ASTR320 Theoretical Astrophysics Spring 2020

Prof: Massimo Ricotti

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Office: Physical Sciences Complex (PSC) Room-1156
Prof. office hours: Friday 10.00am-11.00am, or by appointment

Lectures: Tuesday and Thursday, 11am-12.15pm in room AJC 2134

Discussion section (Alex Dittmann): Wednesday 1.00-1.50pm in room ATL 2428
Alex's Office: PSC 1269
Alex's office hours: Monday, 2:00pm-3:00pm, or by appointment.

Course description

Modern astronomy has its roots firmly grounded in the fundamental principles of physics (both classical and quantum). Furthermore, many branches of physics as we know them today trace their origins to the search for universal physical laws to explain natural phenomena discovered and analyzed by astronomers.

The goal of theoretical astrophysics is to provide physical and conceptual understanding of the diverse systems that represent our universe. Introductory astronomy courses are often organized by scale (planets, stars, galaxies and the universe as a whole) and observational astronomy courses are often organized by wavelength because of the different technologies. To emphasize the different approach needed for developing a theoretical framework, this course is organized into themes of governing physical principles. For each of the three main themes (gravity, gas physics and quantum physics), we start with fundamental principles and then discuss applications in various astronomical contexts. We will also discuss systems in which several principles interact synergistically and demonstrate how astrophysical theories are developed by successive model refinements and confrontation with data. We will show how application of simple physical laws can explain the observed properties of an astounding range of astronomical objects!

I will assume a basic knowledge of astronomical concepts (up to the ASTR120, ASTR121 level) as well as basic physics (up to the PHYS270, PHYS271, PHYS273 level)
The course website is at
http://www.astro.umd.edu/~ricotti/NEWWEB/teaching/ASTR320_20.html

Texts

No textbooks are required for this class. I will use my own class notes that I will hand out and are available for download on ELMS. Since the course is organized by topics, there are no textbooks that follow the structure of this course. You can find some of the topics that will be covered in introductory astrophysics texts. Two of them, on which you may find some useful material are the following:

- Astrophysics for Physicists, by Arnab Rai Choudhuri, (Cambridge University Press, 2010) ISBN-13: 978-0521815536
- Astrophysics in a Nutshell, by Dan Maoz, (Princeton University Press, 2007) ISBN-13: 978-0691125848

These books are merely listed for your convenience, but you do not need to buy either of them. In addition a lot of useful material can be found on the web, including Wikipedia. However, keep in mind that some of the derivations or homework you will be exposed to in this class, are meant to introduce you to research in astrophysics and problem solving, so you will not find all the answers on books or on the web.

Course expectations

Attendance: Attendance in class is crucial. A major part of this course will center around in-class discussions… simply getting hold of the lecture notes will not allow you to be successful in this course. In the event of an emergency where you **have** to miss class, you must make sure that you complete all of the assigned reading, get hold of any lecture notes, **and** see me in my office hours.

Preparation: I expect you to be prepared to work. We will be covering some fascinating but challenging concepts - you will understand this material much more easily if you preview the recommended reading material ahead of time, as well as giving it a more careful read after the lecture. You also should review your class notes sometime before the next lecture to make sure everything is clear. I encourage you to ask questions in the lectures or during my office hours.

Study Habits: Study wisely and ask for help if you need it. It is better to keep up with the material on a daily basis than cram the night before the exam. I encourage you to chat about problems with your friends and classmates – you will learn a huge amount from trying to explain confusing issues to each other. ***However, please keep in mind that all graded materials, including class-assignments and home-works, must be your own thoughts in your own words.***

Grading

Grade will be based on home-works, class participation, one midterm exam and a final exam according to the following weight:

Class participation	10%
Homework	30%
Midterm exam	25%
Final exam	35%

Letter grades will be assigned guided by the following scheme.

A+	100% - 97%
A	96.9% - 93%
A-	92.9% - 90%
B+	89.9% - 87%
B	86.9% - 83%
B-	82.9% - 80%
C+	79.9% - 77%
C	76.9% - 73%
C-	72.9% - 70%
D+	69.9% - 67%
D	66.9% - 63%
D-	62.9% - 60%
F	less than 60%

I may adjust the precise grade boundaries to obtain a fair distribution of final grades, but I will only adjust the above-mentioned grade boundaries downwards (i.e. the above-mentioned grade boundaries are the "guaranteed" boundaries and any curving will only be to your advantage).

