ID #33
Problem Set 3
Physics 202
January 29, 2018

1. Let the length of the rod in the y direction be 1 (which is constant, since the travel is in the x-direction). Then its apparent length in the x direction for the stationary observer is given by

$$\tan(31^\circ) = 1/x \implies x = 1.664$$

Then, for the moving observer, its x-length is

$$\tan(46^\circ) = 1/x \implies x = 0.966$$

Using the Lorentz transformation,

$$\frac{0.966}{1.664} = \sqrt{1-(u/c)^2} \implies u = 0.814c$$

2. The astronaut's time is the proper time, since they are in the same location for the beginning and end measurements. Therefore

$$400\,\mathrm{yr} = 10\,\mathrm{yr}\frac{1}{\sqrt{1-(u/c)^2}} \implies \frac{1}{40} = \sqrt{1-(u/c)^2} \implies u = 0.9997c$$

3. Assume observer $O$ is at the origin when the red light flashes. The time it takes the blue flash to cover the distance and reach the observer is $3.26\,\mathrm{km}/c = 10.87\,\mu\mathrm{s}$. This means the blue flash originated at $t = -3.24\,\mu\mathrm{s}$. Then we can calculate the perceived distance for observer $O'$:

$$3.26\,\mathrm{km} = d'\frac{1}{\sqrt{1-0.625^2}} \implies d' = 2.54\,\mathrm{km}$$

Then the time for the flash of light to reach $O'$:

$$t' = d'/c = 8.46\,\mu\mathrm{s}$$

Since the flash happened at $t = -3.24\,\mu\mathrm{s}$, it is perceived at $t = 5.23\,\mu\mathrm{s}$.

4. (a) To the space station director, the ships appear to be approaching each other at $1.2c$.

   (b)

$$v = \frac{v'+u}{1+v'u/c^2} = \frac{1.2c}{1+0.36c^2/c^2} = 0.88c$$

   (c) Since radio waves are light, they always have an incident speed of $c$.