7A: Introduction to Astrophysics 2016

General Information:

- Instructor: Mariska Kriek (mkriek@berkeley.edu)

- Graduate Student Instructors:
  - Nick Kern (nkern@berkeley.edu)
  - Michael Medford (michaelmedford@berkeley.edu)

- Lectures: Tuesday & Thursday 11:00 am - 12:30 pm, 131 Campbell Hall

- Discussion sections:
  - 101: Monday 1-2 pm, 121 Campbell - Nick Kern
  - 102: Monday 4-5 pm, 121 Campbell - Michael Medford

- The Astronomy Learning Center (TALC); Thursday 5-7 pm, 121 Campbell
  This is a large, collaborative "office hour" where students work on their homework assignments in an informal group setting. TALC is staffed by GSIs who serve as guides, rather than tutors, in helping students with their homework problems. In addition to supervised group work, students may discuss difficulties in their conceptual understanding of lecture and reading topics with their peers and the GSIs. There is no TALC on 08/25, 09/29, and 11/03.

- Midterms (during lecture hours):
  - Thursday 09/29 in 131 Campbell Hall
  - Thursday 11/03 in 131 Campbell Hall

- Final exam: Wednesday 12/14, 8-11 am, Campbell 131 (last names starting with J-Z) and Campbell 121 (last names starting with A-H). If you miss a midterm or the final exam without any notice you will receive zero credit for that portion of the course grade. Exams can be rescheduled in exceptional cases. If you miss the final exam for a good reason, your grade will be an Incomplete.

- Office hours:
  - Nick Kern: Wednesday 2:30-3:30 pm, Campbell Hall 233
  - Mariska Kriek: Tuesday 4:30-5:30 pm, Campbell Hall 355
  - Michael Medford: Monday 12:00-1:00 pm, Campbell Hall 233

- Book: "An Introduction to Modern Astrophysics (2nd edition)" by Carroll & Ostlie (required)

- Prerequisites: Physics 7A & 7B (7B may be taken concurrently). This course uses calculus, vectors, and scientific notation. If you think you would prefer a less mathematical introduction to astronomy, consider taking Astro 10.

- The Astronomy Department's Policy on Academic Misconduct and the Honor Code can be found on: http://astro.berkeley.edu/academics/cheating.htmll

- Other resources:
  - Reporting sexual harassment: http://astro.berkeley.edu/department-resources/reporting-harassment
  - Undergraduate Climate Advisor, Astronomy Department: Sara Gutierrez (s.gutierrez@berkeley.edu)
  - Representative for Astrophysics Undergraduate Students: Diana Kossakowski (dkossakowski@berkeley.edu)
  - UC Berkeley Astronomy Undergraduate Wiki: http://kartp.astro.berkeley.edu/doku.php?id=start
  - Astronomy undergraduate advisor: Dexter Stewart (dexters@berkeley.edu)
  - Astronomy undergraduate faculty advisor: Mariska Kriek (ufa@astro.berkeley.edu)
  - Academic Calendar and Student Accommodations - Campus Policies and Guidelines: http://teaching.berkeley.edu/academic-calendar-and-student-accommodations-campus-policies-and-guidelines

Overview:

This is the first part of an overview of astrophysics, with an emphasis on the way in which physics is applied to astronomy. We will start with an introduction to astronomy, and learn how astronomers observe the night sky and measure the radiation, velocities, and distances of stars. We will interpret the observations of stars in terms of physical properties, and discuss how the telescopes that we use to obtain these observations work. We will also cover mechanics and celestial motions, and we will learn how to derive masses and other properties of stars and (extra-solar) planets. Next we move on to stellar atmospheres and interiors, and learn about stellar energy sources, how this energy is transported out of the star, and the physical processes behind the formation of stellar spectra. We will end with the formation and evolution of stars, and stellar remnants. The physics in this course includes mechanics and gravitation; kinetic theory of gases; properties of radiation and radiative energy transport; optics and quantum mechanics of photons, atoms, and electrons.

Homeworks:

The problem sets will be available on bCourses, and will be due on Fridays at 5 pm following the schedule below. The homeworks should be placed in the special boxes on the ground floor of Campbell Hall (south-west corner). Please note that this building is only open between 7:30 am and 6 pm. The boxes will be marked Astro 7A with the appropriate sections. Do not place your homework in any of the other boxes which are for Astro 10. The homework will be picked up by the grader shortly after 5 pm on Friday. Write you name and section on each homework and please staple your sheets together. Late homework will not be accepted (unless you have a good reason).

