ASTR 1100: Introduction to Astrophysics (winter)

Calendar description: This course provides an introduction to basic concepts of astronomy and astrophysics. Topics include: celestial mechanics; radiation; telescopes; observations and characteristics of stars, binary stars; the interstellar medium; star formation and evolution; galaxies and cosmology. Homework consists of assignments and labs, some of which require the use of the Burke-Gaffney Observatory.

Classes 3 hrs. and lab/telescope observing 1 hr. per week; 1 semester.

Contents

Overview

This first course in the astrophysics stream provides an introduction to basic concepts of astronomy and astrophysics. The first few weeks of the course should focus on basic physical concepts that will be applied to astronomical topics later in the term (*e.g.*, gravity, Kepler's Laws, EM radiation, spectroscopy). Astronomical topics that should be addressed during the course include: observations and characteristics of stars and binary stars (*e.g.*, magnitudes, mass determination, luminosity-mass relation, HR diagram); the interstellar medium; star formation; and stellar evolution (evolution on the HR diagram). As time permits, topics on the Milky Way, galaxies, and cosmology should be included. Historically, student projects, assignments, and labs have required the use of the Burke-Gaffney Observatory, and the astronomy technician has played a role in training students on its use.

Prerequisites

PHYS 1100 University Physics I

The student can be assumed to have a basic understanding of Newton's Laws and conservation theorems, as well as rotation, angular momentum, and torques. As the unit on gravity and Kepler's Laws are often not covered well in PHYS 1100 if at all, these ideas should be covered as though for the first time in this course.

Most, if not all students enrolled in this course are taking PHYS 1101 (University Physics II) at the same time where oscillations and waves are discussed in the first three weeks, thermodynamics in the second three weeks, and electricity and magnetism (integral forms of Maxwell's equations) during the last six weeks. Thus, for example, if the instructor wishes to discuss electromagnetic radiation at the beginning of term, it must be done *without* the benefit of the E&M unit in their concurrent physics class.

Many students, but not all, will be taking PHYS 1500 (Introduction to Modern Physics) in which special relativity is discussed for the first few weeks of term, and elementary ideas in quantum mechanics (*e.g.*, the Bohr model) are disucssed for the remainder.

Nova Scotia grade 12 precalculus math, or equivalent

Students should be competent with ordinary high school algebra, trigonometry, vectors, and simple differentiation, all of which can be satisfied with a NS or equivalent grade 12 precalculus math course. Many students will have taken or are taking concurrently MATH 1210 (Introductory Calculus I), but this level of mathematics is not strictly necessary for this course.

Dependent courses

ASTR 2100 Foundations of Astrophysics

In some ways, ASTR 2100 (fall term of second year) will pick up where ASTR 1100 leaves off, although some topics will be revisited in greater depth (*e.g.*, celestial mechanics, radiation mechanisms, *etc.*). The second and subsequent years of astronomy rely on ASTR 1100 heavily for basic familiarity of key astronomical ideas and skills such as an introduction to the Burke-Gaffney Observatory and basic observing techniques, the celestial sphere, the HR diagram and life cycle of a star, and the overall structure of the galaxy and universe. Each of these areas will be built up in the higher level courses.

Student Outcomes

The main objective of this course is for the student to start building an astronomical intuition and to gain an understanding of some of the tools (*e.g.*, magnitudes, Kepler's Laws) astronomers use to describe the universe.

A student completing ASTR 1100 should be able to:

1. determine masses or orbital properties of two objects in a gravitationally bound system;
2. understand Kirchhoff's Laws and describe how various spectra are formed;
3. understand black body radiation, Wien's Law, Stefan-Boltzmann Law;

4. understand the relation between distance, luminosity and magnitudes;

5. describe how an optical/radio telescope works; and have familiarity with other wavelengths;

6. understand the HR-diagram and illustrate the evolutionary path of a Sun-like star; and

7. describe the stellar evolution (star birth to death) and its dependency on mass.

Typical problems students completing ASTR 1100 should be able to solve:

1. given the spectrum of a active galaxy, determine the redshift and velocity width of the emission lines;

2. given the radial velocity profile of a spectroscopic binary, determine the period and stellar velocities; and masses.

3. knowing the temperature of a star, determine its luminosity, mass, spectral type, and radius.

Curriculum

The following is a possible ordering of subject material for presentation. Some consideration has been given to time the presentation of overlapping subjects with PHYS 1500 (An Introduction to Modern Physics). The approximate number of lectures to spend on each topic in included parenthetically.

1. Spherical Geometry, Coordinate systems, time (2)

2. Celestial Mechanics and Gravity (4)

3. Electromagnetic radiation and spectroscopy (4)

4. Telescopes (1)

5. Stellar distances, magnitudes, photometric systems (2)

6. Sun and Stars (3)

7. Interstellar medium (1)

8. Stellar evolution (5)

9. Selected topics from: Milky Way, Galaxies, Cosmology, Solar System, Exoplanets

Suggested texts

Given that students have taken PHYS 1100 (University Physics I) and likely to have taken MATH 1210 (Introductory Calculus I), an advanced first-year textbook that could possibly be adopted for second-year courses is suggested.

Fundamental Astronomy by Karttunen *et al.* (ISBN 3-540-00179-4) appears to be at an appropriate level. It covers material in sufficient depth that it can be used as a reference for future courses. It includes topics on spherical astronomy that may be appropriate to use in ASTR 2100 (Foundations of Astrophysics).

Notes to the instructor

1. The department's astronomy technician, Dave Lane, can help get students going in the observatory. Besides the mechanics of how the telescope operates, there are safety issues which have to be discussed with the students the first time they are in the observatory. Dave also organises the observatory tours and thus some coordination with him is necessary before this course can begin.

2. Use of the 8" portable telescopes is encouraged. L. Gallo has created a number of exercises that can be used.

3. Weather in the winter semester can be a challenge for observing exercises, and alternative "desktop labs" should be considered.

4. Some coordination with the instructor of ASTR 2100 (Foundations of Astrophysics) would be useful to minimise unnecessary overlap and optimise how the two courses dovetail.