Ex Length.

A car travels down a road at 20.0 $\frac{mi}{hr}$ as measured by a police officer at a speed trap. Determine the length of a door on the car if light speed were 25.0 $\frac{mi}{hr}$ and a person in the car measured the door length as 1.89m.

Note: Your car was built in 1973 as a 2-door sports car.

$L_0 = 1.89\,m$ since the car occupants are at rest relative to the door.

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$c = 25.0 \frac{mi}{h}$

$V = 20.0 \frac{mi}{h}$

$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$

$L_0 = 1.89 m$

$L = 1.89 m \sqrt{1 - \frac{20.0^2}{25.0^2}} = \boxed{1.13 m}$

Ex Length

A particle accelerator consisting of a 64 m long vacuum chamber for subatomic particles contains some protons traveling at 0.65c. How long is the vacuum chamber as measured in the proton reference frame?

$L_o = 64 m$ The lab is measured by people at rest relative to it.

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$L_0 = 64m$

$V = 0.65c$

$L_{proton} = ?$

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$$

$$L = 64m \sqrt{1 - 0.65^2} = 48.6m$$

49m

Ex Length

An observer in a lab measures that an electron travels 8.50 cm in 0.200 E -9 s.

(1) According to the electron reference frame, the lab moves. How far does it move compared to the lab frame?

(2) What is the speed of the electron?

(3) How far does the lab move in the electron's frame of reference?

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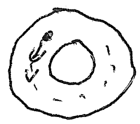
Lab Frame

$t = 0.200\,ns$

$d = 3.50\,cm$

Lab and path at rest



$L_0 = 3.50\,cm$

$\Delta t = 0.200\,ns$

a) In electron frame, how far did the lab travel?

3.50 cm , > 3.50 cm , or < 3.50 cm

Electron measures Δt_0 and L

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$$

so electron frame length is less

b) $v = ?$

Lab and electron measure the same speed of each other.

$$v = \frac{L_o}{\Delta t} = \frac{L}{\Delta t_o}$$

$$v = \frac{3.50\,E{-}2\,m}{0.200\,E{-}9\,s} = 1.75\,E8\ m/s$$

0.583c

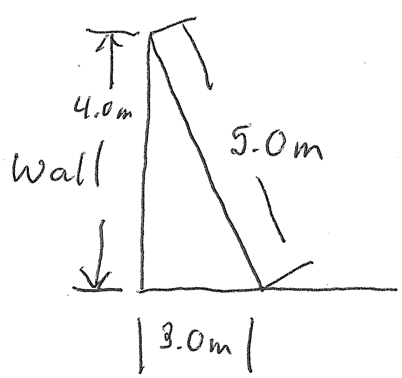
c) $L = ?$

~~$v = \frac{L}{\Delta}$~~ $L = L_o\sqrt{1 - \frac{v^2}{c^2}}$

$$= 3.50\,cm\sqrt{1 - 0.583^2} = \boxed{2.84\,cm}$$

Ex Length

A space station contains a ladder that is 5.0 m long. If the ladder leans against a wall as shown below determine the angle between ladder and floor as measured by an observer who is passed by the station. Let the station move at 0.90c relative to the observer.



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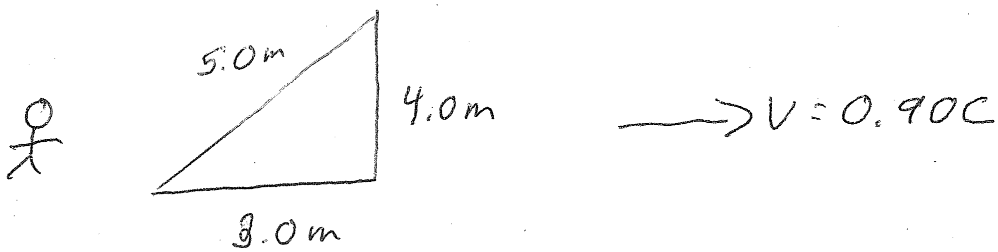
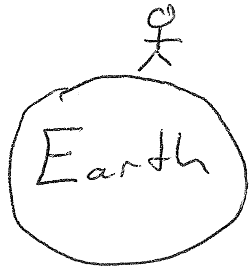
On Ship





Person on ship measures
proper length

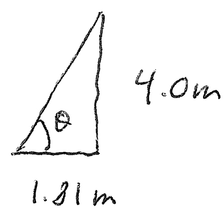
$L_0 = 3.0m$

* Note: both observers measure
4.0m height because
it is ⊥ to velocity

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$$

$$L = 3.0m \sqrt{1 - 0.90^2} = 1.31m$$

Earth



$$\theta = \tan^{-1}\left(\frac{4.0}{1.31}\right) = \boxed{72^{\circ}}$$

The starships Picard and LaForge travel toward the Andromeda galaxy in the same direction. The Picard moves at 0.90c relative to the LaForge. A person on the LaForge measures the length of the two ships and finds the same value.

(1) What conclusion can a person on the Picard make if they make the same measurements?

(Will their conclusion be different?)

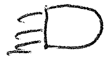
(2) Calculate the ratio of the proper length of Picard to proper length of LaForge.

On the La Forge

Picard

 $\rightarrow V = 0.90c$

La Forge

 $\rightarrow V = 0$

$$L_{o_{LaF}} = L_{Picard}$$

$$L_{Picard} = L_{o_{Picard}} \sqrt{1 - \frac{v^2}{c^2}}$$

$$L_{o_{picard}} = \frac{L_{picard}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Person on picard measures the picard as longer.

* Note: Picard is longer when both are at rest.

Since $L_{o_{LaF}} = L_{Picard}$

$$L_{o_{Picard}} = \frac{L_{o_{LaF}}}{\sqrt{1 - 0.90^2}}$$

$$\frac{L_{o_{Picard}}}{L_{o_{LaF}}} = \frac{1}{\sqrt{1 - .90^2}} = \boxed{2.29}$$