

Title: Ready-To-Use Teaching Resources on Modern Physics

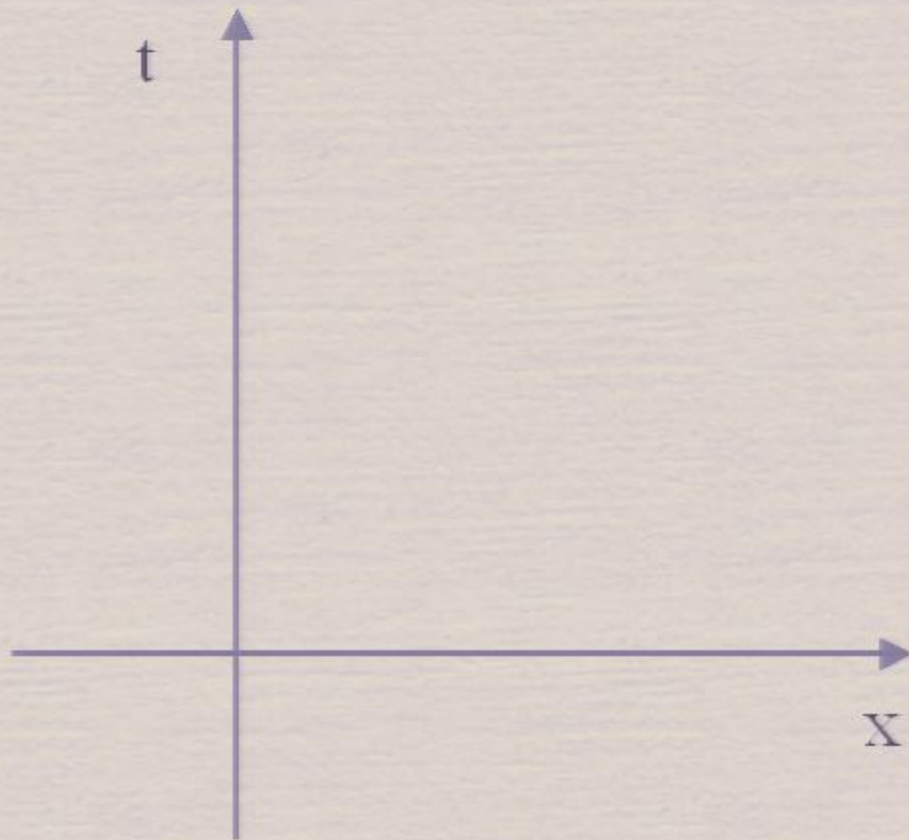
Date: Jul 14, 2006 03:31 PM

URL: <http://pirsa.org/06070032>

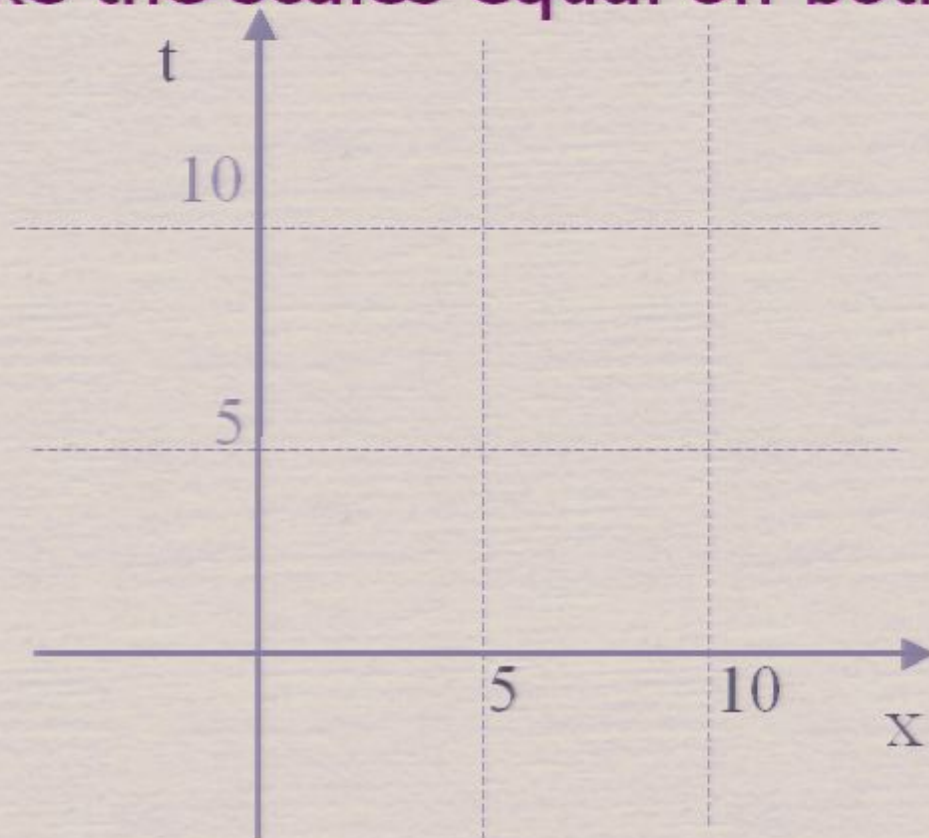
Abstract:

Spacetime Diagrams Seriously Simplified

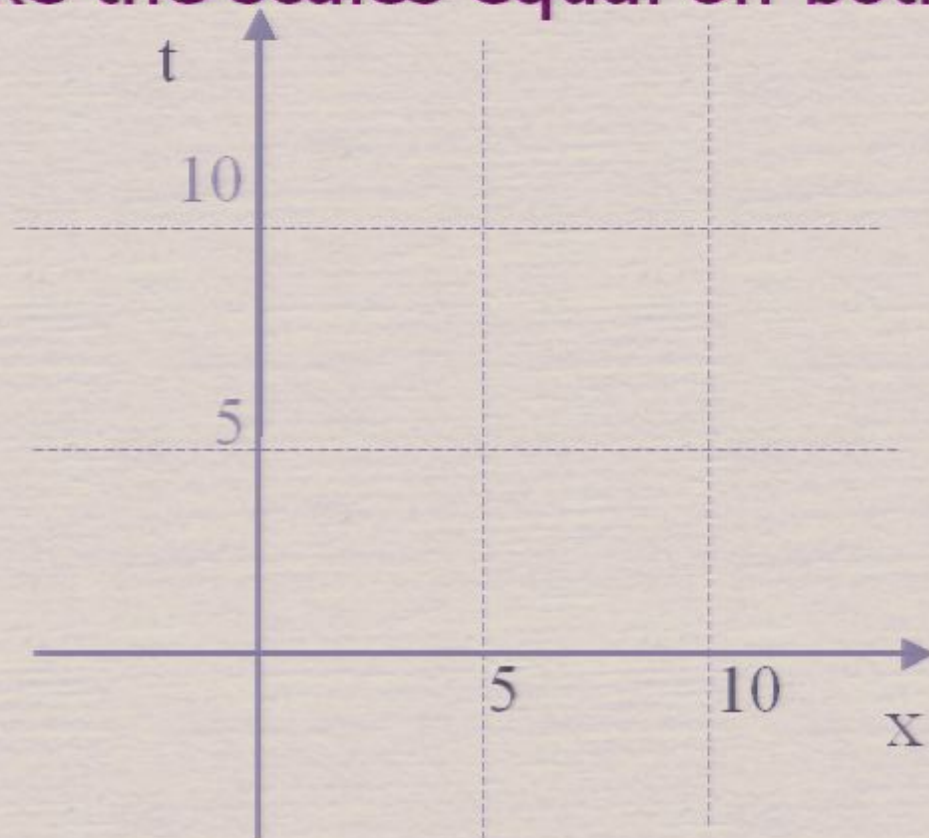
Establish a frame with time vertical.



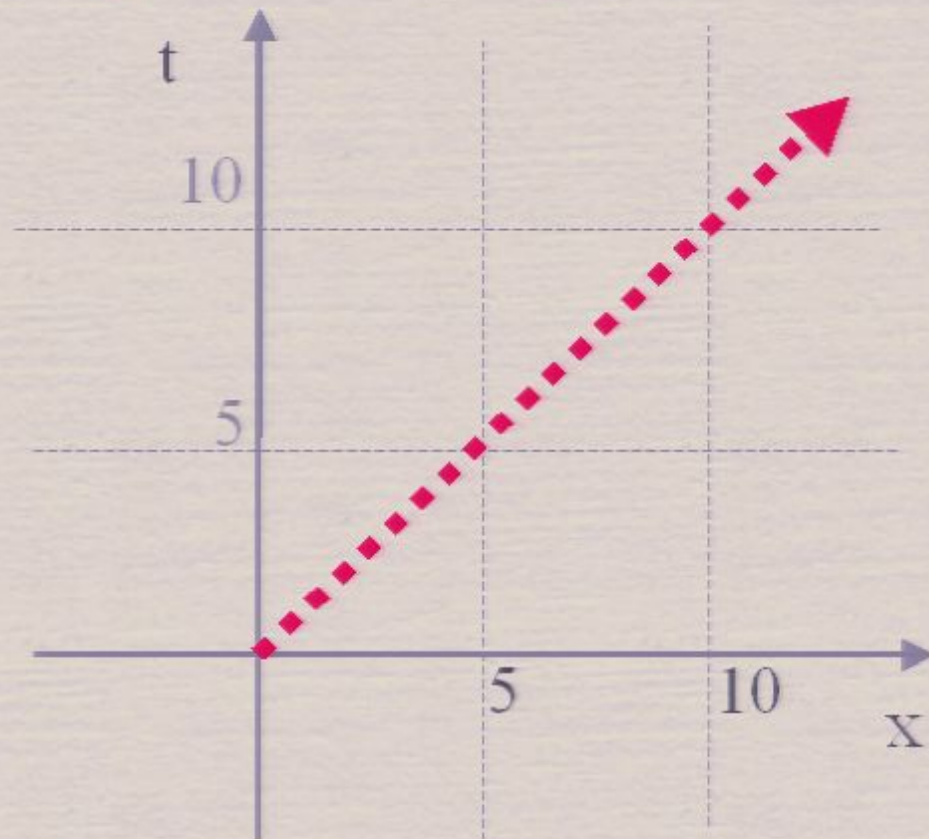
Draw some x gridlines. We want to display really fast speeds. Therefore the x axis must be able to show huge distances (light-years). Make the scales equal on both axes.

