Q1: An observer is standing on the station platform when a modern, high-speed train passes through at u = 0.80c. The observer, who measures the platform to be 60 m long, notices that the front and back of the train line up exactly with the ends of the platform. (a) How long does the ground-based observer measure for the train to pass a fixed point on the platform? (b) What is the proper length of the train? (c) What is the length of the platform, according to an observer on the train? (d) How long will it take for a point on the platform to pass the full length of the train, according to an observer on the train? (e) To an observer on the train, the ends of the train will not simultaneously line up with the ends of the platform. Find the time interval between the front end of the train lining up with one end of the platform and the back end of the train lining up with the other.

(a) To pass a given point, the train must travel a distance of its length as observed from the platform. Thus L = 60 m.
Let Δt = time as measured by an observer on the platform.

$$\Delta t = \frac{L}{u} = \frac{60}{0.80 \times 3 \times 10^8} = 2.5 \times 10^{-7}\ \text{s}$$

(b) Since the ground-based observer is measuring a contracted length of the train as equal to the proper length of the platform which is 60 m, the proper length of the train is:

$$L_t = L'_t\sqrt{1-\frac{u^2}{c^2}} \Rightarrow 60 = L'_t\sqrt{1-(0.8)^2} = L'_t * 0.6$$

$\Rightarrow$

$$L'_t = \frac{60}{0.6} = 100\ \text{m}.$$

L_t = contracted length of train t
L'_t = proper length of train t.

(c) The observer on the train observes the platform as having a contracted length L'_p which is related to its proper length L_p by:

$$L_p = L'_p\sqrt{1-(0.8)^2} = 60 \times 0.6 = 36\ \text{m}.$$

(d) Since the proper length of the train is 100 m $\Rightarrow$

$$\Delta t' = \frac{L'_t}{u} = \frac{100}{0.8 \times 3 \times 10^8} = 4.2 \times 10^{-7}\ \text{s}$$

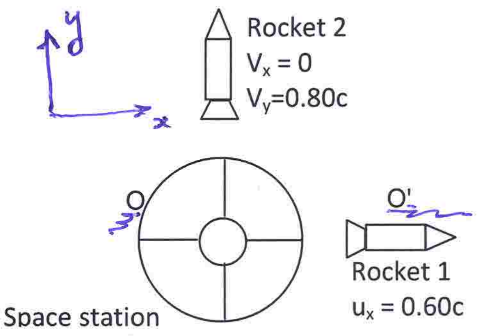
(e) The time interval required is $100 - 36 = 64\ \text{m} = \Delta L''$

$$\Rightarrow \Delta t'' = \frac{\Delta L''}{u} = \frac{64}{0.8 \times 3 \times 10^8} = 2.7 \times 10^{-7}\ \text{s}$$

Thus two events that are simultaneous in one reference frame occur 2.7×10^{-7} s apart in another (i.e. not simultaneous)

Q2. Two rockets are leaving their space station along <u>perpendicular paths</u>, as measured by an observer on the space station. Rocket 1 moves at 0.60 c and rocket 2 moves at 0.80 c, both measured relative to the space station. What is the velocity of rocket 2 as observed by rocket 1?

Observer O is the space station, observer O' is rocket 1 (moving at $u = 0.60c$) and the "event" is rocket 2 (moving, according to O in a direction $\perp$ to rocket 1.



Thus O observes rocket 2 to have velocity components $V_x = 0$, $V_y = 0.80c$ while rocket 1 has velocity $u_x = 0.60c$

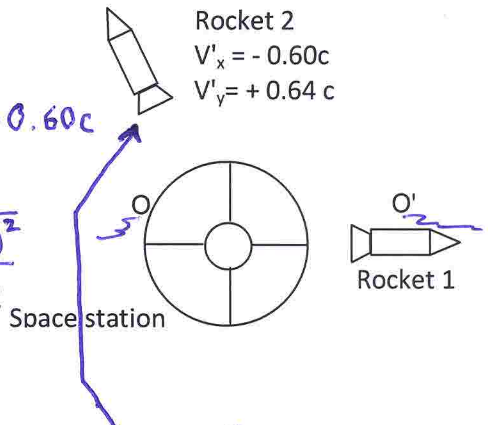
Using L.T.U. $\Rightarrow$

$$V'_x = \frac{V_x - u_x}{\left(1 - \frac{V_x u_x}{c^2}\right)} = \frac{0 - (0.60c)}{1 - \frac{(0)\,u_x}{c^2}} = -0.60c$$

$$V'_y = \frac{V_y\sqrt{1 - u_x^2/c^2}}{\left(1 - \frac{V_x u_x}{c^2}\right)} = \frac{0.80c\sqrt{1-(0.60)^2}}{1 - \frac{(0)(0.60c)}{c^2}}$$

$$= 0.64c$$

Thus according to O', the situation look like this



$$\Rightarrow V_2 = \sqrt{V_x'^2 + V_y'^2} = \sqrt{(-0.60c)^2 + (0.64c)^2} = 0.88c$$