Physics 111: Homework #7
Due Friday (in precept)

1. When we look out at the Universe with sensitive detectors, we find a blackbody curve of radiation known as the “cosmic background radiation.” (Penzias and Wilson won the Nobel Prize in 1978 for the first detection of this cosmic background radiation.) The peak wavelength is slightly bluer than average in one direction and slightly redder than average in the opposite direction. This effect is due to the fact that our entire Galaxy is moving rapidly through space in a “blue” direction.

   (a) Explain how our motion with respect to the radiation in a certain could direction would produce this qualitative effect.

   (b) The shift in wavelength due to this effect is $\Delta \lambda = 2 \times 10^{-6}$m in the peak wavelength of the cosmic background radiation relative to average in each direction. What is the approximate speed of our Galaxy in km/s?

   (c) What would be the effect on the microwave background due to the motion of the Earth around the Sun? Do you think this effect would be big or small compared to the effect above?

2. A Siren emits sound with a frequency of 500 Hz and a speed of 330 m/s. A police car moves towards a pedestrian at 30 m/s. What is the frequency heard by the pedestrian? What is the frequency after the police car passes and continues moving away at 30 m/s?

3. Put your thumb and forefinger a slight distance apart. Explain why a dark streak appears in the middle even though your fingers are not touching.

4. If you send a laser through two slits, you get an interference pattern. If you remove the slits and, instead, have two lasers arranged so that their beams are separated by the same distance as the slits, will you get an interference pattern? Explain why or why not?
5. Pencil and paper Hubble law: Draw a set of 6 X’s spaced 2 cm apart along a straight line on a piece of paper. Imagine the piece of paper could stretch and that, in two seconds, it stretched so that the spacing is now 3 cm apart. To represent the new positions, draw a circle directly below the first X in your line and then continue to draw 5 more spaced 3 cm apart along a line directly below and parallel to your first line.

Make a table with six rows and several columns. In the first column, label the rows 1 to 6. In the second column, put the distance from the first X in centimeters. (X number 1 is zero centimeters away from the first X.) In the third column, put the distance of each circle from the first circle. In the fourth column, place the displacement (the difference between column three and column 2). This represents how much each moved compared to the first in two seconds. In column five, put the average speed each would travel. Make a graph of column five (the average speed) versus column 2 (the initial distance). If you connect the points, what shape results?

How would this graph change if we made the string of X’s longer? How would it change if we sped up the expansion so that the same stretch occurred in one second instead of two seconds? How would the graph change if we had a two-dimensional plot of points and stretched uniformly in both directions by the same amount in the same time? How is all of this related the Hubble’s law about galaxies?

6. Why is the Doppler effect not as commonly observed for light as for sound?

7. Describe three puzzles that cannot be resolved by the classical physics of Newton and Maxwell and require new (quantum) physics to explain.

8. A mass of 2 kg moving at 15 km/s smashes into a stationary mass of 1 kg and sticks. What is the momentum of the two masses after the collision. Compare the kinetic energy before and after the collision. How much energy has been lost to heat?

9. Explain how the double pendulum shown in class is related to the prediction of weather.