FOUNDATIONS OF ASTROPHYSICS I: THE SOLAR SYSTEM

Fall 2015 **Astronomy 241** M,W,F 10:30 — 11:20

ASTR 241 is a rigorous, calculus-based introduction to Solar System astrophysics. In this course, basic concepts of classical mechanics, thermodynamics, electromagnetism, and modern physics are used to understand the structure and evolution of the Solar System. Historically, the Solar System was the original proving ground for much of Newtonian dynamics, and it provides many opportunities to apply physics on a grand scale. In addition to introducing the study of the Solar System, ASTR 241 will deepen understanding and ability to use basic physical concepts. ASTR 241 is the first course in a sequence leading to the astrophysics major.

Time & Place: Monday, Wednesday, Friday, 10:30 — 11:20 in Watanabe 114

Professor: Joshua E. Barnes (barnes at ifa.hawaii.edu)
Office: Institute for Astronomy, Room C-219 (956-8138)
Office hours: Mon 9:30 — 10:20, Thu 14:30 — 15:20 in Watanabe 423, or by appointment at the IfA

Text: ***Foundations of Astrophysics*** by Barbara Ryden & Bradley M. Peterson

Astronomy help: See any Astronomy TA in Watanabe 403; hours are posted outside.

Course Outline & Schedule

Dates			Topic		Reading
8/24	8/26	8/28	**Solar System Overview**	Constituents: Sun, planets, dwarf planets, asteroids, comets, dust, solar wind. Formation scenario. Kepler's laws of planetary motion.	8.1, 2.3 — 2.5
8/31	9/02	9/04	**Orbital Motion**	Newtonian mechanics & universal gravitation. Two-body & reduced problems. Derivation of Kepler's laws. Conservation laws.	3.1 — 3.4
	9/09	9/11	**Earth, Moon, and Sun**	The Earth-Moon system. Tidal force. Response of oceans. Tidal friction. Synchronous rotation. Evolution of the Moon's orbit. Precession of Moon's orbit.	4.1, 4.2, 4.4, 4.5
9/14	9/16	9/18	**Keeping Atmosphere**	Thermal radiation. Solar flux. Temperature equilibrium. Greenhouse effect. Thermal velocity. Mean free path. Escape of atmosphere.	8.2
9/21	9/23	9/25	**Atmospheric Structure**	Gas pressure. Hydrostatic equilibrium. Scale heights. Energy transport. Convection. Temperature profiles. Circulation patterns.	9.2
9/28	9/30	10/02	**REVIEW & MIDTERM**		
10/05	10/07	10/09	**Terrestrial Planets**	Internal structure; differentiation. Heat production & transport. Surface features: impacts, volcanism, erosion, tectonics.	9.1, 9.4, 9.5, 10.1
10/12	10/14	10/16	**Giant Planets, Satellites, & Rings**	Gas giants & ice giants. Gas sphere model. Phases of Hydrogen. Internal structure. Satellites of giants. Roche & Hill radii. Tidal heating. Nature of rings. Resonances.	10.2, 10.3, 4.3
10/19	10/21	10/23	**KBOs & Comets**	The Pluto-Charon system. The Kuiper belt. Origin of comets. Sublimation of comets. Tail dynamics.	11.2, 11.3

10/26	10/28	10/30	**Asteroids & NEOs**	Nature of asteroids. Resonant structure of asteroid belt. Orbital families. Origin of Near-Earth Objects. Orbital dynamics & impact trajectories. Detection & deflection strategies.	11.1, 11.4
11/02	11/04	11/06	**REVIEW & MIDTERM**		
11/09		11/13	**Solar System Formation**	Cloud collapse. Rotation of proto-solar nebula. Condensation of solids. Terrestrial planet formation. The frost line. Giant planet formation.	12.1, 12.2
11/16	11/18	11/20	**Extra-Solar Planets**	Detection of extra-solar planets. Other planetary systems.	12.3, 12.4
11/23	11/25		**Solar Interior. I**	Solar parameters. Atomic structure. Ionization. Gravitational & nuclear timescales. Couloumb barrier & tunneling. Hydrogen burning. Stability.	5.1, 5.2, 15.2, 15.3
11/30	12/02	12/04	**Solar Interior. II**	Opacity. Energy transport mechanisms. Stellar structure equations. Structure of the Sun.	15.1, 15.4
12/07	12/09		**FINAL REVIEW**		

Learning Objectives

This course introduces students to the Solar System as an arena for physics, and teaches them to solve Solar System problems by applying basic physical laws. Students passing this course will be able to calculate orbital trajectories of planets and other objects, evaluate surface temperatures for planets without and with greenhouse atmospheres, apply hydrostatic equilibrium to the atmospheres and interiors of planets and the Sun, estimate the physical consequences of interactions and collisions between Solar System objects, explain how the Sun mantains a steady luminosity over billions of years, and discuss the physical mechanisms which transport energy in the solar interior.

This course aligns with a number of UH Manoa's Institutional Learning Objectives, including: objective 1a (general understanding of the Universe), objectives 2a (critical and creative thinking, problem solving, mathematical reasoning) and 2c (collaborative work with peers), and objectives 3a (intellectual curiosity) and 3c (respect for resources).

Discussions, Problem Sets, Exams, & Grades

Friday class sessions will be devoted to classroom discussion, with an emphasis on problem-solving. To motivate the discussion, a problem set will be distributed at the start of each week. These problems will be discussed by the class as a whole and by students working in small groups. The objective is to insure that all students know how to solve the assigned problems.

Written solutions to the problems will be due the following Monday at the start of class. Late work **must** be handed in by Wednesday, and will receive 70% credit. Work will be graded and returned to the class on Friday.

There will be two midterm exams, on 9/30 and 11/04. A review class will be given before each exam. The final exam will be given from 9:45 to 11:45 on 12/14 in Wat. 114. The final is cumulative.

In-class participation, problem sets, midterms, and the final are worth 20%, 30%, 25%, and 25%, respectively. You must take the final to receive a passing grade.

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Updated: 15 September 2015
`http://www.ifa.hawaii.edu/~barnes/ast241_f15/index.html`