

AY 650 Section 001: Galactic Dynamics

Fall 2011

3 Credit Hours

Primary Instructor: Dr. Ronald Buta

Syllabus subject to change.

Prerequisites

From the Student Records System

No prerequisites found.

A basic undergraduate training in physics, including familiarity with Newton's laws, conservation laws, gravitational dynamics, Hamiltonian and fluid mechanics, and mathematical techniques.

Course Description

The goal of the course is to provide the student with the mathematical tools and knowledge to do research in galactic dynamics. The subject is broad and presents many possibilities for topics of study. The course is rigorously mathematical and mainly theoretical, but will include considerable discussion of observations to support the techniques or models discussed.

Meeting time and location:

TR 1:30-2:45pm

Room 328 Gallalee Hall

Student Learning Outcomes

After taking the class, students should be able to:

- use basic physics to understand the structure and dynamics of galaxies and stellar systems
- apply gravitational theory to different types of systems, including spherical, triaxial, and highly flattened systems.
- determine the properties of stellar orbits in different kinds of systems.
- understand dynamical concepts such as relaxation time, violent relaxation, the collisionless Boltzmann equation, the distribution function, phase space, Jeans theory, the virial theorem, the bar instability, secular instabilities, dynamical friction, the Ostriker-Peebles and Toomre criteria, secular evolution, gravity torques, Lindblad resonances, pattern speed, phase wrapping, and collective effects.
- evaluate the impact of perturbations on galactic disk dynamics, including spiral arms, bars, tides, and mergers. Features such as shells, ripples, resonance rings, catastrophic rings, tidal tails and bridges, major and minor axis dust lanes, counter-winding spirals, boxy-peanut bulges, pseudobulges, warps, and other related

phenomena will be covered. Quasi-steady modes versus transient perturbations.

- understand current theories of the mechanism of galaxy formation and its relation to cosmological models, such as the lambda Cold Dark Matter model.

Outline of Topics

This is a tentative schedule. Significant changes may be required for us to cover the most important topics.

Aug.	25	Introduction to class; overview of observations (1.1)	
	30	Overview of observations (cont.); relaxation time (1.1,1.2)	
Sept.	1	Potential theory: Spherical systems 2.1,2.2,2.3	
	6	Potential theory: Spheroidal and ellipsoidal systems 2.4,2.5	
	8	Potential theory: Disk systems 2.6,2.7	
	13	Notes on N-body codes 2.8,2.9	
	15	Orbits in spherical and axisymmetric potentials 3.1,3.2	
	20	Orbits in non-axisymmetric potentials; orbit integration 3.3,3.4	
	22	Angle-action variables and slowly varying potentials 3.5,3.6	
	27	Perturbations and chaos; orbits in elliptical galaxies 3.7,3.8	
	29	Exam 1	
Oct.	4	Collisionless Boltzmann's equation; Jeans theorems 4.1,4.2,4.3	
	6	Distribution functions for spherical and axisymmetric systems 4.3,4.4,4.5	
	11	Jeans and virial equations 4.6,4.7,4.8	
	13	Phase mixing and violent relaxation 4.9,4.10	
	18	Stability of collisionless systems 5.1,5.2,5.3	
	20	Stability of collisionless systems (cont.) 5.4,5.5,5.6	
	25	Spiral structure, Wave mechanics of differentially rotating disks 6.1, 6.2	
Nov.	1	Global disk stability; evolution of spiral structure 6.3,6.4	
	3	Dynamics of bars and warped disks 6.5,6.6	
	8	Kinetic theory; relaxation processes 7.1,7.2,7.3	
	10	Exam 2	
	15	NO CLASS project time	***TENERIFE***
	17	NO CLASS project time	***TENERIFE***
	22	NO CLASS project time	***TENERIFE***
	27	NO CLASS	***THANKSGIVING HOLIDAY***
	29	Dynamical friction, high-speed encounters 8.1,8.2	
Dec.	1	Tides, Encounters, and Mergers 8.3,8.4,8.5	
	6	Galaxy formation 9.1,9.2	
	8	Galaxy formation (cont.) 9.3,9.4	
	13	Final exam, 11:30am-02:00pm	

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Exams and Assignments

There will be roughly weekly homework assignments, either from the textbook or from sheets handed out in class

There will be two in-semester exams and a final exam.

