Seven Principles for Teaching Relativity to Nonscientists

Notes for a talk at the Tampa APS meeting

April 16, 2005

I. Redefine the foot.

1 ordinary foot (ft) = 0.3048 m

1 relativity foot (f) = 0.299792458 m

(c = 1 f/ns)

(alternatively, 1 phoot = 1 f)

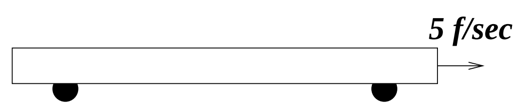
II. Practice viewing simple nonrelativistic collisions from different frames of reference before applying this methodology to counterintuitive relativistic cases.

Question:

	Before	**After**
Known		
Unknown	***10 f/sec***	?

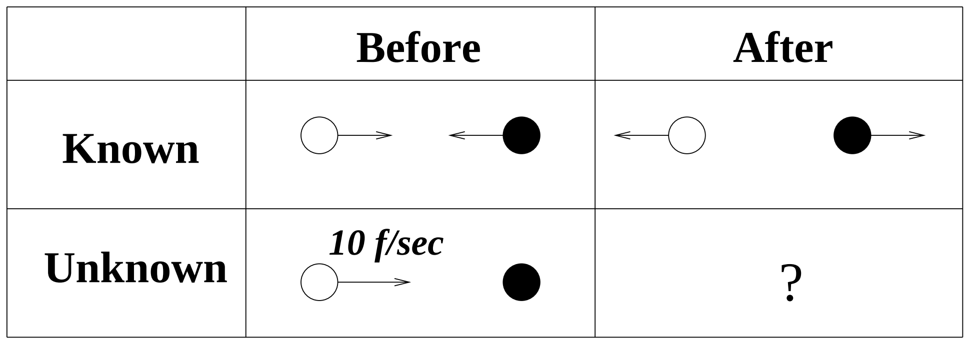
Answer:

	Before	**After**
Station:	***10 f/sec***	?

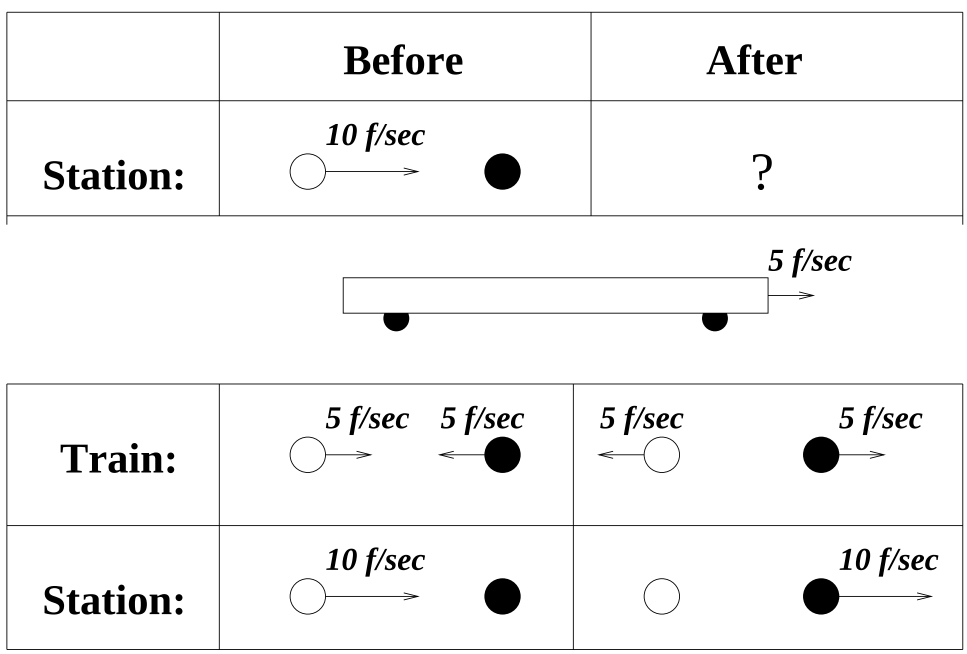


Train:	***5 f/sec*** ***5 f/sec***	
Station:	***10 f/sec***	***5 f/sec***

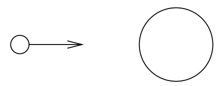
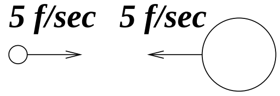
Question:



Answer:

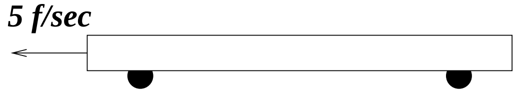


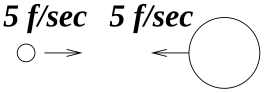
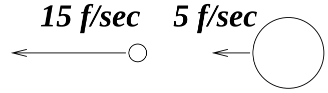
Question:

	Before	After
Known		
Unknown		?

Answer:

	Before	After
Station:		?



