AST 301 Scalo
Review for Exam #7

Exam 7 covers chapters 26 and 27. As on previous exams, emphasis is on understanding the basic ideas and their implications and connections, not on memorization of details or on numerical values. To simplify things, let's agree that I will not test you on any of the Discovery or More Precisely boxes, but strongly encourage you to read them just because they are interesting (e.g. you will learn how strange "string theory" is). There will be a number of questions related to deuterium and helium as produced in the era of nucleosynthesis and how those provide tests of cosmological models. However you do not have to memorize any of the nuclear reactions involved.

A few of the exam questions will be versions of some of the questions found at the textbook web site multiple choice self-tests, or at the end of the chapters, or on this review sheet. Suggested questions are listed below. I strongly suggest that you do not try these questions until you have thoroughly studied—it is a waste of time otherwise, other than indicating whether you need to study more. Another suggestion that bears repeating: Test yourself by seeing if you could explain most of the material, or the answers to the questions at the end of the chapter (Review and Discussion), to someone who hasn't taken the course, without consulting the book at all. Not being able to do this (and it should be pretty clear when you can't) is a sure sign that you don't understand the material enough and need further study. The "Learning Goals" at the beginning of the chapters, in case you haven't noticed them, and the "Review and Discussion" questions at the end of the chapters, are often perfect for this kind of review, although not all of them. I'll suggest some below.

The TA, Julie Hollek-Kruger, will have office hours Thursday 2-4 (as far as I know at the time of this writing). For people who can't make Julie's hours, I am reserving some hours on Wednesday. Otherwise, the best bet is to have a telephone review session: 478-2748, any time between noon and 9pm on Wednesday, and 9am to 9pm Thursday. If I'm not there, leave a message and state your name and phone number clearly, or just call back later—I sometimes don't check my phone messages frequently. Do NOT ask about the material by email—it is too time-consuming and easily misunderstood—feel free to call. But waiting until Thursday evening is generally not a good idea.

Chapter 26 (Cosmology). Because this material has been discussed at length in lecture, I won't enumerate the sections--all of them are important. Don't be too worried if you feel like you don't understand the material on the curvature of space: very few people really understand that. But do remember the 2-dimensional analogies so that you'll know what we're talking about if you encounter the terms "closed" and "open" universe. Similarly, I don't expect you to understand Fig. 26.11, although the evidence presented there is something that you should try to explain in words. Same with Fig. 26.34—I'm not going to be specific about those curves, but you should be able to make sense of them if you understand 26.8 and 26.9. We didn't talk about the reason there is a Fig. 26.18, so the point it is illustrating won't be on the exam.

I found that the "Learning Goals" at the beginning of the chapter provide a clean way to find if you have been keeping up well enough that you can verbalize the answers to the points listed there. All of them should be within your reach, except number 7 which you can skip.
Remember that the first sections of ch.26 are presented in a strange order, telling you about the largest structures in the universe as if it was just because "biggest" is interesting, a curiosity, but actually that observational material is the test for the cosmological principle, which is presented after those observations. The order is corrected in the slides.

End of chapter:
Review and discussion: All except 10, 18, 19, 20. Especially important are 4, 7, 9, 11, 12, 15.
TF/MC: 11, 12, 14, 15, 19, 20. (Most of these are fairly easy).
Online ebook: MC1: 4, 6-13, 15; MC2: 1, 2, 6, 7, 10-13.

Chapter 27 (The Early Universe). This is a challenging but extremely interesting chapter because of all the strange phenomena and physical conditions discussed. I am mostly concerned that you get the basic ideas. In particular, you don't have to memorize the numerical or other details of Table 27-1 (and I won't ask you about much terminology, like what is a hadron or a lepton, etc.). But we did go over a simpler version of this "time line" in detail in class, so I do expect you to know what went on and when (i.e. roughly how old the universe was when this or that occurred) during the following key phases: 1. Nucleosynthesis; 2. Inflation; 3. Creation of virtual particles and antiparticles; 4. Decoupling of matter and radiation (and why that implies that there must be a cosmic background radiation); and 5. The formation of galaxies from fluctuations. *Note: these are not in the correct order, just so you will at least have to learn that much about these events*. The horizon and flatness problems are difficult to understand intuitively for most people, but you should be able to say what they are, and why inflation solves them. We only talked about that briefly in class on Wednesday, but the textbook has an excellent presentation. You should also be able to explain the evidence that supports the big bang theory in general, and inflationary cosmological theory in particular, and which evidence indicates the presence of a large component of "dark energy." These are all related, so see if you can explain that relation. Finally, you should be able to explain what the cosmic background radiation is, and what properties of it are important as a test of the big bang theory, or as a diagnostic of dark matter and energy (for example its temperature, its spectrum, and especially the analysis of its "blotchiness"). Try "Learning Goals" 4-8 at the beginning of the chapter.

