Math 308-101
Term Project
Kevin Greene
88159017

Student Info.

The Terrell Rotation

The following presentation attempts to show what objects look like when traveling at velocities near or at the speed of light.

The ideas presented in this work come directly from an article by Victor Weisskopf, entitled 'The Visual Appearance of Rapidly Moving Objects.' The article was located in a collection of works by this author and was copywrited in 1972.

The pages that follow were meant solely as a visual aid to the ideas put forth by James Terrel, and described by Weisskopf. At no point does this programer lay claim to all of the ideas that lie herein.

It is important to understand that the objects in this work subtend a very small angle when viewed by the observer. As well, only one 'eye' is used to view the object, as binocular vision would lead to distortion. Other effects, like Doppler shift or varient intensity, have been ignored.

What objects look like when traveling at high speeds is rather unintuitive. So first, a few basics:

Part One:
Convex Objects

When viewing an object, your eyes detect the individual photons leaving its surfaces and edges. Notice that some parts of the object can not be seen by an observer, because any photon leaving these areas will collide with the object again. These 'hidden' parts include the rear and side faces of the cube below. Photons from the front face are free to travel towards the observer.

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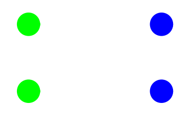

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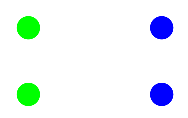

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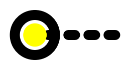
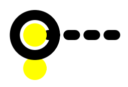


But if the cube starts to travel perpendicular to the observer, an interesting effect occurs. Since the object is moving, photons launched when the yellow corner was at the circled point, travel towards the observer without recolliding with the object.



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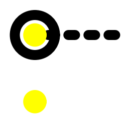

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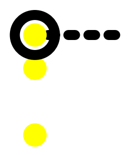

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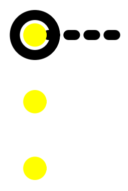

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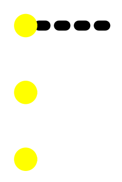
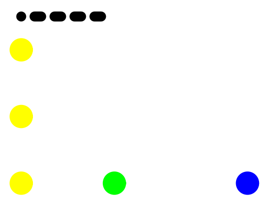


Recall that photons hit your eyes in ’fronts’ or ’waves.’ Since the yellow photon was launched earlier, it takes time for it to catch up to the photons leaving the front face of the cube.



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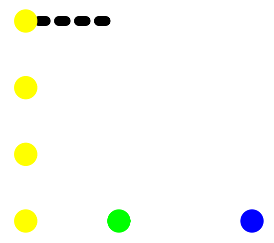

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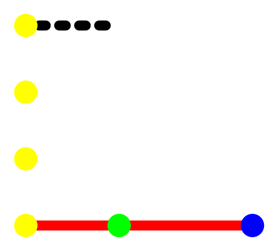
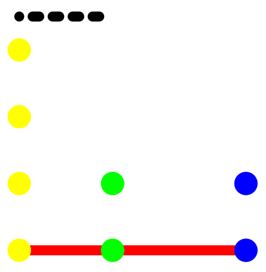


At this point, the photons can travel together so as to hit your eyes at the same time.



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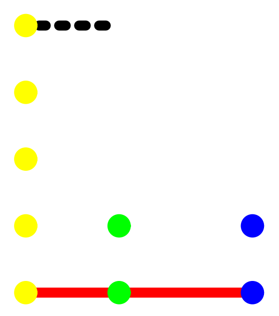

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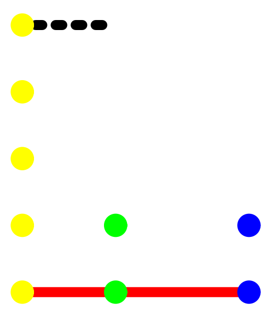
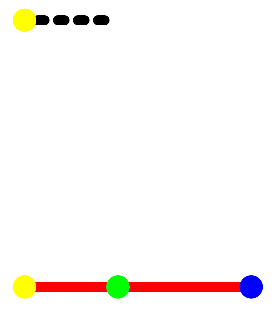
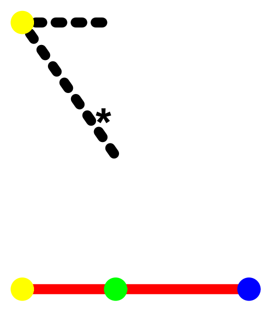


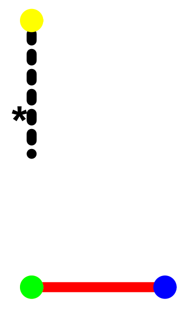
The wave front seen by the observer, when the object is traveling at a high rate of speed, is the lower image seen here. Note that the effects due to relativity have not yet been factored in.



The amount of the ’hidden’ face that is seen by the observer depends on the speed of the object.



Or in other words, the size of the angle * drawn here depends on the speed the object is traveling at.



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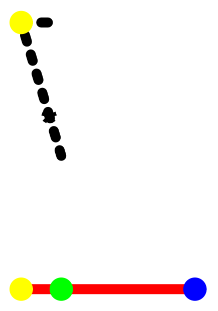

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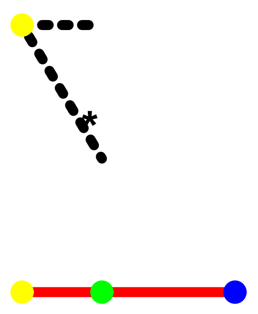

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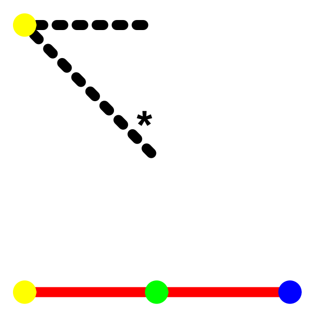

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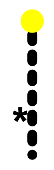
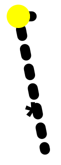
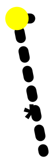


The effect of adding these two ideas together, wave fronts and relativity, can be seen below. On the left is the original wave front theory. On the right, the Lorentz contraction is factored in. Watch as the speed of the object increases until it eventually hits the speed of light.