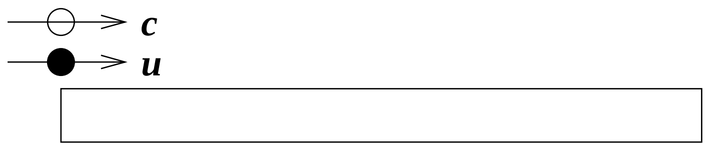
Train:		
Station:		

III. Immediately introduce relativistic parallel velocity addition law

$w \approx u + v$ only when u, v much less than c.

But for any u and v,

$$\frac{c - w}{c + w} = \left(\frac{c - u}{c + u}\right)\left(\frac{c - v}{c + v}\right)$$



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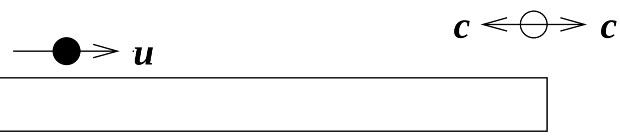

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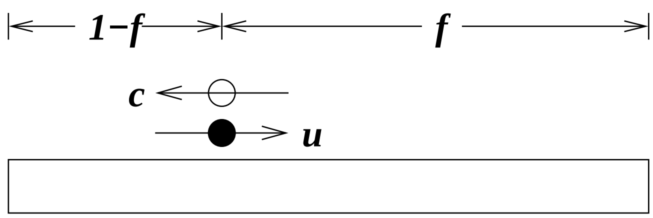
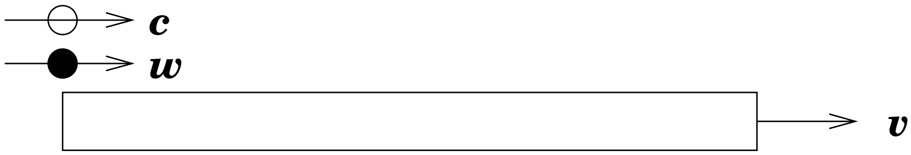


(3)

$$\frac{u}{c} = \frac{1-f}{1+f}$$

$$f = \frac{c-u}{c+u}$$



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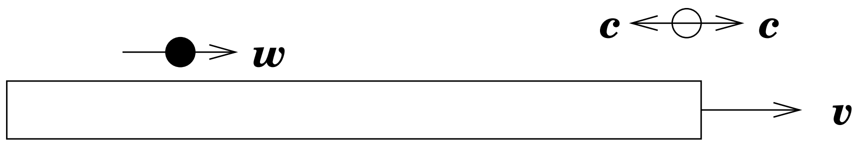

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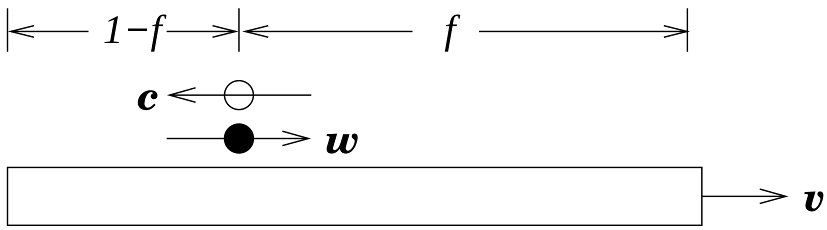


