Syllabus
AST 6112: Origin and Evolution of Planetary Systems
Spring 2015

Josh Colwell
PSB 434
Office Hours: Mondays 2:00-3:00, Tuesdays 4:30-5:30, and Wednesdays 10:30-11:30. It is likely that these times will frequently be swamped by students from my Physics 1 class, so I encourage you to make appointments, and if needed we may set up another time dedicated to this class.

josh@ucf.edu, 407-823-2012
Due to my travel and meeting schedule, it is best to confirm my availability by e-mail.

**Course rationale:** The field of planetary sciences, once confined to studies of objects in our own solar system, now encompasses the planetary systems that are being discovered on a regular basis. There are about 2000 known planetary systems now. The last time I taught this course, four years ago, that number was 400. The bulk of the difference is due to the Kepler mission. These systems display a wide variety of configurations. This course will study the physical processes and astrophysical context of planet formation and dynamical evolution in order to understand not only the history and evolution of our own planetary system but also the frequency and diversity of planetary systems throughout the galaxy.

**Course description:** We will review the observed planetary systems and basic properties of extrasolar planetary systems. We will then study the physics of astrophysical disks in the context of star formation and early stages of planet formation. The first half of the semester, roughly, will focus on disk theory, and the second half on planetesimals and orbital dynamics. The goal is to become familiar with the current state of the art in the theory of planet formation and dynamical evolution of planetary systems. Students will be prepared to read new research papers in the field and will read the latest reviews and key research papers in the field. Students will leave the course with a foundation on which to build independent research in extrasolar planets, solar system dynamics, and planet formation. Because this is the only course you will take from me, I may make occasional tangents to cover related areas of planetary dynamics that I think should be in your graduate education.

**Repeat for credit:** This course cannot be repeated for credit.

**Reading**: We will use Phil Armitage's textbook on *Astrophysics of Planet Formation* (Cambridge University Press) and *Solar System Dynamics* (Murray and Dermott, also Cambridge University Press). Additional reading will be supplied from current and classic research articles in the field as well as review papers. When possible, reading material will be provided electronically. Keep current on your reading because part of your assignments will be leading review discussions of assigned reading (see **Assignments** below).

**Course Outline:**
**(This is a proposed schedule that we may adjust based on pace and on students' interests and their selected projects. In particular we may spend more time on Dynamical Evolution.)**

1. **Introduction and Observations:** 1.5 weeks
   We will do an inventory of our own solar system and examine the key aspects that are relevant for the question for origin and large-scale evolution of the solar system. We will review extrasolar planet detection techniques and campaigns as well as circumstellar disk observations. We will review the properties of these planetary systems and circumstellar disks to provide an observational foundation for the theoretical work to follow.
   Armitage, chapter 1, Marcy et al. (2005) *Prog. Theor. Phys. Supp.*, **158**, 24; Butler et al. (2006) *Astrophys. J.*, **646**, 505.
2. **Protoplanetary Disks:** 4 weeks
   We will study the structure of passive and active disks. We will work through simple parameterized models of disks (e.g., alpha disks). We will look at the temperature profiles within disks, and solve for the diffusive evolution of disk surface mass density. We will also look at the transport of angular momentum within disks.
   Sample reading material: Dullemond et al. (2007) *Protostars and Planets V*; Lynden-Bell and Pringle (1974) *Mon. Not. Roy. Astron. Soc.*, **168**, 603; Chiang and Goldreich (1997) *Astrophys. J.*, **490**, 368.
3. **Planet Formation:** 3.5 weeks
   We will study the formation of planets from the initial coagulation of dust through the end stages of giant impacts. We will examine local gravitational instability versus binary accretion for the formation of planetesimals. We will cover the coagulation/fragmentation equation (Smoluchowski equation) and analytic and numerical approaches to solving it. We will study N-body simulations of planetsimal accretion. We will look at the influence of the forming planet on the disk and gas-disk interactions leading to migration of newly formed planets.
   Sample reading material: Lissauer (1993) *Ann. Rev. Astron. Astrophys.*, **31**, 129; Papaloizou et al. (2007) *Protostars and Planets V*; Levison et al. (2007) *Protostars and Planets V*.
4. **Dynamical Evolution:** 5 weeks
   We will look at the stability of planetary systems and migration of planets. We will study scattering of planetesimals by planets and the back-reaction on planets. This will include a discussion of orbital resonances and chaos.
   Sample reading material: Murray and Dermott *Solar System Dynamics*.

**Assignments:** Grades will be based on homework assignments, a numerical research project, leading discussions of current research papers in class, and one final journal-club-style presentation of a research paper. The research project will account for 25% of your grade, and the remaining 75% will be evenly divded between the other assignments, with exceptions made if some assignments are particularly long. Your research project will be a planetary dynamics project that will make use of existing N-body simulation software available in the planetary science community (preferably Swift, HNBody, or Mercury). The dynamics project will be due by the date of the final exam. The class will meet on the scheduled day of the final exam, **Thursday April 28, 1:00-3:50 p.m.** This period (and the last one or two class periods) will be used for final journal club presentations. Software developed for the project should be thoroughly commented and turned in electronically.

**Grading Scale**: Grades will use the +/- grade scale. Work will be evaluated for technical accuracy, clarity, and completeness. In particular, written work should be clear, concise, in correct English, and following the style of peer-reviewed planetary science publications.

**Other Policies:**

Missed Work Policy: It is Physics Department policy that making up missed work will only be permitted for University-sanctioned activities and bona fide medical or family reasons. Authentic justifying documentation must be provided in every case (and in advance for University-sanctioned activities). In this class there are no fixed exams. If an excused absence prevents an assignment from being turned in on time, then the assignment will be due at the next class period after the original due date.

Golden Rule: Please read this information at the website http://goldenrule.sdes.ucf.edu.

UCF Creed: Please read this information at the website http://www.campuslife.sdes.ucf.edu/UCFcreedpage.html.

Conduct: Please **turn off your cell phones** before entering class. I encourage you to stop the lecture and ask relevant questions in class. In a small graduate class such as this, discussion will enhance our coverage of the material.

Disability Access Statement: As stated on the website http://www.sds.ucf.edu/Faculty_Guide, "The University of Central Florida is committed to providing reasonable accommodations for all persons with disabilities. This syllabus is available in alternate formats upon request. Students with disabilities who need accommodations in this course must contact the professor at the beginning of the semester to discuss needed accommodations. No accommodations will be provided until the student has met with the professor to request accommodations. Students who need accommodations must be registered with Student Disability Services, Student Resource Center Room 132, phone (407) 823-2371, TTY/TDD only phone (407) 823-2116, before requesting accommodations from the professor."

Collaboration Policy: You may not collaborate on homeworks or projects unless they are specifically designated as group or team projects. In such cases it must be made clear what each group member contributed to the overall project.

**This syllabus is subject to change.**

**Version: Jan. 7, 2015**