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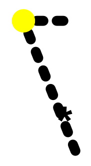

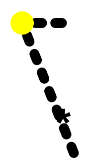

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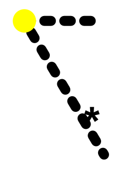

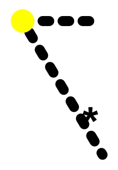

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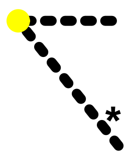

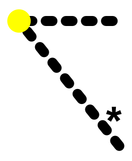

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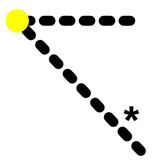

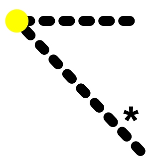

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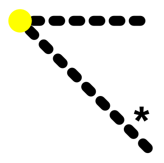

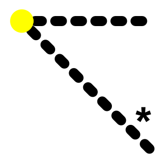

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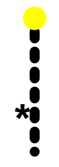
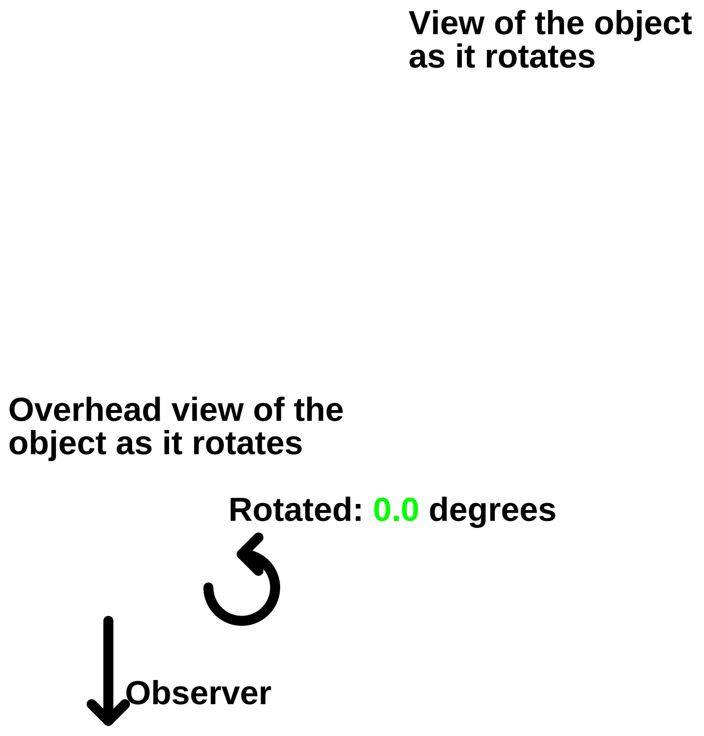
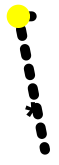
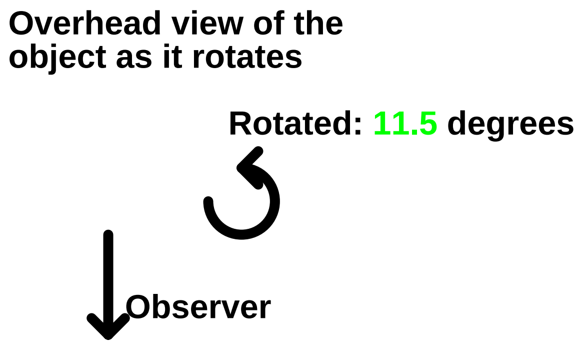




Another way of producing the combined effect of wave fronts and relativity is to rotate the object as a whole. This method replaces the earlier one of shearing one edge and contracting the other. On the right is the relative view, and on the left is a rotated picture of the object. Watch how well the images match each other as the speed increases.



View of the object
as it rotates



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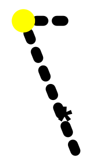
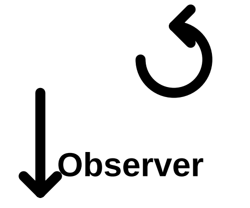


View of the object
as it rotates

Overhead view of the
object as it rotates



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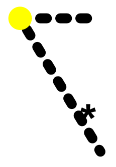

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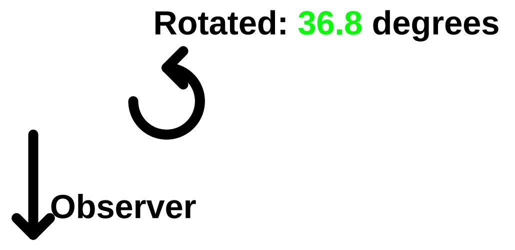

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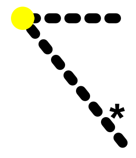

View of the object
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Overhead view of the
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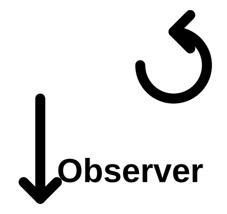

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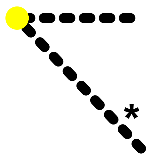
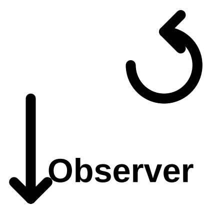


View of the object
as it rotates

Overhead view of the
object as it rotates

Rotated: 71.8 degrees



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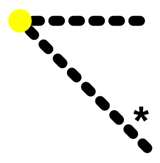

View of the object
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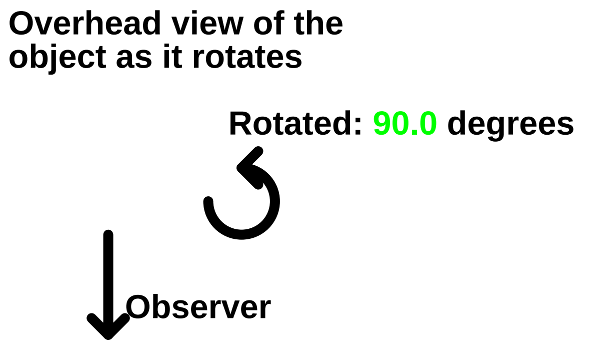

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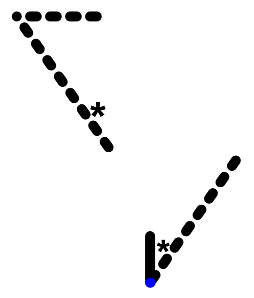
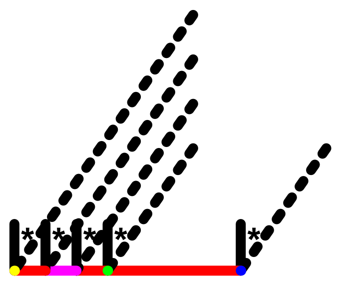
Part Two:

Concave Objects

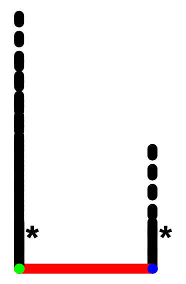
The previous section dealt with the effects on convex objects traveling at high speeds. Our considerations can be expanded to include concave objects like the one below.