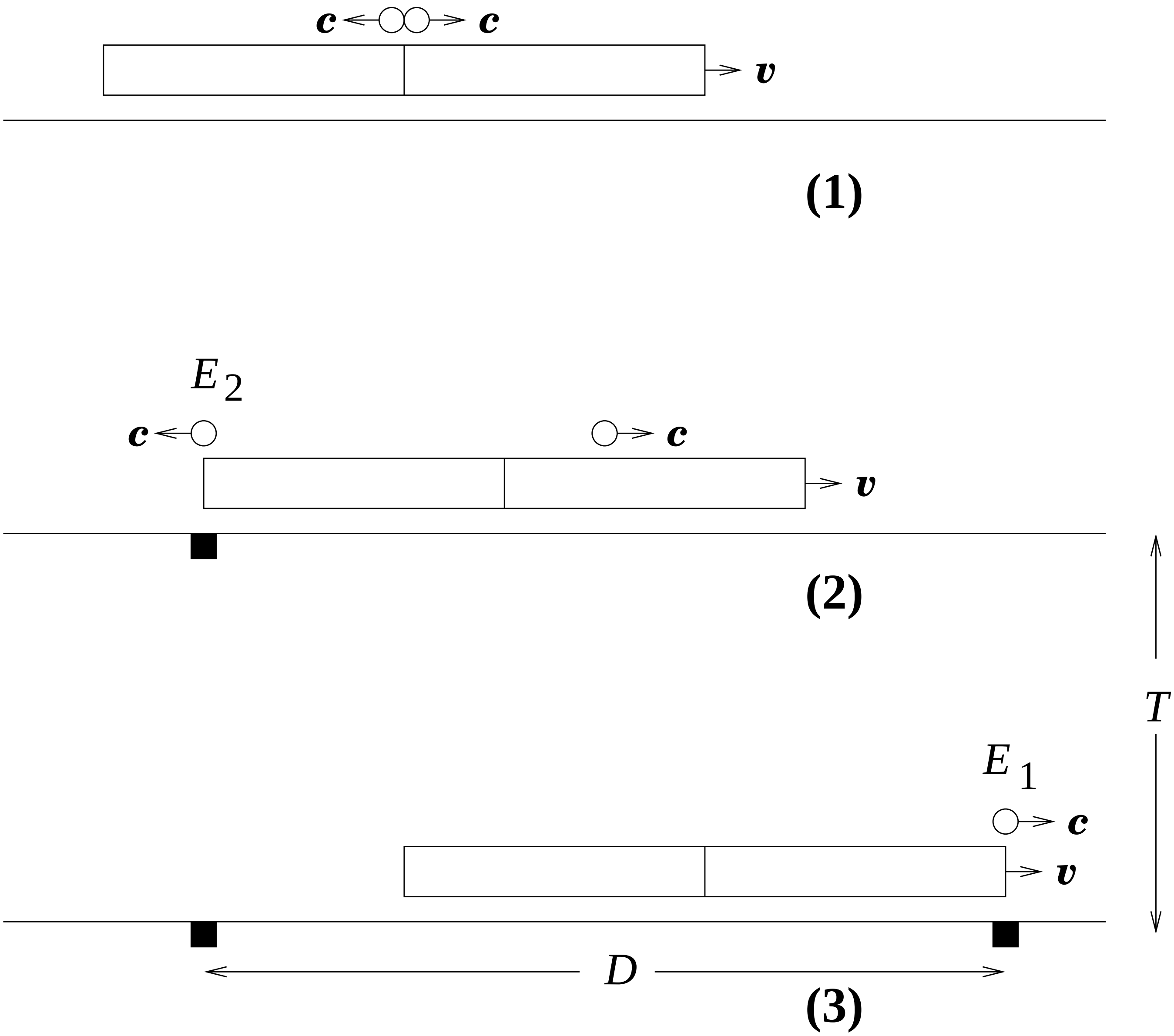
(3)

$$f = \left(\frac{c+v}{c-v}\right)\left(\frac{c-w}{c+w}\right)$$

IV. Immediately introduce quantitative relativity of simultaneity, comparing it with quantitative relativity of simullocation.

