La Geometría de la Teoría Especial de la Relatividad

Tevian Dray

Department of Mathematics
Oregon State University
http://www.math.oregonstate.edu/~tevian
http://www.physics.oregonstate.edu/portfolioswiki

The Geometry of Special Relativity

Tevian Dray

Department of Mathematics
Oregon State University
http://www.math.oregonstate.edu/~tevian
http://www.physics.oregonstate.edu/portfolioswiki

Slides available at:

http://www.physics.oregonstate.edu/portfolioswiki

(follow link on left to: Talks/Workshops)

Textbook available at:

http://www.physics.oregonstate.edu/coursewikis/GSR

Postulate 1:

The laws of physics apply in all inertial reference frames.

Postulate 1:

The laws of physics apply in all inertial reference frames.

Maxwell's Equations:

$$\vec{\nabla} \cdot \vec{\mathbf{E}} = \frac{1}{\epsilon_0} \rho$$

$$\vec{\nabla} \times \vec{\mathbf{B}} = \mu_0 \vec{\mathbf{J}} + \mu_0 \epsilon_0 \frac{\partial \vec{\mathbf{E}}}{\partial t}$$

Postulate 1:

The laws of physics apply in all inertial reference frames.

Maxwell's Equations:

$$\vec{\nabla} \cdot \vec{\mathbf{E}} = \frac{1}{\epsilon_0} \rho$$

$$\vec{\nabla} \times \vec{\mathbf{B}} = \mu_0 \vec{\mathbf{J}} + \mu_0 \epsilon_0 \frac{\partial \vec{\mathbf{E}}}{\partial t}$$

Can measure ϵ_0 and μ_0, so can measure

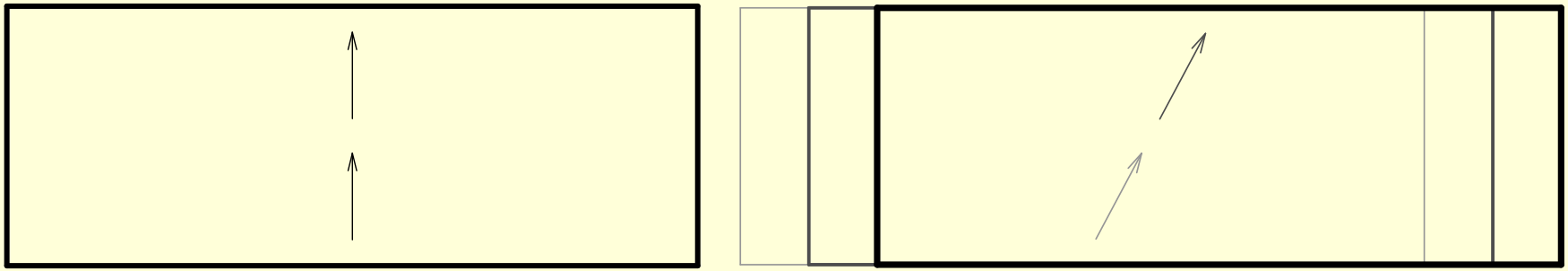
$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = 3 \times 10^8 \ \frac{\mathrm{m}}{\mathrm{s}}$$

Postulate 1:

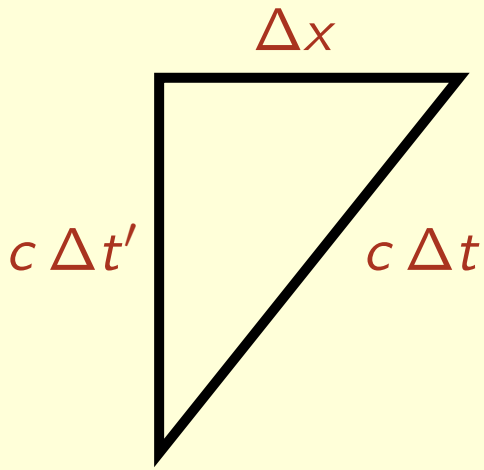
The laws of physics apply in all inertial reference frames.

