Physics of Planets

EAS 4370/6370

Instructor: Indujaa Ganesh (indujaa@gatech.edu) Course website: http://canvas.gatech.edu

Course Description and Goals

The goal of this class is to provide students an understanding of processes operating on planets within and outside our solar system, how those processes shape planetary systems over time, and how remote and in-situ observations of a planet conducted by ground-based and spacecraft instruments, along with theoretical models to interpret these observations, have advanced our knowledge of physics of planets. Students will gain an overall understanding of the physics governing the orbits, surfaces, interiors, atmospheres and magnetospheres of the planets. These concepts will be placed in the context of current formation/evolution theories, and related open science questions will be discussed in terms of potential spacecraft missions.

Prerequisites

Prerequisites include MATH 2552 (or equivalent class on Differential Equations) and PHYS2211.

Course Materials and Recommended Text

Reading materials and course notes will be made available on the course website. There is no required textbook; however the course will follow topics in,

- Murray, C. D. & Dermott, S. F. (2000). *Solar System Dynamics.* Cambridge University Press.
- Lissauer, J. L. & de Pater, I. (2019). *Fundamental Planetary Sciences, Updated Edition.* Cambridge University Press.
- Melosh, H. J. (2011). *Planetary surface processes (Vol. 13).* Cambridge University Press.
- Turcotte, D. L., & Schubert, G. (2002). *Geodynamics.* Cambridge university press.

Course Requirements

This course involves lectures, homework assignments and a final project. The percentage contribution of each component to the final grade is below.

Assignments	Number	EAS4370	EAS6370
Homework assignments	4–6	50%	50%
Participation		20%	20%
Final project		30%	30%

Description of Graded Components

Homework. Homework assignments will be due one week from the date of assignment. Students can expect questions that will require literature review, short text answers, annotated sketches, and simple calculations, based on topics discussed in class. Graduate students will also work with real data. The goal of these homework assignments is to develop skills in synthesizing knowledge and applying concepts learned in class.

Participation. Participation will be evaluated based on regular attendance, presentations, engagement during presentations, in-class activities, and paper discussions.

Final project. This assignment is intended to give students the opportunity to explore a planetary body or process in greater depth, and also practice scientific writing. Students will draft a final paper at the end of the semester, and also provide a brief update on the topic and status of their project mid-semester. For undergraduate students, the final project may be a thorough literature review on a chosen topic, but projects with an original research component are welcome. Graduate students must conduct original research and report their results in addition to literature review.

- The final paper should be 5–10 pages (single spaced) and should include a motivation for the study, the primary problem explored, tools and methods used, results and interpretation, and proper citation of supporting material.
- The mid-semester update should be a presentation not more than 5 minutes long. The presentation should be accessible to a broad audience.
- *Note for EAS 6370:* Graduate students are expected to conduct original research and present the results of a calculation, experiment or model. I encourage students to explore projects that would be useful in advancing their thesis/dissertation. However, students are still required to do original research. Using results from work that has already been conducted outside the class will not count towards your grade.

Project components	EAS4370	EAS6370
Mid-term update	10%	10%
Final paper & presentation	20%	20%
Total	30%	30%

GRADING SCHEME

The final grade will be assigned as a letter grade according to the following scale: **A** $>$90%; 80 $>$ **B** $\geq$90%; 70 $>$ **C** $\geq$80%; 60 $>$ **D** $\geq$70%; **F** $\leq$60%.

ABSENCE AND LATE ASSIGNMENTS

Students are required to attend and actively participate in class. If students foresee the need to miss class, due to other obligations or illness, please contact me to discuss alternate arrangements. If a student needs an extension due to exceptional circumstances, I request them to contact me as early as possible. Absence and/or late submission of assignments due to unexpected dependent care obligations will be treated equivalently to those caused by illness or obligations of the student themselves.

ACADEMIC INTEGRITY

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. It is expected that all students are aware of their individual responsibilities under the Georgia Tech Academic Honor Code, which will be strictly adhered to in this class. For information on Georgia Tech's Academic Honor Code, please visit https://www.catalog.gatech.edu/policies/honor-code/ or https://www.catalog.gatech.edu/rules/18. Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will automatically receive a zero on the assignment and will be reported to the Office of Student Integrity, which will investigate the incident and identify the appropriate penalty for violations.