Exams

There will be one in-class midterm examination on the Tuesday 10-Mar-2020. This exam will be closed book, but calculators will be allowed. University regulations will apply regarding academic honesty and excused absences.

The midterm exam is a "**major scheduled grading event**" and is covered by the relevant rules for excused absence. If you are not able to take an exam due to illness or other legitimate reasons, you must make every reasonable attempt to contact me on or before the day of the exam either by email or voice mail. In addition, you must provide documentation detailing the reason for your absence. *A self-signed note is insufficient*. A make up exam must be taken promptly. I will give at most one make-up exam. If you must miss both the midterm and its make-up exam, I will give an oral examination.
If, for whatever reason, the University is officially closed on the day of the exam, the exam will be re-scheduled for the next lecture date.
As per the University schedule, the final exam for this course will be held on Thursday 14-May-2020 from 8am-10am. The final exam is cumulative in the sense that it will cover all material discussed in this course. Again, the final exam is a "**major scheduled grading event**" and is covered by the relevant rules for excused absence (see above).

Homework

Homework will be handed out approximately once every two weeks and will generally be due the following week. The due date will be clearly stated on the homework. On the due date, homework should be handed in at the front of the class. Late homework will be accepted for a week after the due-date and will be subjected to a penalty of up to 30%. Once the solution sets are handed out, late homework cannot be accepted. If you really cannot make it to class, you should either ask a friend/classmate to hand it in for you, or make sure that it gets to me (room PSC1156) before the time that it is due. If you have a valid emergency that prevents you from making a homework deadline, you should make all reasonable efforts to contact me before the due date telling me the nature of the emergency. Please document all such emergencies; *a self-signed note is sufficient provided that it contains a statement that (1) the information is true and correct and (2) providing false information is prohibited under the Code of Student Conduct.*

Academic Integrity

The University's policies and rules on academic integrity are laid out in this document: http://www.president.umd.edu/policies/docs/III-100A.pdf. In essence, you must never engage in acts of academic dishonesty at any time. Acts of academic dishonest include cheating, fabrication, plagiarism, or helping any other person to do any of these things.

These rules apply to homework and quizzes as well as exams. As a part of these rules, you must give credit to any published article or webpage that you have used to help you with a particular assignment. The University takes these issues extremely seriously, as do I.

Preliminary course outline

	GRAVITY
Jan 28	1 - Introduction; Recap of Newton's laws and the conservation of momentum
Jan 30	2 - Newtonian gravity
Feb 4	3 - One body problem - conservation laws and constants of motion
Feb 6	4 - One body problem - solving the equation of motion
Feb 11	5 - One body problem - derivation of Kepler's Laws
Feb 13	6 - One body problem - epicyclic motion
Feb 18	7 - Two-body problems and binary systems
Feb 20	8 - Two + one (restricted three) body problem - Lagrange points
Feb 25	9 - Two + one (restricted three) body problem - effective potential
Feb 27	10 - N-body dynamics - the virial theorem
Mar 3	11 - N-body dynamics - applications of the virial theorem (sub-lecturer)
Mar 5	12 - N-body dynamics - two body relaxation
Mar 10	MIDTERM (in class)
	GAS PHYSICS
Mar 12	13 - Pressure and the concept of hydrostatic equilibrium
Mar 17	**SPRING BREAK**
Mar 19	**SPRING BREAK**
Mar 24	14 - Atmospheres in an external gravitational field
Mar 26	15 - Self-gravitating atmospheres
Mar 31	16 - Introduction to thermodynamics and statistical mechanics
Apr 2	17 - Statistical mechanics of ideal gas

Apr 7	18 - Radiation gases
Apr 9	19 - Radiation gases (cont) and applications to Cosmology
Apr 14	20 - Brief introduction to hydrodynamics

QUANTUM PHYSICS

Apr 16	21 - The Bohr model of the atom
Apr 21	22 - Particle wave duality and particle in a box
Apr 23	23 - Fermions and bosons; Fermi-Dirac and Bose-Einstein statistics
Apr 28	24 - Degeneracy pressure and while dwarf
Apr 30	25 - Type-1a supernovae and neutron stars
May 5	26 - Schrodinger's approach to Quantum Mechanics
May 7	27 - The structure of the hydrogen atom
May 12	28 - Review
May 14th	Final exam (in class Thursday 8.00-10.00am)