

1 Physics 2424

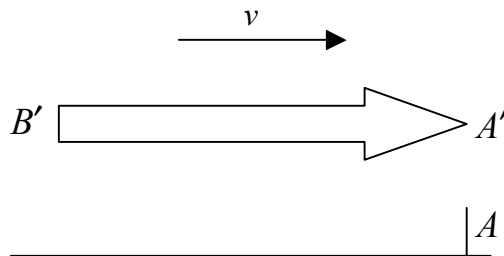
Relativistic Kinematics

1. A particle is created in an accelerator. A detector, 20.0 m away in a straight line, records it 7.41×10^{-8} seconds later.
 - a. How fast is the particle moving?
 - b. What is β ?
 - c. How much time passes in the frame of the particle?
 - d. How far has the particle travelled in its own frame?

2. You are timing a space ship race. Two spaceships both travel at $0.7c$. As the first spaceship reaches the finish line, you start your stopwatch. The second ship arrives 1.5×10^{-5} seconds later.
 - a. From your frame of reference, how far behind was the losing spaceship?
 - b. From the losing spaceship's frame, how long after the winner did he cross the finish line?
 - c. From the winning spaceship's frame, how far behind was the loser?

3. (Tipler, Modern Physics) A meterstick moves parallel with its length with speed $v = 0.6c$ relative to you. (a) Compute the length of the stick measured by you. (b) How long does it take for the stick to pass you? (c) Draw a spacetime-diagram from the viewpoint of your frame with the front of the meterstick at $x = 0$ when $t = 0$. Show how the answers to (a) and (b) are obtained from the diagram.

4. (From French, Special Relativity) A rocketship of proper length L_0 travels at constant velocity v relative to frame S (see figure). The nose of the ship (A') passes the point A in S at $t = t' = 0$, and at this instant a light signal is sent from A' to B' , the back of the spaceship.
 - (a) When, by rocketship time (t'), does the signal reach the tail (B') of the ship?
 - (b) At what time t_1 , as measured in S , does the signal reach the tail (B') of the ship?
 - (c) At what time t_2 , as measured in S , does the tail (B') of the ship pass the point A ?



5. (From French, Special Relativity) Two spaceships, each measuring 100 m in its own rest frame, pass by each other traveling in opposite directions. Instruments on spaceship A determine that the front end of spaceship B requires $5.00 \times 10^{-7}\text{ s}$ to traverse the full length of A .
- (a) What is the relative velocity of the two spaceships?
 - (b) A clock at the front end of B reads exactly one o'clock as it passes by the front end of A . What will the clock read as it passes the rear end of A ?
6. Sketch a spacetime diagram showing two spaceships travelling at $v = 0.6\text{ c}$, one moving away to the right and one approaching from the left. The receding spaceship sends you a radio signal every 20 m of time by its clock. You send it a radio signal every 20 m of time by your clock. The approaching ship sends you a signal every 40 m of time by its clock and you reciprocate by send a signal to it every 40 m of your time. Sketch these signals on your diagram. Determine how often you see the receding spaceships signal and how often it sees your signals. Repeat for the approaching spaceship.
7. Here is a relativity paradox. You are floating in space beside the nose of a space ship that is two lightyears (ly) long. The ship accelerates from zero to $.866\text{ c}$ in 10 seconds. Due to length contraction, the ship is now only 1.00 ly long (in your frame of reference). This means that the tail of the ship has moved 1.00 ly in 10 s (in your frame of reference), thus has an average speed of three million times the speed of light. Try to resolve this paradox or at least point out some of the problems.