*Introducing Spacetime Geometry:*

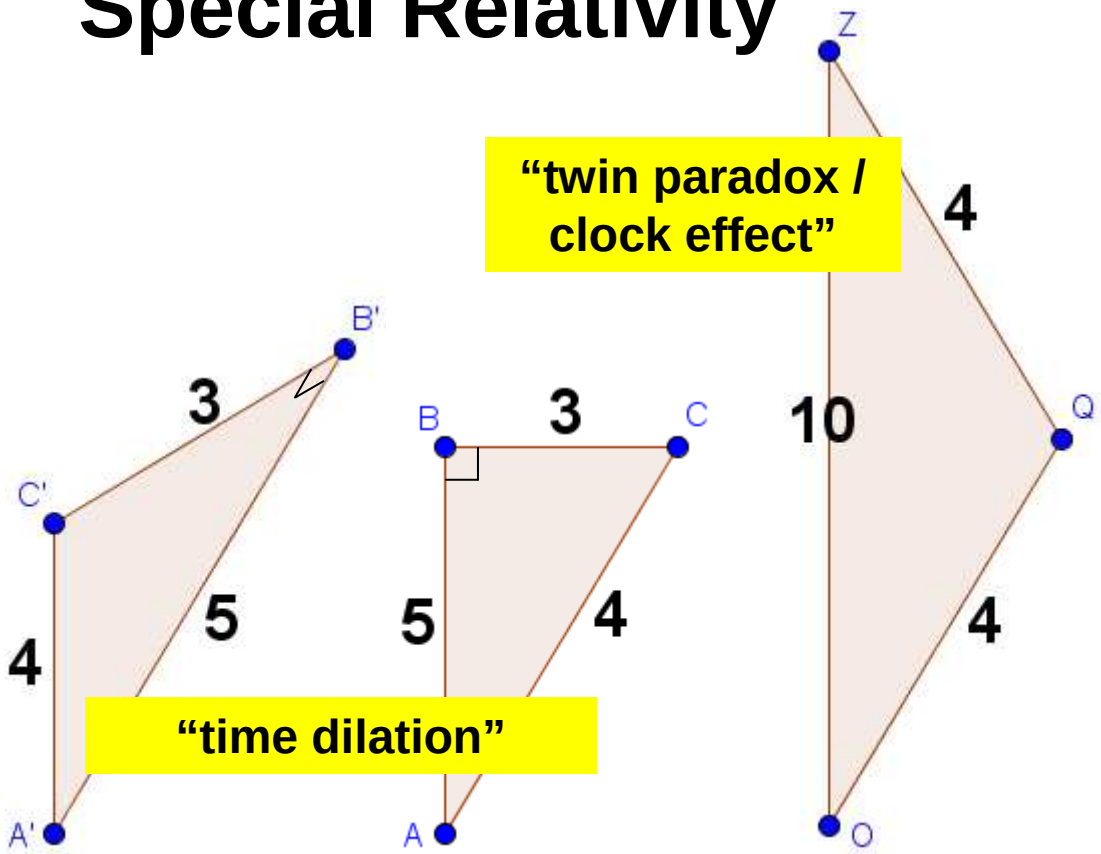
# *Relativity on Rotated Graph Paper*

**Rob Salgado**
Physics Department
U.Wisconsin-La Crosse
**rsalgado@uwlax.edu**

**“Relativity on rotated graph paper”**
**Am J Phys 84, 344 (May 2016)**

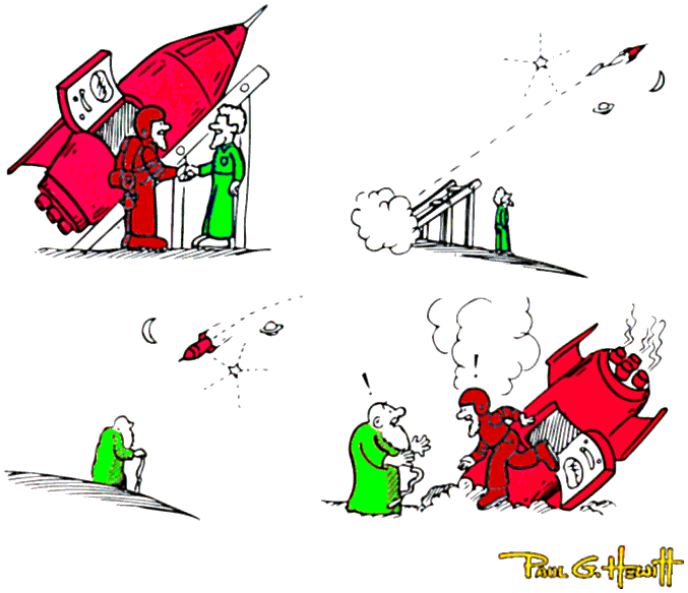