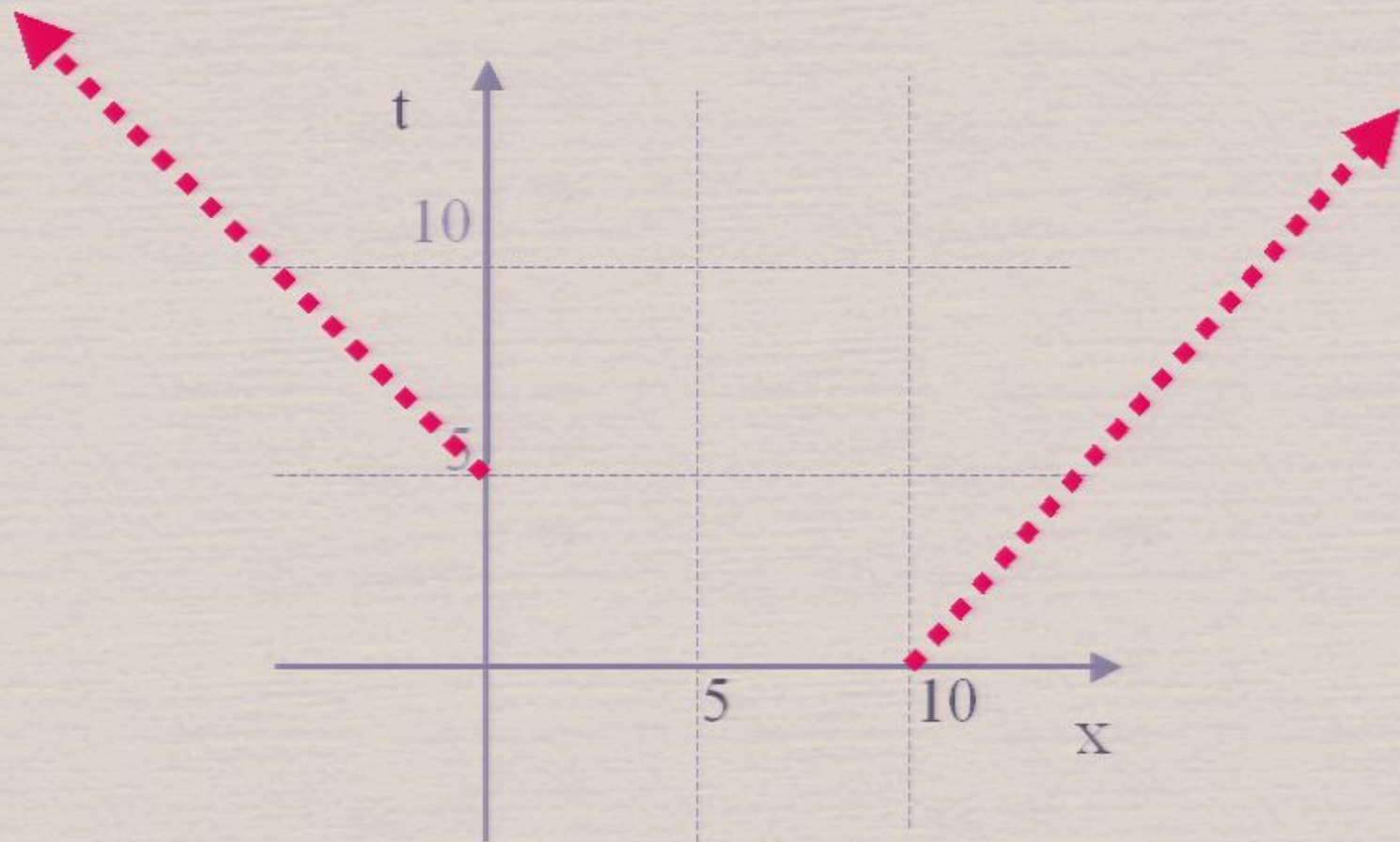


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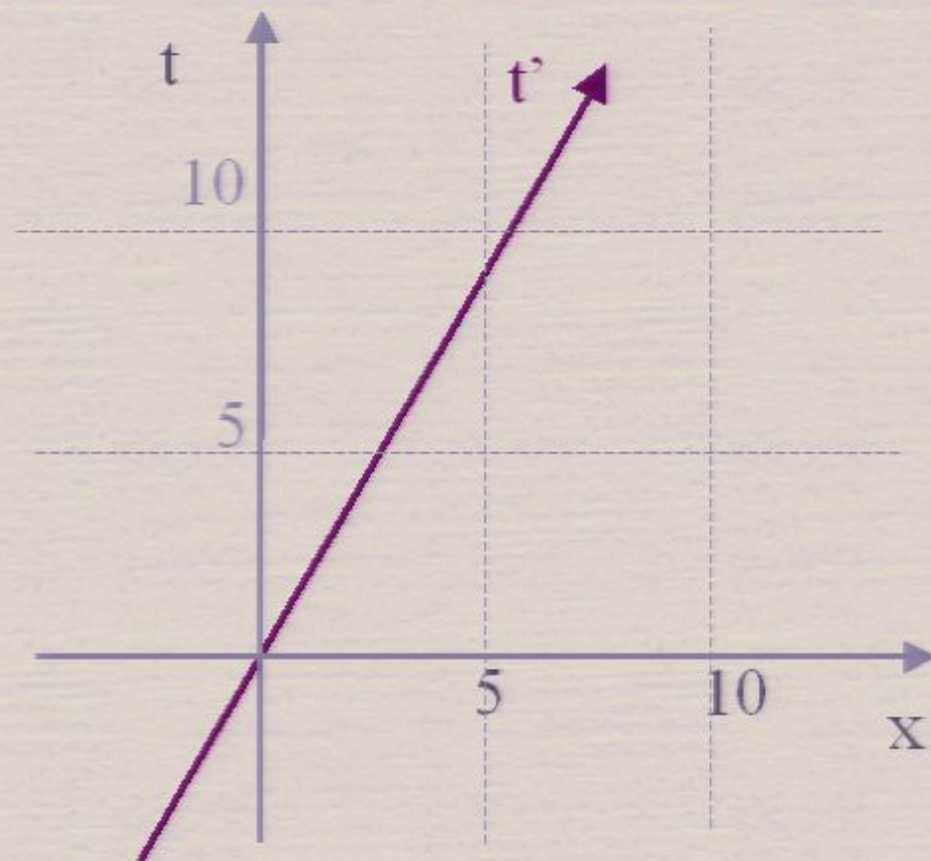


After 10 years, light will travel 10 light-years.
Therefore light will always be a line at $\pm 45^\circ$.





Add a line of something moving at $3/5 c$ relative to the frame F . It has a slope of $5/3$ and will form the t' axis of a frame F' .



Add the x' axis. This is the tricky part.

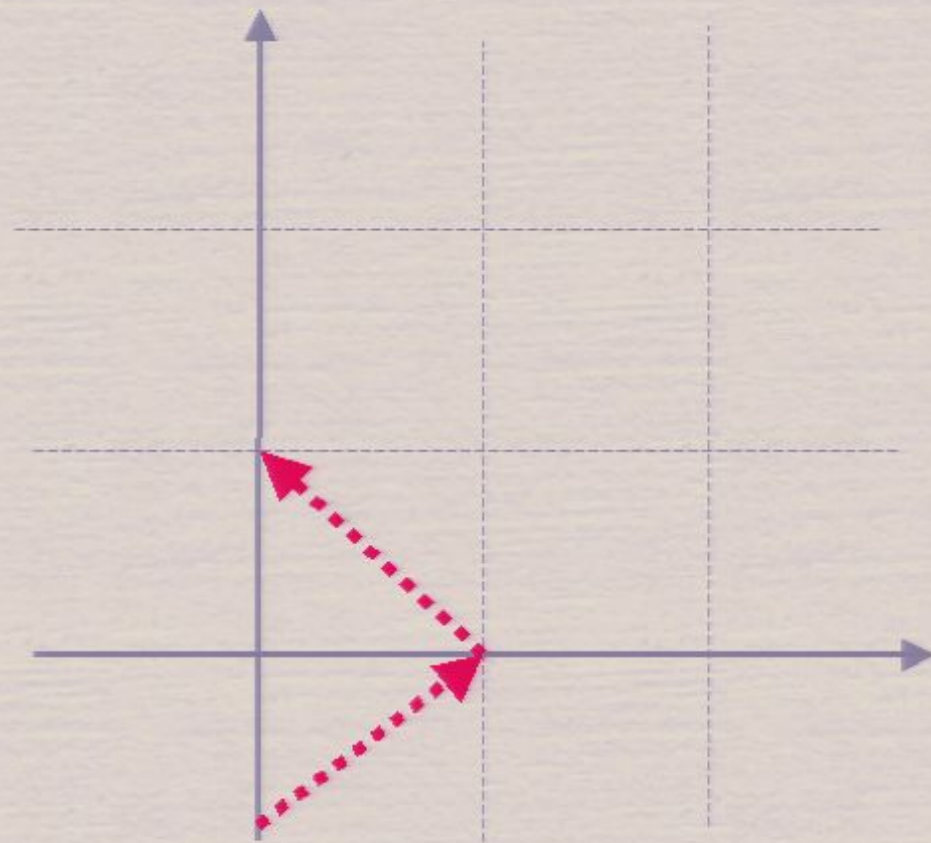
This axis can be found by using light. Suppose you send light towards a mirror at 5 s before noon and receive the reflected light at 5 s after noon.

At what time did the light hit the mirror?

Set noon = 0.

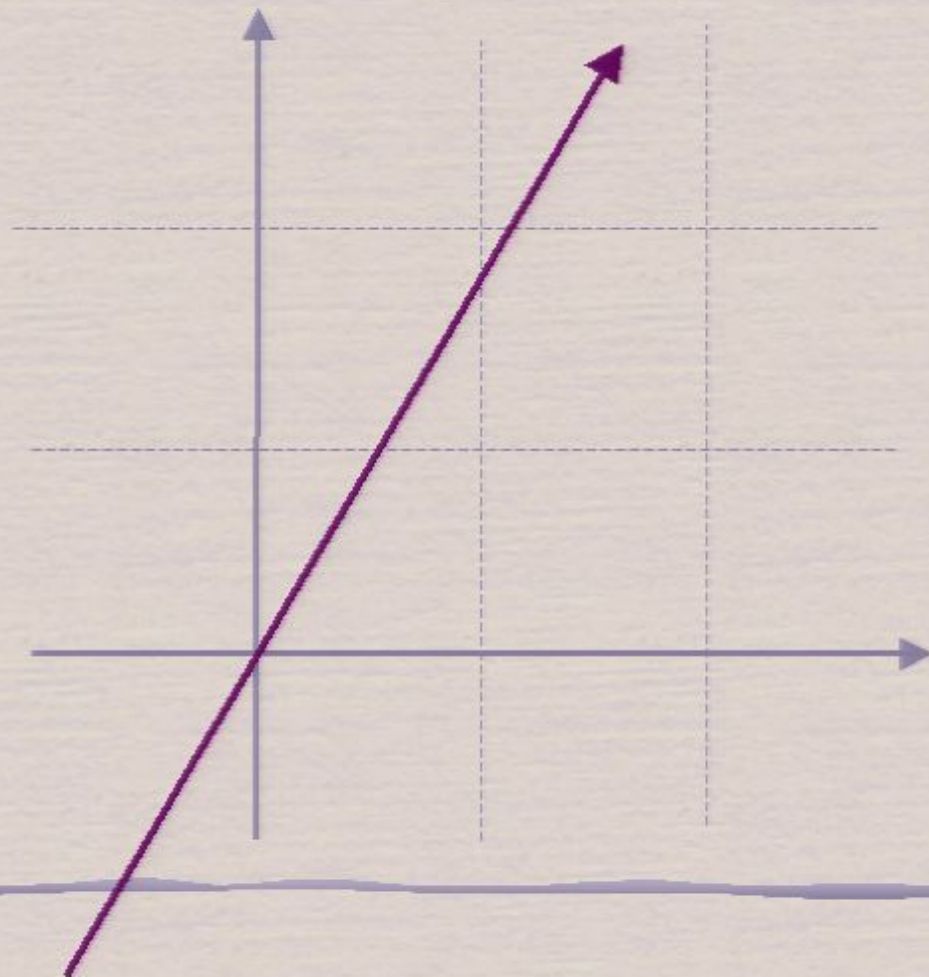
Draw the situation with a mirror in the rest frame.

Set noon = 0.
Draw the situation with a mirror in the rest frame.

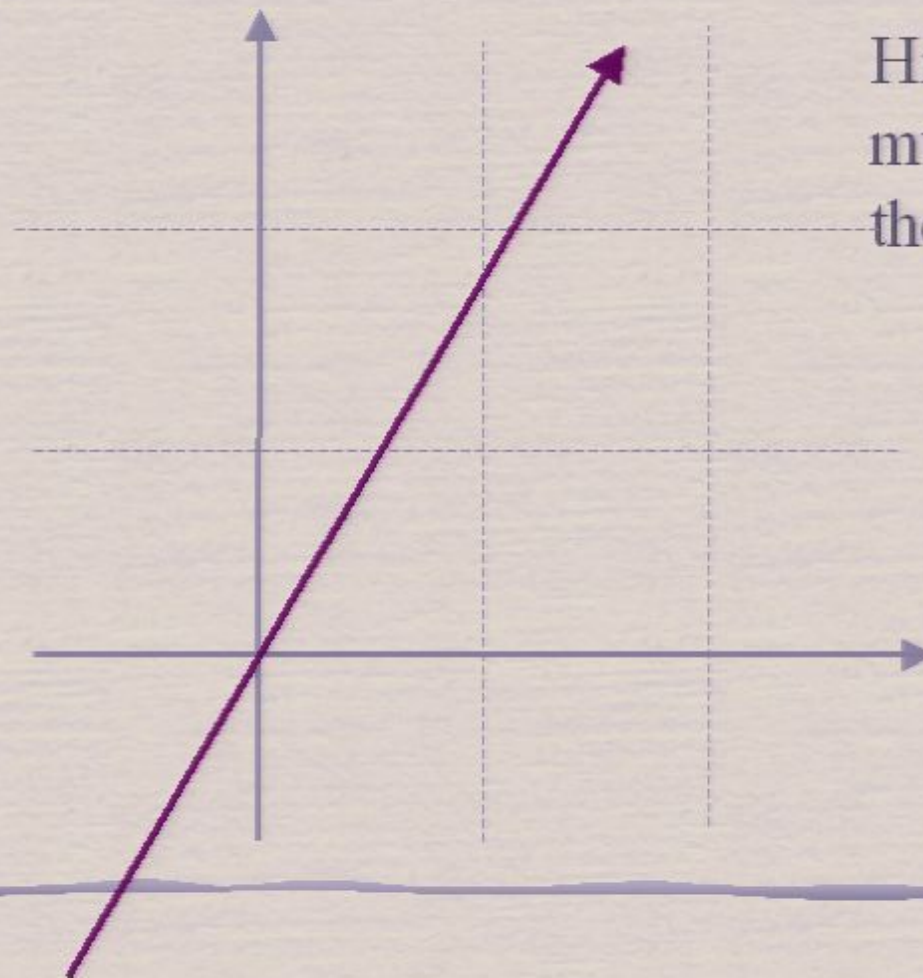


Set noon = 0.
Draw it with a mirror in the moving frame.

