

52. (a) From the length contraction equation, the length L'_c of the car according to Garageman is

$$L'_c = \frac{L_c}{\gamma} = L_c \sqrt{1 - \beta^2} = (30.5 \text{ m}) \sqrt{1 - (0.9980)^2} = 1.93 \text{ m} .$$

- (b) Since the x_g axis is fixed to the garage $x_{g2} = L_g = 6.00 \text{ m}$. As for t_{g2} , note from Fig. 38-21(b) that, at $t_g = t_{g1} = 0$ the coordinate of the front bumper of the limo in the x_g frame is L'_c , meaning that the front of the limo is still a distance $L_g - L'_c$ from the back door of the garage. Since the limo travels at a speed v , the time it takes for the front of the limo to reach the back door of the garage is given by

$$\Delta t_g = t_{g2} - t_{g1} = \frac{L_g - L'_c}{v} = \frac{6.00 \text{ m} - 1.93 \text{ m}}{0.9980(2.998 \times 10^8 \text{ m/s})} = 1.36 \times 10^{-8} \text{ s} .$$

Thus $t_{g2} = t_{g1} + \Delta t_g = 0 + 1.36 \times 10^{-8} \text{ s} = 1.36 \times 10^{-8} \text{ s}$.

- (c) The limo is inside the garage between times t_{g1} and t_{g2} , so the time duration is $t_{g2} - t_{g1} = 1.36 \times 10^{-8} \text{ s}$.
- (d) Again from Eq. 38-13, the length L'_g of the garage according to Carman is

$$L'_g = \frac{L_g}{\gamma} = L_g \sqrt{1 - \beta^2} = (6.00 \text{ m}) \sqrt{1 - (0.9980)^2} = 0.379 \text{ m} .$$

- (e) Again, since the x_c axis is fixed to the limo $x_{c2} = L_c = 30.5 \text{ m}$. Now, from the two diagrams described in part (h) below, we know that at $t_c = t_{c2}$ (when event 2 takes place), the distance between the rear bumper of the limo and the back door of the garage is given by $L_c - L'_g$. Since the garage travels at a speed v , the front door of the garage will reach the rear bumper of the limo a time Δt_c later, where Δt_c satisfies

$$\Delta t_c = t_{c1} - t_{c2} = \frac{L_c - L'_g}{v} = \frac{30.5 \text{ m} - 0.379 \text{ m}}{0.9980(2.998 \times 10^8 \text{ m/s})} = 1.01 \times 10^{-7} \text{ s} .$$

Thus $t_{c2} = t_{c1} - \Delta t_c = 0 - 1.01 \times 10^{-7} \text{ s} = -1.01 \times 10^{-7} \text{ s}$.

- (f) From Carman's point of view, the answer is clearly no.
- (g) Event 2 occurs first according to Carman, since $t_{c2} < t_{c1}$.
- (h) We describe the essential features of the two pictures. For event 2, the front of the limo coincides with the back door, and the garage itself seems very short (perhaps failing to reach as far as the front window of the limo). For event 1, the rear of the car coincides with the front door and the front of the limo has traveled a significant distance beyond the back door. In this picture, as in the other, the garage seems very short compared to the limo.
- (i) Both Carman and Garageman are correct in their respective reference frames. But, in a sense, Carman should lose the bet since he dropped his physics course before reaching the Theory of Special Relativity!