**geogebra.org/robphy**

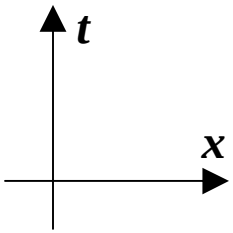
# Some triangles in Special Relativity




**“twin paradox / clock effect”**

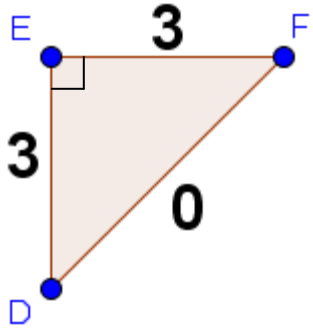
**“time dilation”**






$$s^2 = t^2 - x^2$$

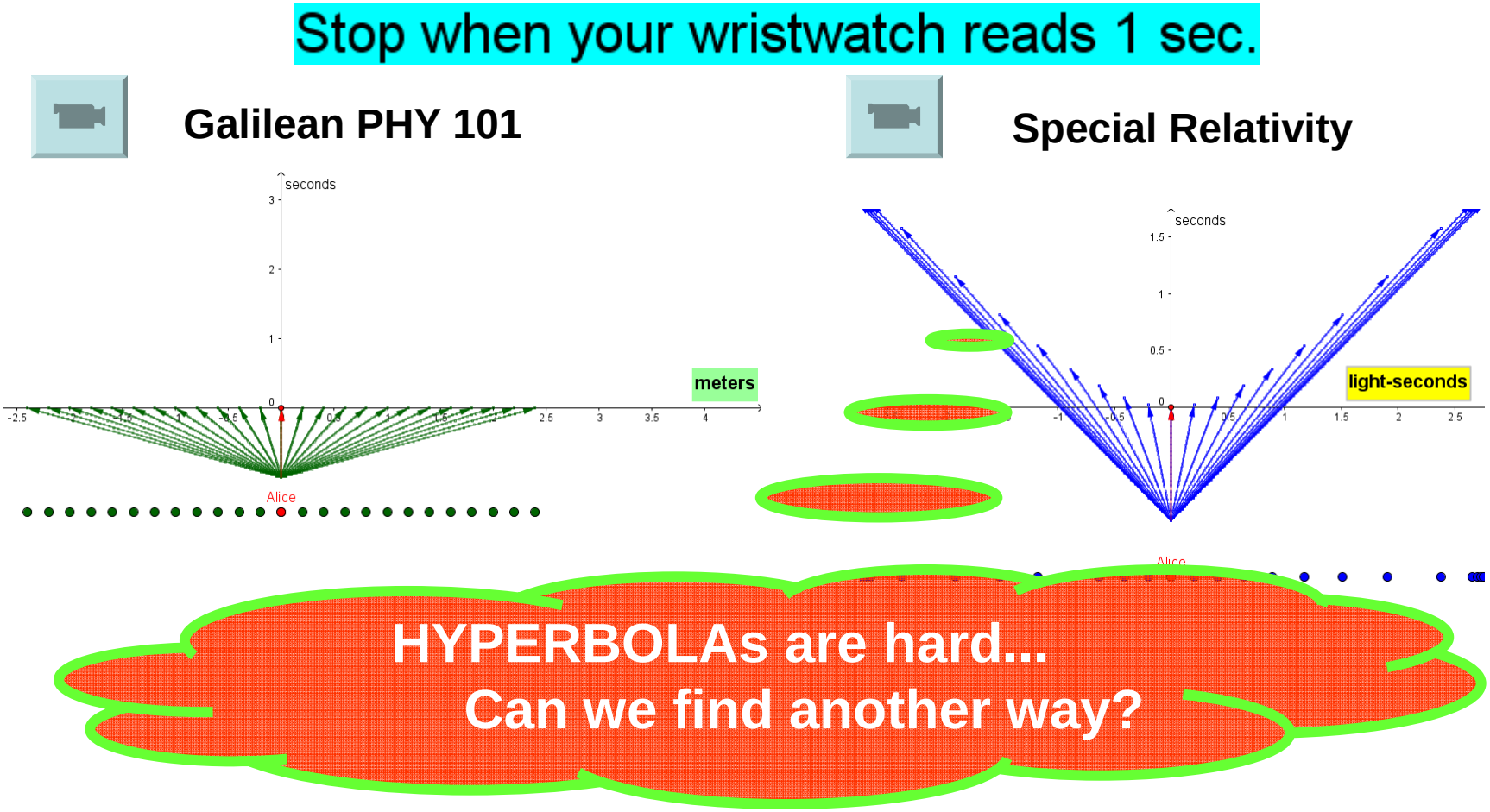
**hyperbola as the “circle in this geometry”**