Postulate 2:

The speed of light is the same for all inertial observers.



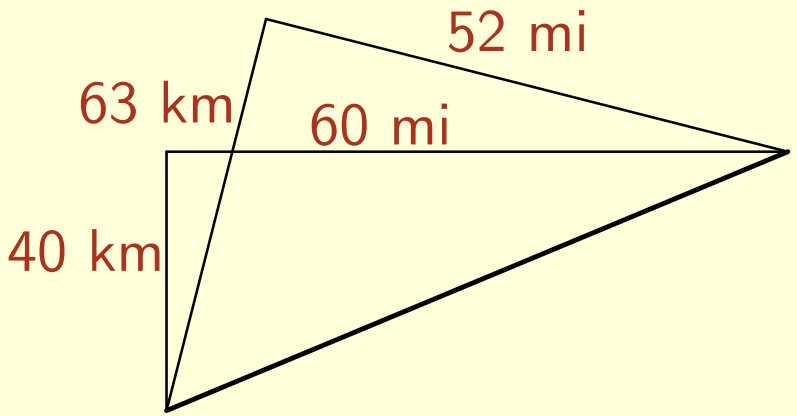
A beam of light bounces up and down between mirrors on the floor and ceiling of a moving train. The time between bounces can be used as a unit of time, but a moving observer and a stationary observer obtain different results.



$$(c\,\Delta t')^2 = (c\,\Delta t)^2 - (\Delta x)^2$$

Suppose a town has daytime surveyors, who determine North and East with a compass, and nighttime surveyors, who use the North Star. These notions of course differ, since magnetic north is not the direction to the North Pole. Suppose further that both groups measure north/south distances in kilometers and east/west distances in miles, with both being measured from the town center. How does one go about comparing the measurements of the two groups?

Suppose a town has daytime surveyors, who determine North and East with a compass, and nighttime surveyors, who use the North Star. These notions of course differ, since magnetic north is not the direction to the North Pole. Suppose further that both groups measure north/south distances in kilometers and east/west distances in miles, with both being measured from the town center. How does one go about comparing the measurements of the two groups?

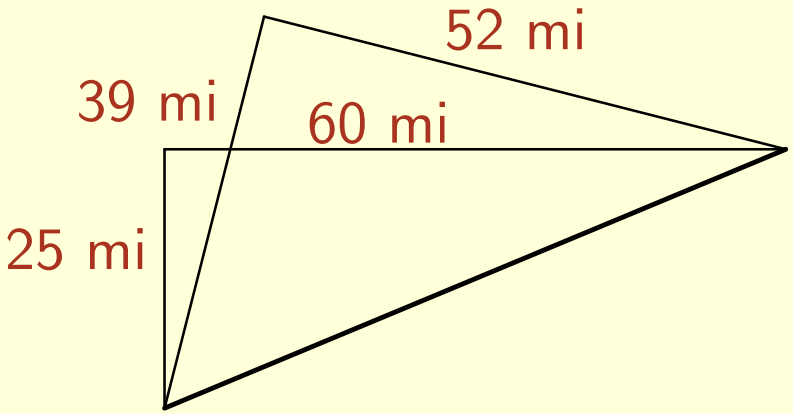


Moral:

Use the same units!

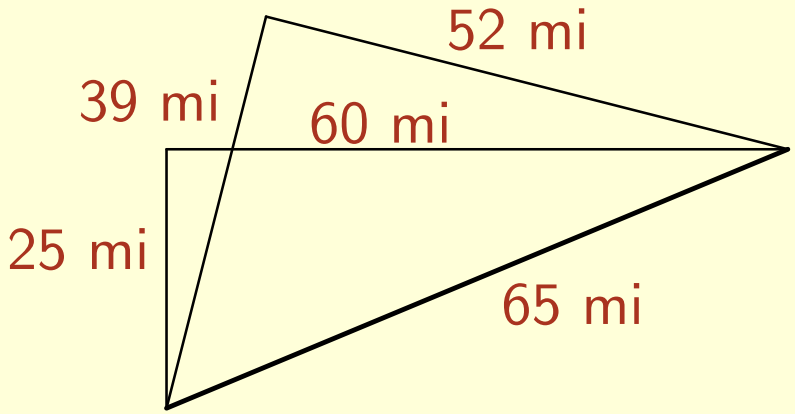
Moral:

Use the same units!



