L&S 295/Astron 299: Principles of Astronomy

Fall 2011, 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

Lectures: MWF 10am Chem 170

- •Attendance and participation at lectures is required.

Lecturer: Prof. David Kaplan

- •Office: Physics 480
- •Office hours: Monday 11am-12p, Tuesday 2pm-3pm or by appointment
- •Email: kaplan@uwm.edu
- •Phone: 414-229-4971

Course Website: http://www.gravity.phys.uwm.edu/~kaplan/astron299/
Lecture notes, reading assignments, and problem sets will be posted there.

Course Textbook:
Astronomy: A Physical Perspective (2nd edition), M. Kutner, Cambridge University Press
We will not follow the textbook in order, but the readings for each week will be discussed in class and included on the assignments.

Evaluation:

- •Problem sets (weekly): 50%; grade will be best 10 of 11 problem sets
- •Midterm exam: 20%
- •Final exam (Dec 22, 10am-12pm): 30%

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

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. This course introduces the key concept of "order-of-magnitude problems", where detailed analysis is impossible but students are led to concentrate on the most relevant ideas. Through discussions of how classical and modern physics inform modern astronomy and hence underpin the workings of the Universe, students will gain appreciation for both the universality of physics and the limits of our knowledge.

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.

Seminar Learning Objectives: The students who take this course will learn the underpinnings of modern astrophysics covering a wide range of areas. They 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.

Assessment of Learning Objectives: 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.

Students will also be asked a series of "order-of-magnitude" problems: questions which have no one right answer but for which basic physical reasoning is paramount. At least one question will be asked on each of 11 problem sets. Overall performance will be tracked over the semester.

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.

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.

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 note 3, page 4 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. No weapons are permitted in any building on the UWM campus.

Detailed Syllabus:

Topic	Contents
Course overview	Syllabus; basic astronomical units; celestial sphere; seasons
Distances	Distances to Sun, Moon, nearby stars; parallax, 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.