**“Doppler effect”**

# Why the hyperbola?

## Experimental evidence

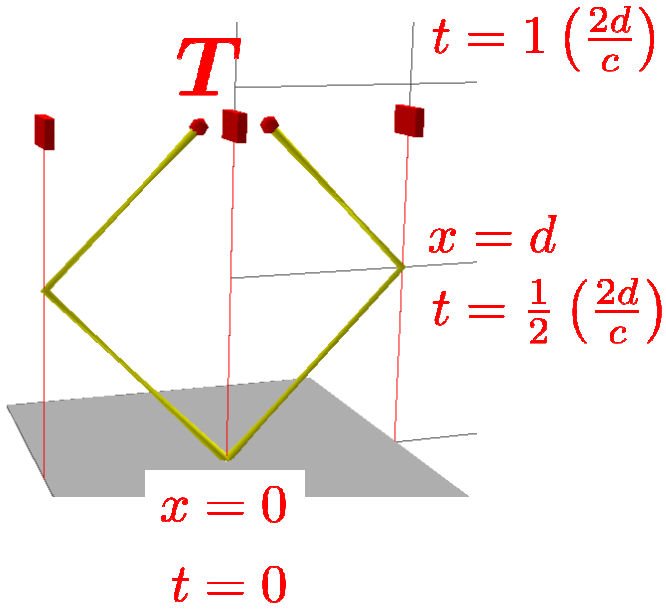


# Einstein's Principles of Relativity

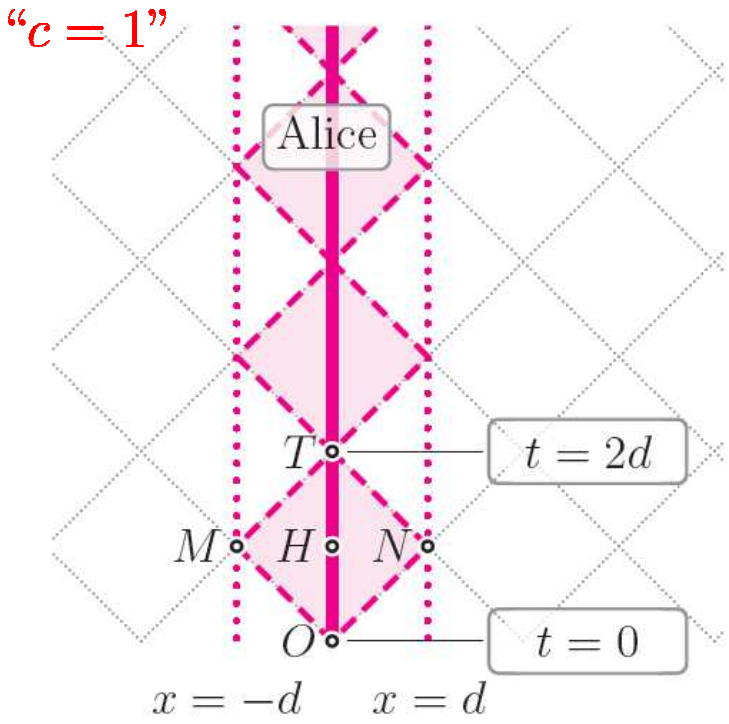
- All inertial observers [traveling in a straight line with constant velocity-vector] are equivalent. ***No experiment can detect the inertial observer's state of motion.***