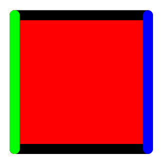
One method is to use the angle * from Part One, but place it underneath, oriented on the other side of the observer vector.



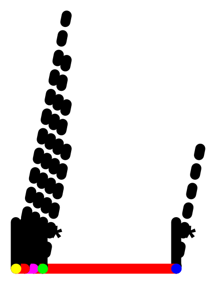
This angle is used to trace out the image of the object seen by the observer.



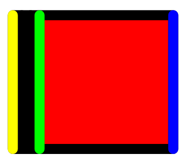
Non-relative view of object
when it is moving



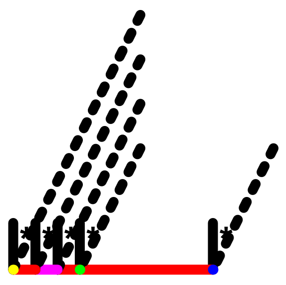
Watch how without relativity, only part of the magenta face can be seen, even as the speed of the object increases.

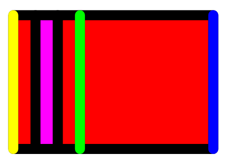


Non-relative view of object
when it is moving



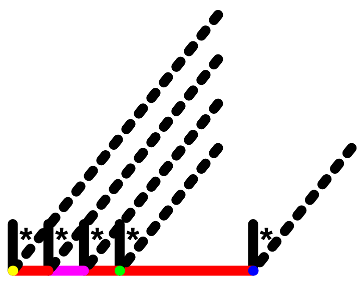
Watch how without relativity, only part of the magenta face can be seen, even as the speed of the object increases.



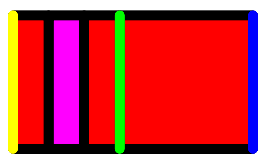


Non-relative view of object
when it is moving

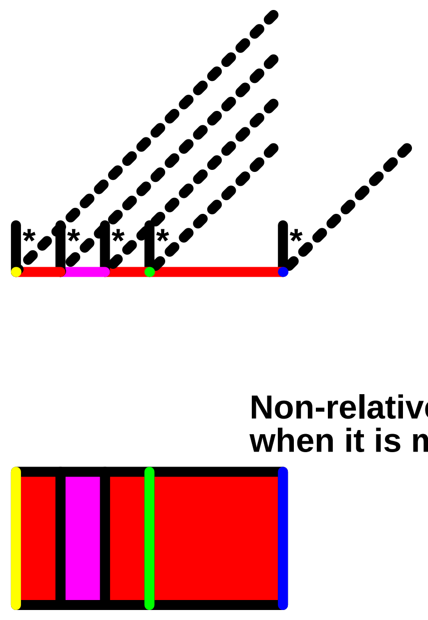
Watch how without relativity, only part of the magenta face can be seen, even as the speed of the object increases.



Non-relative view of object when it is moving

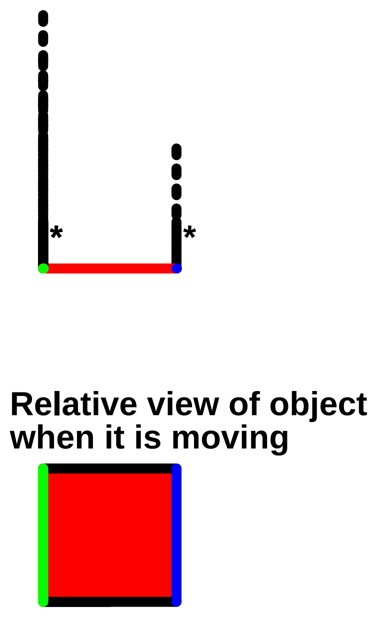


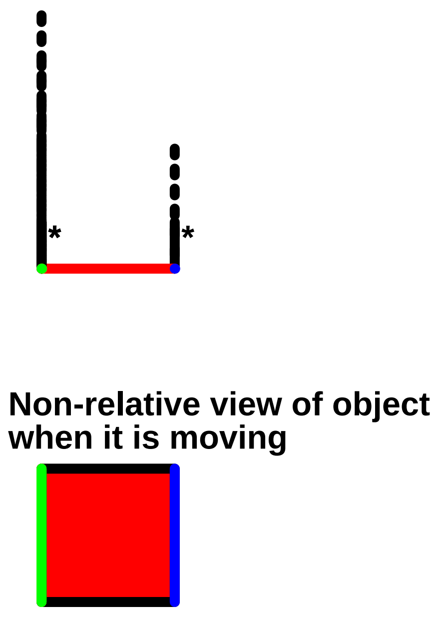
Watch how without relativity, only part of the magenta face can be seen, even as the speed of the object increases.



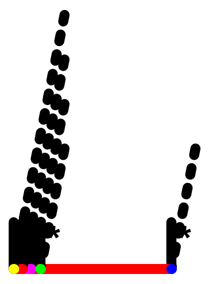
Non-relative view of object
when it is moving

Watch how without relativity, only part of the magenta face can be seen, even as the speed of the object increases.

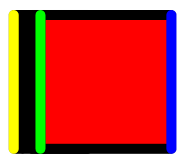


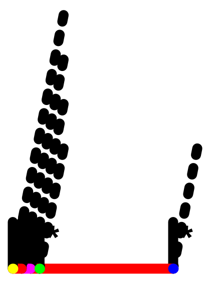


After adding in relativity, the angle * can show us the true image seen by the observer. Watch how at the speed of light, it is the cyan face that is in view on the right, while on the left only the magenta face is visible.

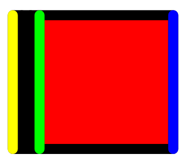


Relative view of object
when it is moving

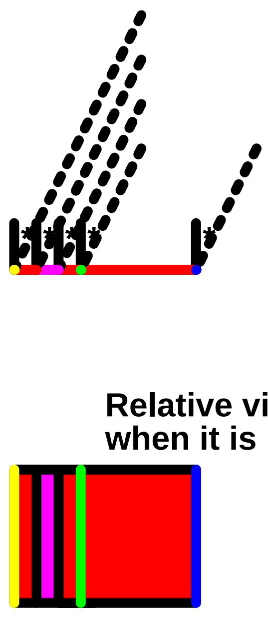




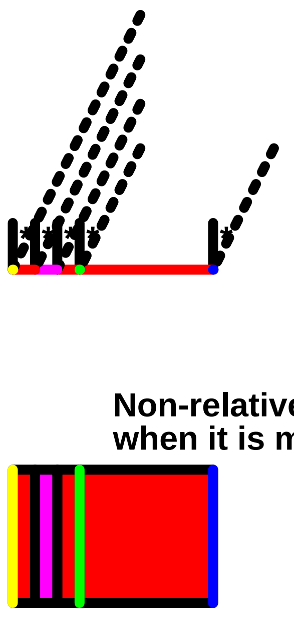
Non-relative view of object
when it is moving



After adding in relativity, the angle * can show us the true image seen by the observer. Watch how at the speed of light, it is the cyan face that is in view on the right, while on the left only the magenta face is visible.

