Time Dilation Problems

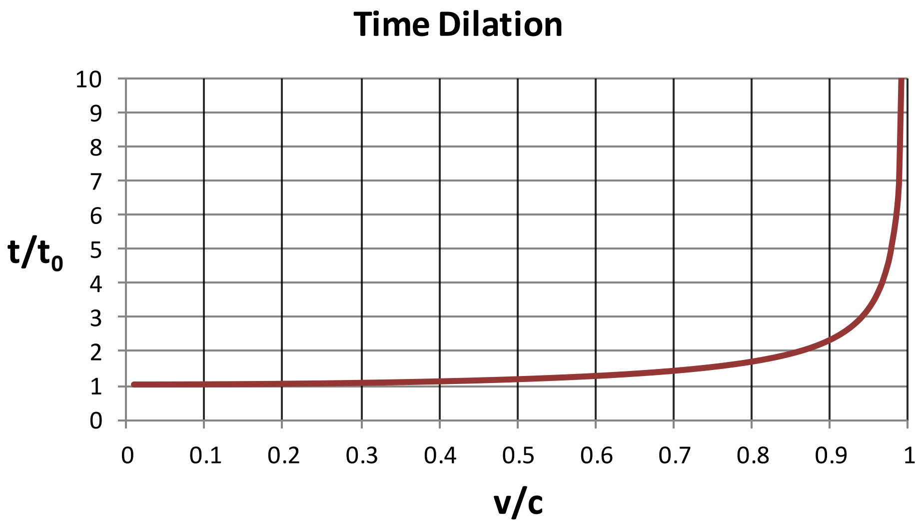
1. Habib is on a train, sitting in the middle of a carriage. He also happens to be in an alternate universe where the speed of light is 2.00×10^{2} ms^{-1} for all observers. Habib shines a single photon of light towards the roof of the train which he sees as 3.00 m above his torch. Joshlyn is sitting on a platform observing the train moving at 25.0 ms^{-1}. Joshlyn sees Habib shine the photon just as the train passes her.
    a. How long does Habib record it takes for the photon to reach the roof of the train?

    b. How long does Joshlyn record it takes for the photon to reach the roof of the train?

    c. Compare the two time values. What do these answers suggest about the nature of time?

    d. What is the proper time it take for the photon to reach the roof of the train? Justify your answer.

2. The graph below shows how the effects of time dilation vary as the velocity of a frame of reference approaches the speed of light. Use this graph as a means to determine the answer to the following questions.



a. Explain why time dilation is not a significant concern for Newton's equations when analysing moving vehicles.

b. An event takes 1.00 minute in the rest frame of the event. How long would the event seem to take for an observer who views the event occurring in a frame moving at 0.95c?

c. What velocity would a spaceship need to be moving for a stationary observer to observe a clock on the spaceship is ticking twice as slow as the watch on the observers wrist?

d. If it was possible, how would an object moving at the speed of light perceive time to be passing in the universe?

3. Kathy says goodbye to Jean as Kathy boards a spaceship which blasts off at a large fraction of the speed of light. Prior to departure the two girls made sure their clocks were in sync.
   a. Would Jean observe Kathy's clock to tick faster, normal or slower compared to her own? Justify your answer.

   b. Would Kathy observe her own clock when on the spaceship to tick faster, normal or slower compared to her own clock when on Earth? Justify your answer.

   c. Would Kathy observe Jean's clock to tick faster, normal or slower compared to her own? Justify your answer.

4. Cooking two minute noodles requires placing the dried noodles into boiling water for two minutes. In the far future, this instruction would probably state that this time is only while in the rest frame with the pot of boiling water. How long would an observer moving at 2.61×10^{8} ms^{-1} relative to the boiling water believe it takes for the noodles to be cooked?

5. Carys believes the watch on her wrist is ticking slowly because of a mechanical malfunction but she does not have another time keeping device to help her check. She asks Bob for help. Bob is passing by at 0.68c and after 10.0 s has passed on his watch tells Carys his watch shows 10.0 s has passed while he sees her watch showing 5.20 s has passed. Carys knows Bob will be observing time dilation but still has gathered the information she needs. Is Carys' watch ticking slower than it should be in her own reference frame because of a mechanical malfunction? Justify your response.

6. It takes 3.00 minutes for a clock on a fast moving spaceship to change by 1.00 minute as recorded by an observer in a different frame of reference. What is the relative velocity between the two inertial frames?

7. Spaceship A is passing by spaceship B at 0.82c when the passengers on both spaceships are awoken at 6:30 am local space time according to the clocks in the respective ships. After getting dressed and having breakfast, passengers aboard spaceship A see the time is now 6:50 am onboard their ship.
   a. What time would passengers on spaceship A observe on the clock aboard spaceship B? Your answer should be to the nearest second.

   b. When passengers on spaceship B observe their clock's to show 6:50 am, what time will the clocks on spaceship A be showing according to spaceship B passengers?

8. Muons are formed in the upper atmosphere and travel at 0.99c towards Earth's surface. The muons are predicted to have a half life of 2.20 μs. This means that, on average, half of all muons will decay within a 2.20 μs time period. Experiments have been conducted to measure the half life of muons. In one experimental setup, two detectors were set up. One detector was placed at sea level which detected 100 muons per hour.
    a. If there was no relativistic effects, how high above sea level would the second detector need to be placed so that it would measure 200 muons per hour? You may find it useful to know that half of these muons must decay before reaching the sea level detector.

    b. The muon count was much higher than expected at this height, suggesting the muon half life was larger than predicted. Physicists realised the predicted half life of the muons was correct only in the rest frame of the muons. Using the speed of the muons and accounting for relativistic effects, calculate the half life of the muons as observed by the Physicists who are at rest relative to the surface of the Earth.

    c. By considering relativistic effects, calculate how high the second detector needs to be placed to detect 200 muons per hour.