PHYS420 (Spring 2002)
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Homework # 2
(due Monday, February 11th, 2002)

Problems

1. Generalize the Galilean transformation of coordinates to motion in three dimensions by showing that $\vec{r}\,'=\vec{r}-\vec{v}t$ & $t'=t$.

2. In a laboratory frame of reference, an observer notes that Newton's 2nd law is valid. (a) Show that it's also valid for an observer moving at constant speed relative to the laboratory frame *(we did this in class)* & (b) Show that it is not valid in a reference frame moving past with constant acceleration. *This problem is simply SMM Chapter 1, Problems 1 & 2 combined.*

3. What happens to Maxwell's equations under a Galilean transformation? In a stationary reference frame (K) in free space, the scalar field $\varphi(x,y,z,t)$ satisfies the scalar wave equation, $\frac{\partial^2\varphi}{\partial x^2}+\frac{\partial^2\varphi}{\partial y^2}+\frac{\partial^2\varphi}{\partial z^2}=\frac{1}{c^2}\frac{\partial^2\varphi}{\partial t^2}$. Show that the form of the wave equation is not invariant under Galilean transformations.

4. **SMM, Chapter 1, Problem 3.** A 2000-kg car moving with a speed of 20 m/s collides with and sticks to a 1500-kg car at rest at a stop sign. Show that because momentum is conserved in the rest frame, momentum is also conserved in a reference frame moving with a speed of 10 m/s in the direction of the moving car.

5. *Michelson – Morley experiment.* Show that we were justified in keeping only the first term of the binomial expansion when deriving the *expected* fringe shift. If you recall, $\mathit{Shift}\cong\frac{2Lv^2}{\lambda c^2}$. In other words, calculate what the fringe shift would be if you kept the next term and compare it to the resolution of the experiment ($\sigma_{Fringe}=0.01$ fringe). Are we justified?

6. Synchronized clocks are stationed at regular intervals, 1million km apart, along a straight line. When the clock next to you reads 12 noon, what time do you *see* (assuming you have a really powerful telescope) on the 90th clock down the line?

7. Solve the non-relativistic Newton's equation of motion ($\vec{F}=\frac{d\vec{p}}{dt}$) in the case of a constant force in the positive x direction ($\vec{F}=F\hat{x}$). As a boundary condition, let $x(t=0)=x_0$ and $x'(t=0)=v_{x0}$. *Ignore motion in the y & z directions.*