# Study Guide

# Midterm 2

# AST 308, Fall 2009

The test will cover [CO 27.1, 27.2, 30.1, and all of chapters 17 and 29].

There will be 1 or 2 straight-forward derivations or back-of-the-envelope calculations, along the lines of the ones you have done as homework or have seen in [CO]. The last lecture note slide at http://www.pa.msu.edu/courses/ast308/1030.pdf has asterisks by the equations you should know. The only two that are complicated are the R-W metric and the Friedmann equation, but they are fundamental and I surely will ask you to write down at least one of them. I may also ask you to write down some of the other shorter equations: for example "What is $\Omega_{matter}$ in terms of $\rho$ and $\rho_c$?".

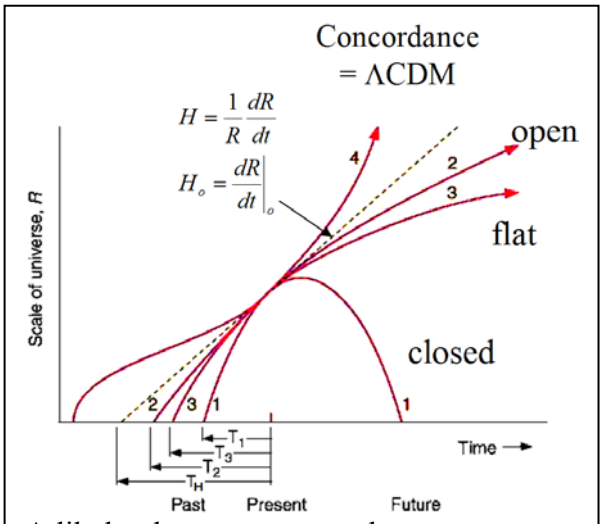
Anywhere you write down an equation, you can invent your own notation if you don't remember what I used. But NO MATTER WHOSE NOTATION YOU USE, briefly describe in words the physical meaning of each constant, variable and term. I want you to show me that you understand what the equation is actually describing.

There will be short essay questions looking for 1-2 brief paragraphs, bulleted outlines, sketches, whatever you can produce to show me that you know about and understand the material. These probably will be more narrowly focused than the last three questions on Midterm 1.

**SOME THINGS TO THINK ABOUT:**

1. Be able to describe in words each of the major methods that Dr. Smith or I talked about in class that are steps in the cosmic distance ladder. What is directly measured? How does that give you a distance? Over what approx. distance range does it work? Say enough to convince me that you understand the basic idea of each method. Know something about the Hubble Space Telescope key project to measure $H_o$. Know how to use the Hubble relation, and what its implications are for cosmology.
2. What is the "Cosmological Principle"?
3. Be able to write down Friedman's eqn. Be able to describe in words how it was derived in the Newtonian cosmology in [CO 29.1]. Where did the cosmological principle get into the act? What kinds of energy are included in the equation? What does this equation have to do with escape velocity? What is *R(t)*?
4. What is the significance of the constant *k*?
   - For $\Lambda = 0$ universes, what does $k < 0, = 0, > 0$ mean for two key parameters describing the universe.
   - For $\Lambda > 0$ universes (like our own), what does $k < 0, = 0, > 0$ mean in terms of the properties of the universe?
5. Know what is meant by the critical density, by $q_o$, and by $\Omega$.
6. Know how to solve Friedman's equation for $k = 0$. I might ask you to set up the integrals needed to solve this equation, for some slightly different circumstance than the examples given in my notes and in CO.
7. Describe what is meant by the Cosmic Microwave Background? How, when and where was it formed? Why did it have a blackbody energy distribution when it was formed? Why does it still have a blackbody energy distribution now?
8. What was the basic idea behind the Steady State Universe model? What ruled out this model?

9. Big Bang nucleosynthesis.
   - What does the primordial $^4$He/H ratio tell us?
   - How is this measured?
   - What do the primordial D/H, $^3$He/H, Li/H ratios tell us?
   - What is meant by "primordial" abundances?
10. Curved space: What does it mean?
    - Explain to me, by analogy with the white sphere, what the $\varpi$ coordinate represents. Why is it used?
    - Why does the R-W metric contain only 3 space-like dimensions plus 1 time-like dimension, if it really represents something curved off into an additional 4$^{th}$ space-like dimension (for a total of 4 space-like plus 1 time-like = 5 dimensions).
    - What are proper time and proper distance?
    - What does a metric equation measure? (think in terms of an answer 1 paragraph long, not 1 word long).
11. Dark Energy:
    - How does it relate to the Cosmological Constant?
    - What is the behavior of the effective force due to Dark Energy? How does it scale with *R(t)*?
12. What is meant by the "radiation era", "matter era", and "$\Lambda$ era"?
13. Know how to use the R-W metric to calculate the path of photons in assorted situations.
14. Particle horizon: What is it? How does horizon distance depend on time?
15. What are luminosity distance and angular size distance?
16. Redshift-mag relation, angular size test: Explain in words and/or equations how these work.
17. What is a standard candle?
    - What are the best standard candles currently available?
    - What have they told us about the cosmological constant? Using what test/relation from (16)?
18. What result does the cosmological constant have on the evolution of the universe? Sketch on a diagram of *R(t)* vs *t*. Be able to explain the shape of the curve you draw, in terms of what forces/densities dominate at what times.



A likely plot to use somewhere.

**WHAT YOU DO *NOT* NEED TO KNOW.**

[CO Ch. 29] has 193 equations in it. That's about 20 times more than the ones you ought to be able to remember. The ones that really matter are summarized on the sheet of equation in the Oct 30 lecture notes.

But many of the equations in [CO] are there as examples of how to work with the basic equations such as the RW metric and the Friedman Equation. So they are a very useful tutorial.

*General Relativity:* I will expect you to know and understand the material in CO Chapter 17. But I will *not* examine you about the additional information that I gave on Slide 8 of Oct. 16 through Slide 3 of Oct 19, concerning the Einstein Equation and how to solve it. Nor will I examine you about how to derive or use the definition of energy in relativity. I told you about that extra stuff because I thought that you rightfully might be wondering about it.