Astron 211: Principles of Astronomy

Fall 2017, David Kaplan

Syllabus

Course Description: This is a general course intended to introduce quantitative astronomy and astrophysics to students with some physics background. A background in algebra-based physics is required. This semester introduces basic concepts in astronomy and astrophysics including:

- Celestial mechanics
- The nature of light and its interaction with matter
- Telescopes
- The structure and evolution of single stars
- The evolution of binary stars
- The end-products of stellar evolution
- The Solar System
- Extra-solar planets
- Galaxies & quasars
- Expansion of the universe & dark matter
- The big bang

Overarching Course Goal: Students will gain an appreciation for how topics from a range of areas of basic physics provide the building blocks for understanding the workings of the Universe.

Prerequisites: basic physics (algebra-based). Students should have completed Physics 120 (or 209), or have consent of the instructor. Math placement level B is required; knowledge of algebra, basic geometry, and basic trigonometry is assumed.

Lectures: MW 9:30-10:45, KEN 1130

- Attendance and participation at lectures is required.

Lecturer: Prof. David Kaplan

- Office: KIRC 4075
- Office hours:
  - Tuesday, 11:00am-12:00pm
  - Friday, 10:15am-11:00am
  - Or by arrangement (email or drop by)
- Email: kaplan@uwm.edu
- Phone: 414-229-4971

Course Website: http://www.gravity.phys.uwm.edu/~kaplan/astron211/
Lecture notes, reading assignments, and problem sets will be posted there.

Quizzes will be done through Desire2Learn (http://d2l.uwm.edu)

Course Textbook:
Astronomy: A Physical Perspective (2nd edition), M. Kutner, Cambridge University Press (2003)
ISBN: 9780521529273

New: $83.99; Used: $62.65

Supplementary Book (not required):
What If?: Serious Scientific Answers to Absurd Hypothetical Questions, R. Munroe, Houghton Mifflin Harcourt (2014)
ISBN: 978-0544272996
New: $9.11

GER Natural Science Requirements: This class satisfies the GER criteria for Natural Science courses (see http://www/Dept/Acad_Aff/academic/ger.pdf). It focuses on exploring and utilizing introductory physics concepts across a range of areas to solve problems of relevance in modern astronomy. Students will explore the foundations underlying our knowledge of the physical world, with the goal of gaining an understanding of the physical laws governing matter, energy, and astronomical phenomena. Astronomy and astrophysics are not about memorizing facts or formulas, but about developing the conceptual framework to connect experiments to the models, theories, and physical laws used to describe the natural world. Throughout the course – in classes and through homework – you will be required to critically assess the presented concepts and be able to apply your knowledge to the solution of physical problems.

Student Learning Outcomes:

1. Students will learn the underpinnings of modern astrophysics covering a wide range of areas, exploring the basis of modern astrophysics deriving from experiment and observation of the Universe (aligns with Divisional Criteria 1, 2, and 4)

2. Students will be able to quantitatively apply the physics knowledge that they are in the process of acquiring to a range of phenomena, pulling together pieces from disparate areas of physics (aligns with UW System Shared Learning Goals 1 and 2)

3. Students will focus on "order-of-magnitude problems", where detailed analysis is impossible but students are led to concentrate on the most relevant ideas.

4. Students will gain appreciation for both the universality of physics and the limits of our knowledge through discussions of how classical and modern physics inform modern astronomy and hence underpin the workings of the Universe (aligns with Divisional Criterion 4).

Assessment of Learning Outcomes:

1. Assessment of Outcomes 1 and 4 will be done through conceptual quizes with minimal quantitative content. Both at the beginning and end of the class, students will complete an anonymous survey looking to connect astronomical objects/phenomena to topics in basic physics. For example, students will be asked to explain the energy source of the Sun and the reason that planets like Jupiter are so much larger than the Earth. This will help assess how qualitative appreciation for the relevant physics topics has been conveyed. We seek at least 80% correct by the second round of this survey.

2. These anonymous surveys will be augmented with weekly conceptual quizes on individual topics related to the weekly lecture material. We seek at least 70% correct averaged over the semester, but individual weeks will be analyzed to identify problematic conceptual areas.

3. Assessment of Outcomes 2 and 3 will be through a series of "order-of-magnitude" problems: questions which have no one right answer but for which basic physical reasoning is paramount. A number of these will be done collaboratively in class to demonstrate the method. At least one question will be asked on each of 11 problem sets. Overall performance will be tracked over the semester. We seek at least 70% correct averaged over the semester,

Evaluation:

- •Problem sets (weekly): 50%; grade will be best 10 of 11 problem sets
- •Weekly D2L quizzes: 5%
- •Weekly in-class problems: 5%
- •Midterm exam: 20%
- •Final exam (Tuesday Dec 19 10am-12pm): 20%

The mid-term will be an in-class exam of 1 hour duration and the final exam will be an in-class exam of 2 hours duration (only calculator allowed).