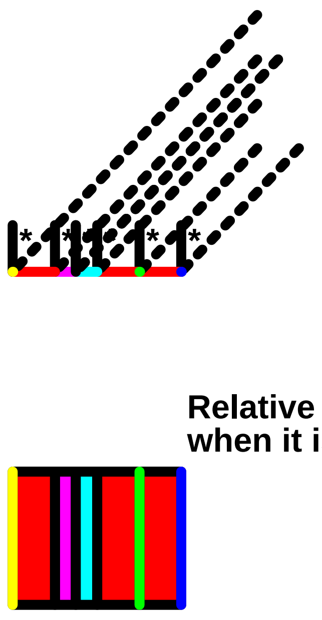


Relative view of object
when it is moving

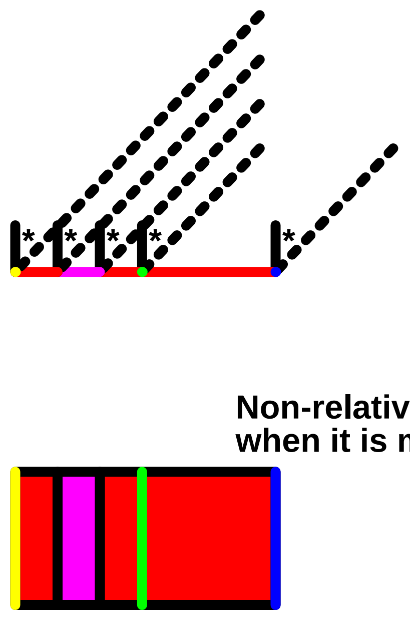


Non-relative view of object
when it is moving

After adding in relativity, the angle * can show us the true image seen by the observer. Watch how at the speed of light, it is the cyan face that is in view on the right, while on the left only the magenta face is visible.

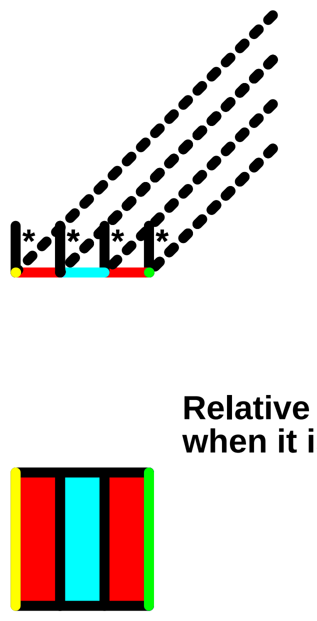


Relative view of object
when it is moving

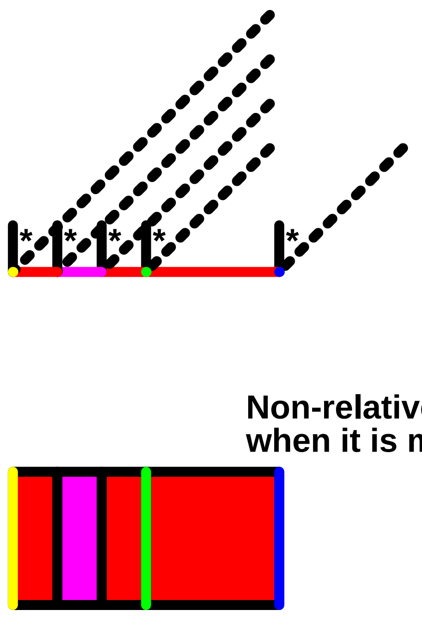


Non-relative view of object
when it is moving

After adding in relativity, the angle * can show us the true image seen by the observer. Watch how at the speed of light, it is the cyan face that is in view on the right, while on the left only the magenta face is visible.



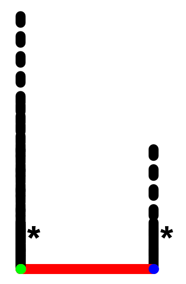
Relative view of object
when it is moving



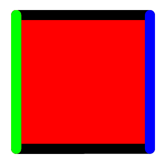
Non-relative view of object
when it is moving

After adding in relativity, the angle * can show us the true image seen by the observer. Watch how at the speed of light, it is the cyan face that is in view on the right, while on the left only the magenta face is visible.

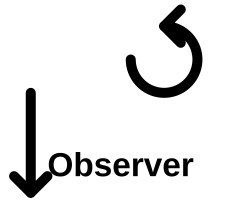
View of th
as it rotate



Relative view of object
when it is moving

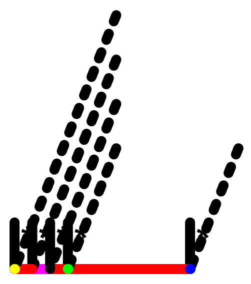


Overhead view of the
object as it rotates

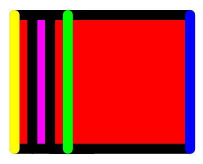


As in the first section, this is the same picture produced by rotating the object. On the right is the relative image, while the on the left is the rotated image of the object.

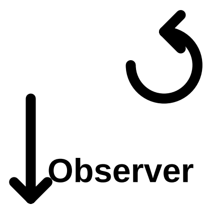
View of the
as it rotate



Relative view of object
when it is moving

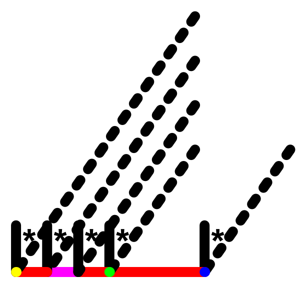


Overhead view of the
object as it rotates

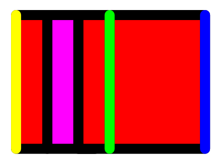


As in the first section, this is the same picture produced by rotating the object by the same amount. On the right is the relative image, while the on the left is the rotated image of the object.

