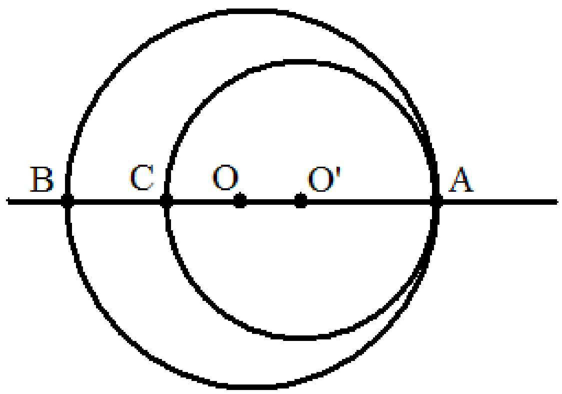
Special Relativity
Homework, Set 2

1. Suppose observer O' is moving to the right with constant speed v relative to observer O. Let us assume that at the very instant O and O' pass each other, rays of light proceed in all directions from the place where they pass. O will observe a spherical light wave front moving away from him with velocity c. After t seconds, the light will have reached all points at distance ct from him. According to O, at the instant the light has reached point A (in the figure), it has also reached point B.



On the other hand, by Postulate 1, the observer O' may consider herself at rest and O as moving. By Postulate 2, she will also observe a spherical wave, moving away from her with velocity c and reaching all points at a distance ct from her t seconds after O passes her. However, as the light travels to A, O' has moved a short distance to the right of O, so that the spherical wave front O' observes is not concentric with the one observed by O. Therefore, in the view of O', at the instant the light has reached A, it has also reached (not B yet, but) C. They cannot both be right, and yet Einstein's postulates imply they are. Resolve this apparent paradox.

2. As pointed out in class, when we see an object at a particular moment, light rays reaching our eyes from the most distant parts of the object must have left the object earlier than rays from the nearer parts, since all these rays enter our eyes at the same instant. Suppose the object we are seeing is a very long train approaching us at a substantial fraction of the speed of light. Would its (seen) length appear longer or shorter than if the train were seen at rest? Explain. (You may be qualitative and not quantitative.)

3. The radius of our galaxy, the Milky Way, is about 5×10^4 light years (one light year $\approx 9.45 \times 10^{17}$cm). Can a person, in theory, travel from the center to the edge of our galaxy in a normal lifetime? Explain, using either time dilation or length contraction.

4. μ-mesons at rest have an average lifetime of about 2.3×10^{-6}sec. These particles are produced high in the earth's atmosphere by cosmic rays. Suppose a μ-meson is created and travels downward with speed $\beta = 0.99$. How far will it travel before disintegrating?

5. In class, we deduced relativistic length contraction from time dilation (in section 2-6). Show, conversely, that if length contraction is assumed, time dilation follows.