Physics 123 section 2 CID ____________

Homework 37

Score ________ / 30

1. (6 pts) A car of mass $m_1 = 1000$ kg is sliding without friction on ice at a velocity $u_1 = 20$ m/s when it strikes another car of mass $m_2 = 1200$ kg which was standing still. The two cars lock together and slide together without friction after the collision. (a) Use the principle of momentum conservation to find the velocity of the two cars after the collision. (b) An observer riding on a bicycle in the same direction as the cars watches the collision while traveling at a velocity $v = 10$ m/s. Find the initial and final velocities of the two cars as measured in an inertial reference frame which is at rest with the bicycle rider using the Galilean transformations. (c) Show that the velocities that you found in (b) satisfy momentum conservation in the bicycle rider's reference frame.

2. (5 pts) Now consider the same car crash as viewed by a bicycle rider who is moving at a speed $v = 10$ m/s at a direction which is orthogonal to the direction that the cars are moving. Let the bike rider be moving in the x direction and the cars moving in the y direction. (a) Use the Galilean transformations to find the x and y components of the cars' velocities be before and after the collision. (b) Show that momentum is conserved in the reference frame of the bike rider.

3. (5 pts) If we assume that Newton's second law ($\vec{F} = m\vec{a}$) is true in a particular inertial reference frame, show that it is also true in the frame of an observer which is moving at a velocity v in the x direction.

4. (5 pts) If we assume that Newton's second law ($\vec{F} = m\vec{a}$) is true in a particular inertial reference frame, show that it is *not* true in the frame of an observer which is accelerating at a constant rate a_0 in the x direction.

5. (3 pts) An observer in a train and an observer standing next to the tracks see different objects moving around (a dog running, a bicycle riding past, etc.) and measure each velocity in their reference frame. At the end of the day they compare notes and find that in most cases they disagree in the magnitude of the velocities that they measured. Which two will the observers always agree on?

6. (3 pts) There are two postulates from which all of special relativity is derived. Write these postulates down in your own words.

7. (3 pts) (a) What important fact did the results of the Michelson-Morley experiment suggest? (b) How did this help lead to Einstein's special theory of relativity?

Extra problems I recommend you work (not to be turned in)

- An observer at rest with respect to the Earth finds that objects falling under gravity accelerate at a constant rate of 9.8 m/s. According to Galilean relativity, will an observer on a train moving at 10 m/s see that objects falling under gravity accelerate at a constant rate in their frame? If so, what is that rate?
- An observer at rest with respect to the Earth finds that objects falling under gravity accelerate at a constant rate of 9.8 m/s. According to Galilean relativity, will an observer on a rocket moving vertically away from the surface of the earth at 10 m/s see that objects falling under gravity accelerate at a constant rate in their frame? If so, what is that rate?
- An observer at rest with respect to the Earth finds that objects falling under gravity accelerate at a constant rate of 9.8 m/s. According to Galilean relativity, will an observer on a rocket accelerating vertically away from the surface of the earth at 10 m/s^2 see that objects falling under gravity accelerate at a constant rate in their frame? If so, what is that rate?
- I throw a ball into the air. An observer at rest with respect to the Earth sees the ball fly in a parabolic path. By Galilean relativity, will an observer on a train see the ball move in a parabolic path?
- If I measure the momentum of a ball in two different inertial reference frames, will I get the same measurement in both frames? Why or why not?