ASTR320  Theoretical Astrophysics  Spring 2016

Prof: Massimo Ricotti

Phone: (301) 405-5097
E-mail: ricotti@astro.umd.edu
Office: Physical Sciences Complex Room-1156
Prof. office hours: Tuesday 2.30-3.30pm, or by appointment
Lectures: Tuesday and Thursday, 11am-12.15pm in room CSS0201
Discussion section (Scott Lawrence): Wednesday 2.00-2.50pm in room CSS0201

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

Texts

There are no required textbooks. I will use my own class notes that I will hand out and are available on the class website. Texts Recommended for this course are:
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:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class participation</td>
<td>10%</td>
</tr>
<tr>
<td>Homework</td>
<td>30%</td>
</tr>
<tr>
<td>Midterm exam</td>
<td>25%</td>
</tr>
<tr>
<td>Final exam</td>
<td>35%</td>
</tr>
</tbody>
</table>

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 8-Mar-2016. 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 12-May-2016 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 week or two 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 26: 1 - Introduction; Recap of Newton's laws and the conservation of momentum
- Jan 28: 2 - Newtonian gravity
- Feb 2: 3 - One body problem - conservation laws and constants of motion
- Feb 4: 4 - One body problem - solving the equation of motion
- Feb 9: 5 - One body problem - derivation of Kepler's Laws
- Feb 11: 6 - One body problem - epicyclic motion
- Feb 16: 7 - Two-body problems and binary systems
- Feb 18: 8 - Two + one (restricted three) body problem - Lagrange points
- Feb 23: 9 - Two + one (restricted three) body problem - effective potential
- Feb 25: 10 - N-body dynamics - the virial theorem
- Mar 1: 11 - N-body dynamics - applications of the virial theorem
- Mar 3: 12 - N-body dynamics - two body relaxation
- Mar 8: MIDTERM (in class)

**GAS PHYSICS**
- Mar 10: 13 - Pressure and the concept of hydrostatic equilibrium
- Mar 15: SPRING BREAK
- Mar 17: SPRING BREAK
- Mar 22: 14 - Atmospheres in an external gravitational field
- Mar 24: 15 - Self-gravitating atmospheres
- Mar 29: 16 - Introduction to thermodynamics and statistical mechanics
- Mar 31: 17 - Statistical mechanics of ideal gas
- Apr 5: 18 - Radiation gases
- Apr 7: 19 - Radiation gases (cont) and applications to Cosmology
- Apr 12: 20 - Brief introduction to hydrodynamics

**QUANTUM PHYSICS**
- Apr 14: 21 - The Bohr model of the atom
- Apr 19: 22 - Particle wave duality and particle in a box
- Apr 21: 23 - Fermions and bosons; Fermi-Dirac and Bose-Einstein statistics
- Apr 26: 24 - Degeneracy pressure and while dwarf
- Apr 28: 25 - Type-1a supernovae and neutron stars
- May 3: 26 - Schrodinger's approach to Quantum Mechanics
- May 5: 27 - The structure of the hydrogen atom
- May 10: 28 - Review

May 12th: Final exam (in class Thursday 8.00-10.00am)