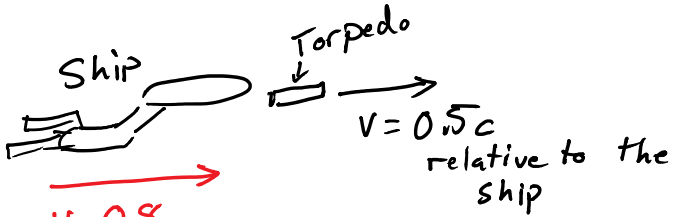
Length Contraction

May-12-16 8:09 AM

Review: $t = \frac{t_o}{\sqrt{1-\frac{v^2}{c^2}}}$

$\sqrt{1-\frac{v^2}{c^2}}$ ← Nothing can go faster than light if $v > c$ then we would square root a negative number, which is bad.

What if.



According to traditional relativity the torpedo is going $0.8c + 0.5c = 1.3c$ ← Too big! Things can't go faster than light!

- When things move very fast their length contracts. From their reference Frame all other lengths in the direction of travel contract.

The relation we have is:

"Fixed" Frame → $\ell = \ell_o \sqrt{1-\frac{v^2}{c^2}}$ ← moving Frame

A ladder is 13m long when at rest. If it is

sped up to $0.75c$, how long will it be to a "fixed" observer?

$$\ell = 13\,m\sqrt{1-\frac{(0.75c)^2}{c^2}} = 13\,m\sqrt{1-\frac{0.5625c^2}{c^2}} = 13\sqrt{0.4375}$$

$$\boxed{\ell = 8.6\,m}$$

Imaginary star is 47 light years away.
→ The distance light travels in one year.

A ship is running at $0.9c$. The ship starts at Earth.

a) How far does the ship have to go relative to a person on Earth?

- The ship is moving relative to the person.
- The star is not moving relative to the person. → therefore we don't see any length contraction.

47 light years.

b) How far away is the star relative to the ship?

→ the star has a relative velocity of $0.9c$.

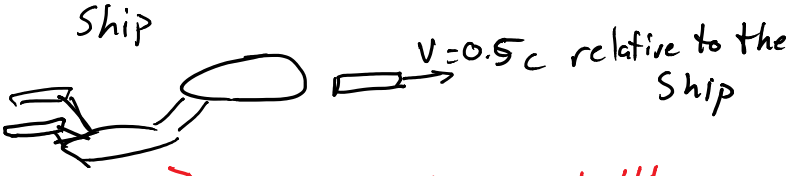
$$\ell = \ell_0\sqrt{1-\frac{v^2}{c^2}}$$

$$\ell = 47\sqrt{1-\frac{(0.9c)^2}{c^2}} = 47\sqrt{1-\frac{0.81c^2}{c^2}} = 47\sqrt{0.19} = 20.5 \text{ light years}$$

$\ell = 20.5$ light years.

Ship ___ $v = 0.5c$ relative to the

Relativistic Speeds



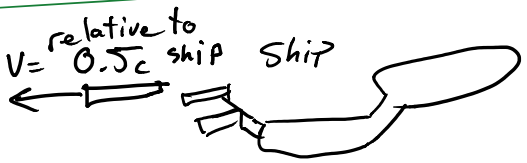
u=0.8c relative to the shuttle

shuttle

w = torpedo relative to the shuttle ?

In the same direction.

$$w = \frac{u+V}{1+\frac{uV}{c^2}} = \frac{1.3c}{1+\frac{(0.8)(0.5)c^2}{c^2}} = \frac{1.3c}{1+0.4} = \frac{1.3c}{1.4} = 0.92c.$$



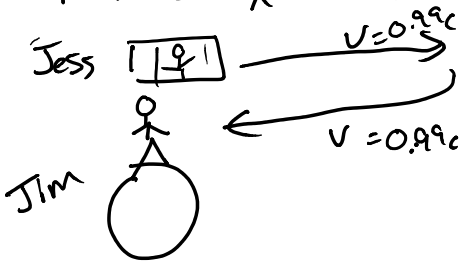
u= 0.8c relative to shuttle

Shuttle

In the opposite direction

$$w = \frac{u-V}{1-\frac{uV}{c^2}}$$

"Paradox" #1 : Twin Paradox

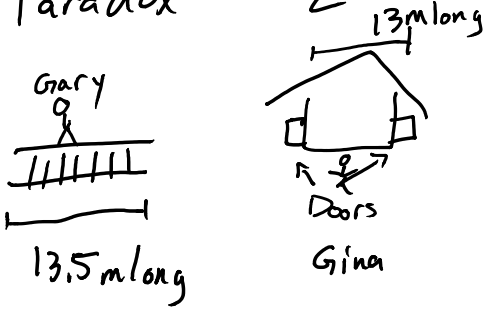


From Jim's Frame: Jess is moving so she experiences time dilation and will be younger than Jim when she gets back.

From Jess's Frame: Jim is moving So he experiences time dilation and will be younger than Jess when Jess gets back.

Who is right?

"Paradox" #2:



Gary sees that the barn contracts in length, which means the ladder really shouldn't fit.

Gary will run at 0.8c with the ladder. Gina will see the ladder contract and will shut both doors simultaneously then open them again. The ladder should fit from Gina's frame.

What will happen?

Why?