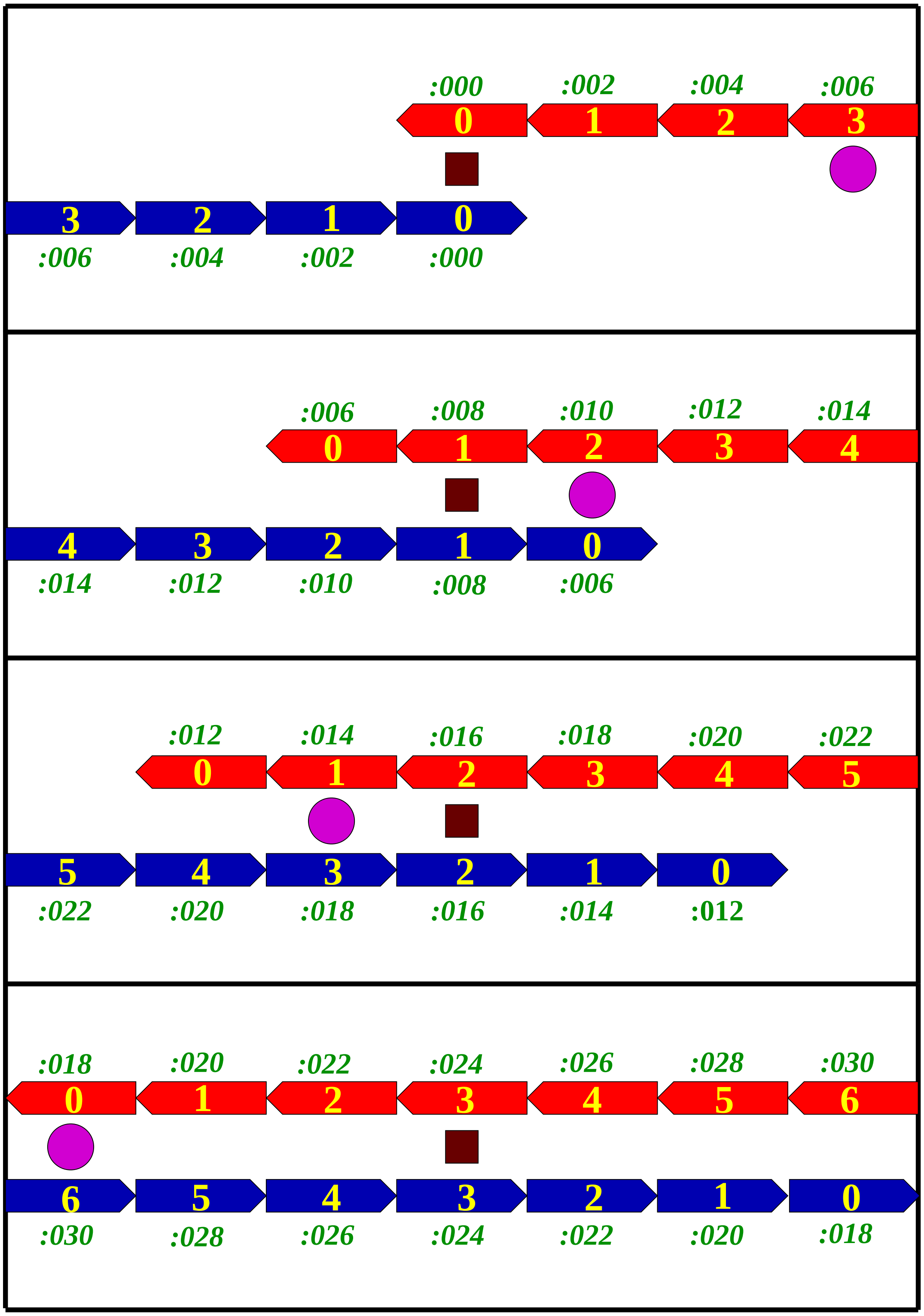
If two events are at the same *place* in the train frame,
then in the track frame the *distance* between them (in *f*)
is v times the *time* between them (in *ns)*,
where v is the track frame speed of the train in f/ns.

