

Astronomy 381: Gravitational Dynamics

Spring 2020; MWF 10:00-11:00am, PMA (RLM) 15.216B
Unique Number 46230

Instructor: Prof. Mike Boylan-Kolchin

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Office hours: By appointment

Textbook (recommended):

Galactic Dynamics, J. Binney & S. Tremaine (Princeton University Press; 2nd edition, 2008).

The standard reference for galactic dynamics.

Additional books: there are **many** books on gravitational dynamics and applications in a variety of fields within astronomy and physics. Some that I recommend are:

- *Galaxy Formation and Evolution*, H. Mo, F. van den Bosch, and S. White (Cambridge University Press, 2010).
- *Dynamics and Evolution of Galactic Nuclei*, D. Merritt (Princeton University Press, 2013)
- *Gravitational Physics of Stellar and Galactic Systems*, W. Saslaw (Cambridge Monographs on Mathematical Physics, 1987)
- *The Large-Scale Structure of the Universe*, P. J. E. Peebles (Princeton University Press, 1980).

These additional books either contain more detail on specific topics or are good references.

Course Description

This course is meant to be a broad overview of gravitational dynamics in an astrophysical context. We will cover orbits, tides, a statistical description of N -body dynamics, self-gravitating fluids, and their application to stars, galaxies, planets, and cosmological structure. Most of the course will assume Newtonian physics; at the end, we will briefly go over the basics of modified gravity theories and General Relativity as well.

What will students in this course learn? My objectives are for students in this course to: develop their skills in dimensional analysis and order-of-magnitude problem solving; understand characteristic scales of gravitational dynamics problems and estimate solutions using pen-and-paper; solve more complicated problems either analytically or through computer calculations; read and understand journal papers of current and historical interest, and discuss these papers with peers and me; develop an appreciation for when gravitational dynamics alone can describe a physical situation versus when other dynamical processes become relevant or dominant.

Prerequisites

Graduate standing or permission of the instructor. AST 381 is suitable for beginning or advanced graduate students in Physics and Astronomy, and potentially for advanced undergraduates

Class Website

This course website will be based on Canvas (canvas.utexas.edu). Make sure that you are able to access and receive emails through Canvas.

Grading

You will receive the grade you earn in this course. **There will be no extra credit awarded during or after the semester**, so please be sure to put in the effort during the semester to earn the grade you want. Your grade will be based on the following components:

- **Homework** (approximately once every two weeks): 40%. Some homework will require basic programming and plotting. Please contact me privately if you have concerns.
- **Numerical project**: 25%. In the second half of the course, we will use techniques learned in the first half to develop a numerical code on the topic of gravitational dynamics. You will have a choice of two different problems, and you will be responsible for writing a numerical code to solve the problem. More details will be given later in the semester.
- **Oral presentations and participation**: 20%. A crucial part of being a scientist is to be able to read papers and present your ideas about them in a fair but persuasive manner. Paper reading, and a brief presentation regarding the paper, will therefore be a regular part of class. I want to emphasize that I am *not* expecting you to be an expert on any paper we read; what I do expect is that you will read the papers, try to understand them, and come ready to discuss interesting, important, or confusing points.
- **Funding proposal**: 15%. Persuasive writing is also crucial in most post-PhD careers. You will be required to write a 3-page funding proposal, modeled on the scientific justification section of *Hubble Space Telescope* proposal. This can be on observational, theoretical, or computational topics that are related to the course material (the topic must be approved by me). More details will be provided in class. This can be turned in any time during the semester.

Grading scale

A: 85 – 100

B: 70 - 84

C: 60 - 69

D: 50 - 59

F: < 50

Class Policies

- *Be respectful of your fellow students and the professor.* Please arrive on time. Do not pack up or leave class early unless you have talked to me in advance. Do not talk in class other than during designated group learning activities. Phone use and texting during class will not be tolerated. Make sure your phones are off, and keep them put away during the class. Students using their phones will be asked to leave, and will not earn participation for that day. If you are using a laptop or tablet to take notes, please make sure you are not a distraction to those around you. If laptop distraction becomes a persistent problem, I reserve the right to modify this policy accordingly.
- My official responsibilities as a professor include conducting astrophysics research, which requires travel during the semester. I will do my best to minimize the impact of this travel

and will try to maintain Canvas communication at while out of Austin. When I am gone, another PhD UT astronomer will lead the class.

