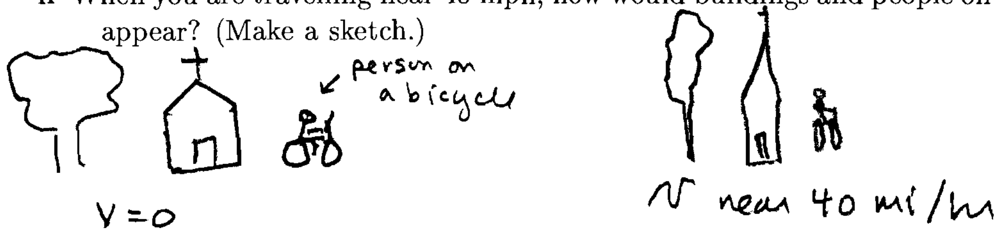
Physics 100 HW 10 (Due 4/2/07 **Monday after the break**) Name S. Olsen

1. Imagine that the speed of light was only 40 mph.

   i Describe what driving a car would be like; how fast could you go? When you are near 40 mph, how would the car accelerate?

   You could never go as fast as 40 mi/hr as you get closer to 40 mi/hr, the car's mass increases & gets harder to accelerate

   ii When you are travelling near 40 mph, how would buildings and people on the street appear? (Make a sketch.)



   iii Would wrist watches be of much use? Would it be easy to keep track of time?

   No; moving clocks run slow. So, since a watch is frequently in motion its time would differ from, say, that of a clock fixed to a wall.

2. I would think that in this $c = 40$ mph world, bus driver and taxi driver jobs would be very popular and hard to get, while college professor and bank executive jobs would not be so desireable. Why do you think that would be so?

   Since drivers are in motion, the time they think they are on the job will be <u>less</u> than the time their dispatcher, who like professors & executives, are mainly sitting at rest behind a desk

3. *Hint: unlike other HW problems, for this one you will need to be careful to use all the decimal places in your calculator.*
   Electrons emerging from Stanford's 3 km long electron accelerator travel at a speed of 0.999999999c, and are sent through a vacuum pipe to an experiment that is 3 km away. Suppose that just when an electron leaves the accelerator, a flash of light is sent to the experiment right next to it in the same vacuum pipe.

   a) How long does it take the light flash to reach the experiment?

   $$t_{light} = \frac{dist}{speed} = \frac{3km}{c} = \frac{3\times10^3 m}{3\times10^8 m/s} = 1.0\times10^{-5} s$$

   difference = $0.000000001 \times 10^{-5}$ s $= 1.0\times10^{-14}$ s

   b) How much longer does it take the electron to reach the experiment?

   $$t_{elect} = \frac{dist}{speed} = \frac{3km}{0.999999999c} = \frac{1}{.999999999} t_{light} = 1.000000001\times10^{-5} s$$

   c) According to the electron, how fast does the light flash travel as it passes by?

   c

4. A rocket travels by you at a speed of 0.99c ($\gamma = 7.1$). You determine its length to be $L =$ 10 m long. How long would the rocket be to an observer in the rocket's restframe?

moving objects are shorter $\Rightarrow L = \frac{L_o}{\gamma}$

$L_o = \gamma L = 7.1 \times 10\,m = 71\,m$

5. The brightest star in the night sky is Sirius. (This is the nose of *Canis Major*, the "big dog," and is easily visible from Hawaii during the spring.) Sirius is 8.6 cyr (i.e. 8.6 light years) away from the Earth. Suppose that just after they graduated from college, one twin left on a trip to Sirius in a rocket with a speed of 0.9c, while the other remained behind on Earth teaching physics. (For v=0.9c, $\gamma = 2.3$.)

a) According to the physics teacher on Earth, how long does it take his twin brother to reach Sirius?

$t_E = \frac{dist_E}{V} = \frac{8.6\,cyr}{.9c} = \frac{8.6\,yr}{0.9} = 9.6\,yr$

b) According to the twin in the rocket, how far (i.e. what distance) does he have to travel to get to Sirius?

moving distances are shorter

$dist_R = \frac{dist_E}{\gamma} = \frac{8.6\,cyr}{2.3} = 3.7\,cyr$

c) According to the twin in the rocket, how long (i.e. how much time) does it take to get to Sirius?

$t_R = \frac{dist_R}{v} = \frac{3.7\,cyr}{0.9c} = \frac{3.7\,yr}{.9} = 4.1\,yr$

6. Suppose that after the twin gets to Sirius, he immediately turns around and goes home, still at a speed of 0.9c. After he returns, **a)** how much has the physics teacher aged during the trip? **b)** how much has the traveling twin aged?

a) Teacher ages by $2 \times 9.6\,yr = 19.2\,yr$

b) traveler ages by $2 \times 4.1\,yr = 8.2\,yr$

7. While he was traveling through space at the speed of 0.9c, would the twin notice a change in his heartbeat? the length of his rocket?

no

8. Suppose, somehow, the physics teacher on Earth was also monitoring these things. What would *he* determine?

yes he would see traveling twin heart beat slow down and the rocket's length shortened