COMPLEXITY AND THE UNIVERSE II
SCI 319U (CRN 63256) PH 367U (CRN 63007)
Portland State University
Course Syllabus Spring term, 2008

"We don't receive wisdom. We must discover it for ourselves after a journey no one can take for us or spare us." —Marcel Proust

Meetings: Tu/Thur 4:00 to 5:50 p.m. Room 469 Science Building 2
Instructor: Doug McCarty
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Office Hours: After class or by appointment

Required Text: *Your Cosmic Context: An Introduction to Modern Cosmology*, Todd Duncan & Craig Tyler, Addison Wesley, 2009. ISBN # 13: 978-0-13-24000010

While reading the text, please note any changes you feel would make the book more effective/helpful/understandable. In May, the co-author of your text, Dr. Todd Duncan, will be visiting the class and is keenly interested in your suggestions.

Course Description: An introduction to cosmology with an emphasis on understanding how knowledge from physics and astronomy affects your view of the universe and your place in it. The course will include lectures, discussions, and reading as well as lab activities to help you understand the experimental and observational basis for our knowledge about the universe. Think of the class as a space to ask "big questions" and formulate your own answers to them, motivated and guided by information from modern scientific cosmology. 3 credits.

Course Objectives:
1. Learn the major insights provided by modern science into the nature of the physical universe as a whole – our cosmic context
2. Understand the scientific method by which these insights were gained, so you can evaluate them for yourself and also be prepared to evaluate future developments
3. Develop your own way of integrating this knowledge of the cosmos into your personal perspective on life

General comments: To do well in this class you need to *be engaged* in making sense out of some pretty mind-stretching information about the universe we live in. Ask questions in class, in your journal, or on the online discussion forum. Try out new ideas that occur to you in response to what you read and what we discuss in class. Experiment with different ways of understanding and picturing the universe around you. Consider your classmates' points of view and notice where you agree or disagree, and why. Don't be intimidated if some of the material is confusing or doesn't make sense at first, or involves math or physics terms that are unfamiliar. To succeed, I don't ask that you figure it all out. Part of the wonder is knowing we'll probably never understand the universe completely. I only ask that you stay engaged with the ideas: react to them, notice what you find difficult to understand, ask questions to pinpoint sources of confusion, and write about your thought process in your journal and/or the class discussion forum on Blackboard. Class activities and reading assignments will help you understand core concepts and provide information to challenge your thinking.

Reading: Reading assignments are to be completed before class on the day they are listed. Not all of the topics will be covered during lecture. Also, we will be discussing basic concepts using participation-based activities and group work. These interactions are the most efficient and the most fun when everyone has read the material. I will sometimes have short reading quizzes at the beginning of class to encourage you to keep up with the reading. I'll hand out

learning objectives for each reading assignment to help focus your attention on the main ideas as you read.

Learning Journals: A central theme of this course is reflecting on what we learn about the universe through science, and figuring out how it applies to our individual lives. To help with this, keeping a journal will be an important part of your learning in the course. This should be a written record of your thinking process: jot down questions that come up for you in class, summaries of lab activities, insights about things you figure out, sketches that help you visualize something or organize a set of concepts, ideas for your final project, examples of things you learned that come up outside of class, etc. Anything you think about that is related to the course is fair game for your journal.

Your journal will be graded in two ways:

1) During each exam, be sure to bring your journal to class with you so I can check for completeness while you're taking the exam (the grade will just be yes or no: are you keeping a reasonably complete journal?).
2) Twice during the term (see schedule) you will go back to your journal, reflect on what you've written, and pull together some parts of it into a *journal paper* (typed, max 1 page single-spaced writing, plus any pictures or drawings you want to include), that you turn in to me for a grade. Grading will be based on clarity and thoughtfulness of your reflections.

Final Project: The final project will form the core thread running through the course. In a way the purpose of everything else in the course is to help you identify a deep, burning question about the universe that you would like to investigate, and the project is your chance to follow this question through, try to answer it, and teach the rest of the class what you have learned. **(See Final Project Description)**

Exams: We will have 3 exams during the term (see schedule), covering the assigned reading and class discussions. The purpose of the exams is to make sure you're learning the key science content of the course well enough to reflect thoughtfully on what it all means to you and your life. Questions will be very similar to those we will work on in class and to the exercises in the text, so if you keep up with the reading and participate actively in class, you should do well on the exams.

Grades: The final grade breakdown will be as follows:

Exams (3)	30%
Final Project	30%
Journal Papers (2)	20%
Journals (3 checks, at each exam)	10%
Class Participation (includes reading quizzes)	10%

A= 90=100% B= 80=90% C= 70=80% D= 60-70%

Academic Honesty: Examples of cheating include (but are not limited to) looking at someone else's test, using unapproved notes on a test, and plagiarism. Anyone caught cheating will receive a minimum sentence of a zero for the work on which the offense occurred. Depending upon the severity of the offense or upon repeated offenses further action may take place including failing this course.