If two events are at the same *moment* on the train frame,
then in the track frame the *time* between them (in *ns*)
is v times the *distance* between them (in *f*),
where v is the track frame speed of the train in f/ns.



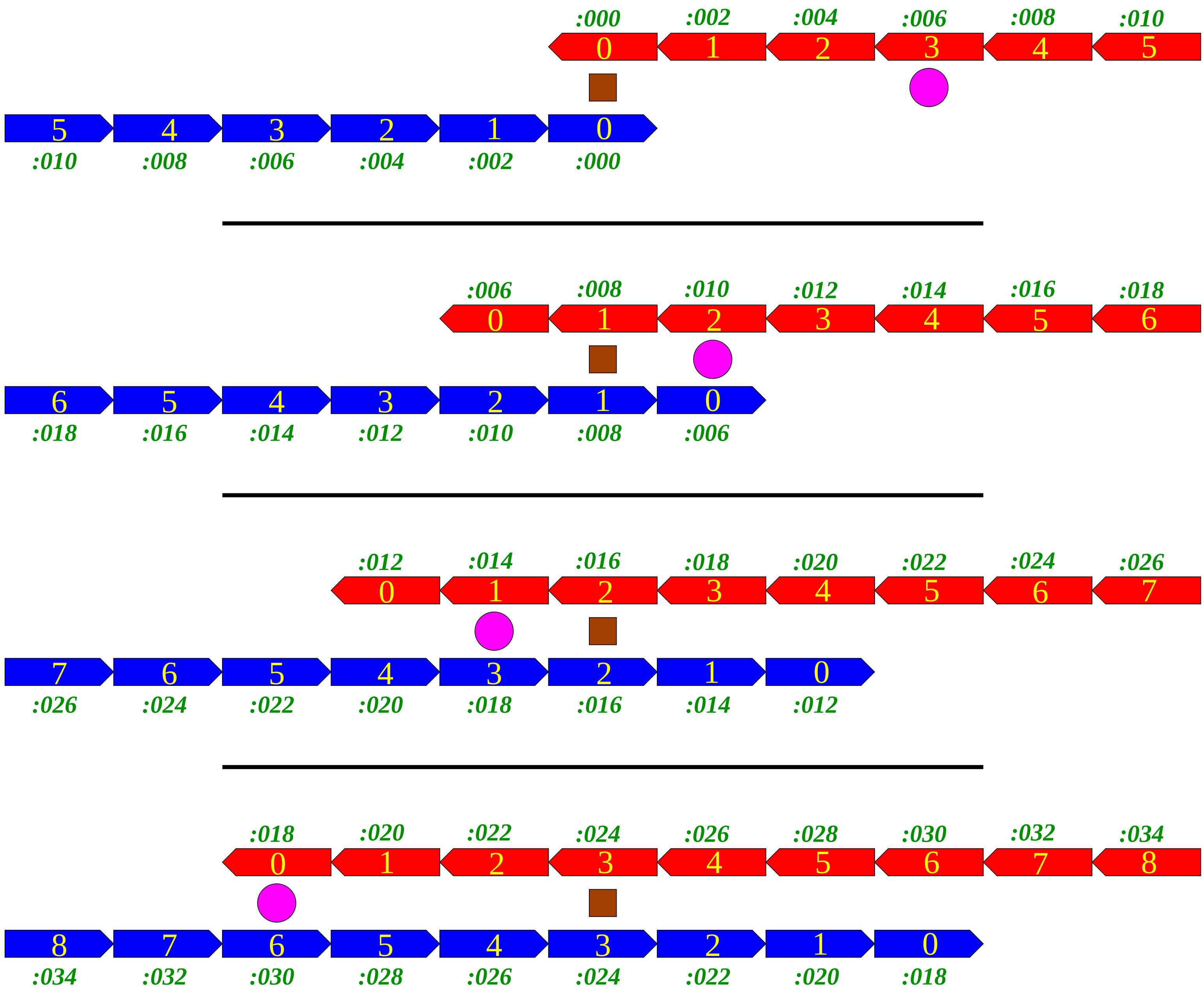
$$T = \frac{vD}{c^2}$$

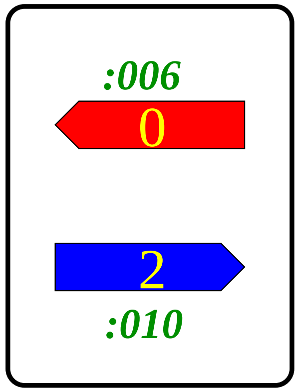
V. Give numerical illustrations.



The Amazing Many-Colored Relativity Engine

(Am. J. Phys. **56**, 600-611 (1988))

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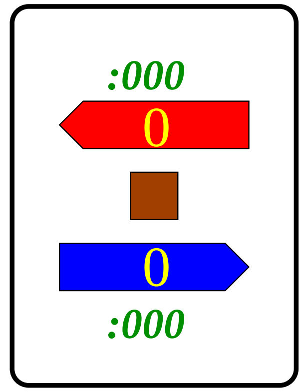
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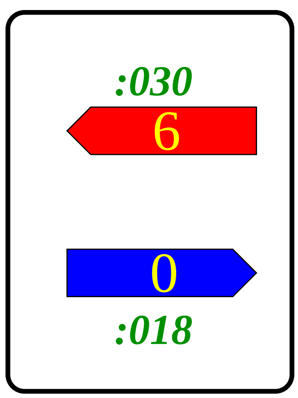
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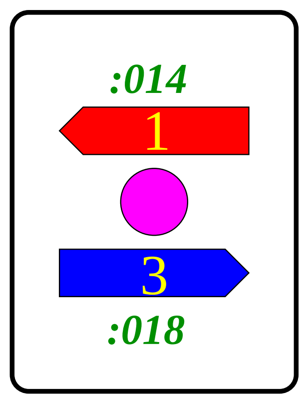
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VI. Teach Minkowski diagrams, starting from Einstein's two postulates, as an exercise in spacetime cartography.

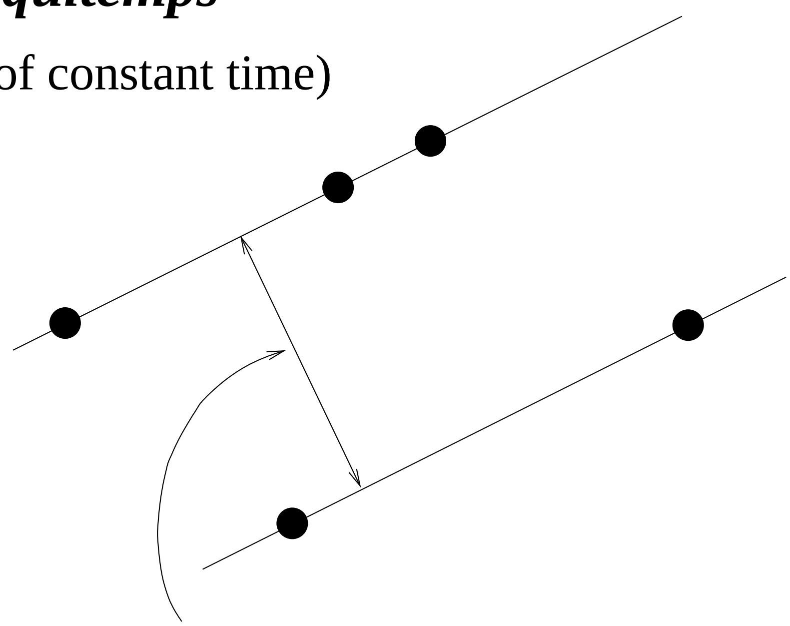
Alice organizes events in her diagram (by time):

Simultaneous events lie on same straight line

● = an event

Equitemps

(lines of constant time)