Expectations:

- •All students must meet with the professor twice per semester: at the beginning and after the midterm
- •Feel free to ask questions in class or in private.
- •Homework assignments are due at the beginning of class
- •Course material will be available at http://www.gravity.phys.uwm.edu/~kaplan/astron211/
- •Announcements will be made via email and http://d2l.uwm.edu - please check at least once per week

Assignments: Weekly assignments will be posted on the course website and handed out in class. Each assignment will consist of a number of single- or multiple-part problems that are homework (private study) exercises for you, the student. Students are encouraged to discuss the problem sets with each other but are not allowed to copy each other.

Time Investment:

- Lectures: 3 hours/week
- Midterm exam preparation: 10 hours
- Final exam preparation: 15 hours
- Weekly problem set: 4 hours/week
- Reading and preparation for lectures: 1.5 hours/week
- Total: 152.5 hours for a 15 week semester, or 50.8 hours/credit

Calculator: Please bring a simple scientific calculator to each lecture, discussion, and test. (N.B. You do **NOT** need a fancy and expensive programmable calculator such for basic calculations). You may use a calculator during tests, but note that you will lose a substantial number of points for clumsy and inaccurate work with a calculator (example: if you forget to switch your calculator from degree to radian mode when you should do so, expect a substantial loss of points; your answer(s) will be hopelessly inaccurate).

Makeups: Students will be able to turn in one problem set late, provided there is a reasonable excuse. The instructor must be notified in advance of the intent to not turn in the problem set, and it will be due before the class following the one in which it was originally due. Note that at least one

assignment will be dropped for each student before final grades are calculated. Tests will be rearranged for students who have conflicts with religious observance (see below for official UW policy). No make up tests will be allowed except in cases of: illness resulting in hospitalization or an emergency/urgent care visit to a physician; family emergencies/bereavement; and verifiable traveling difficulties (such as snow emergencies). All such absences must be supported by appropriate documents. It is the responsibility of each student to attend the tests. Oversleeping, lapses of memory, and similar excuses will not be considered grounds for a make-up. If a student misses any test, including the final, for medical reasons, a physicians's note (clearly showing the signature and letterhead of the physician) must be produced before a make-up can be allowed or (if the final has been missed) an incomplete awarded. The note must state clearly that, in the physician's opinion, the student was not fit to take the test. A note stating only that a student visited (for example) the Norris Health Center is not sufficient. Notes from family members/relations are not acceptable; if the parent/family member is a physician, such notes could constitute a reportable breach of medical ethics.

University Policies: For information on university policies such as religious observances, incompletes, discriminatory conduct, and so forth, see: http://www.uwm.edu/Dept/SecU/SyllabusLinks.pdf

Detailed Syllabus:

Topic	Contents
Course overview	Syllabus; basic astronomical units; celestial sphere; seasons
Distances	Distances to Sun, Moon, nearby stars; parallax; magnitudes, small angles
Gravity I	Kepler's laws (for 1-body); energy & angular momentum
Gravity II	Generalized Kepler's laws for 2-body (binary stars).
Gravity III	Detecting extra-solar planets
Astrophysics I: Hydrostatic Equilibrium	Gravity of spherical body; dynamical collapse; hydrostatic equilibrium; pressure; ideal gas.
Astrophysics II: Virial Theorem	Gravitational, thermal, kinetic energy; virial theorem; application to Sun
Astrophysics III: Nuclear Fusion	Binding energy of nucleus; quantum tunneling; nuclear fusion; stability of the Sun
Astrophysics IV: Radiation	Photons; mean free path, random walk, photon diffusion time; blackbody; photosphere of the Sun.
Astrophysics V: Photon-Matter Interaction	Hydrogen model atom; electronic transitions; stellar spectra; optical depth

Topic	Contents
Stars I: Main Sequence	Basic equations of stellar structure; mass-radius-luminosity relation; life times of stars on main-sequence; color-magnitude diagram; spectral types, UBV photometry.
Stars II: Post Main Sequence	Evolution of stars after core-hydrogen exhaustion
Stars IV: Summary	Summary of the lives of stars; using clusters to check our understanding
Stellar Corpses	End products of stellar evolution; white dwarfs, neutron stars, and black holes; degeneracy; ultra-dense matter.
Explosions	Supernovae & supernova remnants
Star Formation	Jeans mass, observations, disk formation, binary formation.
Solar System	Types of planets; albedos and temperatures; greenhouse effect; frost-line
Galaxies I	The Milky Way
Galaxies II	Types of galaxies; the Hubble diagram
Galaxies III	Formation & evolution of galaxies; galaxies in the early universe
Quasars & AGN	Supermassive blackholes; interactions with galaxies
Large-scale structure	Galaxy clusters & groups; lensing
Cosmology I	Hubble flow; redshift
Cosmology II	Dark matter; inflation; cosmic-microwave background; constraining cosmology through observations
Cosmology III	Big bang; nucleosynthesis
Telescopes	Diffraction limit; seeing and atmospheric turbulence; radio telescopes and interferometry; X-ray & gamma-ray telescopes.

