Physics H190
Spring 2013
Homework 8
Due Friday, April 12 at 5pm

Reading Assignment: Lecture notes from Wednesday, April 3, concerning uniformly accelerated motion in special relativity. This is important background for the Unruh effect.

1. The nearest star, Alpha Centauri, is 4 light years away. The first star travellers are going there on a relativistic rocket ship. For the comfort of the passengers, the ship operates its engines so that the effective gravity felt is $g = 9.8\text{m/sec}^2$. The ship accelerates at this rate for half the trip, then decelerates at the same rate for the other half. It then turns around and comes back. Find how long it takes the ship to return, as seen by an observer back on Earth. Find how much the passengers have aged when they return. Find the maximum velocity (at the midpoint of the trip). Assume the time spent at Alpha Centauri is negligible.

2. Now suppose the rocket ship continues to accelerate so that the effective gravity felt by the passengers is g, without turning around to come back. One of the passengers and a person left on earth are twins, born at the same time. To keep in touch the twin on the rocket ship turns on a TV camera and keeps it on, sending the signal back to earth on a carrier wave of frequency ω_0, as indicated by the TV transmitter on the ship. The twin back home watches her TV to see what is happening to her sister on the ship.

Find the frequency ω of the TV signal as received on earth, as a function of time t, as indicated by a clock on earth. **Hint:** the frequency and wave number of a light wave, (ω, k), transform as a 4-vector (really a $1+1$-vector in this case, since we are only using one spatial dimension) under Lorentz transformations. Given that the energy of a photon is $E = \hbar\omega$, how does the strength of the signal (the power received, or energy per unit time) depend on t (Earth time)?