- ***All observers measure the same speed of light (regardless of the state of motion of the source or the observer).***

# Light Clocks on a Spacetime Diagram

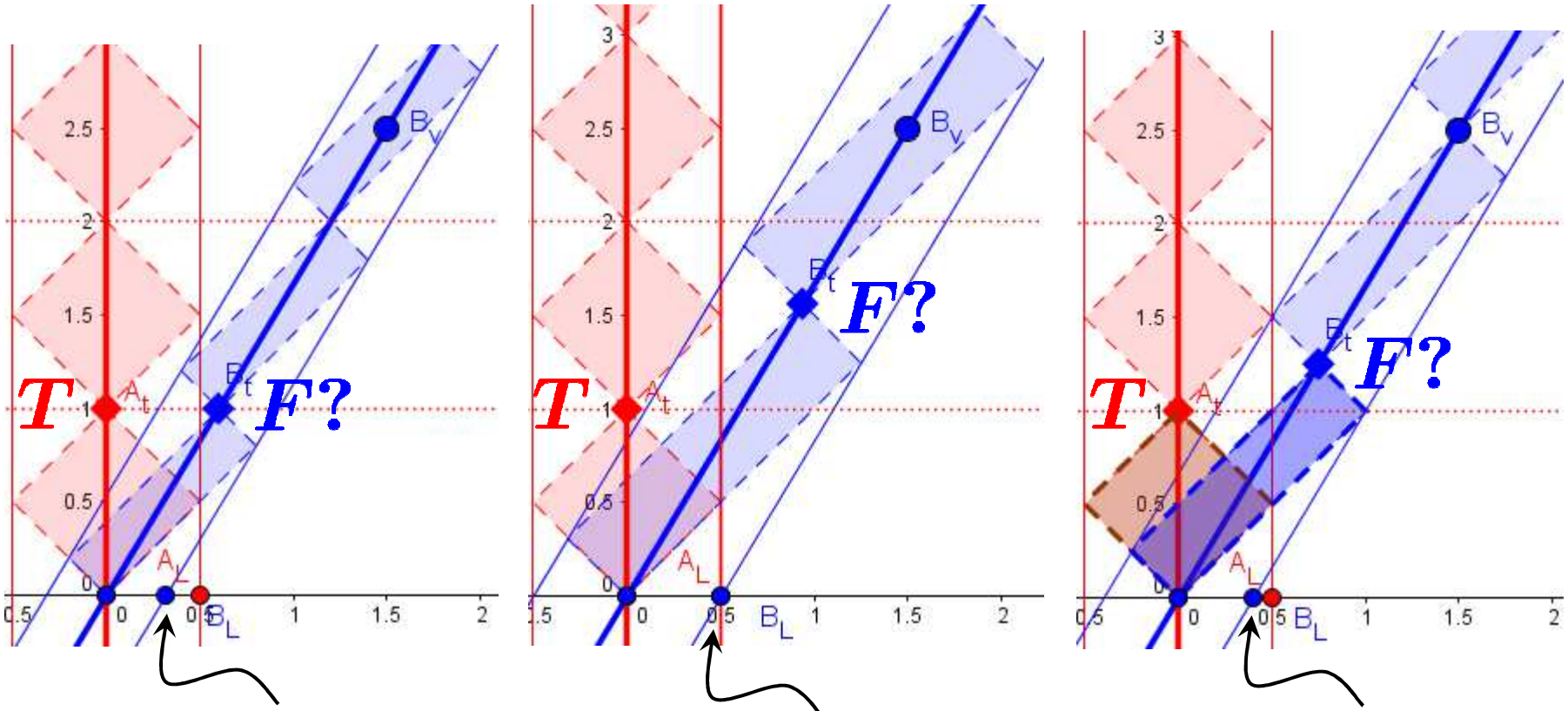



Alice's **light-clock** and light signals reflecting off her distant mirrors a length *d* away (in her frame)