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Draw it with a mirror in the moving frame.

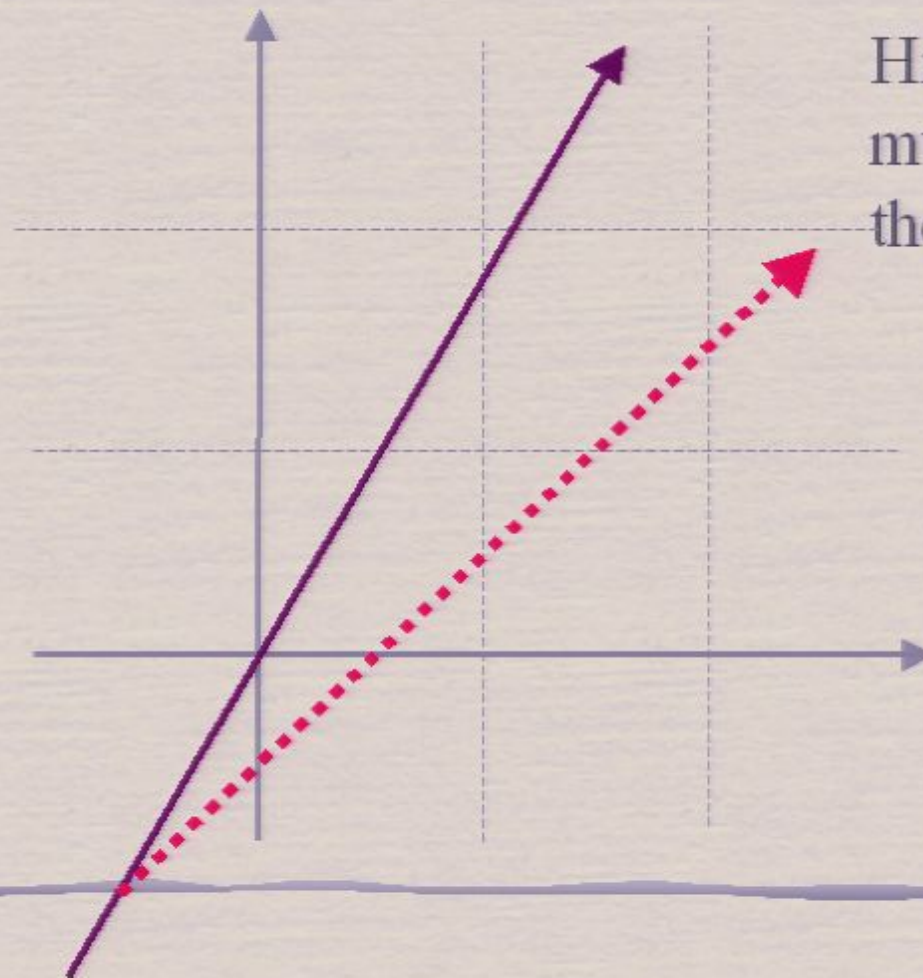


Set noon = 0.
Draw it with a mirror in the moving frame.



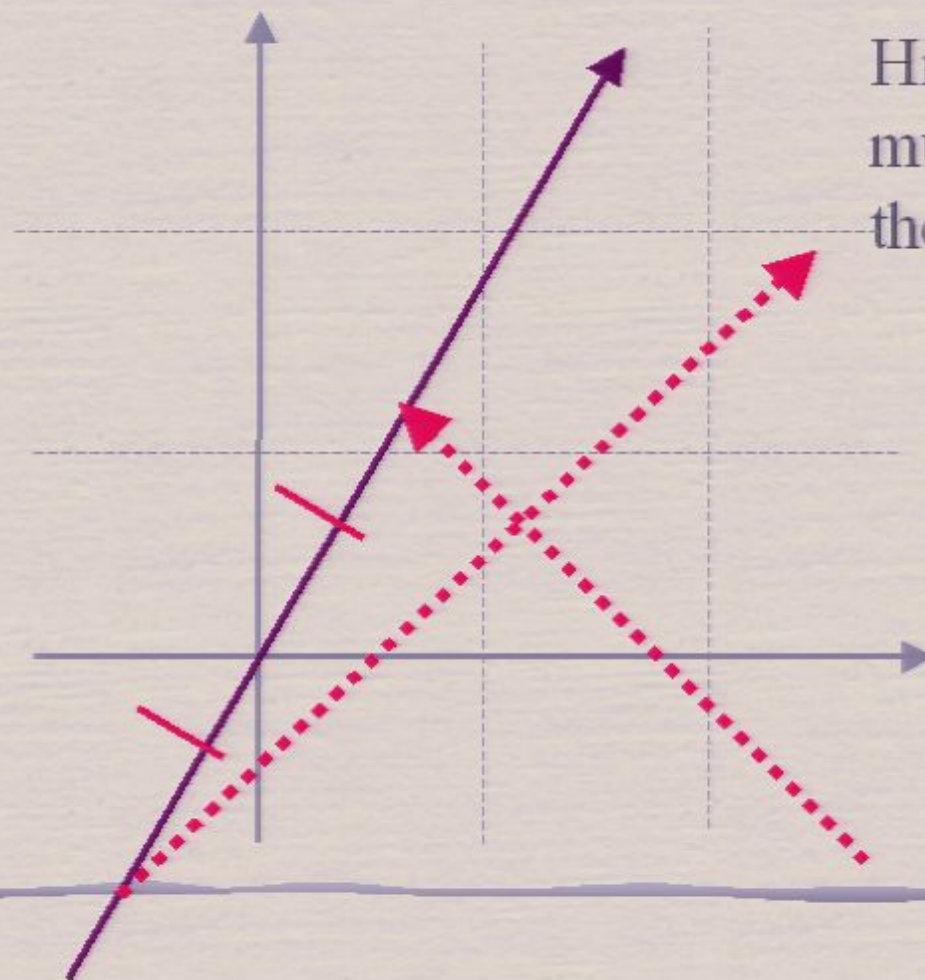
Hint: Light rays must be at 45 to the rest frame.

Set noon = 0.
Draw it with a mirror in the moving frame.



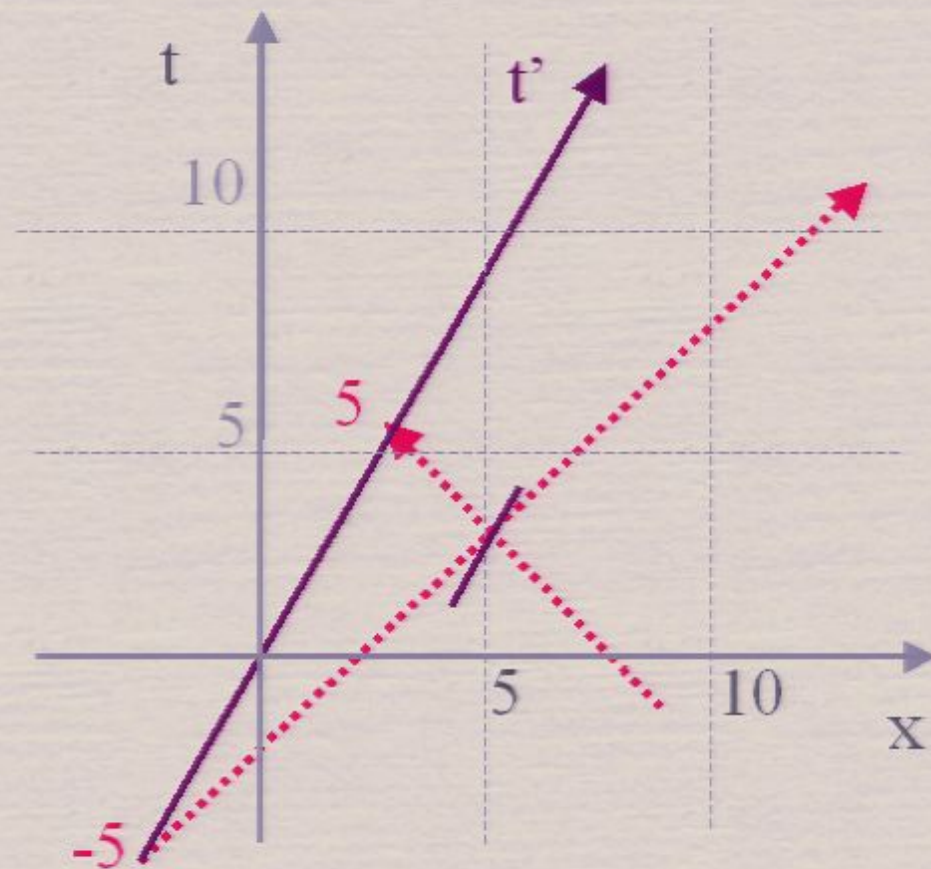
Hint: Light rays
must be at 45 to
the rest frame.

Set noon = 0.
Draw it with a mirror in the moving frame.

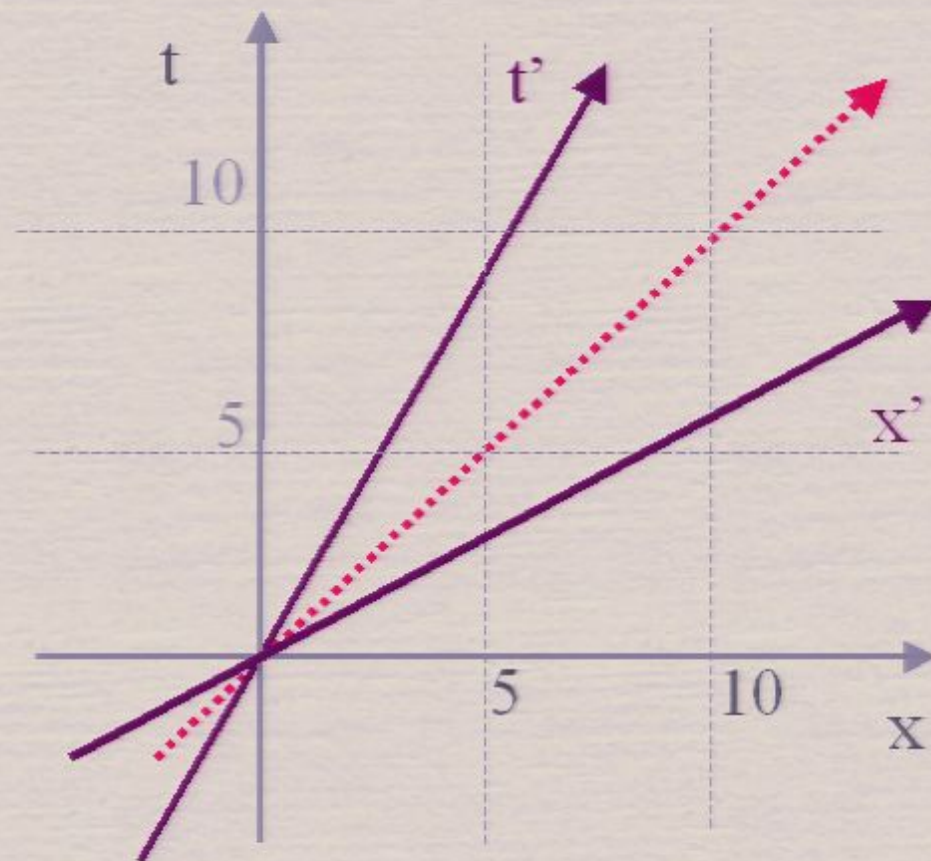


Hint: Light rays must be at 45° to the rest frame.

The light rays intersect at $t' = 0$. /
The origin is another point where $t' = 0$.
A line joining these two points is the x' axis.