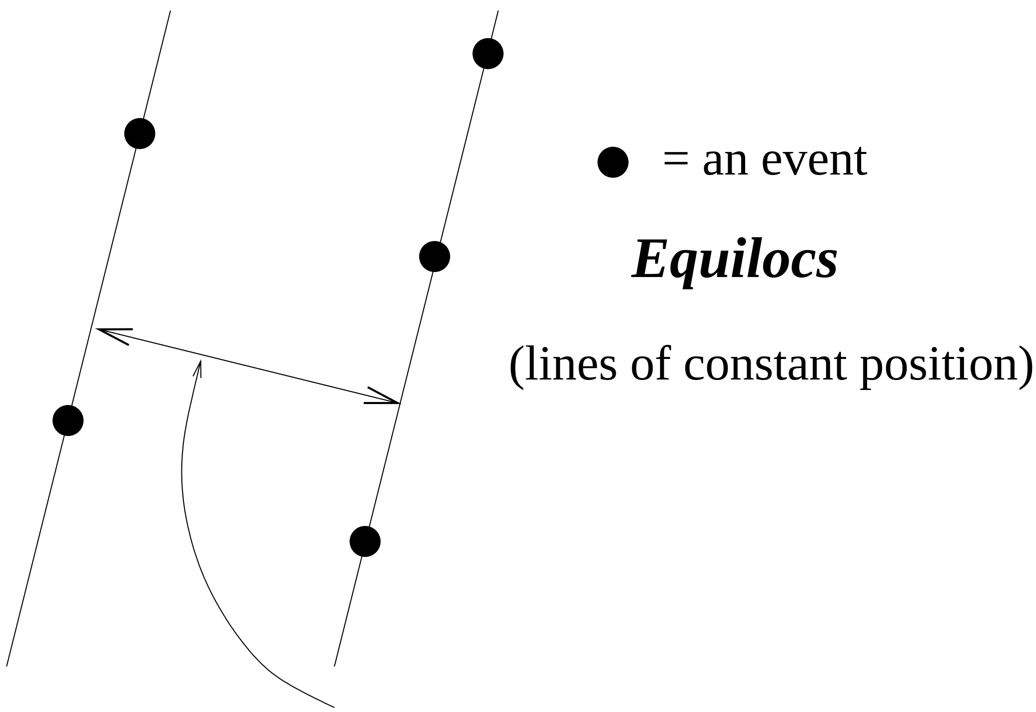


Distance between equitemps pro−
portional to time between events

Equitemps must be parallel.

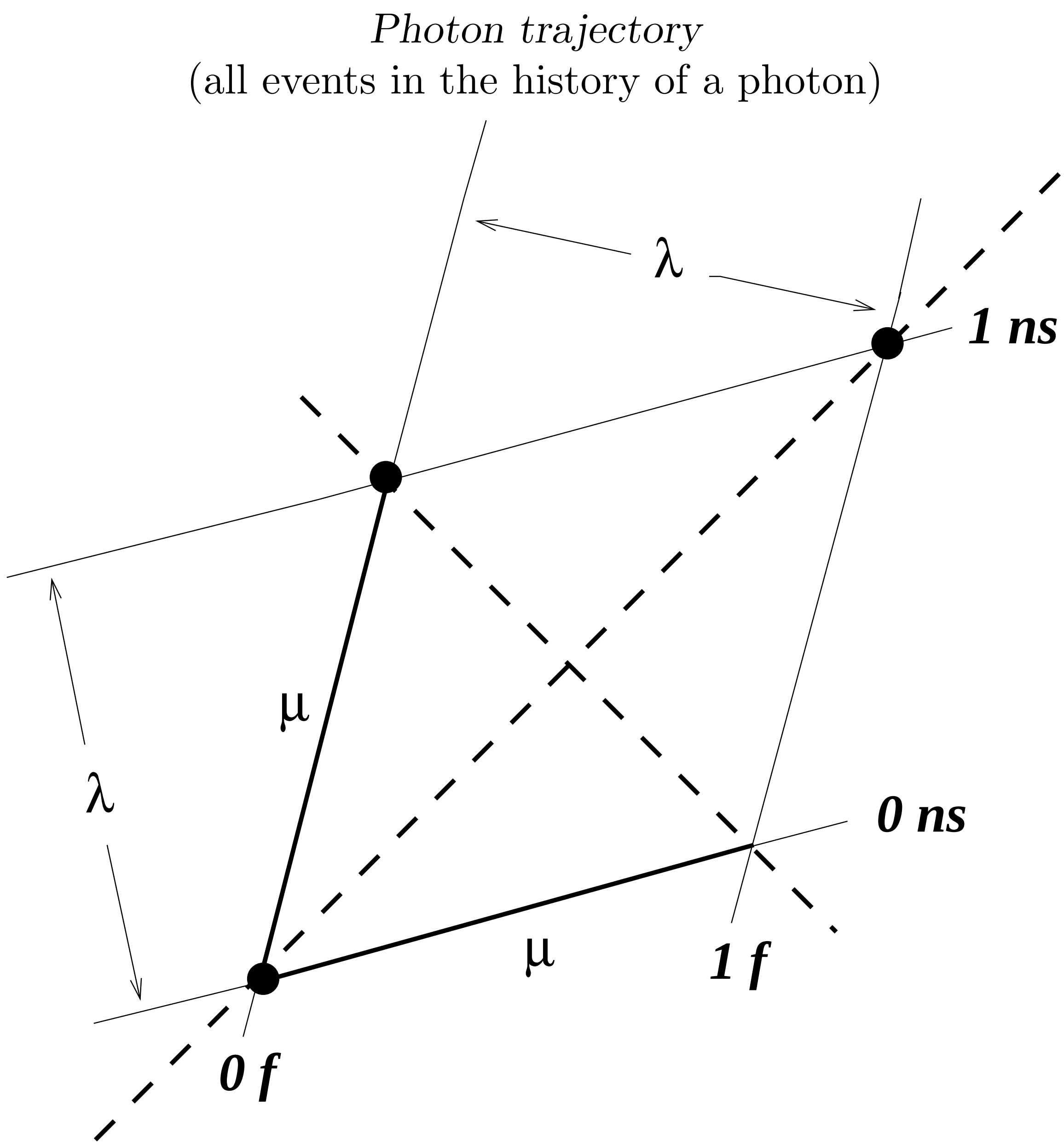
Alice organizes events in her diagram (by location):