End of chapter:

Review and discussion: All except 1, 8, 17. Also, 10 requires a long narrative answer.
Especially important are 4, 6, 7, 11, 12; 13-16 are all about inflation, so think about these as a group; 19, 20 are about COBE and WMAP.
TF/MC: 13, 16, 17, 18, 19. NOT 14, 15, 20.

Online ebook: MC1: 2, 4, 7, 9-14. MC2: 1, 2, 3, 5, 7, 8.

We will try to get the scores to Blackboard by Friday night or Saturday morning. After that I will send you a guide for computing your final average score, so in principle you should be able to compute your final grade by Saturday night. You should already have a record of your scores, but they are preserved at Blackboard. If you are a borderline case, you will have to be patient—please don't call me and ask to be pushed up to the next highest grade. I try to be as generous as possible with the final grades, but can't make any exceptions unless there is truly a special circumstance.

Good luck.

Sample questions follow.

Here are ***eight sample review questions****; they are of the more difficult variety, so don't be too discouraged if you have to think a while to come up with the answer. On the other hand, if you think you are guessing at many of the answers, or if it seems to you like more than one answer could be correct, you probably need more studying. Some will be recognized as versions of questions you see at the end of the chapters or at the online ebook.*

1. Whether or not the universe will expand forever can, in principle, be determined by
a. an accurate measurement of the Hubble constant.
b. an estimate of the average density of the universe.
c. observations of the cosmic background radiation.
d. measurements of the helium abundance in very old stars.

2. If the expansion age of the universe was determined to be 8 billion years,
a. it would be difficult to understand how galaxies had time to form.
b. it would be difficult to understand how globular cluster stars could be as old as we think they are.
c. it would be difficult to understand the cosmic background radiation in terms of the big bang theory.
d. it would be difficult to understand the observed abundances of the elements.

3. Five billion years in the future the predominant wavelength of photons in the cosmic background radiation will be _______ (Assume the universe will expand for at least this long.)
a. ultraviolet b. visible c. infrared d. radio

4. What happened during the era of the big bang that gave rise to the cosmic background radiation?
a) Strong, weak, and electromagnetic forces were no longer one single force.
b) Neutrons and protons were formed.
c) Dark matter and baryonic matter no longer interacted.
d) Electrons and nuclei combined to form atoms.
e) Galaxies formed, emitting large amounts of light.

5. What primary role was played by dark matter in the early universe?
a) It gave rise to the period of inflation.
b) The cosmic microwave background radiation is the result of dark matter decoupling from baryonic matter.
c) Its density fluctuations determined the overall large-scale structure of the universe.
d) It limited the nucleosynthesis of heavy elements during the Big Bang.

6. The current deuterium abundance tells us that
a) the dark matter cannot be baryons. b) a phase transition probably took place.
c) the universe is probably closed. d) the universe is probably open.

7. Observations of the cosmic background radiation by WMAP are most important for:
a.. confirming the expansion of the universe
b. determining that the temperature of the radiation is almost exactly what was predicted by the big bang theoretical calculations.
c. showing that there are features analogous to spectral lines in its spectrum, so it is not a perfect blackbody as was previously thought.
d. providing strong evidence in favor of a universe that is almost exactly flat.

8. One of the appeals of the theory of "inflation" in the early universe is that it explains
a. how galaxies formed.
b. why the average density of the universe is close to the critical density.
c. how our universe got so large in only 10 billion years.
d. the difference between the ages of the oldest stars and the Hubble time.