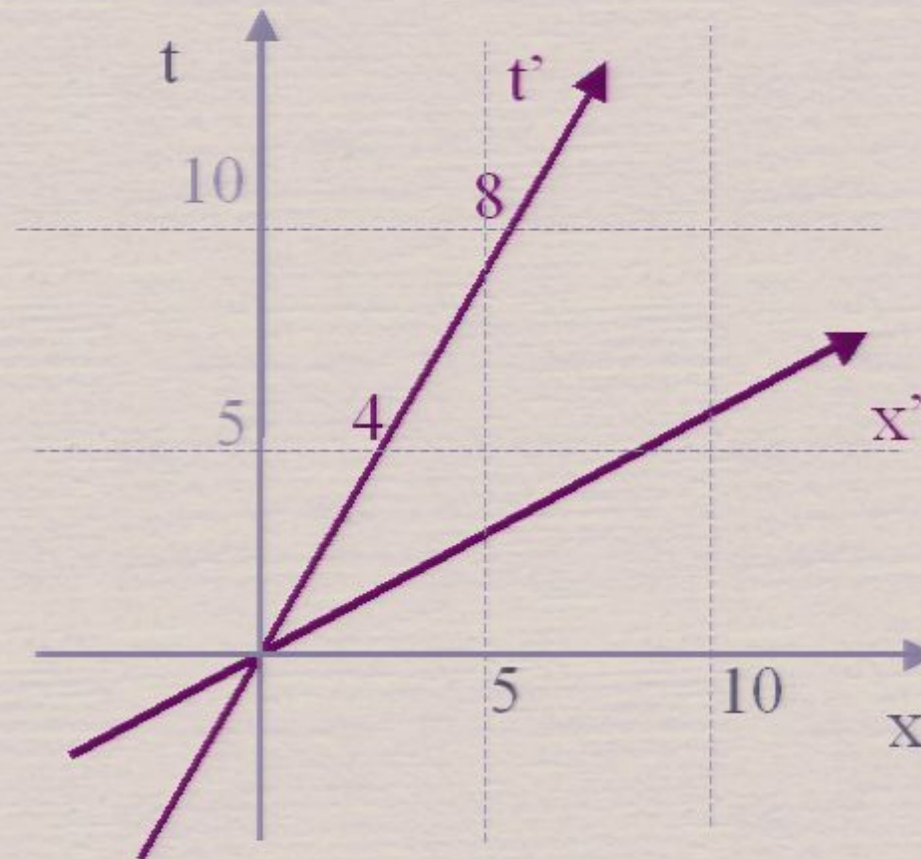
The x' axis has a slope of $3/5$.
The x' and t' axes are symmetric about 45° ,
light, just as the x and t axes are.



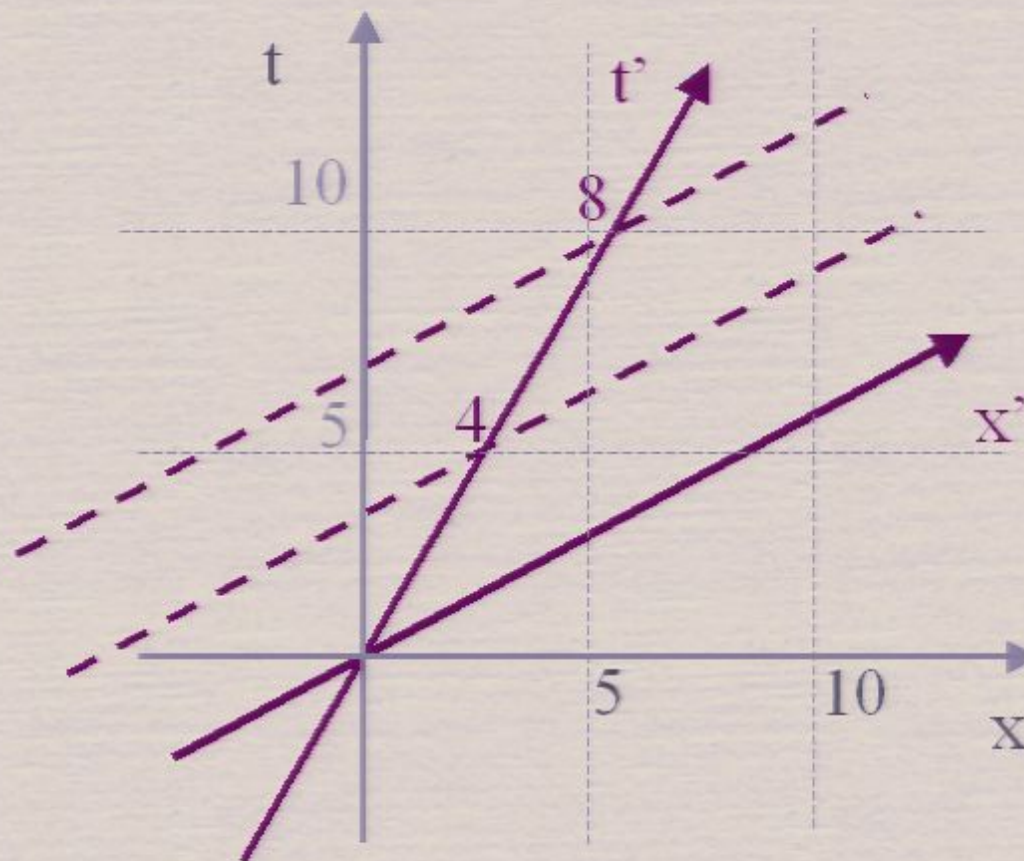
Calibrate the t' axis.

At a speed of $3/5 c$, gamma is $5/4$.

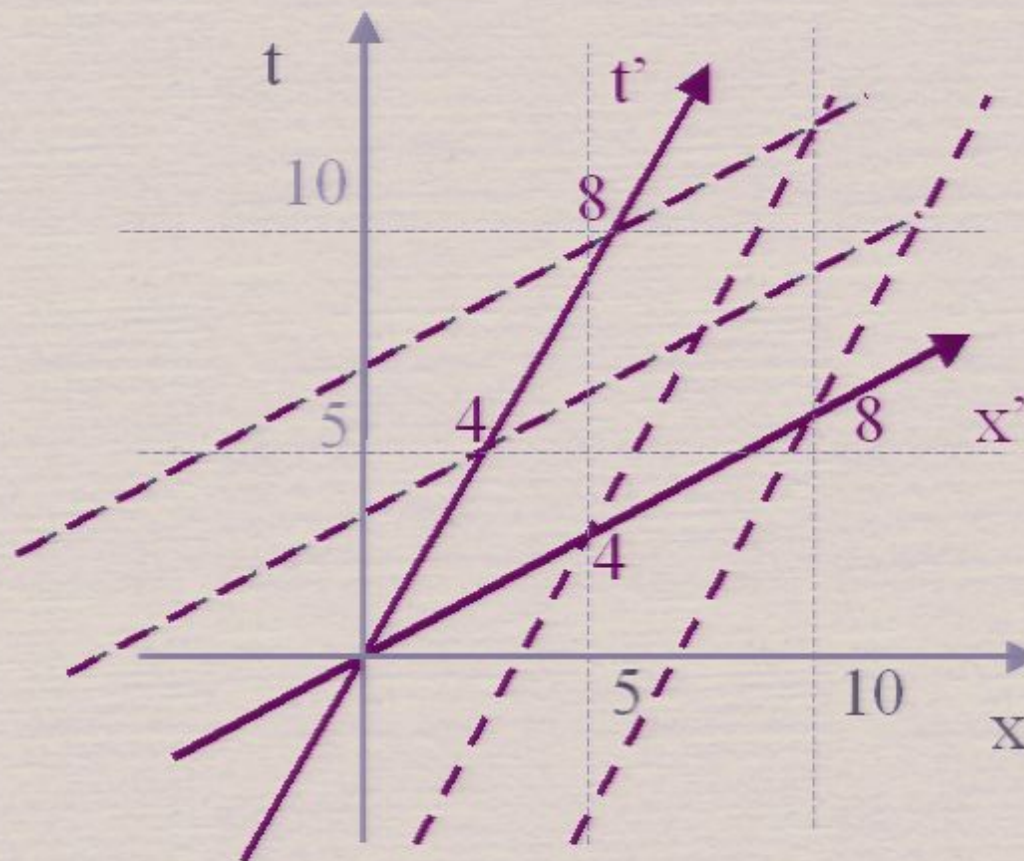
Where the t gridlines meet the t' axis is $t' = 4/5t$.



Draw t' gridlines for $t' = 4$ and 8 light units.
They will be parallel to the x' axis.

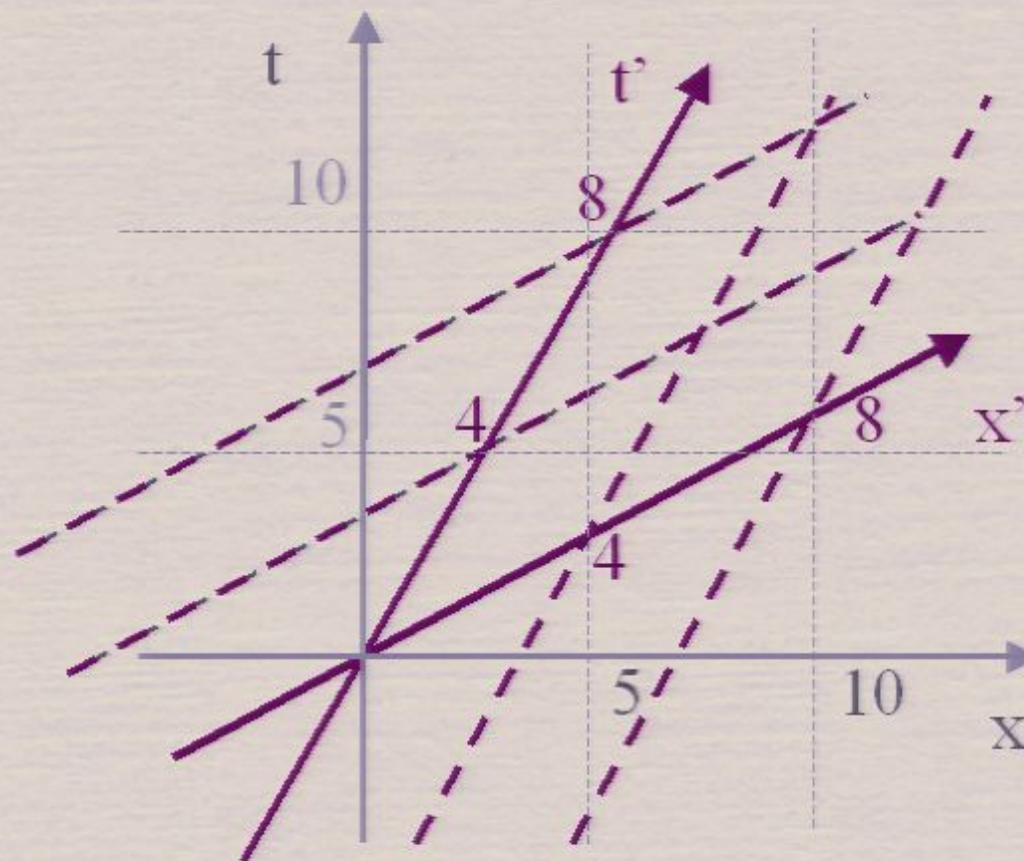


Draw x' grid lines in a similar fashion.



You now have a very powerful tool that allows you to visualize and quantify all sorts of problems in relativity: space contraction, the 'twin' paradox, addition of velocities, relativistic Doppler shift etc.

Draw x' grid lines in a similar fashion.



