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ASTR 351.01: Planetary Science

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Astronomy 351: Planetary Science

University of Montana, Fall 2016
MWF 10:00 – 10:50 am, CHCB 231
Course Number 74858

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Office Hours: MWF 11am – noon, Th 1 – 2pm, and by appointment
Course website: Available via UMOnline/Moodle (umonline.umt.edu)

Course Description

In the past decade, planetary science has expanded beyond its traditional status as a subfield of astronomy. Technological advances in remote sensing, a growing fleet of space probes, dedicated observatories, super-high resolution adaptive optics imaging, and increased computing power have opened a huge number of new avenues of study on the nature and evolution of planetary systems. The tremendous increase in raw data and means of study has made planetary science an interdisciplinary field that draws upon astronomy, physics, geosciences and chemistry. This course will present a contemporary perspective of planetary systems – both our own solar system and the growing number of detected exoplanetary systems. The emphasis will be on application of fundamental physics to topics including orbital motion, atmospheres, interiors, and planet formation theory.

Course Objectives

My goals in this course are to…

1. Provide a survey of the interdisciplinary field of planetary science.
2. Apply fundamental physics to interpret observations of planets.
3. Develop the theory of planet formation based on observational evidence.
4. Introduce students to exoplanet science.

Reading Materials

The field of planetary science is rapidly changing, and texts more than a few years old are now significantly dated. There is no assigned textbook for this course – instead we will rely on recent journal articles to provide scientific background and motivation. These materials are available on the course website through UMOnline/Moodle. If you would like to purchase an optional textbook to supplement the course materials, I recommend *Fundamental Planetary Science*, by Lissauer and de Pater (2013).

Expectations of the Professor

This upper-division course is intended for physics majors with a concentration in astrophysics, though others with appropriate preparation are of course welcome. I expect that you will have completed the designated pre-requisite courses: Physics 215 (physics with calculus) and Math 171 (Calculus I). You should also be comfortable working with logarithms, scientific notation and the Greek alphabet!

Time in the classroom is an essential part of this course, and it will be to your benefit to attend lectures. Exams will be based on material presented in class and reading assignments. I expect students to read the material in advance of the class on a topic, and to be prepared to discuss the material. Readings from journal articles will be accompanied by a short list of questions. We will discuss the reading, and you will turn in the assignment during class. Expect to have two reading assignments and one problem set to turn in each week. Late reading assignments will not receive credit.

This course is a collaborative effort – please ask questions, offer your ideas and be prepared to participate in the discussion. Written work submitted in this course must be expressed in your own words. I specifically encourage students to work together, but each student must write up their own response to problems and prepare their own computer plots. This step is essential to your learning – writing up the answer to a question requires you to understand the conclusion of your study group, whereas transcription of the work of another student does not. When in doubt, please ask me what is acceptable.

Pedagogical Philosophy of the Professor
My primary goal in teaching upper-division majors is to help you develop physical intuition and apply principles of fundamental physics learned in introductory coursework. This class in particular is an advanced course in planetary science, an interdisciplinary field of applied physics and geosciences. As with any applied field, there is a large amount of vocabulary specific to the discipline. This course will help develop your fluency in the language of planetary science.

Research in how people learn indicates that the knowledge of an expert in a topic is organized around core concepts. In order to help you develop expertise in planetary science, I have organized this course around several core concepts. These are outlined on the class schedule in this syllabus. Each concept is associated with a number of specific learning goals, a complete list of which I will provide for your use as a study aid. Each learning goal is stated from the student's perspective. If you can achieve these specific goals, you will succeed in this course – and be well on your way towards expertise in planetary science!

Grading Policy
This course will be graded on the University's traditional letter grade system. Your grade will be based on reading assignments (15% total), weekly homework sets (35% total), three midterm exams (10% each), and a cumulative final exam (20%). I have not determined in advance how many As, Bs, etc will be assigned – I'm happy to give every student an A if they demonstrate mastery of the material. You are most definitely **NOT** competing with each other for grades! Do work together – you will learn a significant amount from your peers. Along the way I will provide regular updates regarding your grade in the course to avoid any surprises.

Homework problems will be graded on a four-point scale as follows:

4: a good effort with correct results *and* reasoning
3: a good effort with minor conceptual or math errors
2: a fair effort with modest conceptual errors *or* a good effort with serious conceptual errors
1: a very poor effort
0: no effort

A *good effort* involves at least *some* English language explanation and use of appropriate diagrams along with any calculations. I expect you to recognize an implausible result if you get one. Homework and reading assignment responses must be legible! If your first attempt is messy, use it as a draft to rewrite a final version for submission. If I can't read it easily, you'll get no credit!

