AS311: Planetary Physics **Course Perspective and Syllabus** **Fall 2016**

Instructor: Professor Jeffrey Hughes
Office: CAS Rm 402; e-mail: hughes@bu.edu; tel: 3-2696
Lectures: Tuesday and Thursday, 12:30-2:00, Rm CAS 502
Discussion: Friday, 12:00-1:00, Rm CAS 502
Office Hours: Tuesday 2:00-3:00, Friday 8:30-9:30, 1:00-2:00, or by appointment.
Prerequisites: PY211/212 or 251/252; MA123/124 or 127.
Recommended Text: **Fundamental Planetary Science,** by Jack Lissauer and Imke de Pater, Cambridge Univ. Press, ISBN 9780521618557
The Solar System, 1st or 2nd Edition, by John A. Wood, Prentice Hall.
Other Texts (All these books are available in the Astronomy Library):
Planetary Sciences, Imke de Pater & Jack Lissauer (Camb Univ Press)
Physics and Chemistry of the Solar System, John S. Lewis
Discovering the Solar System, Barrie W. Jones
The New Solar System, Beatty, Petersen, and Chaikin
Planetary Science, George Cole & Michael Woolfson,

THE COURSE:
Planetary science is concerned with understanding the origin, evolution, and structure of planetary bodies, primarily those in our own solar system, but increasingly those orbiting other stars. Planetary scientists must apply a knowledge of physics, chemistry, and to a lesser extent biology, to the study of planets, as well as extrapolating understanding gained from studying our own planet, Earth, that is earth science. (In many universities, there is a single department of Earth and Planetary Science, often separate from the astronomy department.) While this course will assume a basic familiarity with chemistry and earth science, it emphasizes using the physics and mathematics learned in freshman courses to understand the planets in our solar system and solve related problems. Although the subject matter has a lot of overlap with AS202, we will be going deeper into the physics, and covering less descriptive material. The process of science is to take observations, things we can directly measure or see, and use these to deduce the nature of what is around us. We use our knowledge of how the physical universe behaves, the laws of physics, to do this. Having completed at least freshman physics and calculus, you are now in a position to really start doing that, so we will.

Material Covered: The topics to be covered in this course are listed in the course outline (last page of this syllabus). I have divided the material into six major **Topics**. For each I have listed the relevant chapters from the two recommended texts (see below). We begin with celestial mechanics – that is, motion under the force of gravity. Then we go on to treat planetary atmospheres, surfaces, and interiors. Next we discuss minor bodies in the solar system, which are the most primitive. Finally we discuss planets discovered around other stars and the formation of planetary systems, including our own. Underlying this structure there is a second thread that deals in turn with mechanics, thermal physics, nuclear physics, and then brings it all together in the formation of the solar system. There is a rough (but not exact) correspondence between each subtopic in the course outline and each lecture.

Readings & Texts: This course is based on the notes I have developed through teaching the course many times. However, I have never found a completely satisfactory textbook. This year

I'm recommending (but not requiring) a book that I used last time I taught the course *Fundamental Planetary Science,* by Jack Lissauer and Imke de Pater. We'll cover about two thirds of this book, but not the detailed treatments of individual planets. I'm also strongly recommending you read *The Solar System* by John Wood. This book provides a planetary scientist's view at a much less technical level. I will cover everything in *Wood*, except Chapter 7, but again not in the same order and not always with the same emphasis. This book is out of print but second hand copies are available on Amazon starting at 29c.

Since I won't be closely following a text, you are going to have to do your reading intelligently. Your best resource will be your own course notes, but I expect you to supplement your notes by reading texts. I will **NOT** give you detailed **assigned readings**. You should read the texts in parallel with the lectures. The chapters of *Lissauer and de Pater* and *Wood* most relevant to each major topic are listed in the course outline (last page). Keep referring to this outline. By this stage in your academic career you should be learning to use texts independently and know whether you benefit most from reading the text before we cover material in class, afterwards, or perhaps both.

Lectures and Discussion Section: This course meets twice a week for a lecture and once for discussion. I will use the 26 lectures primarily to present new material and answer questions from the previous lecture. I will use the discussion section at noon on Friday for various purposes: to discuss the problem sets and problem solving; to show you examples; to hand back and discuss assignments; to discuss the paper assignment and paper writing; to review for midterms; and to discuss any questions or issues you want to raise. I will also use these times to hold midterms, and occasionally I might use that time for a make-up lecture (giving you good notice). It is important that you attend these discussion sections. Right after these sections I will continue with an office hour session. Office hours are immediately after class and on Tuesdays and Fridays and on Friday at 8:30; office hours are held in my office inside CAS Rm 402.

ASSESSMENT:

I will use three means of assessing you in this course: take-home assignments and problem sets, a term paper, and examinations. These are described below.