Assignments. Students are encouraged to work together on assignments; however, the answers that are turned in must be the work of each individual. Please include in your assignments the names of those that you collaborated with.

Final project and paper. Each student is expected to develop their unique project; please discuss with me beforehand if you have any concerns regarding topic selection for your project. The final paper should properly cite supporting material and not plagiarize any previous publications.

ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu /, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Then please contact me as soon as possible to discuss your learning needs.

STUDENT-FACULTY EXPECTATIONS

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The Student-Faculty Expectations articulates some basic expectations that you can have of me and that I have of you. Additional information for research-related work is given in The Expectations of Advisors and Advisees. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

USE OF ARTIFICIAL INTELLIGENCE

The use of generative artificial intelligence (AI) and large language model (LLM) tools is not permitted. Materials generated by these programs may be inaccurate, incomplete, biased, problematic, and hinder independent thinking and creativity (see results from a recent study).

RESOURCES

ACADEMIC SUPPORT

- Center for Academic Success
  - 1-to-1 tutoring
  - Peer-Led Undergraduate Study (PLUS)
  - Academic coaching
- Residence Life's Learning Assistance Program
  - Drop-in tutoring for many 1000 level courses
- OMED: Educational Services
  - Group study sessions and tutoring programs
- Communication Center
  - Individualized help with writing and multimedia projects
- Academic advisors for your major

PERSONAL SUPPORT

- The Office of the Dean of Students; 404-894- 6367; Smithgall Student Services Building 2nd floor
  - You also may request assistance here
- Counseling Center; 404-894-2575; Smithgall Student Services Building 2nd floor

  - Services include short-term individual counseling, group counseling, couples counseling, testing and assessment, referral services, and crisis intervention. Their website also includes links to state and national resources.
  - Students in crisis may walk in during business hours (8am-5pm, Monday through Friday) or contact the counselor on call after hours at 404-894-2204.
- Students' Temporary Assistance and Resources (STAR)
  - Can assist with interview clothing, food, and housing needs.
- Stamps Health Services; 404-894-1420
  - Primary care, pharmacy, women's health, psychiatry, immunization and allergy, health promo- tion, and nutrition
- OMED: Educational Services
- Women's Resource Center; 404-385-023
- LGBTQIA Resource Center; 404-385-2679
- Veteran's Resource Center; 404-385-2067

List of Topics

Orbital Dynamics: 2-body problem
Kepler's laws of planetary motion, orbital properties (position, angular momentum, velocity, and energy), Barycentric orbits

Orbital Dynamics: Restricted 3-body problem
Equations of motion, Jacobi integral, Tisserand parameter, Lagrange Points, Hill radius

Orbital Dynamics: Tides
Impacts of tides on planetary shape and motion, Roche limit

Practicum: SPICE

Planet formation
Solar system observations, Minimum Mass Solar Nebula, Protoplanetary disk structure and properties, Oligarchic and Runaway growth of planetary cores, Pebble Accretion, Planet migration

Planets: Atmospheres
Formation of planetary atmospheres, Hydrostatic equilibrium, Atmospheric scale height, Radiation energy balance, Clouds

Planets: Differentiation and Crustal formation
Formation of planetary interiors and surfaces

Planets: Collisions and Cratering
Impacts in the solar system, Energy from impacts, Impact cratering mechanics, Impactor interactions with atmosphere, Planetary surface age dating

Planets: Heating and Thermal evolution
Sources of heat in planetary interiors, Heat transport (conduction & convection), Boundary layer theory, Thermal evolution models for radiogenic and tidal heat production

Planets: Magnetic Fields
Cause of planetary magnetic fields, Observed fields, Geophysical conditions needed for a dynamo, Conditions needed for convection in the core

Planets: Gravity, Shape, and Topography
Hydrostatic equilibrium, Rotational deformation, Moment of Inertia, Fluid Love Numbers, Gravitational field and anomalies, Topographic Support