



### Problem 1

Fred stands on the ground, holding a clock. Jane and Violet fly past on their Super Jet, which travels at a speed of  $v = 0.8c$  to the left. Jane, at the front of the ship, and Violet, at the back, are separated by a distance  $L = 50$  m, based on their own measurements. Jane and Violet have synchronized their clocks in an intelligent manner.

The ship zooms past Fred so low that it barely misses his head. As Jane passes Fred, she sees that his clock and her clock both read exactly  $t = 0$  meters. The ship continues to fly to the left at a constant speed.

- When Violet passes Fred, what does her clock read?
- When Violet passes Fred, what does Fred's clock read?
- Fred uses the speed of the ship and his own measurements to determine the distance between Jane and Violet. What is the distance that he deduces?

a) Distance between Jane & Violet = 50 m, Fred is moving at  $v = 0.8c$ , so

$$\Delta t_{\text{Violet}} = \frac{L}{v} = \frac{50 \text{ m}}{0.8} = \boxed{62.5 \text{ m}}$$

b) Fred's clock is running slower than Violet's, due to time dilation

$$\Delta t_{\text{Fred}} = \frac{\Delta t_{\text{Violet}}}{\gamma} = \frac{62.5 \text{ m}}{1.667} = \boxed{37.5 \text{ m}}$$

c) Fred sees ship moving at  $v = 0.8c$ , and it takes  $\Delta t_{\text{Fred}} = 37.5 \text{ m}$  to pass him. So he deduces the length of the ship must be

$$L_{\text{Fred}} = v \cdot \Delta t_{\text{Fred}} = 0.8 \cdot (37.5 \text{ m}) = \boxed{30 \text{ m}}$$

Note  $L_{\text{Fred}} = L_{\text{Violet}} / \frac{1}{\gamma} = 50 \text{ m} / 1.667$