Students will also have the opportunity to do a dynamics project for part of their grade.

The dynamics project can be the following:

- writing a program that calculates an analytic potential, a force field, some orbits, and surfaces of section
- converting an infrared image into a potential, and using it for various things like estimates of bar strength
- using an existing dynamics code to model a galaxy or compute a time sequence of morphologies
- examining a class topic in more detail, such as:
 - the Lambda CDM model and its relation to current observations
 - how dynamics and kinematics are used to interpret elliptical and disk galaxies
 - topics in spiral galaxies
 - etc.

During the second half of November, Prof. Buta will be giving lectures at the XXIII IAC Winter School in Tenerife. Students may use this absent time to work on their projects.

Grading Policy

The course grade will be based on the following:

- regular homework assignments: 30%
- two semester exams (may have take-home component): 15% each
- comprehensive final exam (all in-class; some questions conceptual): 25%
- dynamics project: 15%

Policy on Missed Exams & Coursework

Assignments will generally have due dates, and students should try hard to turn their work in on time. If I feel an extension is needed, then it will be granted to the whole class.

If you are going to miss an exam, let me know in advance.

Required Texts

UA Supply Store Textbook Information

- **BINNEY / GALACTIC DYNAMICS**
(*Required*)
- **BINNEY (RENTAL) / (RENTAL) GALACTIC DYNAMICS**
(*RENTAL*)

Other Course Materials

none.

Policy on Academic Misconduct

All students in attendance at the University of Alabama are expected to be honorable and to observe standards of conduct appropriate to a community of scholars. The University expects from its students a higher standard of conduct than the minimum required to avoid discipline. Academic misconduct includes all acts of dishonesty in any academically related matter and any knowing or intentional help or attempt to help, or conspiracy to help, another student.

[The Academic Misconduct Disciplinary Policy](#) will be followed in the event of academic misconduct.

Disability Statement

If you are registered with the Office of Disability Services, please make an appointment with me as soon as possible to discuss any course accommodations that may be necessary. If you have a disability, but have not contacted the Office of Disability Services, please call 348-4285 or visit 133-B Martha Parham Hall East to register for services. Students who may need course adaptations because of a disability are welcome to make an appointment to see me during office hours. Students with disabilities must be registered with the Office of Disability Services, 133-B Martha Parham Hall East, before receiving academic adjustments.

Severe Weather Protocol

In the case of a tornado warning (tornado has been sighted or detected by radar, sirens activated), all university activities are automatically suspended, including all classes and laboratories. If you are in a building, please move immediately to the lowest level and toward the center of the building away from windows (interior classrooms, offices, or corridors) and remain there until the tornado warning has expired. Classes in session when the tornado warning is issued can resume immediately after the warning has expired at the discretion of the instructor. Classes that have not yet begun will resume 30 minutes after the tornado warning has expired provided at least half of the class period remains.

UA is a residential campus with many students living on or near campus. In general classes will remain in session until the National Weather Service issues safety warnings for the city of Tuscaloosa. Clearly, some students and faculty commute from adjacent counties. These counties may experience weather related problems not encountered in Tuscaloosa. Individuals should follow the advice of the National Weather Service for that area taking the necessary precautions to ensure personal safety. Whenever the National Weather Service and the Emergency Management Agency issue a warning, people in the path of the storm (tornado or severe thunderstorm) should take immediate life saving actions.

When West Alabama is under a severe weather advisory, conditions can change rapidly. It is imperative to get to where you can receive information from the [National Weather Service](#) and to follow the instructions provided. Personal safety should dictate the actions that faculty, staff and students take. The Office of Public Relations will disseminate the latest information regarding conditions on campus in the following ways:

- Weather advisory posted on the UA homepage
- Weather advisory sent out through Connect-ED--faculty, staff and students ([sign up at myBama](#))
- Weather advisory broadcast over WVUA at 90.7 FM
- Weather advisory broadcast over Alabama Public Radio (WUAL) at 91.5 FM
- Weather advisories are broadcast via WUOA/WVUA-TV, which can be viewed across Central Alabama. Also, visit wuatv.com for up-to-the-minute weather information. A mobile Web site is also available for your convenience.