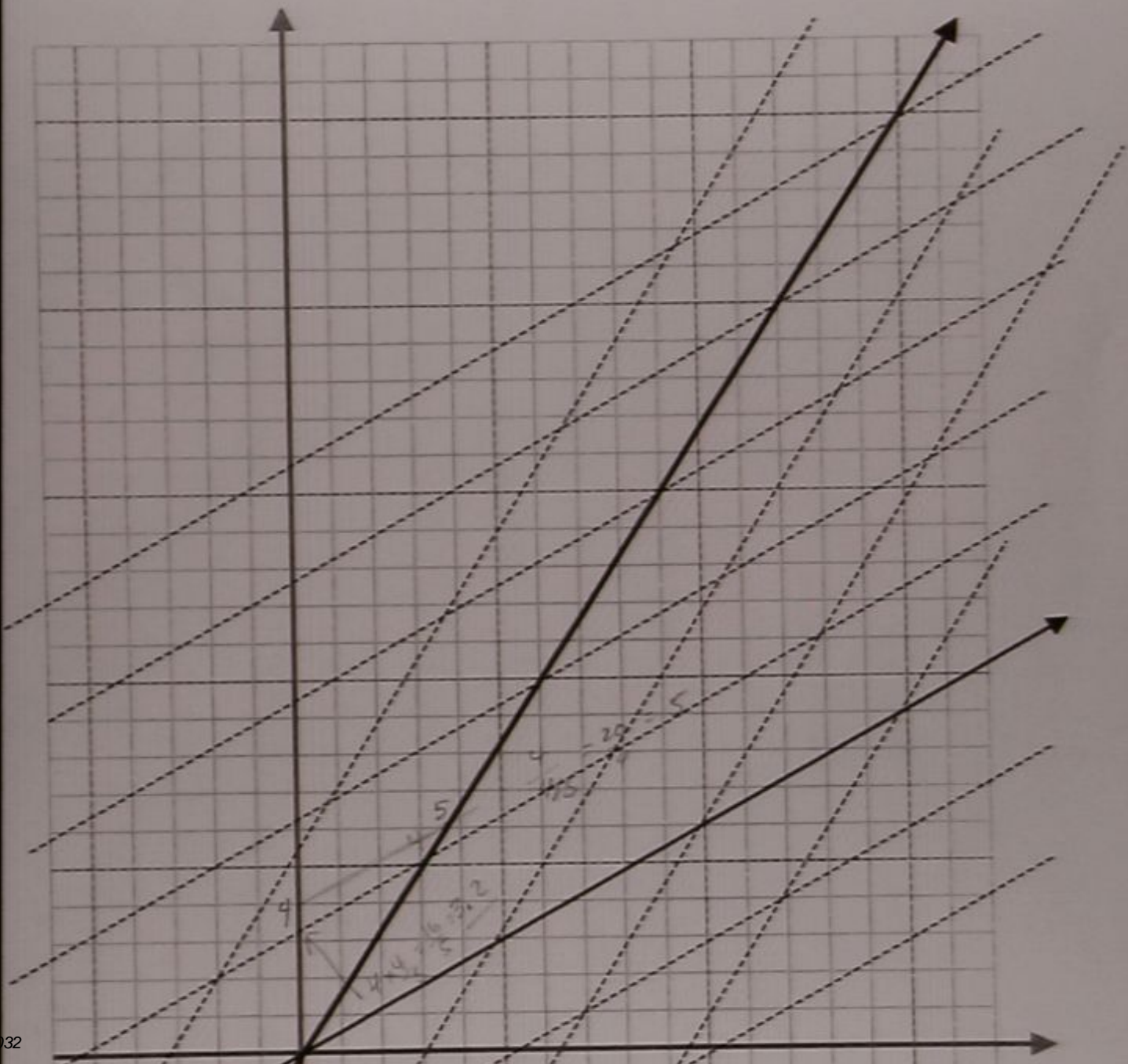
For a more thorough development of spacetime diagrams try Thomas Moore's

"A Travelers Guide to Spacetime"

or

"Six Ideas that Shaped the World, Unit R"

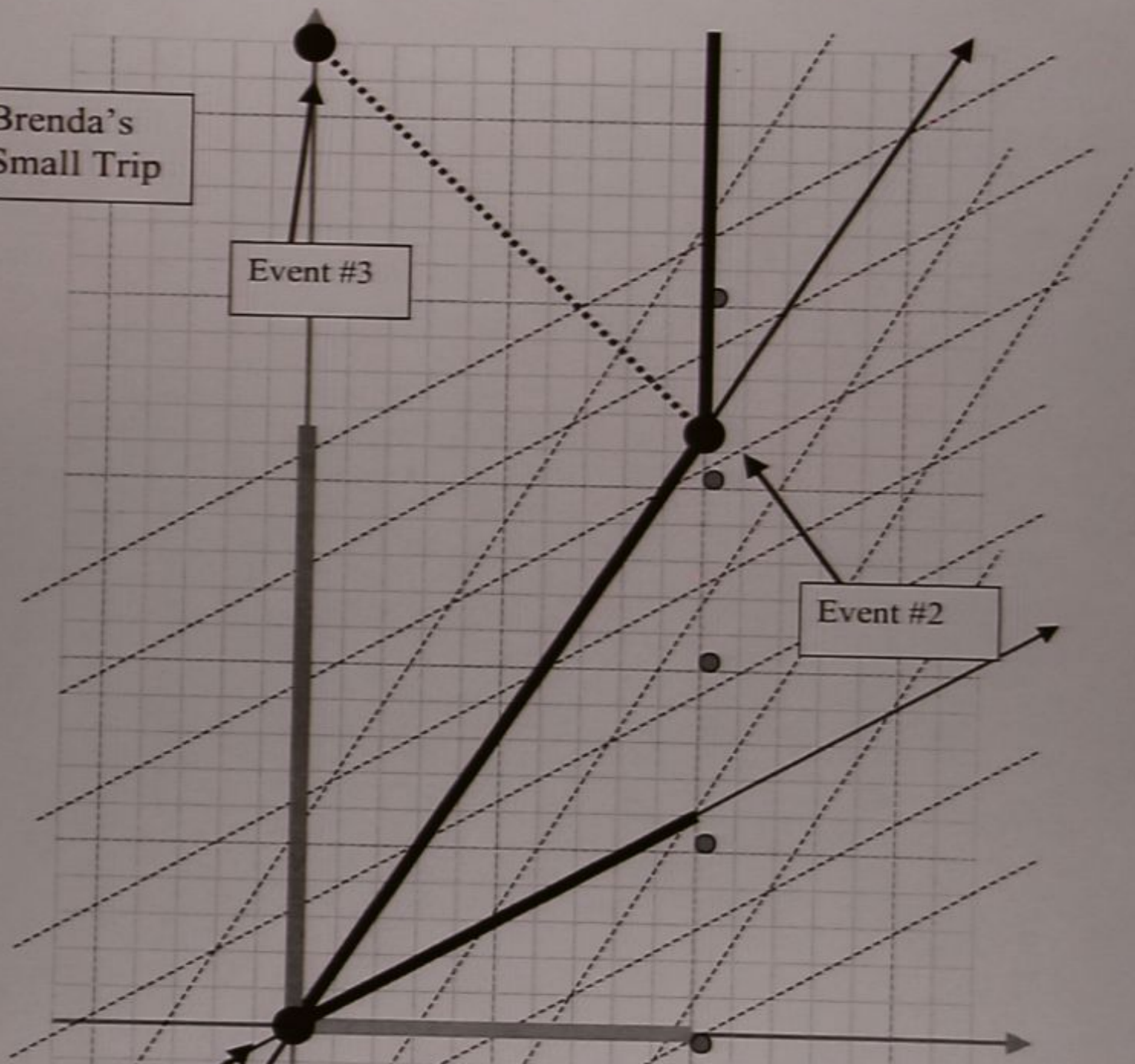
End of slide show, click to exit.



Brenda's
Small Trip

Event #3

Event #2

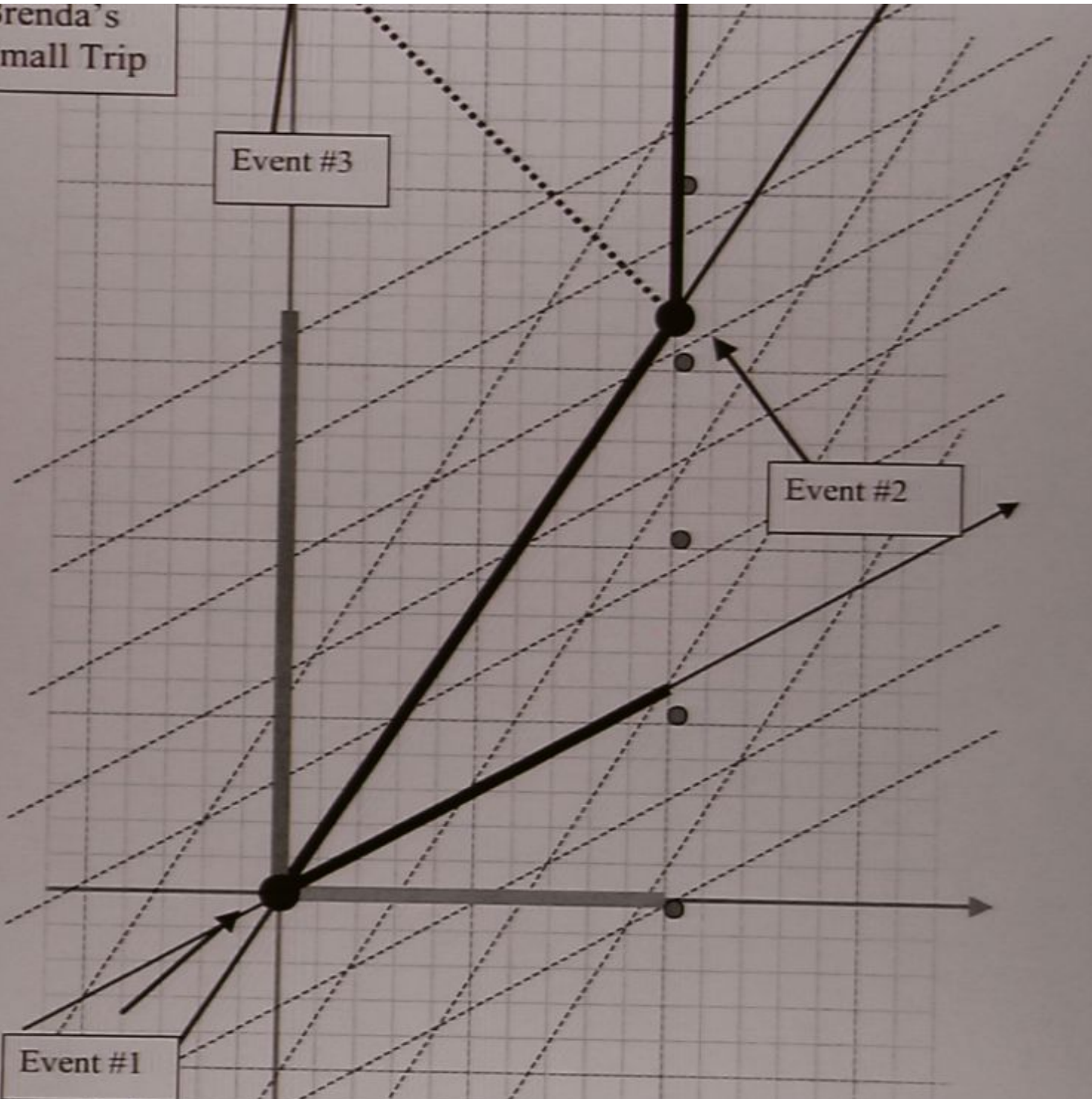


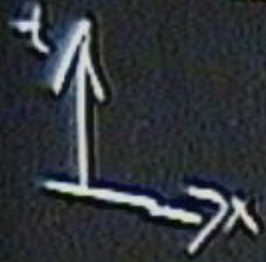
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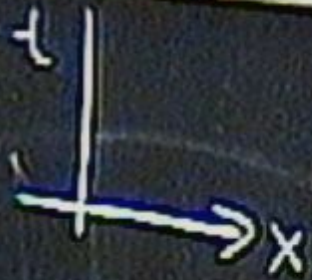
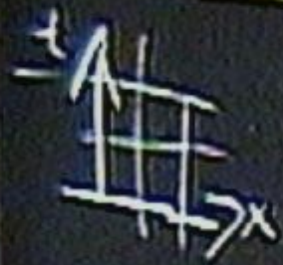
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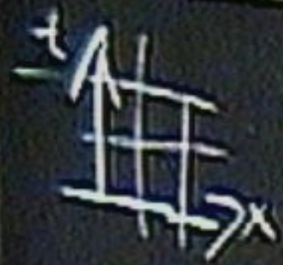
Event #2

Event #1

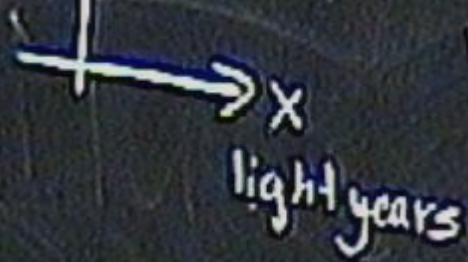






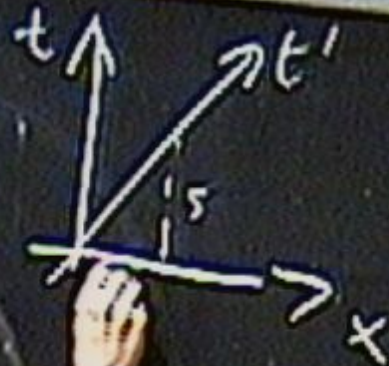
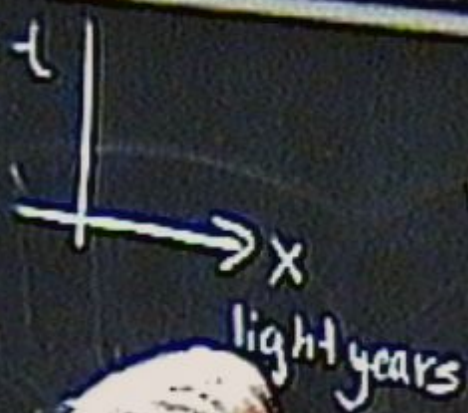