Alice's light-**clock diamonds**

# How do we draw Bob's Light Clock?



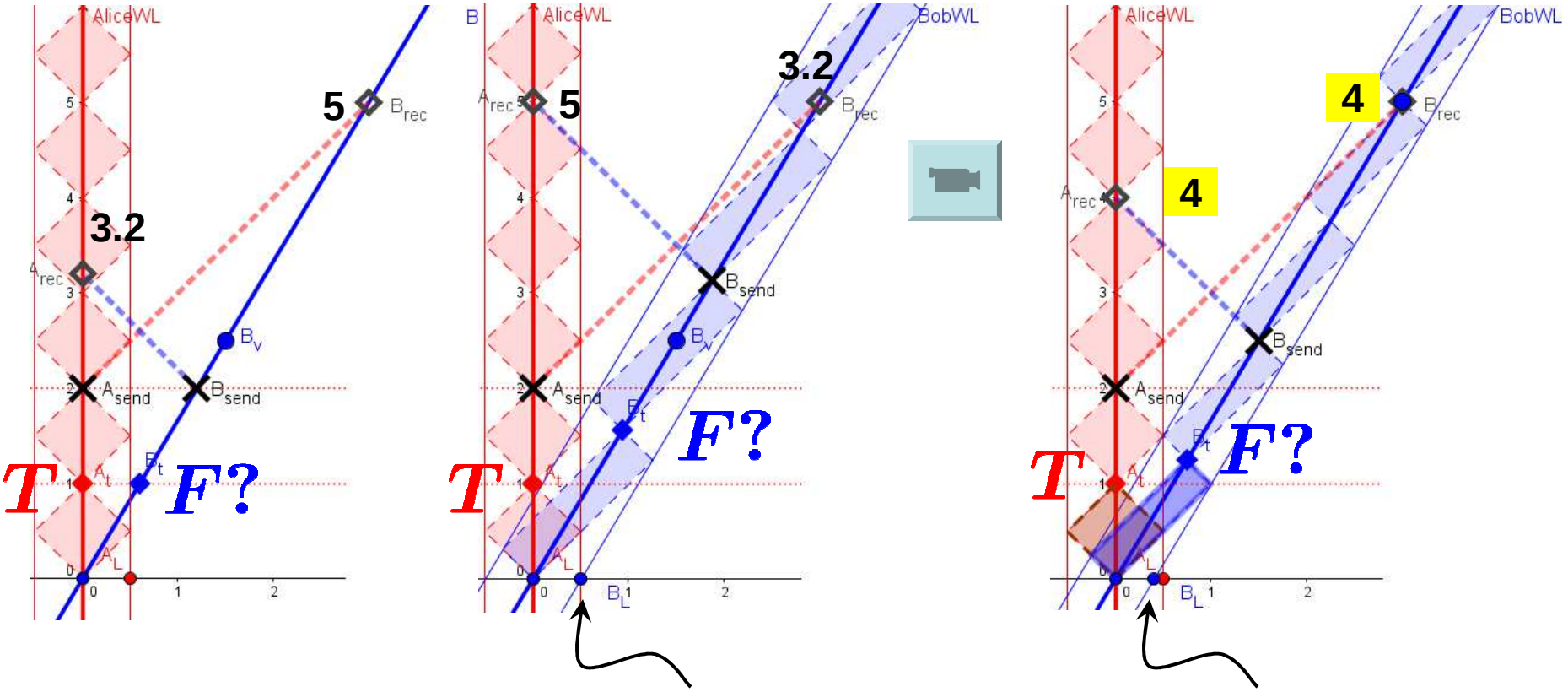

Calibrating Bob's Light-Clock….