Moral:

Use the same units!



A *spacetime diagram* represents both space (horizontal axis) and time (vertical axis).

A *spacetime diagram* represents both space (horizontal axis) and time (vertical axis).

Draw a spacetime diagram showing yourself standing still.

A *spacetime diagram* represents both space (horizontal axis) and time (vertical axis).

Draw a spacetime diagram showing yourself standing still.

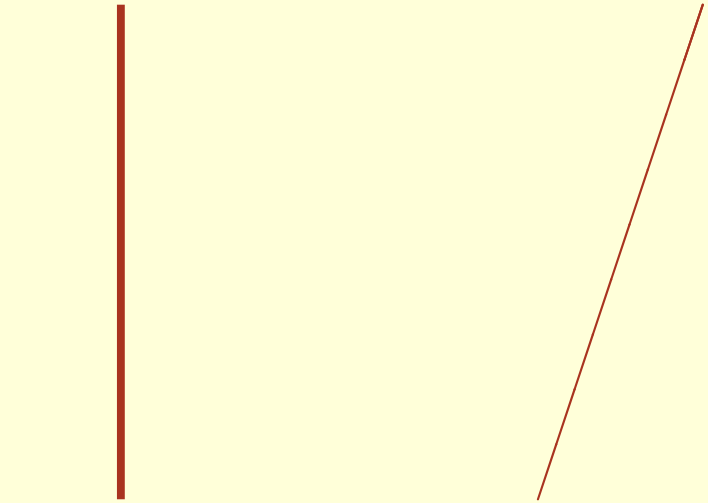
Draw a spacetime diagram showing your friend moving to the right at constant speed.

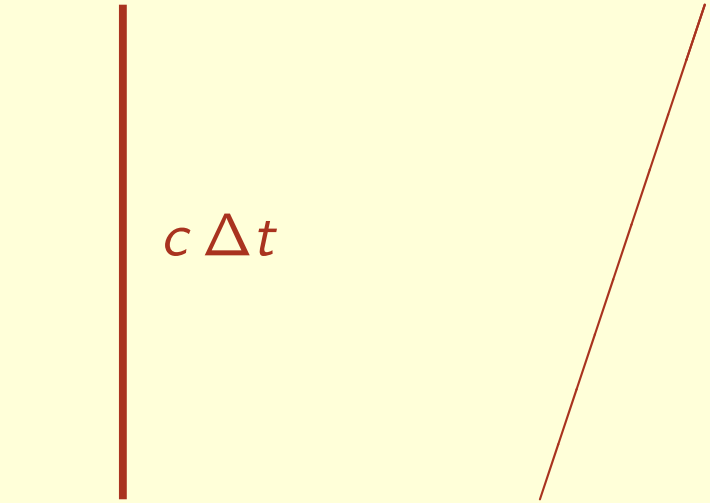
A *spacetime diagram* represents both space (horizontal axis) and time (vertical axis).

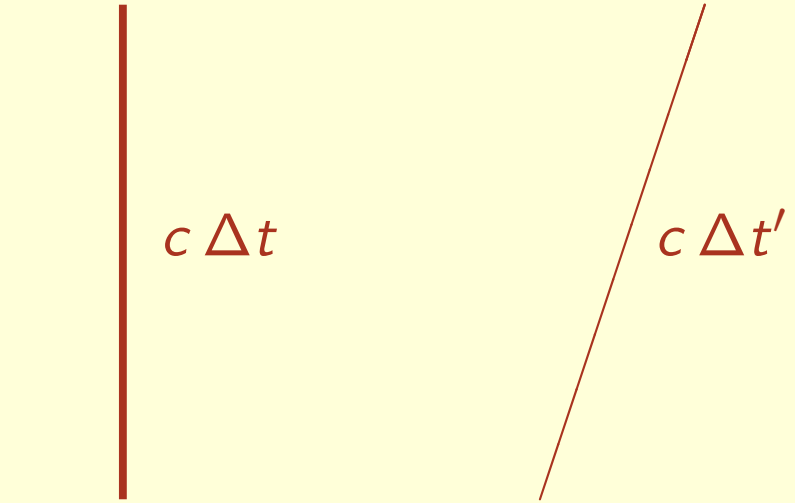
Draw a spacetime diagram showing yourself standing still.

