Relativistic Velocity Addition Problems

1. A policeman is using a speed camera to help keep law abiding citizens safe. Hazeem is driving at 50.0 km hr^{-1} towards the policeman. Ahead of Hazeem is Jeffrey. In Hazeem's reference frame, he observes Jeffrey to be driving at 5.00 km hr^{-1} towards the policeman.

    a. Using Galilean relativity, calculate Jeffery's speed as recorded by the policeman.

    b. Describe any issues with trying to solve a similar problem using Gallilean relativity when Hazeem is driving at 50.0 % of the speed of light while observing Jeffery moving at 60.0 % of the speed of light.

    c. Using Einstein's theory of special relativity, calculate Jeffrey's speed as observed by the policeman when the policeman records Hazeem's speed as 50.0 % of the speed of light and Hazeem observes Jeffrey's speed as 60.0 % of the speed of light.

    d. By referring to the relativistic addition of velocity formula, show why it is not necessary to consider relativistic effects and Galilean relativity is an adequate approximation when observing velocities at normal driving speeds.

2. Large particle accelerators are capable of accelerating protons up to 99.0 % of the speed of light. A ground based observer monitors a beam of protons accelerated by a particle accelerator which is on a spaceship moving past the Earth at 75.0 % of the speed of light.
    a. In the frame of reference of the proton, what is the speed of the space ship?

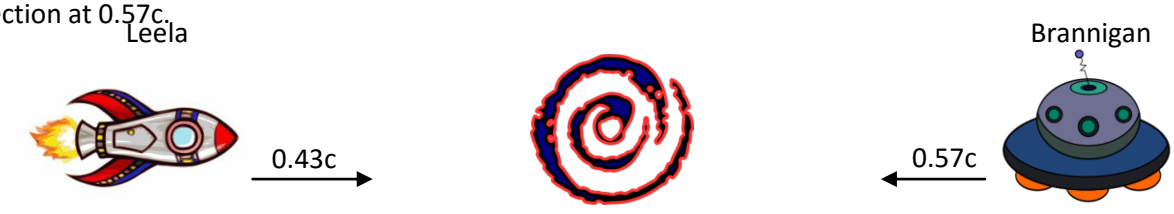
    b. Calculate the speed of the protons as observed by the ground based observer.

    c. In the frame of reference of the proton, what is the speed of the ground based observer?

3. A blazer is a blob of hot gas emitted from energetic galaxies. Blazers can travel at really high speeds. Earth observatories observe two blazers moving in the same direction. The velocity of each blazer is recorded in the frame of Earth.

Calculate the velocity of blazer B in the frame of blazer A.

4. Captain Leela and Captain Brannigan are in a race to the galactic core. As referee it is your duty to decide who reaches the destinations first. While remaining at rest with the galactic core you notice Leela's ship approaching from one direction at 0.43c while Brannigan's ship approaches from the other direction at 0.57c.



Calculate the velocity of Brannigan's ship from the frame of Leela.

Question 5 and 6 requires prior knowledge of time dilation and/or length contraction

5. Celine sits within her spaceship. Finn observes Celine's ship fly past at 0.60c. Finn also sees an electron move from the back of Celine's spaceship to the front at 0.85c. Finn records the time that the electron takes to move from the rear to the front of the spaceship as 7.20×10^{-6} s. Calculate the proper length of the spaceship.

6. Jack is sitting at a busy spaceport watching Vivian in a spacecraft approaching the spaceport at 0.60c. Jack also observes Shagun who is approaching the spaceport from the other side moving at 0.75c. Shagun and Vivian each observe the other's spacecraft to have a 125 m length. What is the length of Shagun's spacecraft as observed by Jack?

7. Two observers are moving relative to each other at a speed v. Observer one shines a light which he perceives to move at a speed c towards observer two. Show that the formula for the relativistic addition of velocities accurately predicts that the speed of the light as perceived by observer two is also c.