OTHER IMPORTANT INFORMATION

1. **Discriminatory conduct (such as sexual harassment):** Discriminatory conduct will not be tolerated by the University. It poisons the work and learning environment of the University and threatens the careers, educational experience, and well-being of students, faculty, and staff. See: https://www4.uwm.edu/secu/docs/other/S_47_Discrimina_duct_Policy.pdf

2. **Cheating and academic misconduct:** all work handed in for grading (including electronic submissions) must be the result of your own efforts. Copying the work of another student or reproducing the solutions/answers to problems from an on-line or other source and presenting them as your own, original work, will be regarded as cheating. Cheating/academic misconduct will be dealt with by the instructor according to the UW policies and procedures. Cheating on exams or plagiarism are violations of the academic honor code and carry severe sanctions, including failing a course or even suspension or dismissal from the University. See: http://www4.uwm.edu/dos/conduct/

3. **Special Consideration.** The principle of equal treatment of all students shall be a fundamental guide in responding to requests for special consideration. No student should be given an opportunity to improve a grade that is not made available to all members of the class. This policy is not intended to exclude reasonable accommodation of verified student disability, or the completion of work missed as the result of religious observance, verified illness, or justified absence due to circumstances beyond the student's control. (**Authority:** UWM Faculty Documents 860B and 1927)

4. **Religious observance.** In the syllabus, you will find a schedule of tests. Please inform the instructor ASAP and no later than MONDAY FEBRUARY 13TH if you see a conflict with religious observance. Also inform the instructor ASAP and no later than MONDAY FEBRUARY 13TH if the deadline of a quiz or an assignment conflicts with religious observance. A suitable date/time for the test (that does not conflict with the religious observance) or other deadline can then be arranged. Please note the following official UW policies: http://www4.uwm.edu/secu/docs/other/S1.5.htm See also: http://uwm.edu/academicaffairs/wp-content/uploads/sites/32/2014/12/calendar.pdf

Authority: UWS 22 and UWM Fac. Doc. 1918

I. Declaration of policy. It is the policy of the board of regents that students' sincerely held religious beliefs shall be reasonably accommodated with respect to all examinations and other academic requirements. The board of regents adopts this chapter in order to ensure that all institutions of the university of Wisconsin system have in place appropriate mechanisms for ensuring the reasonable accommodation of students' sincerely held beliefs, and for appeals related to these matters.

II. Accommodation of religious beliefs.

1. A student shall be permitted to make up an examination or other academic requirement at another time or by an alternative method, without any prejudicial effect, where:

(a) There is a scheduling conflict between the student's sincerely held religious beliefs and taking the examination or meeting the academic requirements; and

(b) The student has notified the instructor, within the first three weeks of the beginning of classes (within the first week of summer session and short courses), of the specific days or dates on which he or she will request relief from an examination or academic requirement.

2. Instructors may schedule a make-up examination or other academic requirement before or after the regularly scheduled examination or other academic requirement.

3. Instructors shall accept, at face value, the sincerity of students' religious beliefs.

4. Student notification of instructors and requests for relief under sub. (1) shall be kept confidential.

5. Complaints of failure to provide reasonable accommodation of a student's sincerely held religious beliefs as required by this rule may be filed under UWM Complaint and Grievance Procedures.

6. The chancellor shall, through appropriate institutional publications (to include at a minimum the Schedule of Classes and Bulletin), provide notification to students and instructors of the rules for accommodation of religious beliefs, and of the procedure and appropriate office for filing complaints.

5. **Students with disabilities:** please give me the written authorization issued by the Accessibility Resource Center (ARC) **as soon as possible**. Suitable arrangements can then be made. Students with special requirements/learning disabilities should see me as early as possible during the semester: this is the student's responsibility. The ARC will issue formal instructions to me about how students with disabilities are to be accommodated. See: http://www4.uwm.edu/sac/ for ARC contact information.

6. **Students called to active military duty:** accommodations for absences due to call-up of reserves to active military duty are available at this link: http://www4.uwm.edu/current_students/military_call_up.cfm

7. **Complaint procedures:** Students may direct complaints to the head of the academic unit or department in which the complaint occurs. If the complaint allegedly violates a specific university policy, it may be directed to the head of the department or academic unit in which the complaint occurred or to the appropriate university office responsible for enforcing the policy. See: https://www4.uwm.edu/secu/docs/other/S_47_Discrimina_duct_Policy.pdf
For your information:
Chair of Physics: Professor Prasenjit Guptasarma: KEN 3077, (414)229-6497, pg@uwm.edu

Dean of Students' Office: http://www4.uwm.edu/dos/

Equity and Diversity: http://uwm.edu/equity-diversity-services/about/

8. **Grade appeal procedures:** A student may appeal a grade on the grounds that it is based on a capricious or arbitrary decision of the course instructor. Such an appeal shall follow the established procedures adopted by the department, college, or school in which the course resides or in the case of graduate students, the Graduate School. These procedures are available in writing from the respective department chairperson or the Academic Dean of the College/School. Two useful links are given below.
http://www4.uwm.edu/secu/docs/other/S_28_Grade_Appe_by_Students.pdf
http://uwm.edu/letters-science/advising/answers-forms/policies/appeal-procedure-for-grades