
ASTR 506

Dynamics and Hydrodynamics

Overview

This course will focus on the dynamics of gravitating systems, with emphasis on Celestial Mechanics, Stellar Dynamics, and Fluid Mechanics. The course will also contain numerical techniques used in the computational studies of these systems.

Goals

By taking this course the student will be familiarized with the theory and numerical techniques used professionally on research on the following questions: what happens when you have a large number of particles orbiting under the influence of their mutual gravity? What happens to massless particles orbiting in these gravitational fields? How does gas behave in astrophysical systems?

Requirements

The course is restricted to astronomy graduate students.

Course notes

The lecture notes will be posted on Canvas, but students are encouraged to take their own hand-written notes to better follow the material. The notes will be complemented with slides, images, and videos when appropriate.

Textbooks

The lecture notes will be complemented by the textbooks "Solar System Dynamics" by Murray & Dermott, "Galactic Dynamics" by Binney & Tremaine and "The Physics of Fluids and Plasmas", by Choudhuri.

Spring 2021 Tue/Thu 10:30-11:45am
Prof Dr Wladimir Lyra

wlyra@nmsu.edu

Zoom: <https://nmsu.zoom.us/j/7631131283>

Slack: rb.gy/cam2pm

Office Hours: TBD.

Materials

- Scientific calculation (or computer).
- NMSU Canvas will be used for lecture notes, assignments, and grades.



Class Structure

Classes will combine the elements of flipped classroom, with team-based learning. Videos of the lecture will be made available, and it is expected that the students should watch them before class. A quiz will be given to ensure it. The first 10-15 minutes of class, students will be in breakout room to discuss the content of the videos/quiz among themselves, after which they return and give a summary of the discussion, along with any doubt. The remainder (majority) of the class will be spent on computational exercises pertaining to the content of the class. This will be done also in breakout rooms, in teams that will pre-assigned for the duration of the semester.

Videos

The videos can be watched either directly on canvas, or on YouTube:

<https://www.youtube.com/playlist?list=PLatuGW739E0nGciM-qHez1qT9dgP0HWZU>

Grading

Homework will be given periodically, involving conceptual, analytical, and computational exercises. Each assignment is worth 100 points; the final grade is $(\sum_{i=1,n} HW^i)/n$, where HW^i is an individual homework assignment and n the number of assignments. Redos of the homeworks will be allowed. Homework assignments comprise 40% of the grade. Quizzes will be given regularly, comprising 20% of the final grade. Computational assignments will account for 40% of the grade.

A note on collaboration: I strongly encourage you to work with other students on the problem sets. You will find it very helpful to discuss the course material with your classmates, reviewing the overall concepts together, or discussing in general terms how to approach tricky aspects of a derivation or coding exercise. However, anything that you submit for course credit with only your name on it must be your original work and reflect your own thinking. If your solutions draw any inspiration from your classmates or group work, then please note whom you worked with.

The final grade will range from 0 to 100, and then converted to letter format. I will determine the mapping from numerical to letter grades at the end of the semester.

Topics to be covered

This is a **PRELIMINARY** list of the topics that will be covered. The list is **DYNAMIC** and **WILL** be updated as the course goes, based on how in-depth we decide to go on some topics, as well as on the interest of the class.

Class #	Date	Field	Subtopic
1	01/26	Elements of celestial mechanics	Two-body problem recap
2	01/28		Three-body problem, Jacobi constant
3	02/02		Hamiltonian dynamics, angle-action variables
4	02/04		Kozai-Lidov oscillations
5	02/09		Secular Dynamics, Resonances
6	02/11	Stellar Dynamics	Potential Theory
7	02/16		Spherical Potentials
8	02/18		Non-spherical potentials: Epicycle approximation
9	02/23		Non-spherical potentials: Types of orbit, resonances
10	02/25		Dynamical Time, Infall Time
11	03/02		Virial theorem

12	03/04		Two-body scattering
13	03/09		Dynamical friction
14	03/11		Violent relaxation
15	03/16		Boltzmann Equation
16	03/18		Boltzmann Equation
17	03/25	Hydrodynamics	Equations of Hydrodynamics
18	03/30		Dimensionless numbers
19	04/01		Bernoulli Equation
20	04/06		Kelvin circulation theorem
21	04/08		Acoustic waves
22	04/13		Jeans Instability
23	04/15		Shock waves
24	04/20		Instabilities: Toomre
25	04/22		Instabilities: Bar
26	04/26		Instabilities: Kelvin-Helmholtz, Rayleigh-Taylor
27	04/27		Bondi flow
28	05/04		Bondi-Hoyle accretion
29	05/06		Supernova explosions

Office hours

The office hours will be defined in the first week of class. A poll will be sent to find the time most suitable to everyone. If a student cannot make it in the chosen time, contact me so we can find a time that fits both our schedules. If you are able to phrase/illustrate your doubt in a clear way in writing, you are welcome to do so instead of scheduling an in-person meeting.

Student Responsibility

You are responsible, as the student, for all material presented in class and in assignments, and for any announcements made during class time (which may include changes to the schedule), whether you are present or absent. It is your responsibility to attend and keep up with the rhythm of the class. Changes to assignments may happen, in which case I will communicate the change via Canvas. It is the student's responsibility to check Canvas periodically for these updates.