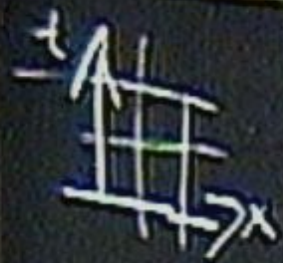
years t



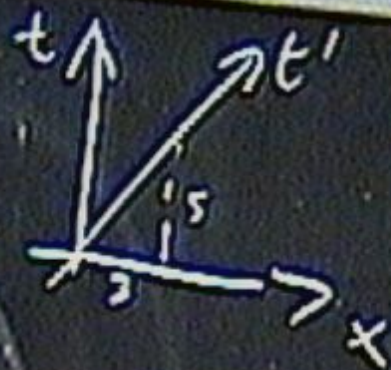
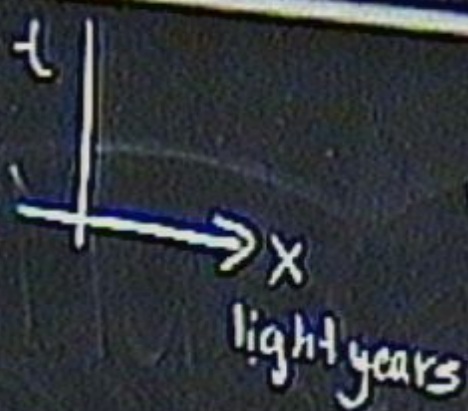


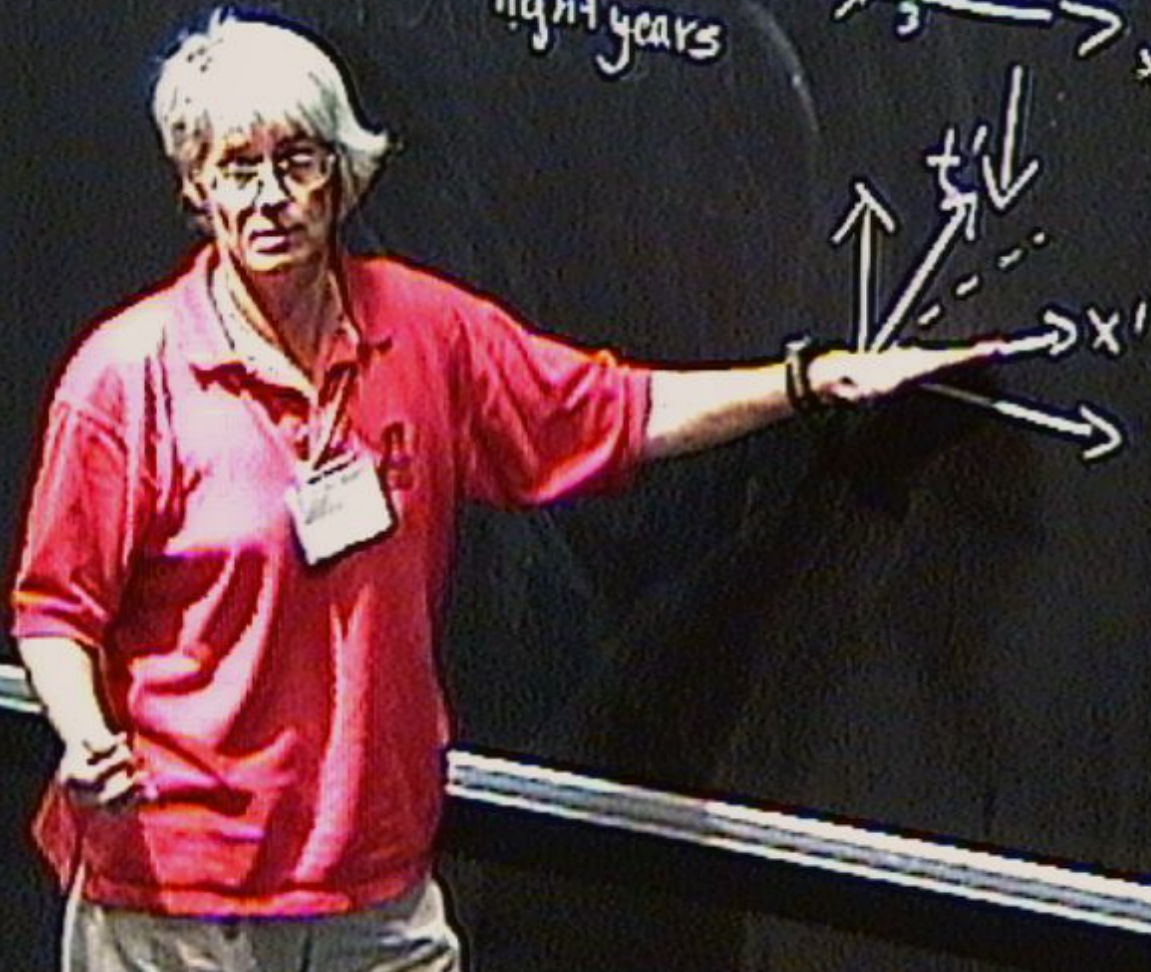
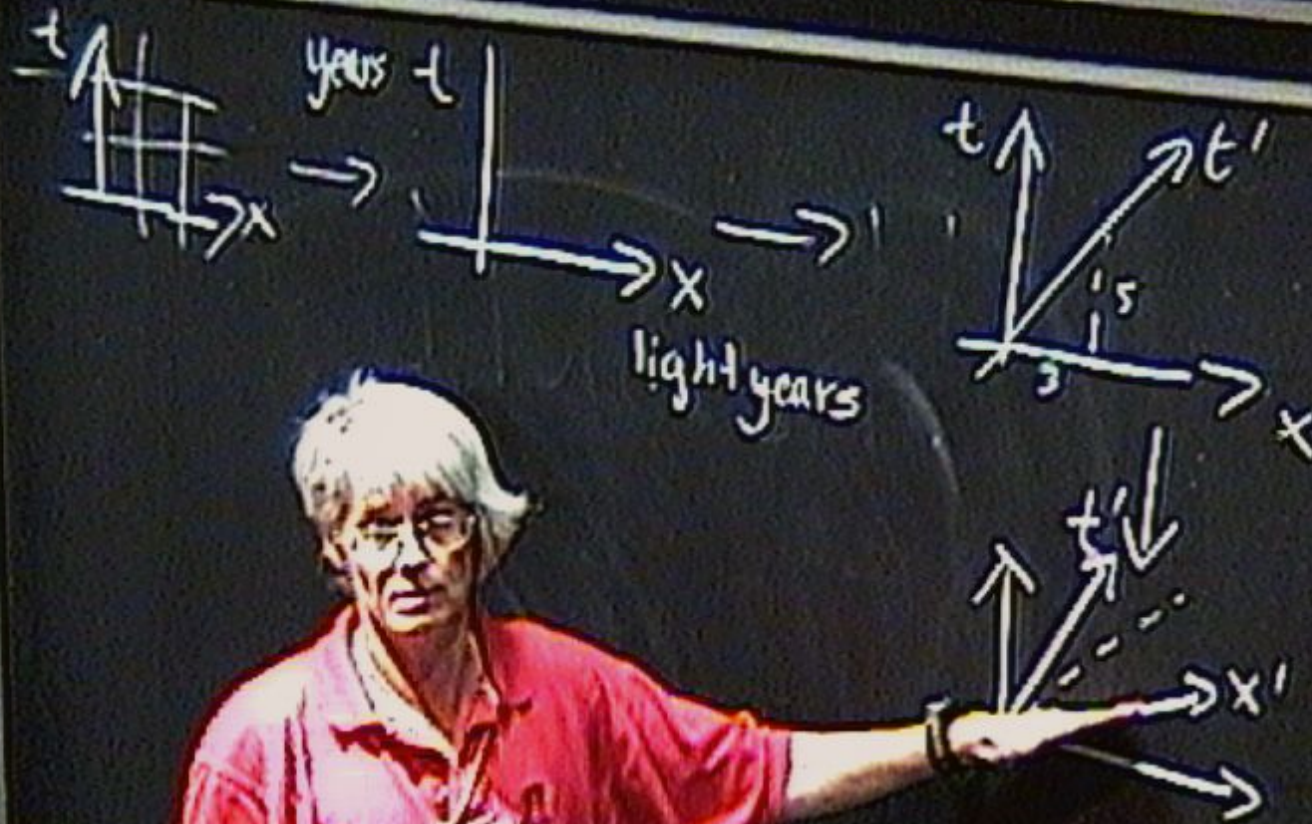
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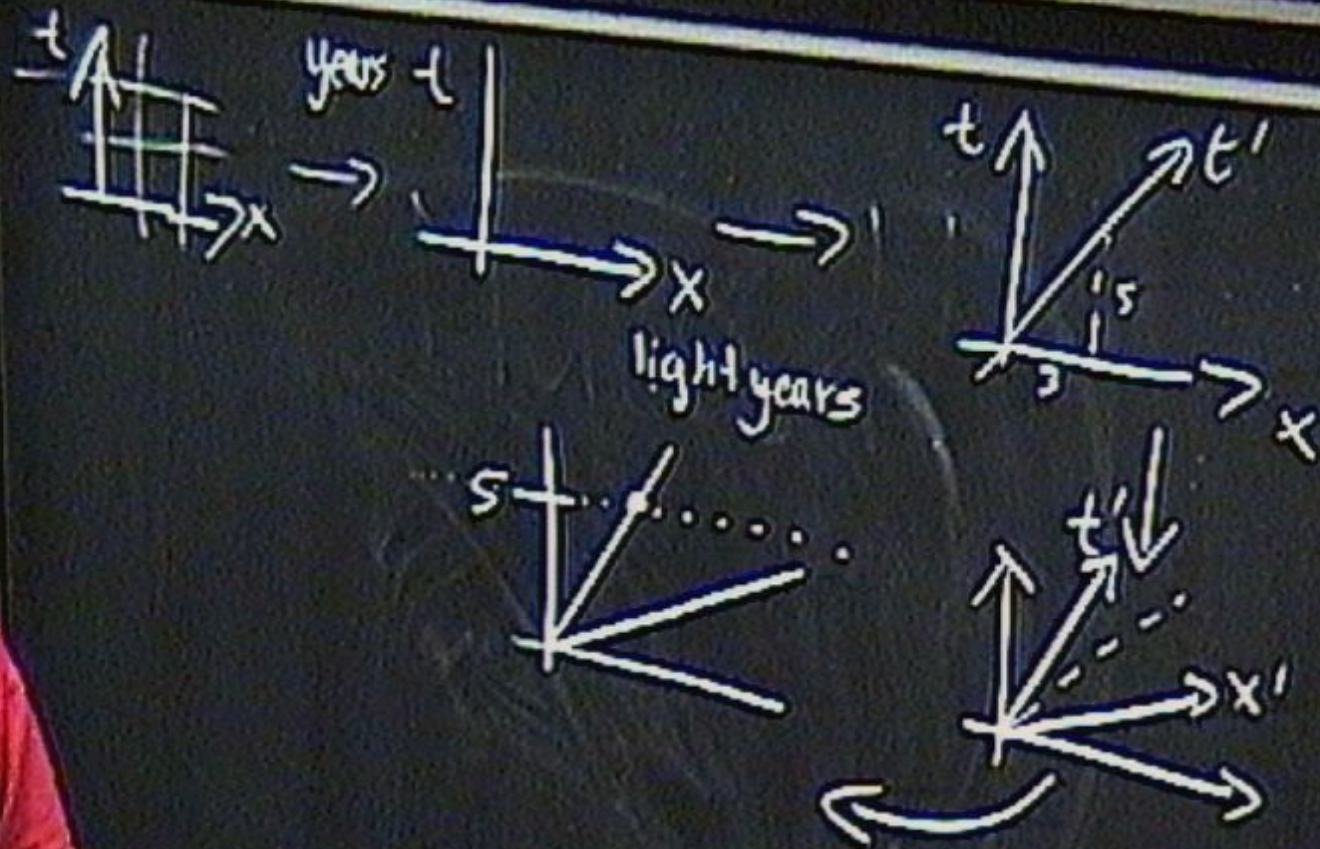