- **Video and/or audio recording of lectures is prohibited unless explicitly approved by the instructor.**
- **Religious Holidays:** According to UT Austin policy, you must notify the professor of a pending absence at least fourteen days prior to the date of observance of a religious holy day. If you must miss a class, an examination, a work assignment, or a project in order to observe a religious holy day, you will be given an opportunity to complete the missed work within a reasonable time after the absence.

Academic Dishonesty

University of Texas Honor Code: The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the university is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community. Students who violate University rules on scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and/or dismissal from the University. Standards for Academic Integrity are posted at <http://deanofstudents.utexas.edu/sjs/acint.student.php>

Plagiarism: As a research university, The University of Texas at Austin takes plagiarism very seriously. Do not risk getting involved in a plagiarism infraction – the consequences simply are not worth it. Always cite your sources, and when in doubt, consult a professor or librarian. You may also read more about plagiarism at the Student Judicial Services website:

http://www.utexas.edu/cola/cwgs/_files/pdf-4/ai2012.pdf

Additional Items

Documented Disability Statement: Please notify me of any modification/adaptation you may require to accommodate a disability-related need. The University of Texas at Austin provides, upon request, appropriate academic accommodations for qualified students with disabilities. For more information, contact Services for Students with Disabilities at 471-6259 (voice) or 232-2937 (video phone) or <http://ddce.utexas.edu/disability/>

Personal Pronouns: Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender, gender variance, and nationalities. Class rosters are provided to the instructor with the students legal name, unless they have added a “preferred name” with the Gender and Sexuality Center

(<http://diversity.utexas.edu/genderandsexuality/publications-and-resources/>). I will gladly honor your request to address you by a name that is different from what appears on the official roster, and by the gender pronouns you use. Please advise me of any changes early in the semester so that I may make appropriate updates to my records.

Email: Email is recognized as an official mode of university correspondence; you are therefore responsible for reading your email for university and course-related information and announcements.

Emergency Procedures: In the event of an evacuation, follow the instruction of faculty or class instructors. Occupants of buildings on The University of Texas at Austin campus are required to evacuate buildings when a fire alarm is activated. Students requiring assistance in evacuation should inform their instructor in writing during the first week of class. Familiarize yourself with all exit doors of each classroom and building you may occupy and remember that the nearest exit door may not be the one you used when entering the building. Do not re-enter a building unless given instructions by the following: Austin Fire Department, The University of Texas at Austin Police Department, or Fire Prevention Services office. Information regarding emergency evacuation routes and emergency procedures can be found at utexas.edu/emergency.

Behavior Concerns Advice Line (BCAL): The Behavior Concerns Advice Line is a service that provides The University of Texas at Austins faculty, students and staff an opportunity to discuss their concerns about another individuals behavior. This service is a partnership among the Office of the Dean of Students, the Counseling and Mental Health Center, the Employee Assistance Program, and The University of Texas Police Department. An individual can call the line 512-232-5050. Your call can be anonymous. If something doesn't feel right, trust your instincts and share your concerns about fellow students, TAs, or Professors.

Title IX Reporting: Title IX is a federal law that protects against sex and gender based discrimination, sexual harassment, sexual assault, sexual misconduct, dating/domestic violence and stalking at federally funded educational institutions. UT Austin is committed to fostering a learning and working environment free from discrimination in all its forms. When sexual misconduct occurs in our community, the university can: (1) Intervene to prevent harmful behavior from continuing or escalating; (2) Provide support and remedies to students and employees who have experienced harm or have become involved in a Title IX investigation; (3) Investigate and discipline violations of the universitys relevant policies.

Faculty members and certain staff members are considered "Responsible Employees" or Mandatory Reporters, which means that they are required to report violations of Title IX to the Title IX Coordinator. **I am a Responsible Employee and must report any Title IX related incidents that are disclosed in writing, discussion, or one-on-one. Before talking with me, or with any faculty or staff member about a Title IX related incident, be sure to ask whether they are a responsible employee.** By state law, any responsible employee who does not report any Title IX related incidents that are disclosed to them must be fired from the University (and can be charged with a criminal offense – Class B or Class A Misdemeanor).

If you want to speak with someone for support or remedies without making an official report to the university, email advocate@Austin.utexas.edu For more information about reporting options and resources, visit titleix.utexas.edu or contact the Title IX Office at titleix@Austin.utexas.edu.