Class attendance is essential for the understanding of the material. If you should decide to drop the class, you must do so before the deadline listed in the schedule of classes, or a grade will be assigned. Dropping the class is the student's responsibility, not the instructor's.

Due diligence is defined as a measure of prudence, activity, assiduity, effort, expediency, and/or disclosure, as is properly to be expected from, and ordinarily exercised by, a reasonable and prudent person under the particular circumstances. If you exercise due diligence with respect to your responsibilities in this course, you will find that I am very sympathetic and will work very hard to resolve any problems that come up to our mutual satisfaction.

What you can expect from me: I love astronomy. If you don't get excited about anything we study this semester I will consider it a failure on my part. I will do my best to be respectful of your time and effort. I will strive to make every reading, class session, and homework assignment as useful to your learning as possible. I will listen to and respectfully consider any comments or suggestions you have about any aspect of this course. I will be respectful of any protected status recognized by the university, as well as many that are not, assuming that you are duly diligent in alerting me to any possible issues before or as they arise. I will not tolerate harassment or bullying.

Use of Laptop Computers & Mobile Phones

You may use a laptop computer in the classroom only for class purposes. You may not surf the web, play games, or engage in any activity, which I would consider disruptive to you, or students around you. Smartphones and tablets must be silent and turned to airplane mode, and can only be used to participate in class.

Use of Listening, Video, or Other Recording Device

The use of any electronic listening, or recording devices by anyone in class are not permitted. If you need to use a recording device as an authorized disability accommodation, you must provide me with verification from the Student Accessibility Services (SAS) prior to the use. The SAS office is located at Corbett Center, Rm. 208 Phone: (575) 646-6840 E-mail: sas@nmsu.edu Website: <http://sas.nmsu.edu/>

Academic Misconduct

Academic and non-academic misconduct: The Student Code of Conduct defines academic misconduct, non-academic misconduct and the consequences or penalties for each. The Student Code of Conduct is available in the NMSU Student Handbook online:

<http://studenthandbook.nmsu.edu/>

Academic misconduct is explained here:

<http://studenthandbook.nmsu.edu/student-code-of-conduct/academic-misconduct/>

Discrimination and Disability Accommodation

Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act Amendments Act (ADA) covers issues relating to disability and accommodations. If a student has questions or needs an accommodation in the classroom (all medical information is treated confidentially), contact:

Main Campus

Student Accessibility Services (SAS)
Corbett Center Student Union Room 208
Trudy Luken, Director
575-646-6840
sas@nmsu.edu

New Mexico State University, in compliance with applicable laws and in furtherance of its commitment to fostering an environment that welcomes and embraces diversity, does not discriminate on the basis of age, ancestry, color, disability, gender identity, genetic information, national origin, race, religion, retaliation, serious medical condition, sex (including pregnancy), sexual orientation, spousal affiliation, or protected veteran status in its programs and activities, including employment, admissions, and educational programs and activities. Inquiries may be directed to the Laura Castille, Executive Director, Title IX and Section 504 Coordinator, Office of Institutional Equity, P.O. Box 30001, E. 1130 University Avenue, Las Cruces, NM 88003; 575.646.3635; 575-646-7802 (TTY); equity@nmsu.edu.

Title IX prohibits sex harassment, sexual assault, intimate partner violence, stalking and retaliation. For more information on discrimination or Title IX, or to file a complaint contact:

Laura Castille, Executive Director and Title IX Coordinator
Office of Institutional Equity (OIE) - O'Loughlin House, 1130 University Avenue
Phone: (575) 646-3635 E-mail: equity@nmsu.edu
Website: <http://equity.nmsu.edu/>

Other NMSU Resources

NMSU Police Department:	(575) 646-3311	www.nmsupolice.com
NMSU Police Victim Services:	(575) 646-3424	
NMSU Counseling Center:	(575) 646-2731	
NMSU Dean of Students:	(575) 646-1722	
For Any On-campus Emergencies:	911	

Special Accommodation

Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act Amendments Act (ADAAA) covers issues relating to disability and accommodations. If a student has questions or needs an accommodation in the classroom (all medical information is treated confidentially), contact:

Trudy Luken, Director
Student Accessibility Services (SAS) - Corbett Center, Rm. 208
Phone: (575) 646-6840 E-mail: sas@nmsu.edu
Website: <http://sas.nmsu.edu/>

Discrimination

NMSU policy prohibits discrimination on the basis of age, ancestry, color, disability, gender identity, genetic information, national origin, race, religion, retaliation, serious medical condition, sex, sexual orientation, spousal affiliation and protected veterans status. Furthermore, Title IX prohibits sex discrimination to include sexual misconduct: sexual violence (sexual assault, rape), sexual harassment and retaliation. For more information on discrimination issues, Title IX, Campus SaVE Act, NMSU Policy Chapter 3.25, NMSU's complaint process, or to file a complaint contact:

Laura Castille, Title IX Coordinator
Agustin Diaz, Title IX Deputy Coordinator
Office of Institutional Equity (OIE) - O'Loughlin House, 1130 University Avenue
Phone: (575) 646-3635
E-mail: equity@nmsu.edu
Website: <http://eeo.nmsu.edu/>

This syllabus may be subject to change