MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Physics Department

Physics 8.286: The Early Universe Tuesday, February 5, 2002
Prof. Alan Guth

COURSE INFORMATION

INSTRUCTOR: Alan H. Guth, Room 6-209, Ext. 3-6265, guth@ctp.mit.edu.
TEACHING ASSISTANT: Jamie Portsmouth, Room 37-638, Ext. 5-9755, jamiep@mit.edu.
SECOND TEACHING ASSISTANT: Catalina Buttz, cmbuttz@mit.edu
CLASS HOURS: Tuesdays and Thursdays, 9:35 – 10:55 a.m., in Room 4-159.

REQUIRED TEXTBOOKS:

The First Three Minutes, 2nd updated edition (Basic Books, 1993), by Steven Weinberg.

Cosmology, Third Edition (Clarendon Press, Oxford, 1996), by Michael Rowan-Robinson.

RECOMMENDED BOOKS:

Particle Physics in the Cosmos (W.H. Freeman, 1989), edited by R.A. Carrigan, Jr., and W.P. Trower. A collection of readings from *Scientific American*.

The Inflationary Universe (Perseus Books, 1997), by Alan H. Guth.
(I know him, I think)

LECTURE NOTES AND OTHER READING:

There is no textbook that I know of that is really appropriate for the intended content of this course. Weinberg's **The First Three Minutes** is a superbly written book which gives an excellent description of the synthesis of the light chemical elements, but it does not describe the mathematical details. It has a mathematical appendix, but the description there is very sketchy. Before 2000 I used Joseph Silk's **The Big Bang** as the second required book in this course, but this year, as in 2000, we will be using Rowan-Robinson's **Cosmology** instead. The main purpose that I would like this book to fulfill is to acquaint you with the observational aspects of cosmology.

The bulk of the course, however, will be based on lecture notes that will be handed out periodically. The material in these lecture notes will be essential for doing the problem sets and quizzes, and will in fact form the backbone of the course.

For the first part of the course (classical cosmology), the lectures and the associated lecture notes will describe the subject at a level of detail somewhat

beyond the level of the textbooks. For the second part of the course (modern particle physics and its recent impact on cosmology), we will rely almost entirely on the lecture notes which will be handed out. You will also be asked to read several articles from *Scientific American*. Most of these articles will be contained in the reprint volume listed above. I recommend that you buy this book, because it contains a number of interesting articles, but I will try to make available xerox copies of the assigned articles for those of you who choose not to buy the book.

GRADING:

75% of the course grade will be based on quizzes, which will be given in class during the normal lecture period. There will be four of these quizzes, and there will be no final exam. The remaining 25% of the grade will be based on problem sets. Problem sets will be assigned about once every two weeks, depending on the length of the problem sets and on the pacing of the material being covered.

SPECIAL RELATIVITY:

In the old days I began this course with a unit on special relativity, which consisted of two sets of lecture notes and about four lectures. However, with the advent of 8.033 this seemed a bit redundant, so in 1996 I dropped relativity from the syllabus. Nonetheless, since the notes are written and the subject has some relevance to cosmology, I will still hand out the lecture notes, for those who want to read them. You will be required to read only the part about the Doppler shift, which is on pp. 1–6 and 20–21 of Lecture Notes 1. Except for these sections, there will be no homework and no quiz problems related to special relativity. There are just a few notions from special relativity that are really necessary for the rest of the course (such as $E = mc^2$), and I will make sure to point them out and summarize them carefully as we go along.

COURSE OUTLINE:

1. Kinematics of Newtonian Cosmology
2. Dynamics of Newtonian Cosmology
3. Introduction to Non-Euclidean Spaces
4. Black-Body Radiation and the Early History of the Universe
5. The Accelerating Universe and the Cosmological Constant
6. Big-Bang Nucleosynthesis
7. Problems of the Standard Cosmological Model
8. The Standard Model of Particle Physics
9. Grand Unified Theories and the Magnetic Monopole Problem
10. The Inflationary Universe Model

HOMEWORK POLICY:

In this course I regard the problem sets primarily as an educational experience, rather than a mechanism of evaluation. I have allocated 25% of the grade to problem sets in order to encourage you to do them, and to make it easier for students who find it difficult to do well on tests. You should feel free to work on these problems in groups, and I would encourage you to do so. However, it is important pedagogically that each student write up the solution independently. The simple copying of a friend's paper is not the kind of diligence that the grading is intended to encourage, and if discovered it will result in zero credit for that assignment. Solutions to many of the problems have been handed out in previous years, but I urge you for pedagogical reasons not to use these solutions— it is far better for you to figure out the answers, either on your own or with a group of friends. A homework paper which appears to be copied from a solution handed out in a previous term will also be given zero credit.

MORE ADVANCED READING:

There are some excellent graduate-level textbooks on cosmology that you might want to look at. These books are well beyond the level of this course, but I mention them in case any of you become interested in pursuing some topic at a more advanced level. The first two are written from the astrophysical point of view, while the last three describe the early universe from the particle physicists' slant:

Cosmological Physics (Cambridge University Press, 1999), by John A. Peacock.

Principles of Physical Cosmology (Princeton University Press, 1993), by P.J.E. Peebles.

The Early Universe (Addison-Wesley, 1990), by Edward W. Kolb and Michael S. Turner.

Particle Physics and Inflationary Cosmology (Harwood Academic publishers, 1990), by Andrei Linde.

Inflationary Cosmology (World Scientific Publishing Co, 1986), edited by Laurence F. Abbott and So-Young Pi. (This is a reprint book of published technical articles.)