Theory of Relativity – Quiz
July 2, 2014

Names of group:______________________________________

Below are short questions and problems. Answer to the best of your ability. Each question is worth 1 point.

1. Inertial observers in Newton's theory are related by what type of coordinate transformation? Either the name or equations are valid answers.

Answer: Galilean transformation. $t' = t$, $x' = x - wt$

2. What type of motion is possible for an object experiencing no force (no pushes or pulls)?

Answer: Straight line or at rest

3. True or false? (a) In an inertial reference frame it's possible to have acceleration in the absence of a force. (b) In a non-inertial reference frame it's possible to have acceleration in the absence of a force.

Answer: (a) False (b) True

4. Suppose two inertial observers (moving at a speed 10 meters per second relative to each other) measure an object's position, length, velocity, and acceleration. Which measurements will they agree on? Which measurements will they disagree on?

Answer: Agree on length and acceleration. Disagree on position and velocity.

5 . Devise an experiment to show you are in a non-inertial frame.

Answer: Look for objects which appear to spontaneously move.

6. Suppose you are in an enclosed spacecraft drifting in outer space. Can you devise an experiment to show you are moving with a constant speed? If not, why not.

Answer: NO! This would violate the principle of relativity (laws of physics would be different).

7. Background information: Yesterday we discussed that the "laws of physics" are the same for all inertial observers, for which we mean they can use $F = ma$ to describe the motion of an object of mass m when a force F is applied: by measuring F, m, $x_{\texttt{initial}}$ and $v_{\texttt{initial}}$ you know (i) the object will accelerate at $a = F/m$ and (ii) the object's final position will be $x_f = x_{\texttt{initial}} + v_{\texttt{initial}} t + \frac{1}{2}at^2$.

Suppose a boat has a hockey rink inside of it and in the middle of the rink there is a hockey puck at rest. The boat turns on its engine and accelerates at a rate $10m/s^2$ in the positive x-direction.

Can you write down the "modified" form of Newton's equation appropriate for describing experiments in the boat? Describe with words or an equation the motion of the hockey puck.

Answer: The puck will start moving backwards at $a = -10m/s^2$. The modified Newton's law will be $F = Ma + M(10m/s^2)$. You might be able to convince yourself of this by considering some special cases:

- Suppose there are no external forces applied to the puck and so, according to someone in the ship, $F = 0$. Our modified Newton's law then gives $a = -10m/s^2$, and the puck's motion is $x_f = x_i + (1/2)(-10m/s^2)t^2$. This is the motion you expect (its moving backwards).
- Suppose you wish to keep the puck at a fixed location. How to do this? You will need to push the puck in the positive x direction with a force of $F = M(10m/s^2)$. Our modified Newton's law becomes $F = M(10m/s^2) = Ma+M(10m/s^2)$, which implies $a = 0$.