View of the
as it rotate

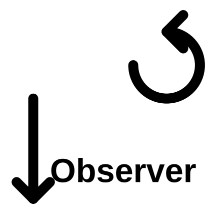


Relative view of object
when it is moving



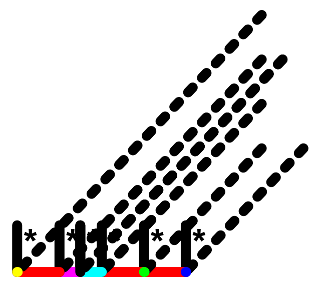
Overhead view of the
object as it rotates

Rotated: 44.4 degrees

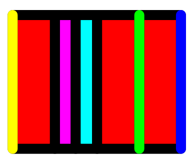


As in the first section, this is the same picture produced by rotating the object by the same amount. On the right is the relative image, while the on the left is the rotated image of the object.

View of the
as it rotate

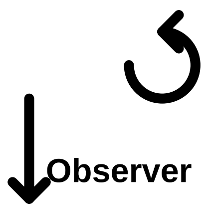


Relative view of object
when it is moving



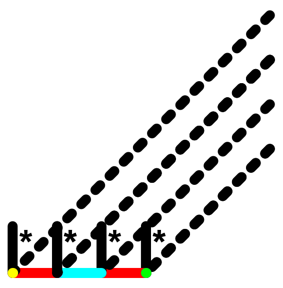
Overhead view of the
object as it rotates

Rotated: 71.8 degrees

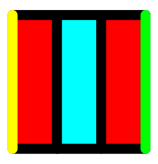


As in the first section, this is the same picture produced by rotating the object by the same amount. On the right is the relative image, while the on the left is the rotated image of the object.

View of the
as it rotate

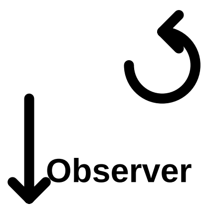


Relative view of object
when it is moving



Overhead view of the
object as it rotates

Rotated: 90.0 degrees



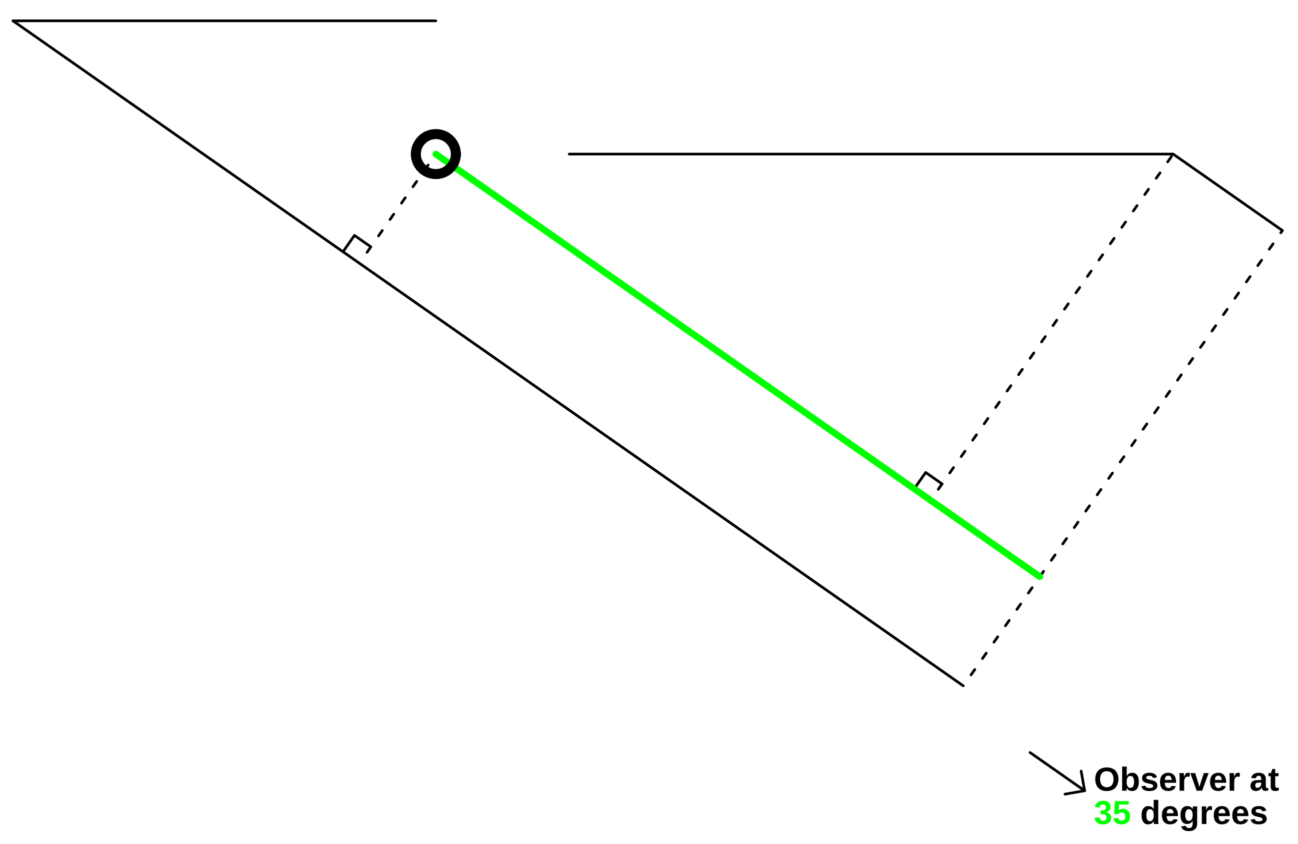
As in the first section, this is the same picture produced by rotating the object by the same amount. On the right is the relative image, while the on the left is the rotated image of the object.

Part Three:

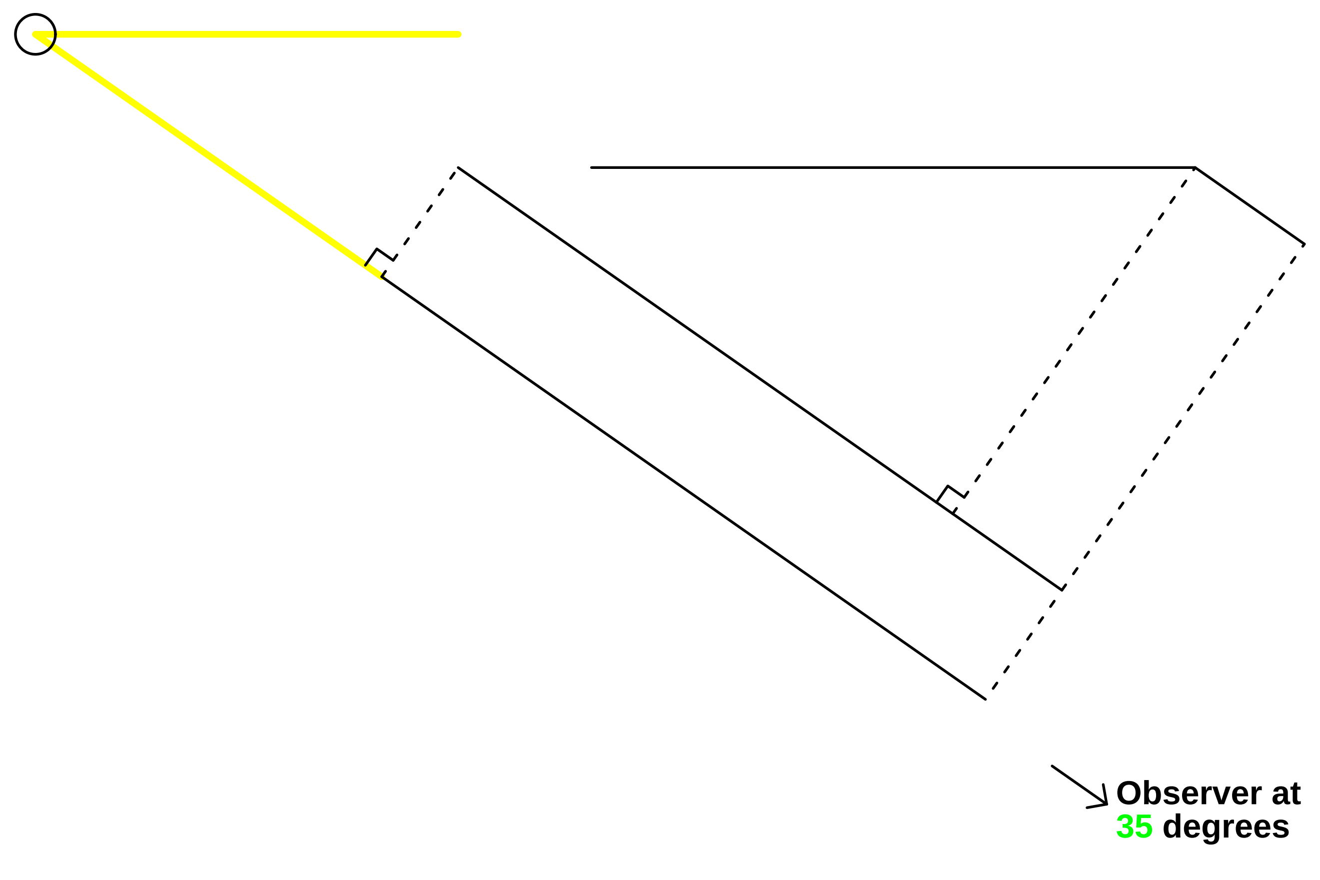
Alternate Angles at the Speed of Light

This section will explain what occurs when the observer is not positioned 90 degrees to the velocity. In order to reduce the complexity of the following diagram, we will consider only the special case when the velocity of our object equals the speed of light. The forth section will demonstrate the effects of other speeds.

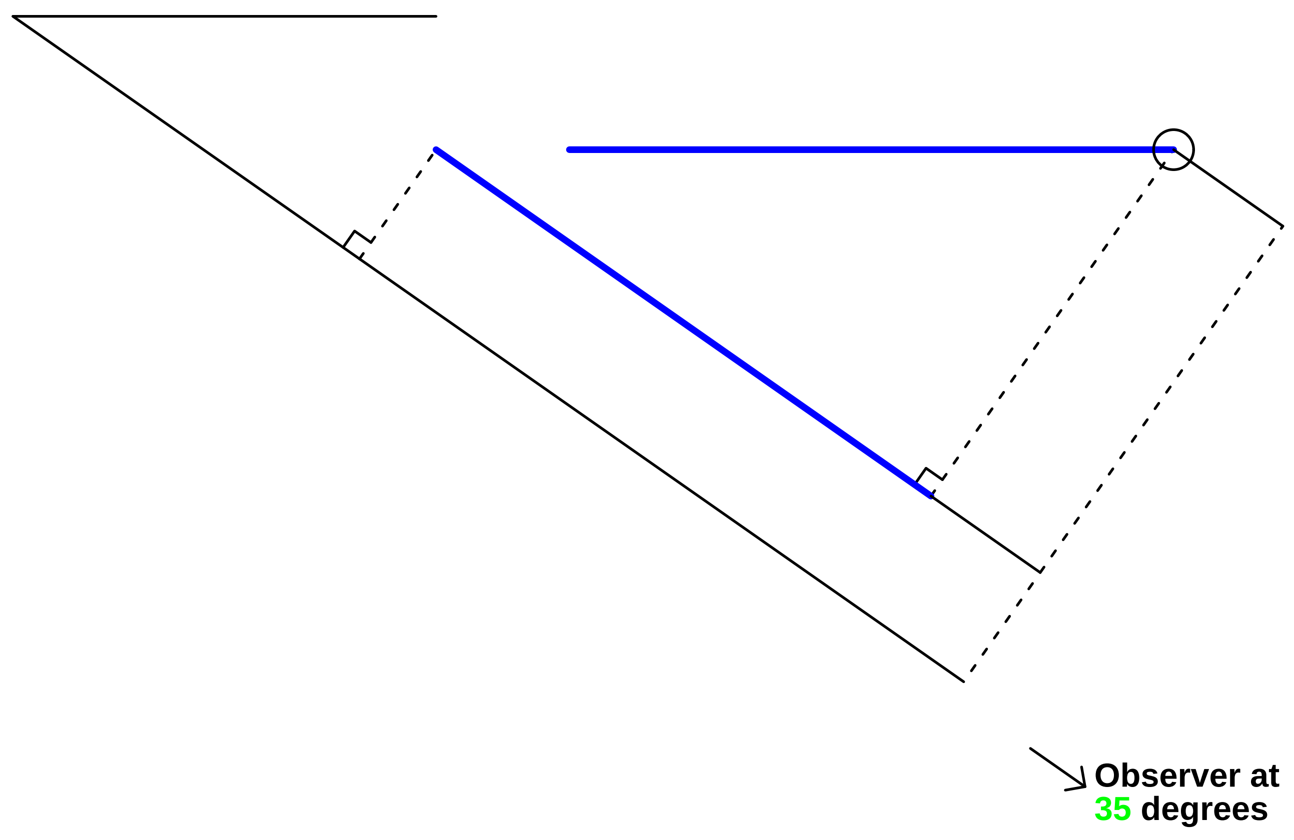
The diagram below was formed exactly when a photon left the green corner (circled) to travel towards the observer. Here, the Lorentz contraction has not been factored in.