Where is Bob's first tick event $F?$

*(What is the separation of Bob's mirrors?)*

**Clock diamonds have equal areas!!**

# How do we draw Bob's Light Clock?



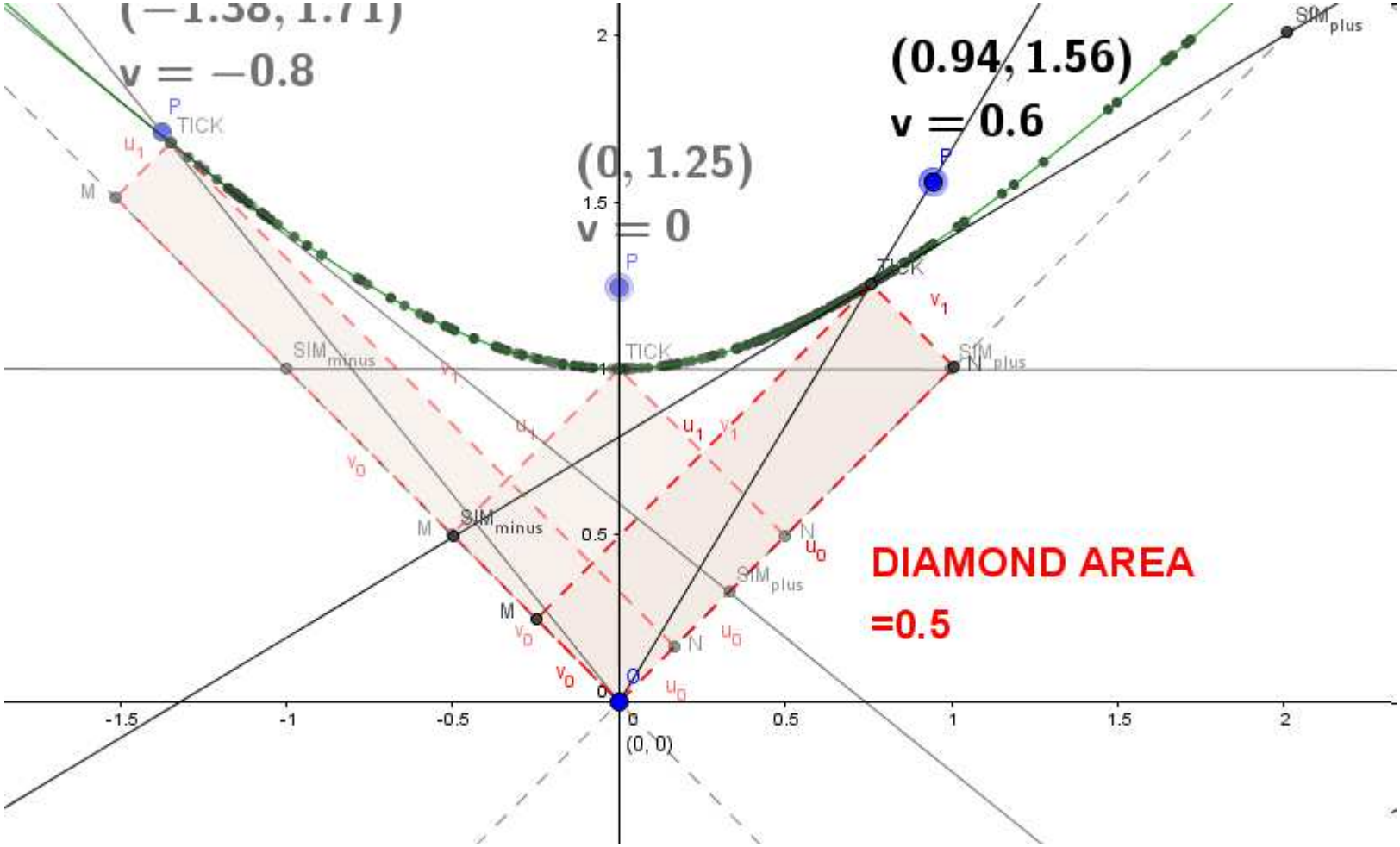

Calibrating Bob's Light-Clock….

