PH 429/529 **PARADOXES II** Spring 2010

1. **LENGTH**

   How can two observers both see each other's meter sticks contract? Draw spacetime diagrams which show the measurements from both frames.

2. **TIME**

   How can two observers both see each other's clocks run slow? Draw spacetime diagrams which show the measurements from both frames.

3. **THE POLE AND THE BARN**

   (Problem 5-4 on p. 166 of Taylor & Wheeler; Example 12.3 on pp. 491–492 of Griffiths)

   A 20 foot pole is moving towards a 10 foot barn fast enough that the pole appears to be only 10 feet long. As soon as both ends of the pole are in the barn, slam the doors. How can a 20 foot pole fit into a 10 foot barn? Draw spacetime diagrams which describe the situation from each point of view.

4. **SPACE WAR** (Problem 3-7 on pp. 79–80 of Taylor & Wheeler)

   Two rockets of equal rest length pass each other. Rocket A fires a gun mounted in its tail at Rocket B when the tip of Rocket A reaches the tail of Rocket B. Does the bullet hit or miss Rocket B? Draw spacetime diagrams which describe the situation from each point of view.

5. **SEARCHLIGHT MESSENGER** (based on Problem 3-14c on pp. 88–89 of Taylor & Wheeler)

   A powerful laser on Earth makes a red dot on the surface of the Moon, where Astronauts A & B are working. A is told that when he sees the laser beam, he should shine a blue laser at B. B is told that when he sees the red laser beam, he should duck, to avoid the blue laser beam which A will have fired. But if the red beam is rotated fast enough, surely the red dot on the Moon moves faster than the speed of light. Has a message been sent from A to B faster than the speed of light?

6. **TRAVELING FASTER THAN LIGHT I** (based on §4.5 on pp. 124–125 of Taylor & Wheeler)

   Canopus is 99 light-years from Earth. If you travel at speed $v = 99c/101$, how long does it take you to reach Canopus. But surely it should take at least 99 years? Explain.

7. **TRAVELING FASTER THAN LIGHT II** (Problem 3-15 on pp. 89–90 of Taylor & Wheeler)

   A rocket streaks under the Golden Gate Bridge in San Francisco and emits a flash of light. It then streaks under the Gateway Arch in St. Louis, where it emits another flash of light. The flashes arrive in New York at nearly the same time, so that an observer in New York sees both events happen nearly simultaneously. Doesn't this mean that the observer thinks the rocket traveled faster than the speed of light? Draw a spacetime diagram showing this situation from the point of view of the observer in New York.

8. **CAUSALITY** (based on Box L-1 on pp. 108–109 of Taylor & Wheeler)

   Suppose a missile could go faster than the speed of light, say 3 times the speed of light from the base located at the origin. Consider now a spaceship traveling at speed $v = 3c/5$, starting from the event $(x, ct) = (0, -4)$. The missile would collide with the ship at the event $(x, ct) = (3, 1)$. Draw a spacetime diagram showing this situation from the point of view of the base (in which the above coordinates were given). Then draw a spacetime diagram from the point of view of the ship. Who fired the missile?