Learning Support: Services and accommodations are available to students covered under the Americans with Disabilities Act. If you require accommodations in this course, you must immediately contact Edna K. Gehring, Director of Learning Support Services for Students with Disabilities at x2107 or email her at LSS@pacificu.edu. She will meet with you, review the documentation of your disability and discuss the services Pacific offers and any accommodations you require for specific courses. It is extremely important that you begin this process at the beginning of the term. Please do not wait until the first test or paper.

Complexity – Spring 2008 - Schedule

** **Note:** *Reading should be completed* BEFORE CLASS *on the day it's listed*. We will sometimes have short reading quizzes at the start of class to encourage this habit.

YCC = *Your Cosmic Context*

Week	Day	Date	Topics Covered	What's Due
1	Tu	1-April	What's the course about and why should you care about cosmology? "Powers of Ten" video. Introduce yourself. Informal survey.	
	Th	3-April	What is science? Expanding awareness, Observing the sky, angles, constellations Quick tour of what we can see	YCC ch 1
2	Tu	8-April	Our cosmic neighborhood, Light, parallax, distances to stars, , the Doppler effect, "Where the Galaxies Are" video	YCC ch 2
	Th	10-April	Spectroscopy	Reading Quiz # 1
3	Tu	15-April	Inverse square law, standard candles, the astronomical distance ladder, distance scales	YCC ch 3 Submit presentation topic-one paragraph will suffice.
	Th	17-April	Galaxies, the Local Group, globular clusters, galactic superclusters	Reading Quiz # 2
4	Tu	22-April	Gravity, spiral structure, dark matter	Exam # 1 Bring Journal to class YCC ch 4
	Th	24-April	The Hubble Law, Cosmic Microwave Background, Olber's Paradox	Journal paper#1due YCC ch 5
5	Tu	29-April	General relativity and curved space, the Equivalence principle, black holes, quasars	YCC ch 6 Reading Quiz # 3
	Th	1-May		journal check
6	Tu	6-May	Expanding space, balloon analogy	Exam # 2 Bring journal to class YCC ch 7
	Th	8-May	Photons and gravity	
7	Tu	13-May	The Cosmic Background Radiation	YCC ch 8
	Th	15-May	Dark matter	
8	Tu	20-May	Stellar genetics (The ancient history of you)	YCC ch 9
	Th	22-May	Energy fusion in stars	
9	Tu	27-May	Tools for interpreting observations: instruments for observing at many wavelengths	Journal paper # 2 due
	Th	29-May	The Big Bang Theory aka "The expanding Universe Theory". What does it mean to you? Anthropic thoughts.	YCC ch 10; scan chapters 11,12 & 13
10	Tu	3-June	History of the universe; evolution of complexity and structure. Emergence of life The Drake equation	YCC ch 14 Student presentations
	Th	5-June	Your cosmic context	Student presentations Project paper due

Learning Outcomes for Reading *Your Cosmic Context*
Complexity and the Universe, Spring 2008

After reading Chapter 1 you should be able to:

1. Recognize the importance of asking good questions, describe some of the questions we will investigate in this course, and articulate some of your own questions about the universe.

2. Explain the key elements of the scientific method and what distinguishes science from other ways of knowing about the world. (Including the importance of observations, the meaning of a "theory" and how theories are tested, and the meaning of uncertainty in scientific results.)

3. Work with numbers in scientific notation and read basic graphs.

4. Give a thoughtful answer to the question, " What relevance does learning about the vast universe have to your daily life?"

After reading Chapter 2 you should:

1. Understand angles and how they can help you find your way around on the sky.

2. Be familiar with the different types of objects in the sky and what they look like (e.g. planets, stars, galaxies, nebulae).

3. Know what waves are and the relationship between speed, wavelength, and frequency for waves.

4. Understand light as a wave and know what distinguishes light of different colors. You should also be familiar with the different kinds of light on the electromagnetic spectrum.

5. Understand spectroscopy (separating light into different "colors") and why it is useful in astronomy.

6. Be familiar with different ways of measuring distance and velocity of objects in space (e.g. Doppler shift, proper motion, and parallax). You should have a thorough understanding of parallax and how it enables us to measure distances.

After reading Chapter 3 you should:

1. Recognize that hot objects glow with a color that depends on the temperature of the object ("blackbody radiation").

2. Understand the inverse square law for light and know how to use it to determine the distance to a star of known luminosity ("standard candle").