***No experiment can detect the inertial observer's state of motion.***

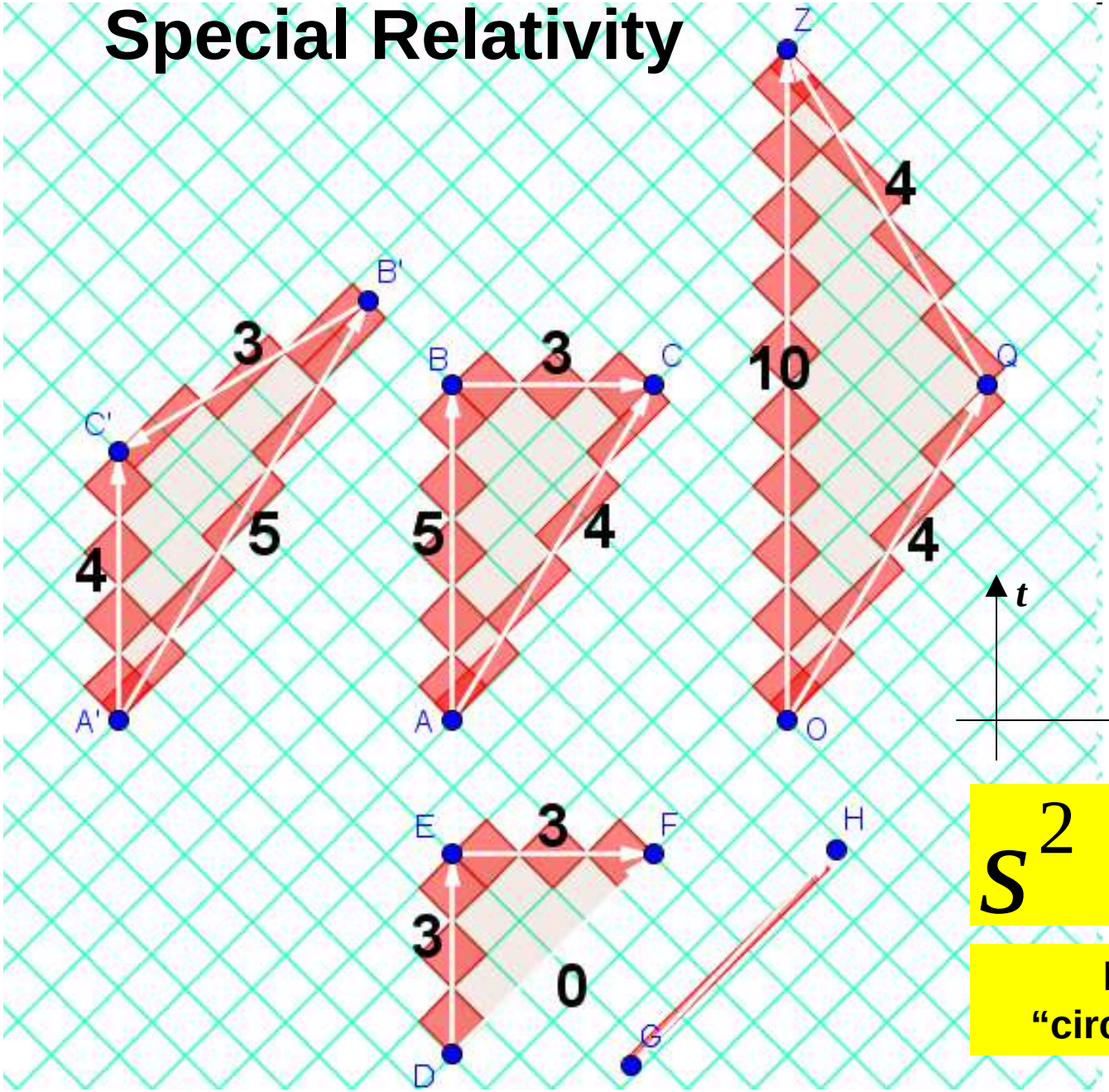
**Identical experiments should result in identical results**

**Clock diamonds have equal areas!!**

# Clock diamonds have equal areas!!



# Some triangles in Special Relativity




$$s^2 = t^2 - x^2$$

**hyperbola as the "circle in this geometry"**

Ordinary Graph Paper rotated
can be used in a simple way to
allow **visual calculations in**
**Special Relativity**
by counting “ticks”.

**Rob Salgado**
Physics Department
U.Wisconsin-La Crosse
**rsalgado@uwlax.edu**

**“Relativity on rotated graph paper”**
**Am J Phys 84, 344 (May 2016)**

**geogebra.org/robphy**