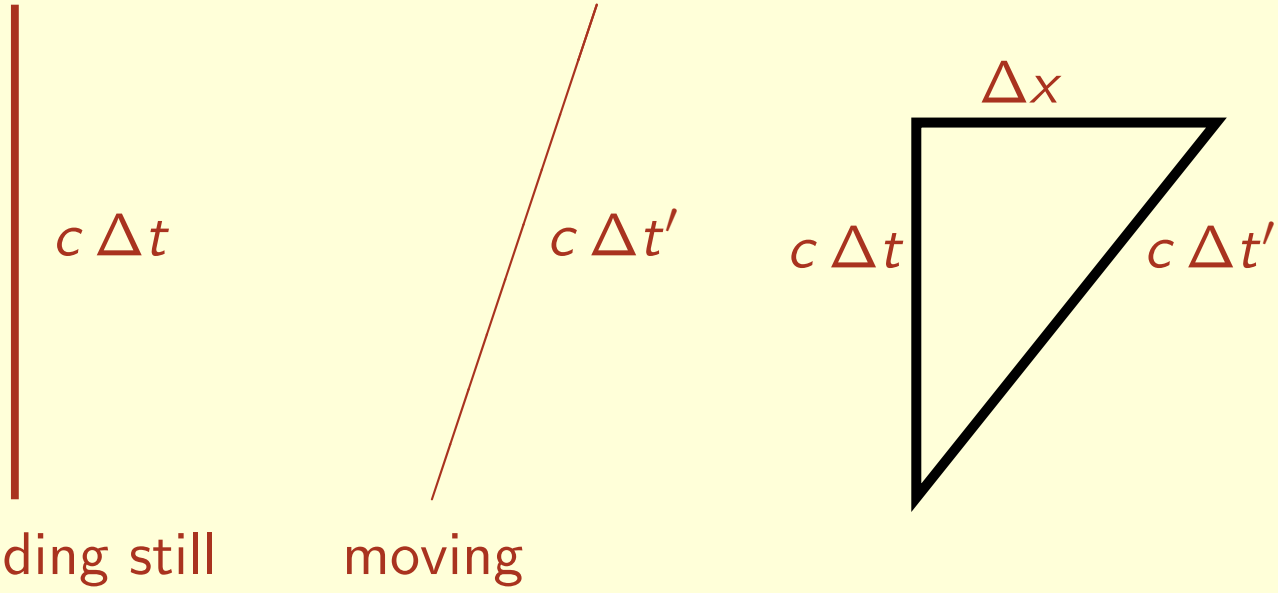
Draw a spacetime diagram showing your friend moving to the right at constant speed. How do you determine the speed?

