AST 301
Homework #10
Due Friday Dec. 3

It may be easiest to do this homework with a helper. If two students do it together, one of you should use distances from galaxy A and one from galaxy B, and say on your paper who you were working with.
I want you to make a balloon model of the expanding Universe. Find a balloon or a couple of balloons, preferably balloons that will inflate to close to a foot in diameter and are reasonably spherical when inflated. If you find a package of more balloons than you need, bring the extras in for others to use.
Inflate your balloon until it is more or less round, but still small, maybe 3-4 inches across. With a pen, write some letters (A,B,C,D) on the balloon to represent some galaxies.
Measure the distance from galaxy A to each of the other galaxies. You could cut the ruler off of the side of this paper to make your measurements.
Inflate the balloon some more, until it is twice as big as for your first measurements. Measure the distances again. Write your distances down in a table like that below.
Inflate the balloon until it is three times its first diameter, and measure the distances again.
Let's assume the time between each of your measurements is 1 second. Then the speed of a galaxy in cm/sec is the distance it moved between two of your measurements.
Enter the galaxy speeds in your table.
Make a Hubble diagram for your speeds and distances, using the distances you measured for the second balloon size. That is, make a diagram with distance on the horizontal axis and speed on the vertical axis, and put a dot on the diagram for each pair of galaxies.
Do your dots fall near a straight line on the diagram?
What is your Hubble constant?
From your Hubble constant calculate the age of your Universe.
Make another Hubble diagram for the third set of distance measurements.
Calculate the Hubble constant and age of the Universe at this time.
When did the big bang occur in your expanding Universe?
Since the Hubble constant changed between your three measurements, in what sense is it a constant?

Here's a sample table of measurements:

	A-B	A-C	A-D	average H
3 in. balloon speed/distance	2 cm 1.25 (cm/s)/cm	3 cm 1.00 (cm/s)/cm	5 cm 0.90 (cm/s)/cm	 1.02 (cm/s)/cm
6 in. balloon speed/distance	5 cm 0.50 (cm/s)/cm	6 cm 0.50 (cm/s)/cm	9 cm 0.50 (cm/s)/cm	 0.50 (cm/s)/cm
9 in. balloon speed/distance	7 cm 0.36 (cm/s)/cm	9 cm 0.33 (cm/s)/cm	14 cm 0.32 (cm/s)/cm	 0.33 (cm/s)/cm
average speed	2.5 cm/sec	3 cm/sec	4.5 cm/sec	