Midterm exams take place during regular class time on the scheduled days. If you cannot be present, tell me *before* the exam day and we can discuss arrangements. For *well-documented* compulsory absences, we will arrange a time for you to take the exam *early*. Homework must be turned in by 5pm on the due date. Except in the case of *prior* permission from me, late homework will be docked 20% per weekday.

Course Schedule

	Date	Topic	Reading
		GRAVITY AND ORBITS	
M	Aug 29	Overview of our solar system	
W	Aug 31	Kepler's laws and orbital motion	*My Solar System*
F	Sept 2	Newtonian gravitation and the Virial Theorem	Osserman (2001)
M	Sept 5	*Labor Day*	
W	Sept 7	Orbital resonances	Minton (2009)
F	Sept 9	Tidal forces	Miller (2009)
		SOLAR HEATING	
M	Sept 12	Energy transport	
W	Sept 14	Thermal radiation and the Planck function	Pierrehumbert (2011)
F	Sept 16	Planetary energy balance	Pierrehumbert (2011)
		PLANETARY ATMOSPHERES	
M	Sept 19	Hydrostatic equilibrium	
W	Sept 21	Thermal structure	Patzold (2007)
F	Sept 23	Winds and escape	Birner (2014)
M	Sept 26	Atmospheric composition and clouds	
W	Sept 28	Comparative planetology: atmosphere origin and evolution	Hunten (1993)
F	Sept 30	**Midterm 1**	
		PLANETARY INTERIORS & SURFACES	
M	Oct 3	Morphology, bulk density, rocks & ice	
W	Oct 5	Interior of Earth: composition & structure	Wood (2011)
F	Oct 7	Internal heat sources	Brandon (2011)
M	Oct 10	Comparative planetology: interiors and differentiation	Buffet (2013)
W	Oct 12	Magnetic fields and the solar wind	
F	Oct 14	Impact cratering	Kyte (2012)
		SMALL BODIES	
M	Oct 17	Meteorites	Levi (2011)
W	Oct 19	Radiometric dating	Kita (2005)
F	Oct 21	**Midterm 2**	
M	Oct 24	Minor planets: asteroids	
W	Oct 26	Minor planets: Trans-Neptunian objects	Soter (2007)
F	Oct 28	Comets: size, structure and composition	Hand (2015)
M	Oct 31	Comets: orbits and origins	A'Hearn (2006)
W	Nov 2	Small bodies: clues to solar system formation	Brown (2007)
		PLANET FORMATION	
F	Nov 4	Star formation overview	

M	Nov 7	Disks: circumstellar and protoplanetary	Tsiganis (2015)
W	Nov 9	Planetesimals and differentiation	Canup (2004)
F	Nov 11	*Veterans Day*	
M	Nov 14	**Midterm 3**	
		EXOPLANETS	
W	Nov 16	Detection: radial velocity method	Lunine (2009)
F	Nov 18	RV method: biases and results	
M	Nov 21	Detection: transit method	Lunine (2009)
W	Nov 23	*Thanksgiving break*	
F	Nov 25	*Thanksgiving break*	
M	Nov 28	Detection: direct imaging and microlensing	Marois (2008)
W	Nov 30	Kepler mission	Clery (2016)
F	Dec 2	Observed planetary systems: orbits, masses	Howard (2013)
M	Dec 5	Hot Jupiters and planet migration	
W	Dec 7	Exoplanetary atmospheres	Hecht (2016)
F	Dec 9	Habitable planets	Seager (2013)
M	Dec 12	Astrobiology	Seager (2015)
Tu	Dec 20	**Final Exam, 8:00 – 10:00am**	

Additional Reading

Planetary science draws from astronomy, physics, geosciences, atmospheric sciences and chemistry. The field has become increasingly interdisciplinary in recent years, and newer texts reflect this change. The books below have been used to prepare lectures and course material.

Planetary Sciences, 2nd Ed., I. dePater and J. Lissauer, 2010

Atmospheric Science: An Introductory Survey, 1st Ed., J. Wallace and P. Hobbs, 1977

Physical Processes in the Solar System, J. Landstreet, 2003

Introduction to Planetary Science: The Geological Perspective, G.Faure and T. Mensing, 2007

The Solid Earth: An Introduction to Global Geophysics, C. Fowler, 2005

Exoplanets, S. Seager (ed.), 2010

Transiting Exoplanets, C. Haswell, 2010