Problem set 1: available on 08/26, due on 09/02
Problem set 2: available on 09/02, due on 09/09
Problem set 3: available on 09/09, due on 09/16
Problem set 4: available on 09/16, due on 09/26 (note: this is a Monday)

Problem set 5: available on 09/30, due on 10/07
Problem set 6: available on 10/07, due on 10/14
Problem set 7: available on 10/14, due on 10/21
Problem set 8: available on 10/21, due on 10/28
Problem set 9: available on 11/04, due on 11/14 (note: this is a Monday)
Problem set 10: available on 11/11, due on 11/21 (note: this is a Monday)
Problem set 11: available on 11/18, due on 12/02 (note: you have two weeks)

Please start the homework questions yourself, independently of other students. If, after serious effort, you remain unsure of how to proceed, you are welcome to discuss the homework with classmates or instructors, for example during TALC. Under all circumstances, the answers must be written up individually.

Grading

- Final exam: 30%
- Midterms: both 15%
- Homeworks: 40% (each homework has the same weight)

Reading:

In addition to the reading below, you should also study your lecture notes, not all materials are covered in the book.

08/25: Chapter 1: Celestial sphere (ecliptic, equator, equinox, solstice); Altitude-Azimuth coordinate system; equatorial coordinate system (RA & DEC); proper motions and tangential velocity

08/30: Section 3.1 & 3.2: Parallax, flux, luminosity, apparent magnitude, absolute magnitude, distance modulus

09/01: Section 5.1: classical Doppler shift and radial velocity; Page 231-232: specific intensity, solid angle

09/06: Section 3.3-3.4: Young's double-slit experiment; Wien's displacement law; Stefan-Boltzmann equation

09/08: Section 3.5-3.6: Planck function; Rayleigh-Jeans law; Wien's tail; color indices and bolometric correction; filter sensitivity function

09/13: Section 5.3-5.4: Bohr model and line transitions; Heisenberg's uncertainty principle

09/15: Section 9.2 (stop reading at continuum opacity), 9.3 (stop reading at radiation pressure gradient): opacity and sources of opacity; cross section; mean free path; optical depth; random walk

09/20: Section 6.1-6.2: focal plane and plate scale; diffraction, resolution and Rayleigh criterion; seeing; telescope optical systems; telescope mounts; adaptive optics

09/22: Section 6.3-6.5: interferometry; Section 5.1: spectrographs

09/27: No new reading, we will finish the materials from previous lectures

09/29: MIDTERM 1 (all reading and lecture notes up to now)

10/04: Section 2.1-2.3: Kepler's laws; Newton's laws; kinetic and potential energy; escape velocity; center of mass reference frame; derivations of Kepler's laws

10/06: Section 2.4: Virial theorem; Section 7: Determining properties (masses, radii, and temperature ratios, etc.) using binary systems

10/11: No new reading, we will finish materials from previous two lectures

10/13: Section 8.1: Spectral types; Maxwell-Boltzmann velocity distribution; Boltzmann equation

10/18: Section 8.1 (from the Saha equation onward): Saha equation, partition function

10/20: Section 8.2: Hertzsprung-Russell diagram; 10.1-10.2 (up to radiation pressure): Hydrostatic equilibrium; mass conservation equation; ideal gas law; mean molecular weight; kinetic energy per particle

10/25: No new reading (finish materials previous lecture)

10/27: Section 10.3: (stop reading at quantum tunneling): Kelvin-Helmholtz contraction; energy released by fusion/nuclear timescale

11/01: No new reading, review lecture

11/03: MIDTERM 2 (all reading and lecture notes up to now)

11/08: Section 10.3 (stop reading at Nuclear reaction rate and start reading again at luminosity gradient equation): quantum tunneling; PP chain; CNO cycle; conservation laws; binding energy per nucleon

11/10: Section 9.3 (random walk + radiation pressure gradient sections), 10.4 (up to 325): Radiative diffusion; radiative temperature gradient; convection; adiabatic temperature gradient

11/15: Section 12.2 (up to 419): Jeans mass and jeans length; fragmentation; two phase collapse

11/17: Section 10.6 (skip part on Eddington limit), 13.1 (up to the Schonberg-Chandrasekhar limit), 13.2, 13.3: Stellar evolution

11/22: Section 16.2, 16.3, 16.4: remnants; white dwarfs; degenerate material; electron degeneracy pressure

11/29: Section 16.4, 16.6 (page 578-583), 17.3 (up to eq 17.27): neutron degeneracy; Chandrasekhar limit, Schwarzschild radius

12/01: No new reading, review lecture