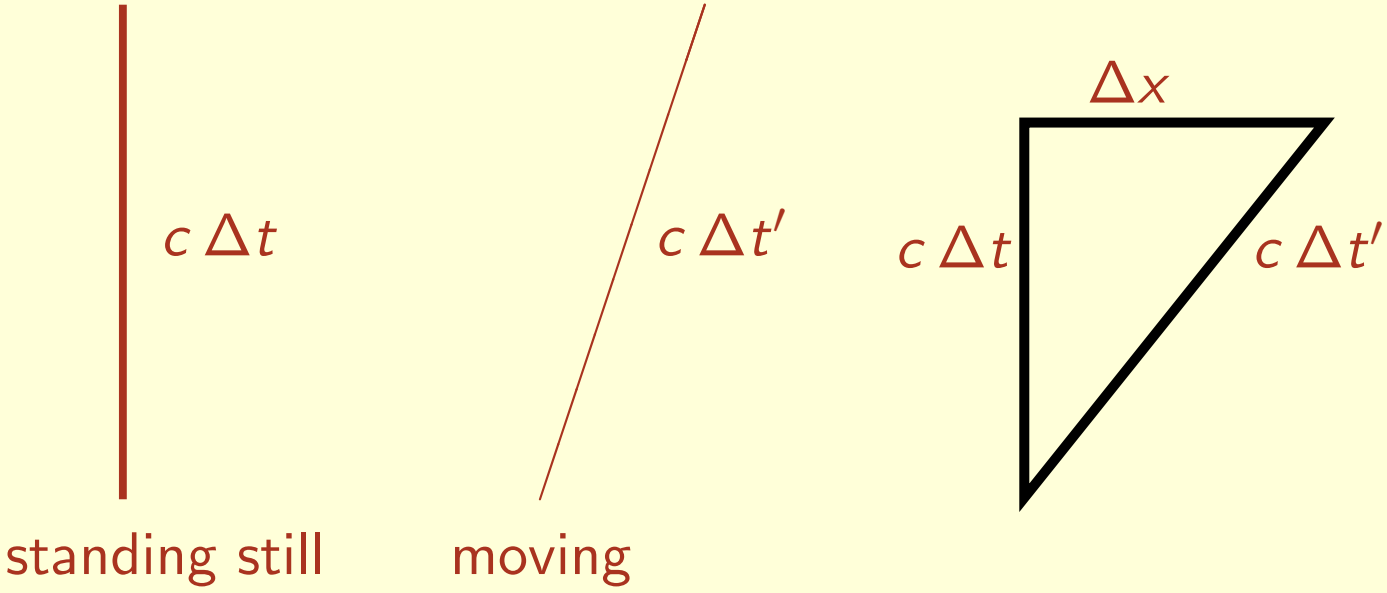
standing still


standing still
moving


$c\,\Delta t$
standing still
moving


$c\,\Delta t$
$c\,\Delta t'$
standing still
moving


$c\,\Delta t$
$c\,\Delta t'$
Δx
$c\,\Delta t$
$c\,\Delta t'$
standing still
moving



$$\frac{v}{c} = \frac{\Delta x}{c\,\Delta t}$$

$$(c\,\Delta t')^2 = (c\,\Delta t)^2 - (\Delta x)^2$$

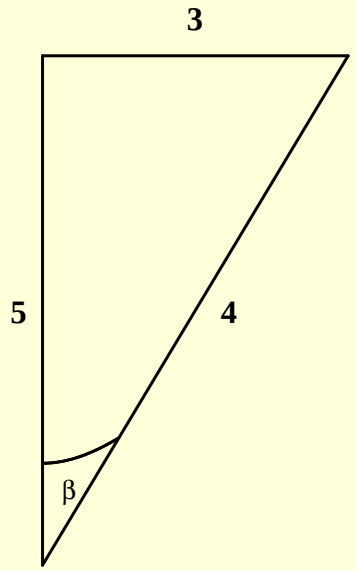
The geometry of special relativity is not Euclidean!

The geometry of special relativity is not Euclidean!

Draw a 3–4–5 triangle in this new geometry.

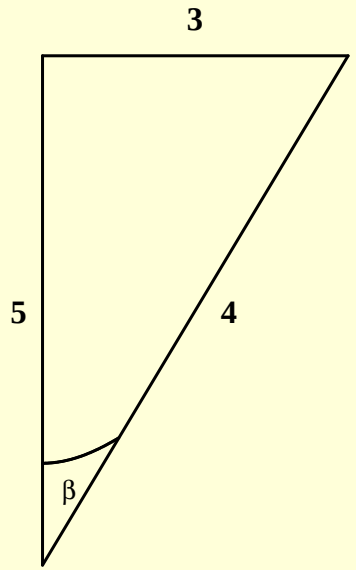
The geometry of special relativity is not Euclidean!