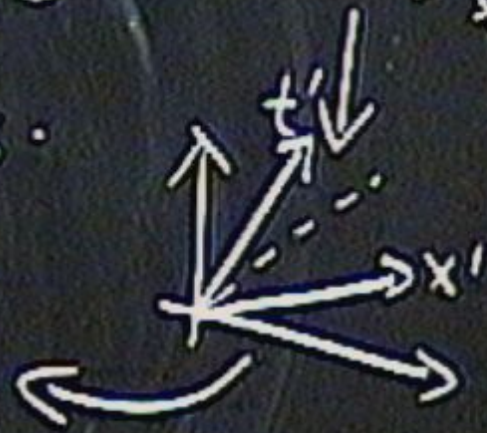
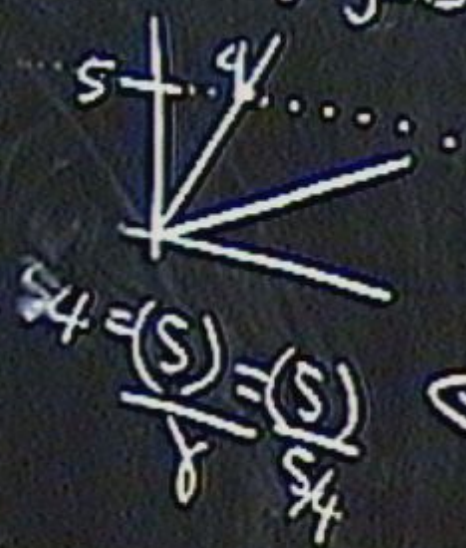
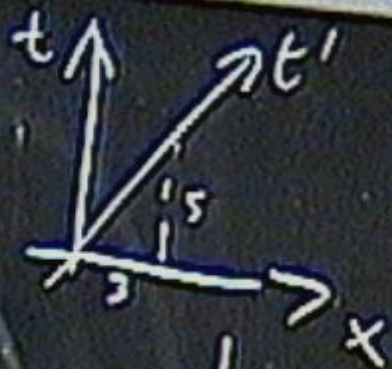
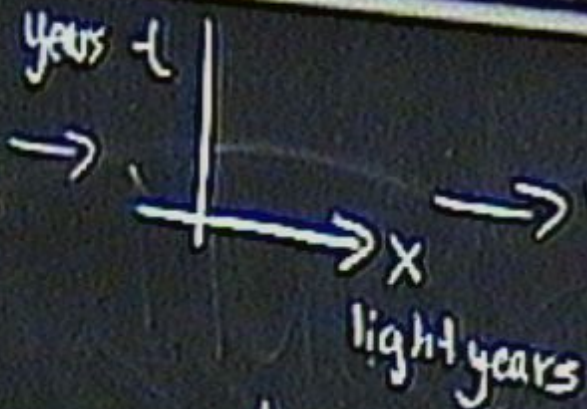
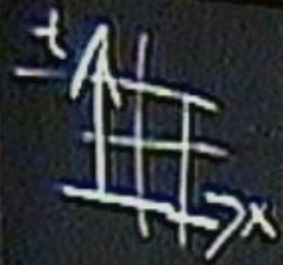


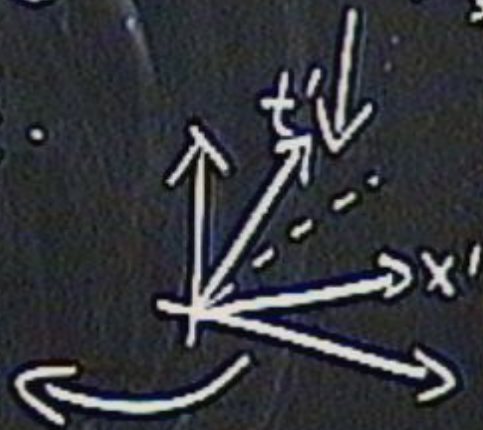
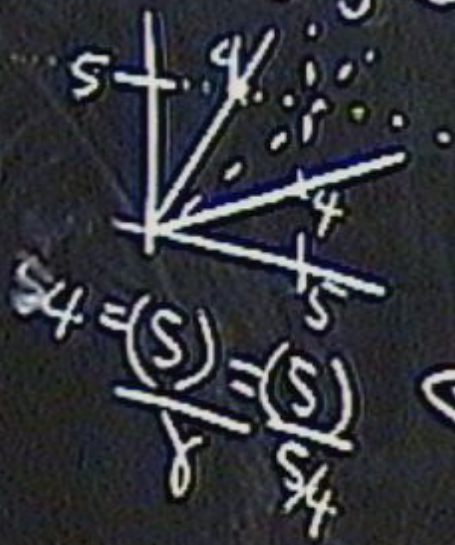
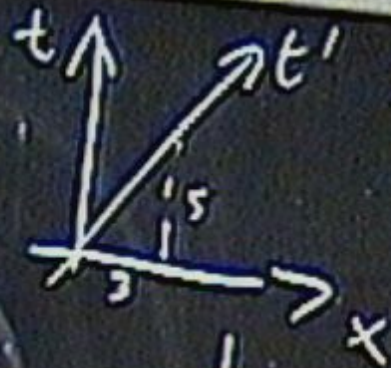
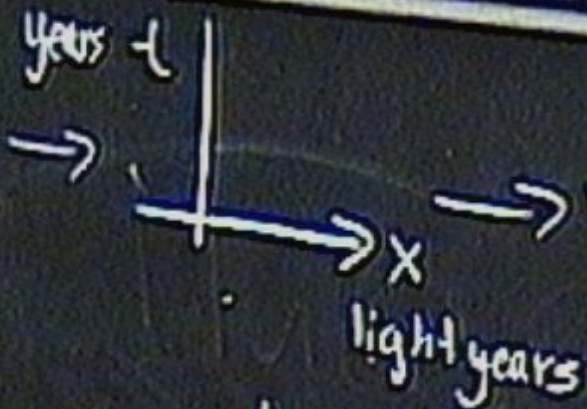
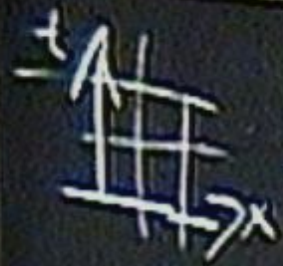
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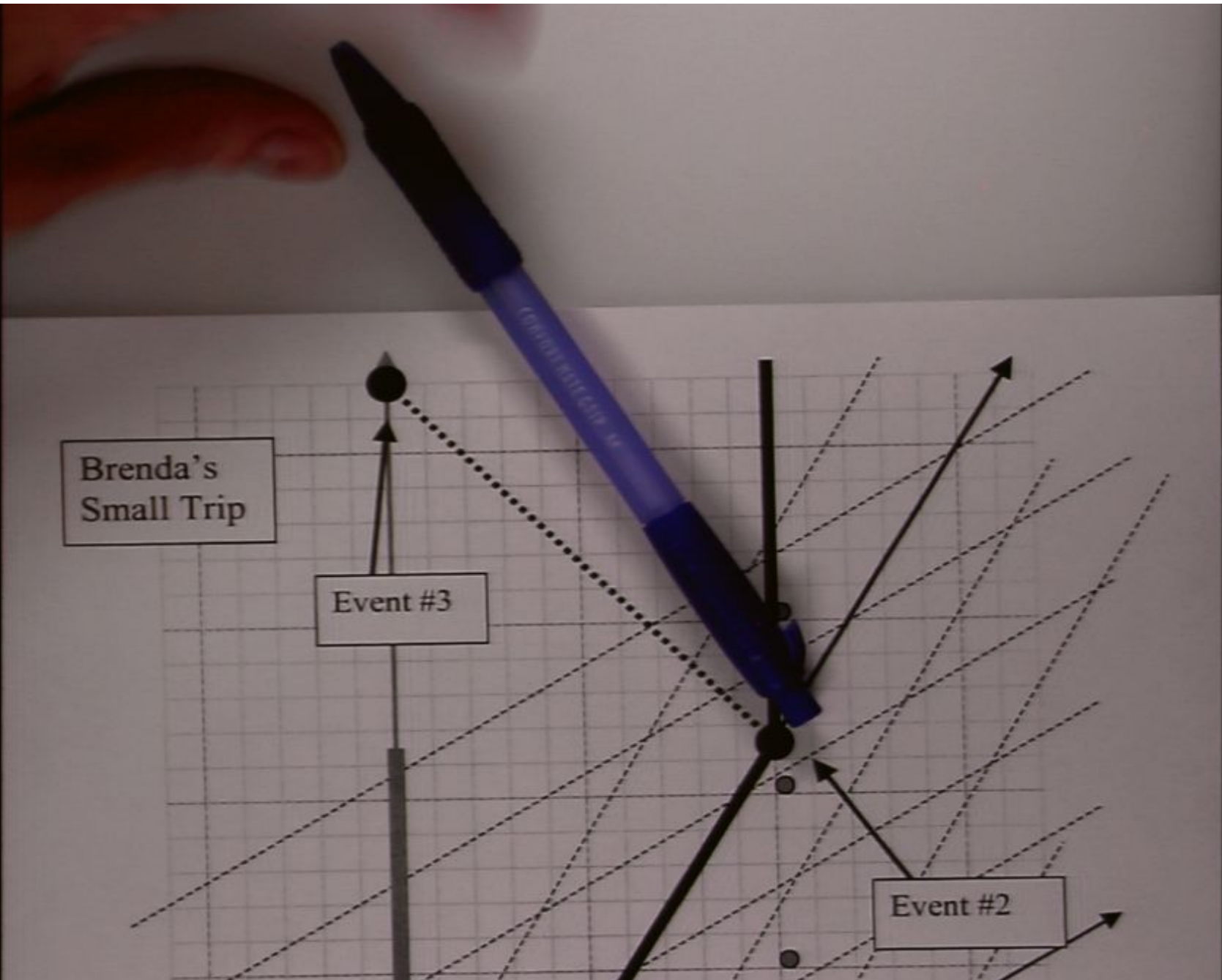


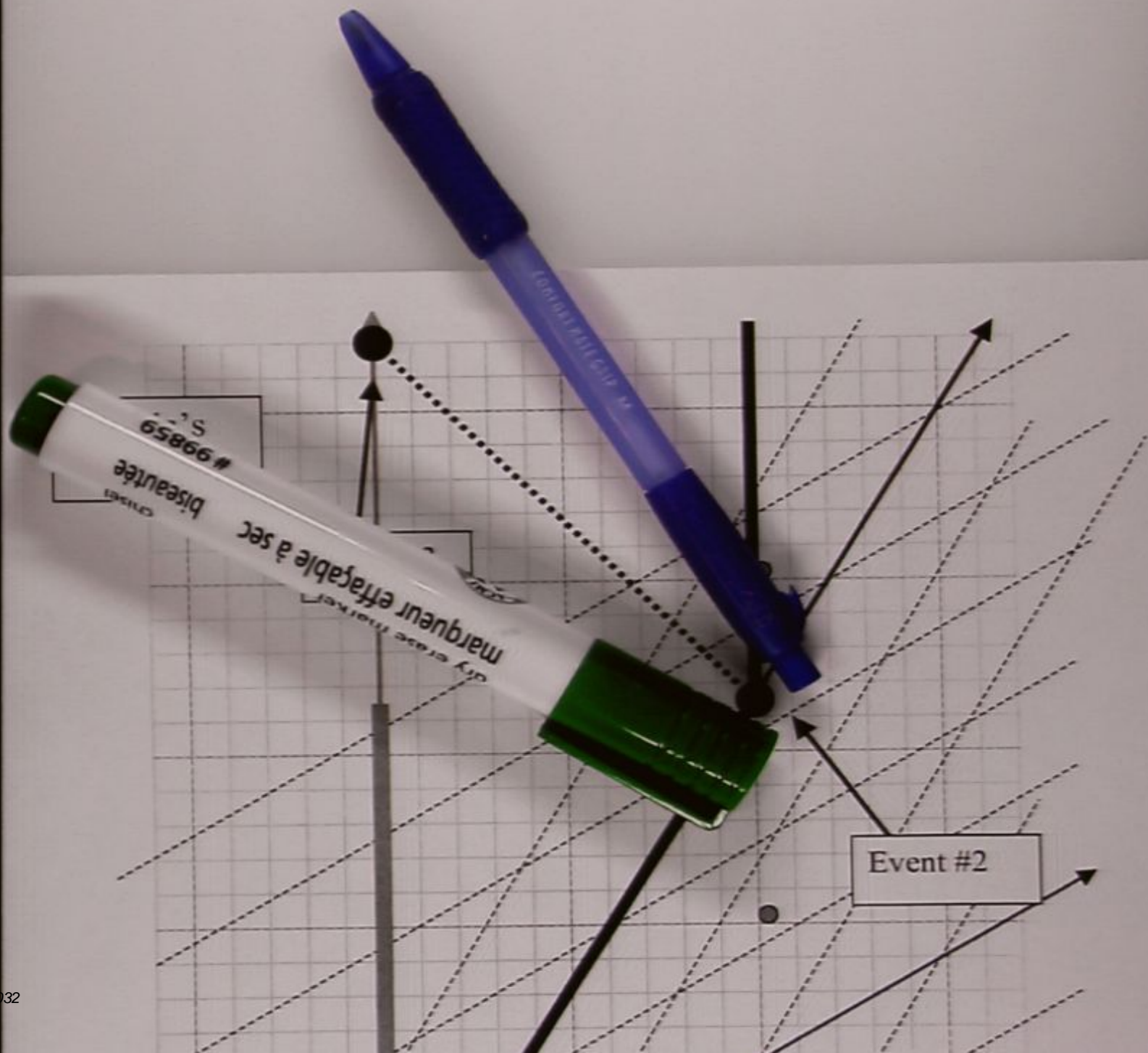
$$s_4 = \frac{(s)}{\gamma} = \frac{(s)}{s_4}$$