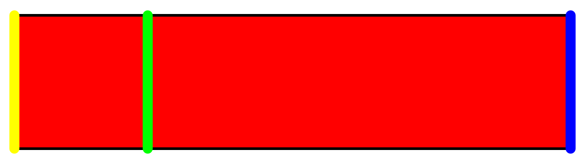
In order to reach the observer at the same time as the green photon, a photon from the yellow corner had to have been launched earlier, as indicated on the diagram. This point is found by the equality of the two highlighted lines.

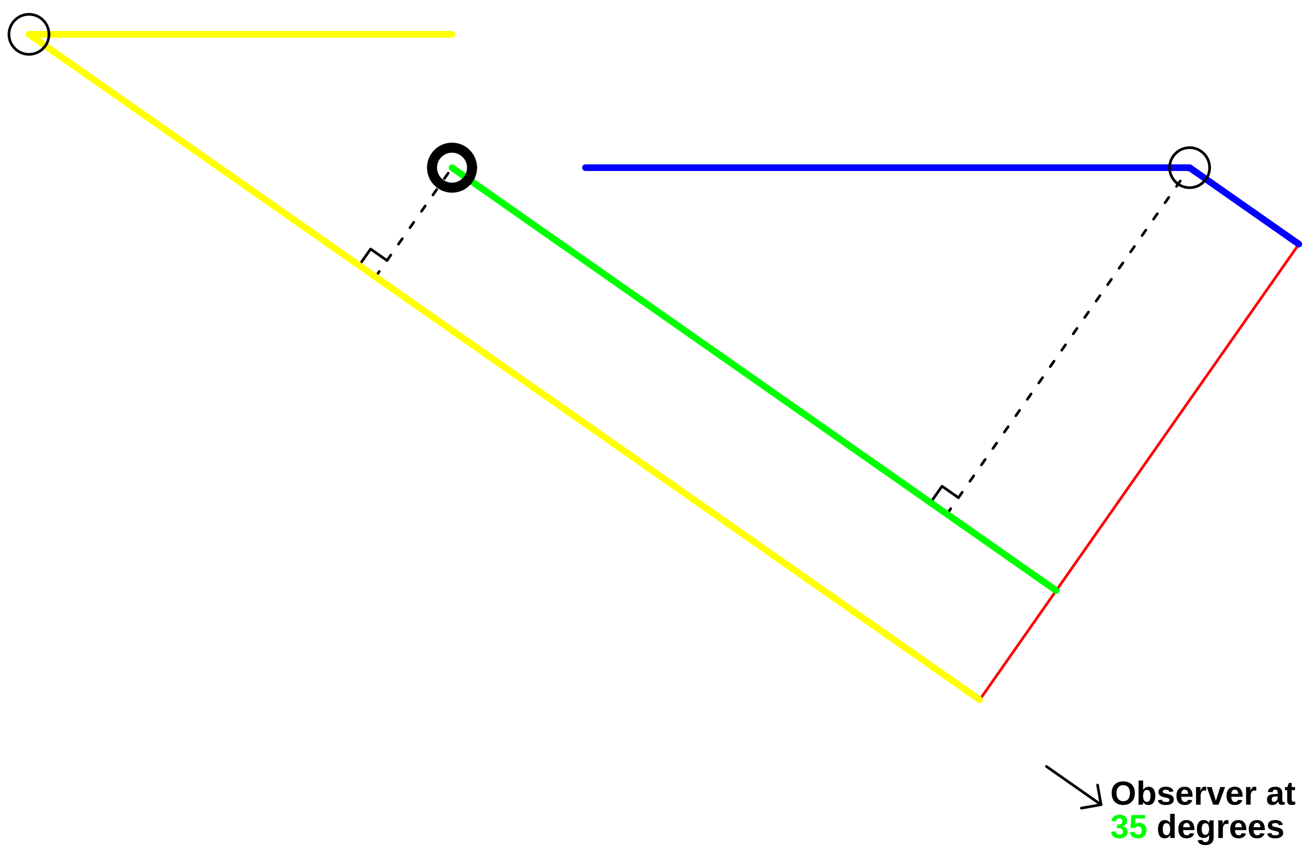


Meanwhile, a photon from the blue corner has to be launched later. Again, this point is found by the equality of these distances.



Photons launched at these three different times give the observer this view. Note how as the observer moves to 90 degrees, the side opposite the velocity always projects a square.