Events in same place lie on same straight line



Distance between equilocs proportional to real space distance between events

Equilocs must be parallel.

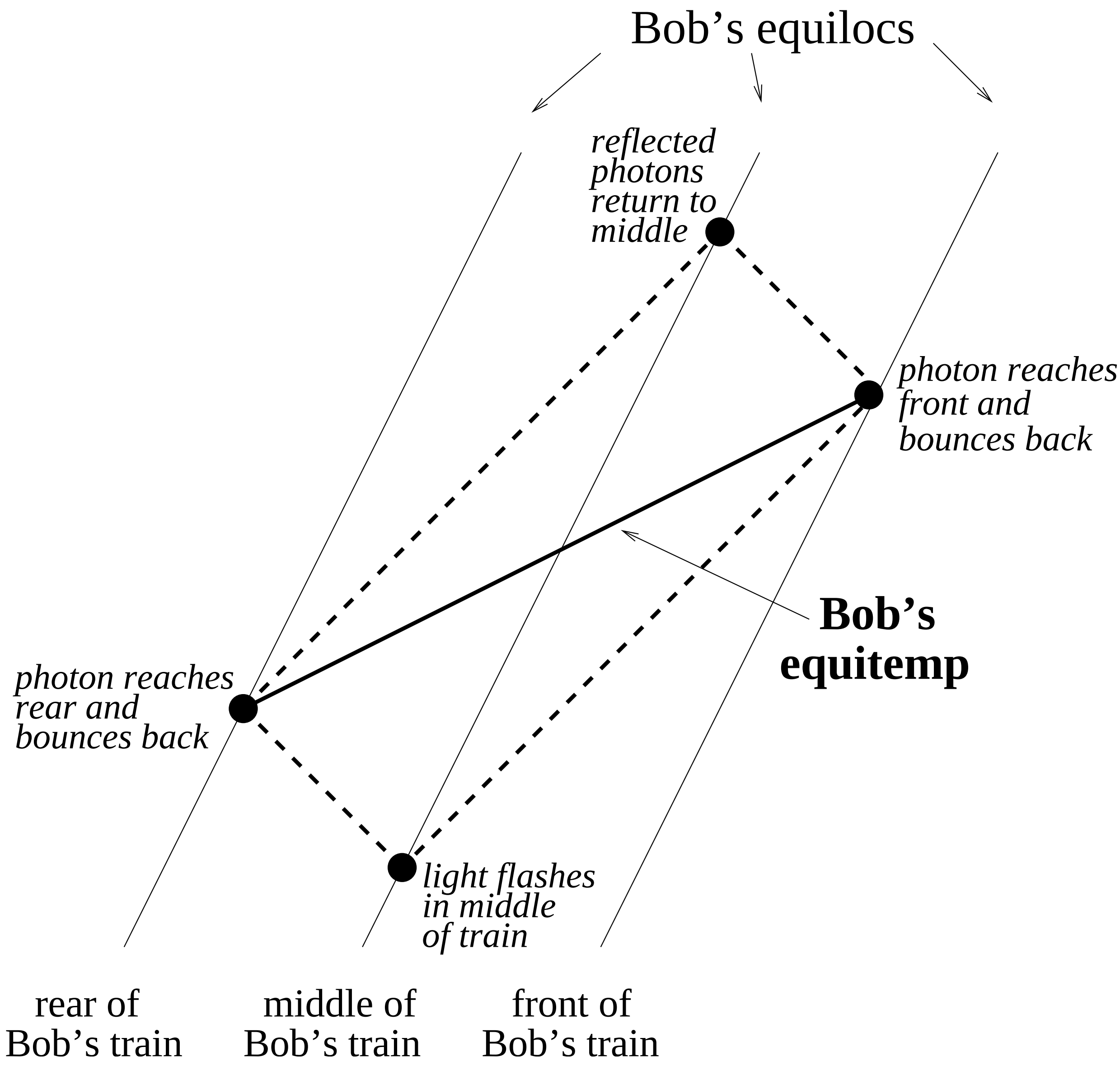


Alice's equitemps and equilocs make same angle with photon trajectories.

Trajectories of oppositely moving photons are perpendicular.