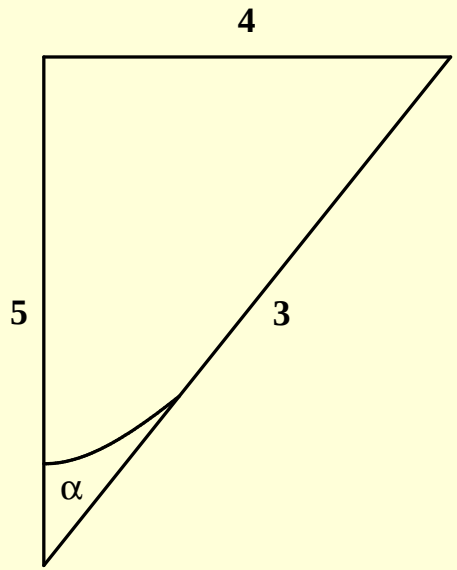
Draw a 3–4–5 triangle in this new geometry.



The geometry of special relativity is not Euclidean!

Draw a 3–4–5 triangle in this new geometry.





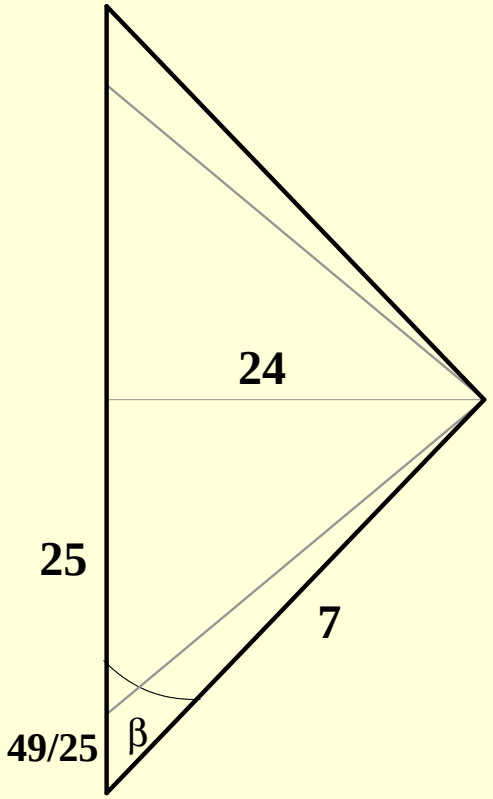
One twin travels 24 light-years to star X at speed $\frac{24}{25}c$; her twin brother stays home. When the traveling twin gets to star X, she immediately turns around, and returns at the same speed. How long does each twin think the trip took?

One twin travels 24 light-years to star X at speed $\frac{24}{25}c$; her twin brother stays home. When the traveling twin gets to star X, she immediately turns around, and returns at the same speed. How long does each twin think the trip took?

Draw a spacetime diagram!

One twin travels 24 light-years to star X at speed $\frac{24}{25}c$; her twin brother stays home. When the traveling twin gets to star X, she immediately turns around, and returns at the same speed. How long does each twin think the trip took?

Draw a spacetime diagram!



SUMMARY

- The speed of light is constant.
- Moving observers measure time differently.
- Space and time should be measured in the same units.
- Times (and distances) can be measured in spacetime diagrams.
- The geometry is different...

SUMMARY

- The speed of light is constant.
- Moving observers measure time differently.
- Space and time should be measured in the same units.
- Times (and distances) can be measured in spacetime diagrams.
- The geometry is different...

Tomorrow: The *trigonometry* of special relativity.

SUMMARY

- The speed of light is constant.
- Moving observers measure time differently.
- Space and time should be measured in the same units.
- Times (and distances) can be measured in spacetime diagrams.
- The geometry is different...

Tomorrow: The *trigonometry* of special relativity.

`http://www.physics.oregonstate.edu/portfolioswiki`
`http://www.physics.oregonstate.edu/coursewikis/GSR`