Relativity Workshop II: Basic Postulates

- Work in groups of 4 or 5
- Use the portable whiteboards at your table
- Each person in a group should have a different color marker (in groups of 5, two people might have the same color)
- Write large so everyone (including me when I come to your table) can see
- Each person in the group should be working on the problems and contributing to the whiteboard – take turns as needed
- Please consult with me as frequently as needed
- Attempt the following problems before class on Monday November 28: 1), 2), *at least one of* 3) – 5), *at least one of* 6) – 9), 10) and 11)
- Come to class Mon. Nov. 28 with specific questions about problems you had difficulty with
- I encourage you to attempt all the problems
- Numerical results provided at end

1) You've likely noticed the importance of the factor $\sqrt{1-(v/c)^2}$.

a) Show enough work to demonstrate to your group that when $v = 0.6c$, then $\sqrt{1-(v/c)^2} = 0.8$.

b) When $v = 0.8c$, what is $\sqrt{1-(v/c)^2}$?

c) When $\sqrt{1-(v/c)^2} = 0.5$, what is v ?

2) Duck Dodgers hops in his spaceship and leaves the Earth at a constant velocity of 0.6*c* in an attempt to reach the newly discovered Planet X before aliens from Mars.

a) Mission control on Earth sends an encoded message (a flashing beacon) to Duck Dodgers warning him about the progress of the Martian ship. The light pulses travel at a speed *c* relative to observers on the Earth. How fast are the pulses traveling relative to Duck Dodgers?

b) Duck Dodgers doesn't understand the message that he received, so he sends a radio wave message back toward the Earth asking for clarification. The radio signal is traveling at a speed *c* relative to the Duck. How fast is the signal traveling relative to observers on the Earth?

c) The radio message is intercepted by Marvin the Martian who is behind Duck Dodgers but traveling in the same direction at a speed 0.8*c* relative to the Earth. How fast is the radio message relative to Marvin?

d) At this point, you might be asking yourself "What was the point of this problem?" What *was* the point of this problem?

Strategy for problems 3) – 5): Draw a sketch. Consider how you'd determine the velocity classically. Apply the relativistic correction. COMPLETE *AT LEAST ONE* OF PROBLEMS 3) – 5) DURING TODAY'S WORKSHOP.

3) Zeph travels at speed 0.50*c* to the right relative to Adam. Sam is traveling at 0.70*c* to the left relative to Adam. Calculate the velocity of Zeph relative to Sam.

4) Dan, Julia, and Zoe are returning home, traveling at a speed 0.75*c* relative to and toward the Earth. Dan is particularly anxious to get back to Earth, so he hops on the emergency shuttlecraft, which leaves the ship traveling at a speed of 0.75*c*, relative to Julia and Zoe. How fast is Dan traveling relative to the Earth?

5) Shayne's speed is measured at 0.6*c* relative to Joe, who is at rest on the earth, and +0.8*c* relative to Red, who is passing by in a rocket. Determine the speed of Red's rocket relative to Joe on the earth.

Strategy for problems 6) – 9): Identify events important to the problem. Determine if anyone measures proper time. See which time, if any, you are given. When needed, use distance = (speed) x (time); make sure that the distance and time are measured in the same reference frame. COMPLETE *AT LEAST ONE* OF PROBLEMS 6) – 9) DURING TODAY'S WORKSHOP.

6) Larissa and Andrew are sitting in a spaceship moving at constant velocity 0.80 lt·s/s travels between two planets A and B in 1000 s, as measured by synchronized clocks on the planets. Calculate the elapsed time according to a clock carried on Larissa and Andrew's spaceship.

7) Miles and Tath are sitting on a train. How fast do they have to travel relative to James and Abby, who are at rest relative to each other, in order that the elapsed time as read by a clock on the train is one-tenth the elapsed time measured by James and Abby?

8) Tom and Elise are on a meteorite that is observed to travel a distance 1.00×10^5 lt·s in a time of 6.00×10^5 s (distance and time measured relative to the Earth rest frame, velocity of the meteorite assumed to be constant). Calculate the elapsed time for this trip as measured by Tom and Elise.

9) Kevin and Alejandra are in a car stopped at a traffic light. They beeps the horn, and 2.4 μs later beep the horn again (1 μs = 1 microsecond = 10^{-6} s). What is the time between the two beeps as measured by Max and Olivia, who are passing by the car in a ship moving at a constant velocity 0.8*c*?

---

10) Amanda, Peter, and River travel in a rocketship moving at a constant velocity of 0.80*c* from Earth to a near-by star, Alpha Centauri, a distance of 4.00 lt·yr. Note: velocity and distance are measured according to the Earth/Alpha Centauri rest frame.

a) How long does the trip take according to Vivian, who is at rest relative to Earth?
b) How long does the trip take according to Ruthie, who is at rest relative to Alpha Centauri?
c) Calculate the time for the trip as measured by Amanda, Peter, and River.
d) Based on your answer to c), calculate the distance between Vivian and Ruthie, as determined by Amanda, Peter, and River using the relation distance = (speed) × (time), where distance, speed and time are all measured from their reference frame.
e) Calculate the distance between Vivian and Ruthie from Amanda, Peter, and River's reference frame, but this time use length contraction. You should end up with the same result as for d). Hopefully, this will convince you that length contraction and time dilation are really the same thing (i.e., you can't have one without the other).

11) There is a supergiant star named Betelgeuse which (from the Earth's reference frame) is 80 lt·yr away. Betelgeuse is a supergiant star located in the constellation Orion that could go supernova anytime in the next million years, and *that* will be quite a show for us when it does.

a) Herman, Arielle, and Lisa are astronauts traveling toward Betelgeuse, traveling at a constant speed 0.8*c* relative to the Earth-Betelgeuse reference frame. What is the separation between Earth and Betelgeuse in the astronauts' reference frame?
b) Another crew consisting of Gloria, Taylor, and Asia is traveling toward Betelgeuse, and measures the Earth-Betelgeuse distance to be 23 lt·yr. How fast is this second crew traveling relative to the Earth?

---

12) **this is a particularly challenging problem, both conceptually and algebraically** A spaceship crew wants to make the trip from Earth to Alpha Centauri (4.00 lt·yr apart in the Earth/Alpha Centauri rest frame) in only 2.0 years as measured by clocks on board their spaceship which travels at constant velocity. Determine how fast the crew must travel relative to Earth.

---

answers: 1b) 0.6; 1c) 0.866*c*; 2a) *c*; 2b) *c*; 2c) *c*; 3) 0.889*c*; 4) 0.96*c*; 5) 0.385*c*; 6) 600 s; 7) 0.995*c*; 8) 5.916×10^5 s; 9) 4 μs; 10a) 5 years; 10b) 5 years; 10c) 3 years; 10d) 2.4 lt-yr; 11a) 48 lt-yr; 11b) 0.958*c*; 12) 0.894*c*