Problem Sets: Learning to solve problems using math and physics tools is a major part of this course. The only way I know for you to learn problem solving is to solve problems. So homework problem sets are a major component of the grade. I will give you about eight assignments or problem sets during the semester. Each problem set will have a due date clearly indicated at the top. This date will normally be one week after the assignment is given to you. Assignments may be turned in either at the end of class, or in my mailbox in the Astronomy Department Office (CAS 514) up until 5:00 pm. NO ASSIGNMENTS WILL BE ACCEPTED LATE FOR CREDIT. The office closes at 5:00 pm sharp.

Paper: Most of you will have completed WR100/150. But reading original refereed research papers and writing as a scientist does will be something new to many of you. In this course you will do both. Building on your experience with WR100/150, you will write a paper that focuses on a science problem associated with a planetary body of your choice and that is structured like a typical science paper. To explore the problem you will need to read original research papers from the planetary science literature. Writing a good science paper is not that different from writing a good analytical paper in any discipline. It consists of presenting evidence and laying out a logical argument based on that evidence clearly. I will discuss this assignment in detail, giving you precise instructions and due dates, during the first Friday discussion section.

Examinations: There will be two midterms and a final. The midterms will held on Fridays during discussion section roughly one month and two months into the semester.

1st Midterm: Friday, October 7 will cover Topic I
2nd Midterm: Friday, November 11, will cover Topics II and III (see outline).
Final Exam: Saturday, December 17, 12:30-2:30 in CAS 502. Covers the entire course.

Grades: The final semester grade will be computed as follows:

Problem Sets	30%
Paper	25%
2 Midterms, each 12.5%,	25%
Final Exam,	20%
TOTAL	100%

Academic Conduct: Every student is expected to be familiar with the Academic Conduct Code: http://www.bu.edu/academics/policies/academic-conduct-code/

All work submitted for credit must be the student's own. Forming study groups to discuss and review class material is an excellent study practice that I encourage. By all means discuss the homework assignments/problem sets with your fellow students, or with me in office hours. However, when you prepare the solution that you will hand in, work alone. I take identical answers to the same question to be evidence of collusion. When preparing your paper, you will need to refer to a number of sources, including refereed papers. Be mindful of what constitutes plagiarism (that is, not giving credit to the ideas and work of others). Be certain to give full and proper credit to all your sources. Take note of how it's done in the papers you read.

I will treat any evidence of academic misconduct very seriously, and report it to the dean's office. PLEASE DON'T RISK YOUR ACADEMIC CAREER BY ATTEMPTING TO CHEAT IN ANY FASHION.

AS311 Planetary Physics: Course Outline

Introduction: (*L & deP:* Chapter 1; *Wood*: Chapter 1)

1. Planetary Science – Astronomy or Earth Science?
2. Solar System overview – What is a Planet?

Topic I: Orbital Mechanics and Tides (*L & deP:* Chapter 2**)**

1. Simple orbits: Kepler and Newton
2. Energy, momentum, and the *vis viva* equation
3. Specifying an orbit – Orbital elements
4. Changing orbits, interplanetary orbits
5. 3 body problems – Planetary flybys, Lagrangian points, and Orbital resonances
6. Tides – Orbital decay, the Roche limit, Planetary Rings.

Topic II: Solar Heating & Planetary Atmospheres (*L & deP:* Chap. 4 & 5; *Wood:* Chap. 5)

1. Solar Radiation and Planetary Surface Temperatures
2. Heat Transport
3. Hydrostatic Equilibrium
4. Atmospheric Structure and Heat
5. Atmospheric Escape and Evolution
6. Atmospheric Dynamics

Topic III: Planetary Surfaces (*L & deP:* Chapter 6; *Wood:* Chapters 2 and 3)

1. Cosmo-chemical Constraints – abundance of the elements
2. Minerals and rocks
3. Exogenic Processes – cratering
4. Surface Processes – weathering and sedimentation
5. Tectonic Processes – volcanism, mantel motions

Topic IV: Planetary Interiors (*L & deP:* Chapter 6; *Wood:* Chapter 4)

1. Remote sensing an interior – density and moment of inertia
2. Hydrostatic Equilibrium (revisited)
3. Heat Flow and Thermal History
4. Seismology
5. Planetary Magnetism

Topic V: Non-Planetary Bodies (*L & deP:* Chapters 10, 11 & 12: *Wood:* Chapters 6, 9 & 10)

1. Planetary Satellites -- Moons
2. Meteorites
3. Asteroids
4. Pluto, Kuiper Belt, and Comets

Topic VI: Exoplanets & the Formation of Planetary Systems (*L & deP:* Chapters 14 & 15; *Wood:* Chapter 8)

1. Planets orbiting other stars
2. The habitable zone – planets and life
3. Formation of the solar system and other planetary systems