First Gedanken Experiment (Einstein's Train)

Orienting Bob's equitemps in Alice's diagram, by using the invariance of the speed of light:



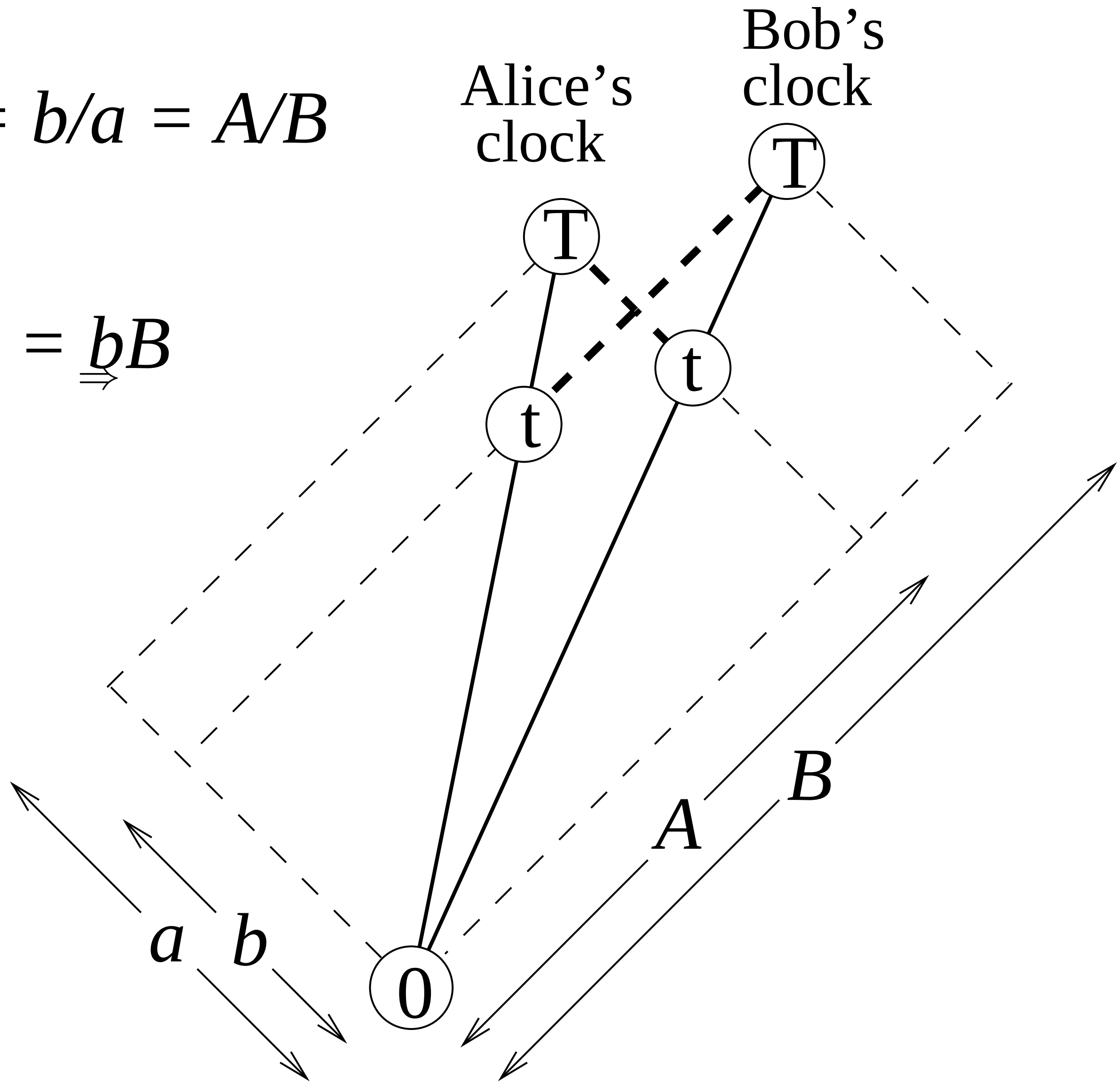
Conclusion: *Bob's equitemps make same angle with photon trajectories as his equilocs.*

Second Gedanken Experiment (Doppler Effect)

Determining relation between Alice's and Bob's scale factors using the principle of relativity

$$t/T = b/a = A/B$$

$$aA = bB \Rightarrow$$



Light rectangles have the same area.

VII. Lorentz transformations of spacetime coordinates have no more relevance than rotations of Cartesian coordinates have in a course on Euclidean geometry.

(Lorentz transformations of energy and momentum are another matter.)

Summary

I. Redefine the foot.

II. View nonrelativistic collisions from different frames.

III. Immediately introduce relativistic velocity addition law.

IV. Immediately introduce relativity of simultaneity.

V. Give numerical illustrations.

VI. Minkowski diagrams, direct from Einstein's postulates.

VII. Don't bother with the spacetime Lorentz transformation.

For details see *It's About Time*
Princeton University Press
September, 2005.