the mother's point of view, the order of events is grin, flush, then open drawer.

c) In the mom's frame, the father opens the drawer after the keys were flushed.

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ep1) $ct_1 = 3$

$ct_2 = 10$

a) $t_1 = \frac{3}{c}$ $\quad \Delta t = t_2 - t_1 = \frac{10}{c} - \frac{3}{c} = \frac{7}{c}$

$t_2 = \frac{10}{c}$

$c\Delta t = c\frac{7}{c} = \boxed{7\text{ m}}$

b) Timelike: $|\Delta x| < c|\Delta t|$

$|\Delta x| < 7\text{ m}$ (ex) $x_1 = 0\text{ m}$

$x_2 = 5\text{ m}$

c) Spacelike: $|\Delta x| > c|\Delta t|$

$|\Delta x| > 7\text{ m}$ (ex) $x_1 = 0\text{m}$

$x_2 = 10\text{m}$

d) Lightlike: $|\Delta x| = c|\Delta t|$ (ex) $x_1 = 0\text{m}$

$|\Delta x| = 7\text{n}$ $\quad x_2 = 7\text{m}$

ep2) False. Two events must be timelike for one to cause the other.