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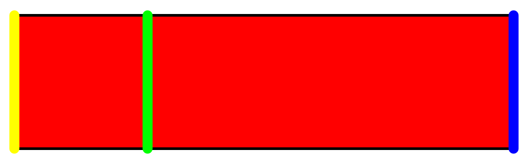
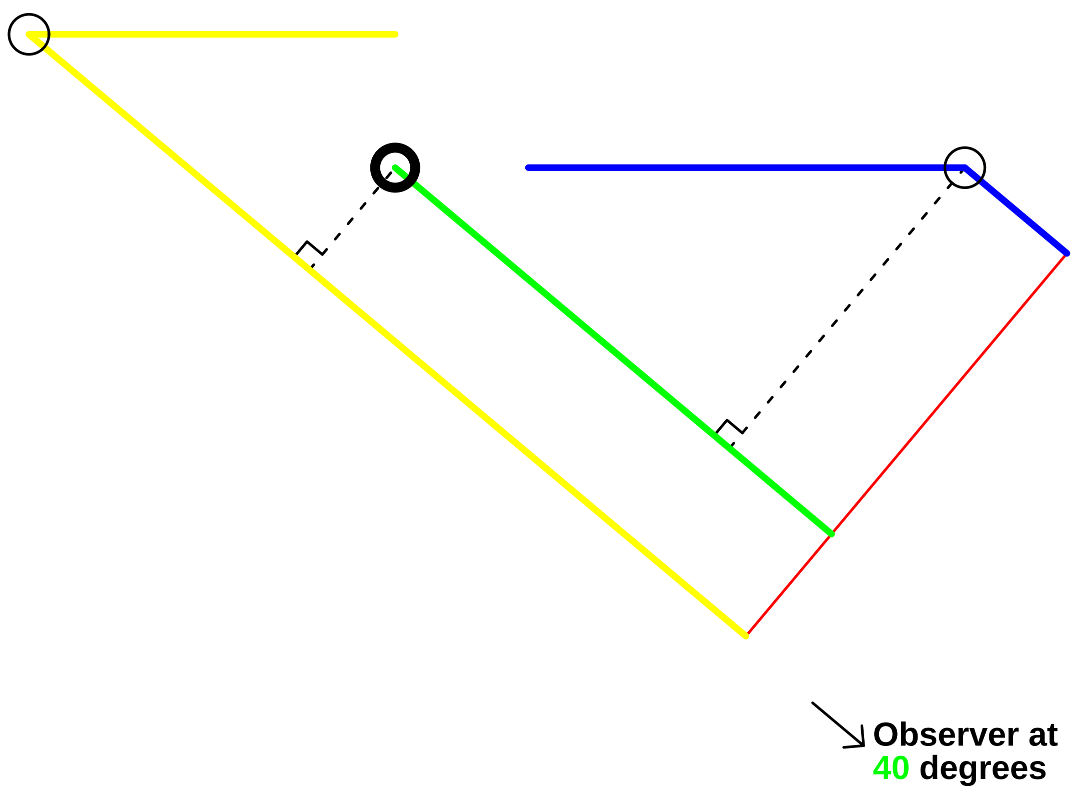
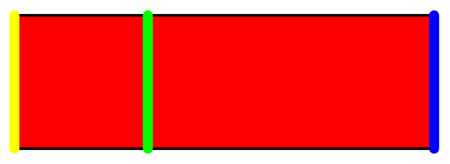
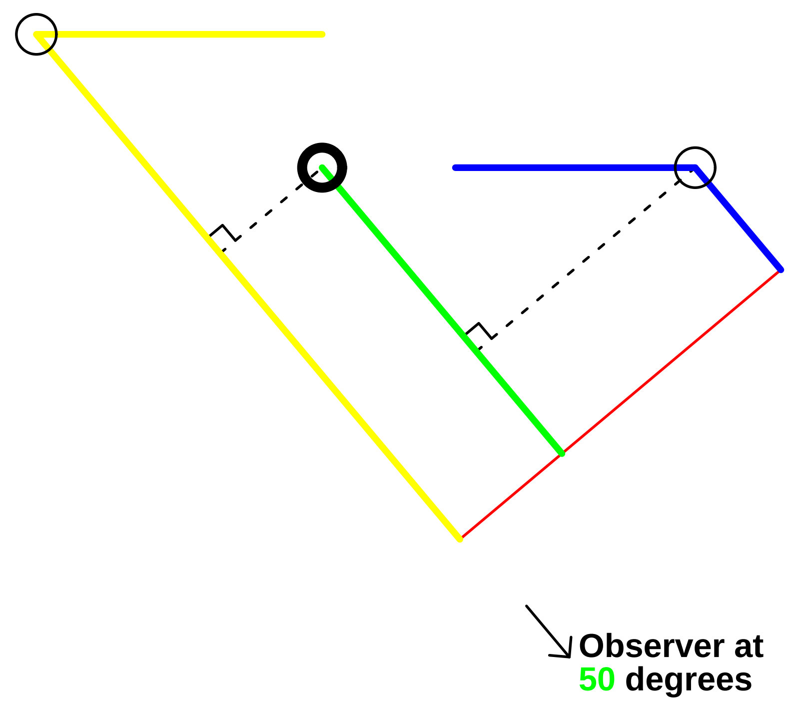
Photons launched at these three different times give the observer this view. Note how as the observer moves to 90 degrees, the side opposite the velocity always projects a square.



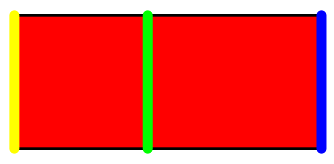


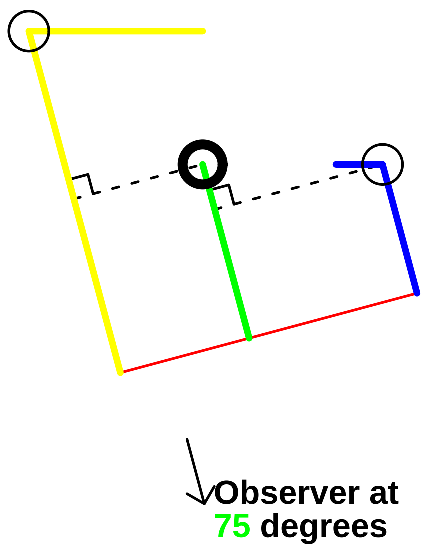
Photons launched at these three different times give the observer this view. Note how as the observer moves to 90 degrees, the side opposite the velocity always projects a square.





Photons launched at these three different times give the observer this view. Note how as the observer moves to 90 degrees, the side opposite the velocity always projects a square.





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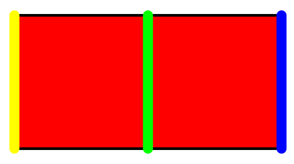
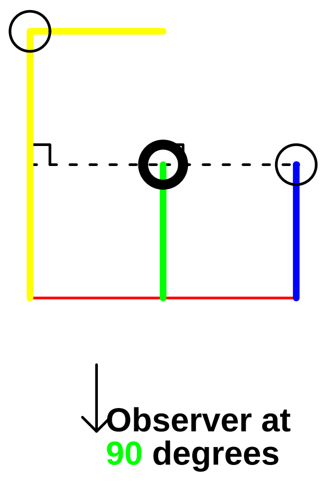
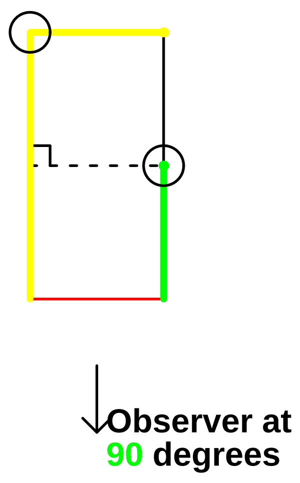
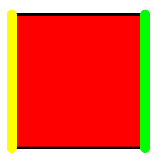




Once relativity is factored in, we need not consider the projection of any length in the direction of motion. This is because those lengths go to zero once the object reaches the speed of light. So at all times, no matter what non-zero angle the observer is at, he or she will only see the rear face of the object when it's at the speed of light.





Part Four:

Alternate Angles at Other Speeds

We shall consider the effects of both wave fronts and relativity by rotating the object we’re looking at.
Also, the angle the observer makes to the velocity will be factored in, from the object traveling directly towards the observer, to the object traveling directly away.
All of these effects will be viewed with the object traveling at different speeds.

Below are eight objects traveling at different speeds.
Closely watch each cube as the observation angle increases,
and compare them to the upper-right image for reference.
Note: The following pages are looped.