

Physics 216: Problem Set 3

Due Thursday, Feb 19, 2004

1. The star Canopus is 99 light years from the Solar System. [A light year is the distance that light travels in one year.] A spacecraft travels from the Earth to Canopus with uniform velocity.

- a. How fast must the spacecraft be moving so that the astronauts onboard will have aged by 7 years by the time they reach Canopus?
- b. If the spacecraft travels at this speed, how long would the outward trip take as measured by clocks on the Earth?
- c. What would be the distance between the Earth and Canopus, according to the astronauts onboard the spacecraft?

2. Rockets A and B, each 100m long in their own rest frames, pass each other moving in opposite directions. According to the clocks on Rocket A, the front end of rocket B takes 1.5×10^{-6} s to pass the entire length of rocket A.

- a. What is the relative velocity of the two rockets?
- b. According to the clocks on rocket B, how long does the front end of A take to pass the entire length of rocket B?
- c. According to the clocks on rocket B, how much time passes between the time when the front end of A passes the front end of B, and the time when the rear end of A passes the front end of B? Does this time agree with your answer in part b? Should it? [Hint: draw a spacetime diagram].

3. *K&K 12.8*: The frequency of light reflected from a moving mirror undergoes a Doppler shift because of the motion of the image. Find the Doppler shift of light reflected directly back from a mirror which is approaching the observer with speed v , and show that it is the same as if the image were moving toward the observer with speed $2v/(1 + v^2/c^2)$.

4. *The twin paradox*: Stella and Terra are identical twins, each twenty years old. Stella leaves the Earth (you can neglect the motion of the Earth around the sun) in a spaceship and travels at a speed $v = c/2$ to a neighboring star. She then reverses the motion of her spaceship (almost instantaneously) and returns to the Earth at the same speed $v = c/2$. She arrives home on Terra's 30th birthday.

- a. Show that Stella is 28.7 years old when she arrives home.
- b. As seen from Stella's reference frame, it is Terra who moved away at velocity $v = c/2$ and then came back. Therefore, it would seem that Terra should suffer the effects of time dilation, and should end up younger than Stella, rather than the other way around. This is the twin paradox. Can you resolve the paradox?