3. Be able to provide a rough description of the physical scale of things in the universe (Section 3.3 and "The Size of the Skies").

After reading Chapter 4 you should:

1. Understand the relationship among gravitational force, mass, and distance that is summarized by Newton's law of gravity: $F = G\frac{m_1 m_2}{r^2}$.

2. Understand how astronomers can use Newton's law of gravity to reveal the presence of objects they cannot see.

3. Be able to describe the dark matter problem and the evidence for it.

After reading Chapter 5 you should:

1. Be able to summarize each of the six cosmic clues about the overall nature of the universe.

2. Be able to describe the observational evidence behind each clue.

After reading Chapter 6 you should be able to:

1. Comment thoughtfully on the meaning and mystery of the concepts of space and time.

2. Explain what it means for space to be curved vs. flat, and give examples of how you could tell if you are living in a curved space.

3. Describe the equivalence principle.

4. Summarize how general relativity explains gravity and describe some of the evidence supporting general relativity as a correct theory of gravity (compared to the Newtonian theory of gravity).

After reading Chapter 7 you should be able to:

1. Explain what it means for space to be expanding.

2. Describe how expanding space arises naturally within the framework of the theory of general relativity.

3. Describe how the expansion of space explains the Hubble law for galaxies, one of the key cosmic clues from Chapter 5.

4. Define the term "dark energy" and explain why astronomers believe it must exist.

After reading Chapter 8 you should:

1. Know the conditions required for an object or collection of particles to emit light as a blackbody spectrum.

2. Understand how photons interact with electrons and recognize that studying the photons we receive tells us about the conditions (temperature, structure, etc) of the electrons they last interacted with.

3. Be able to describe how the CMB was produced and be able to interpret the clues it gives us about the conditions of the early universe.

After reading Chapter 9 you should:

1. Understand the principle of conservation of energy and its applications.

2. Recognize that thermonuclear fusion is the energy source that powers stars and constructs heavy elements out of lighter ones in the process.

3. Be able to describe the major events in the life cycles of low-mass and high-mass stars.

4. Be able to describe the cosmic origins of the elements in your everyday surroundings, including your own body.

After reading Chapter 10 you should be able to:

1. Summarize the key observations that any theory of the universe must be able to explain.

2. Describe what the big bang theory says and how it explains the key observations about the universe.

3. Respond thoughtful to the question, “Isn’t the big bang just a theory?”

After reading Chapter 11 you should be able to:

1. Describe how the densities of matter, radiation, and dark energy in the universe have changed over time.

2. Describe some of the major events in the history of our universe within the context of the big bang theory.

3. Describe possibilities for the future evolution of the universe and explain how the destiny of the universe is connected to the density of matter, radiation, and dark energy within it.

Chapter 12

How structure emerged from smoothness

Chapter 13
Life

Chapter 14

What does it mean?
Anthropic
Describe your universe again - what does it mean to be human within this cosmic context

Final Project Description

Summary

This is where you get to personalize the material in the course and explore in-depth a question that is meaningful to you. Pick something that matches your interests, *articulate a clear question to guide your research,* and then prepare a **paper** and a **poster** (this can be on the computer) to tell me and the rest of the class about what you learned. You may work individually or in groups of up to 3.

Requirements

• Identify a clear question or objective to address related to the course content in some way. This part is very important: picking a clear question to tackle is often more than half the battle in science. To emphasize its importance, 10% of your project grade will be for a short write-up of this question (**due Thursday, April 10**), explaining what the question is, why it is of interest to you, and how you will go about answering it.

* Turn in a paper that explains what you learned (**due Thurs. June 7**). Whether you are working alone or in a group, every individual is required to turn in a write-up. I don't want to give specific restrictions on this paper because its form depends on the type of project. (a paper explaining a work of art you've made will be very different from a library research paper, or a procedure description for an experiment you conduct, for example), so I'll talk to you individually or in a group once a question has been chosen. But in most cases I expect it will be roughly a 2 to 3 page paper (double-sspaced) explaining the background of your question, what you did to investigate the question, and what you learned.

* Present a "poster" for your classmates to view during the last week of class (your key points pinned to a poster board or the wall, or displayed on one of the computers in the classroom). A PowerPoint presentation is fine. Humor is not discouraged! Please limit your presentation to ten minutes. (**Due last week of class**).

Generating project ideas

The best way to find a project you'll care enough about to work on is simply to start asking yourself questions. What interests you about the universe? What have you always wondered about? Start with your big questions and focus them into a project. Bring up your ideas during class, so you can get feedback and other ideas from classmates.

There are a myriad of sources to be found on the web. Enjoy your voyage of discovery!