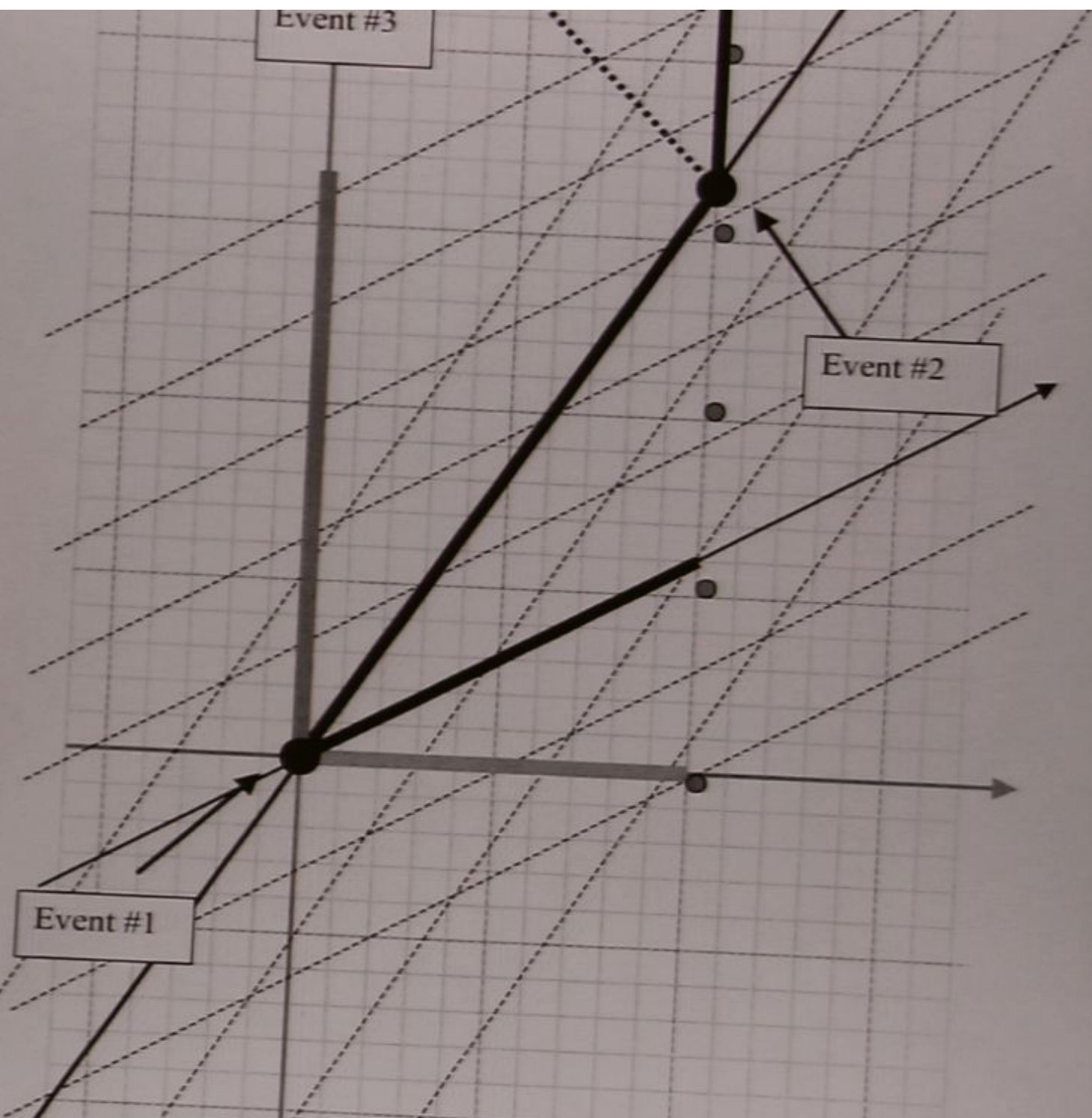
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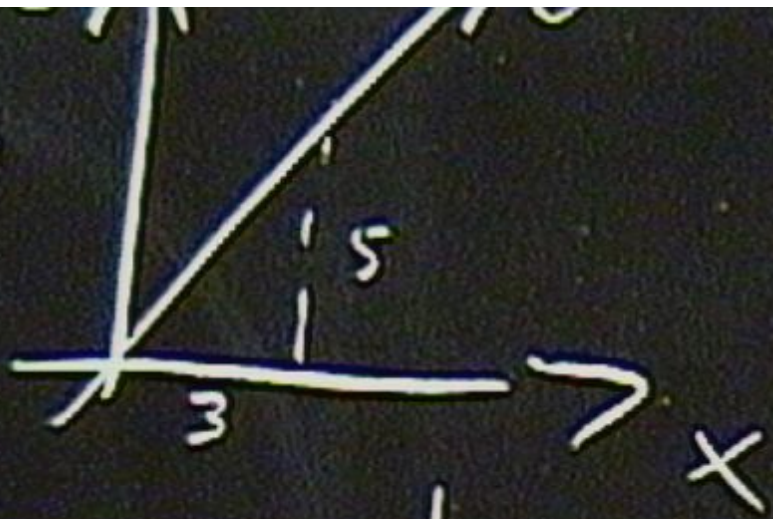
Event #3

Event #2



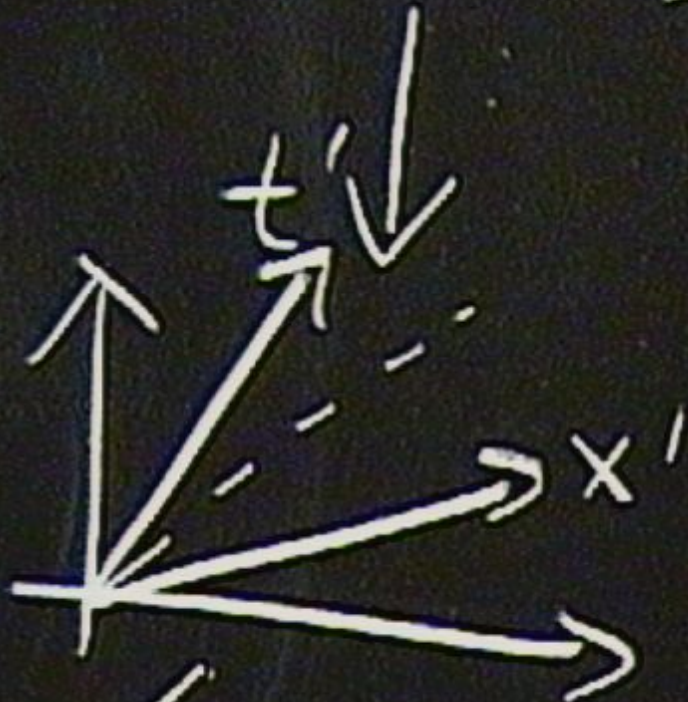


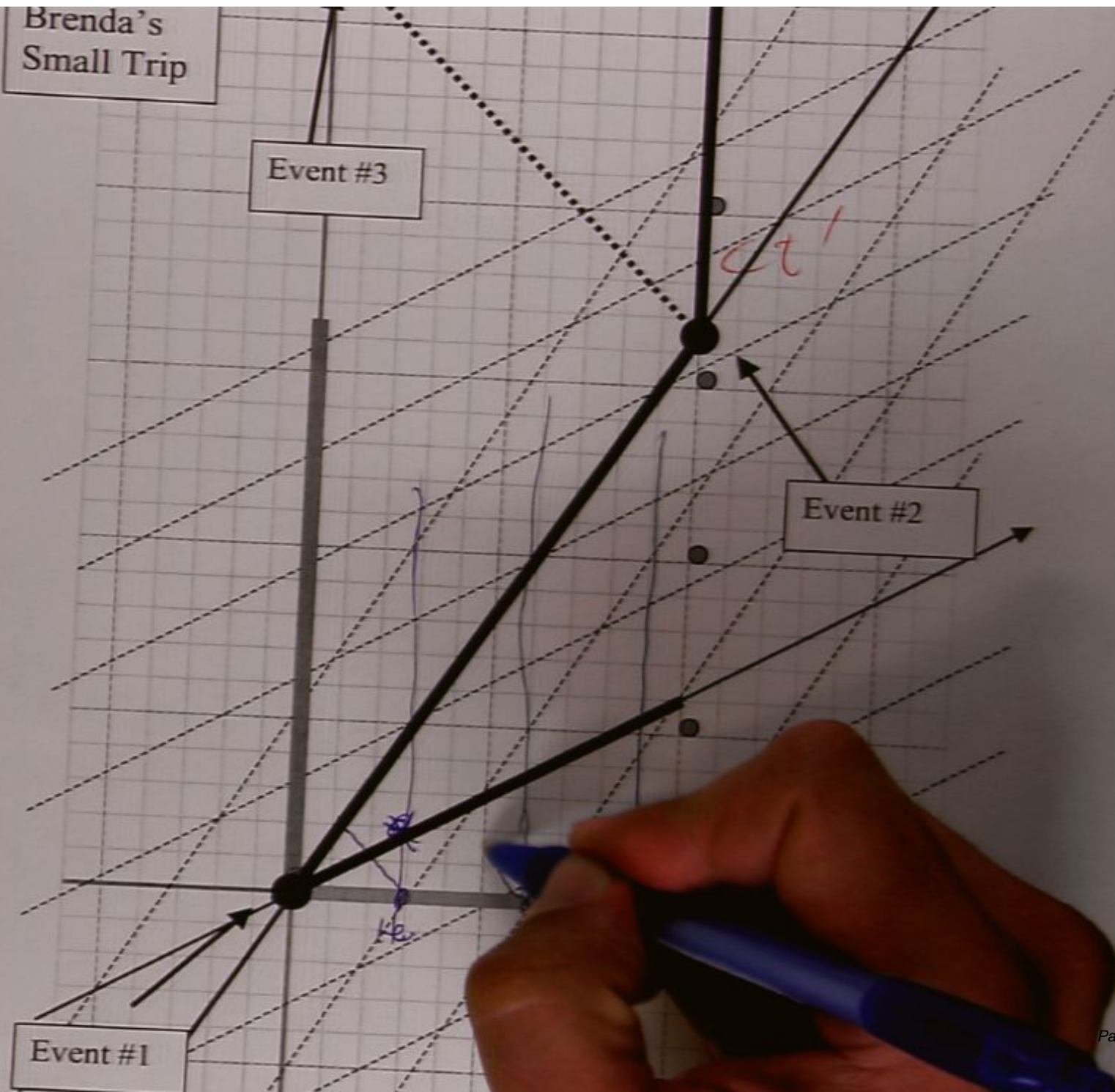




$$E = \frac{1}{2}mv^2$$

$$E' = \frac{mv^2}{2\sqrt{1-\frac{v^2}{c^2}}}$$





Event #3

Event #2

Event #1

