Introduction to Astronomy and Astrophysics

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In this class we will take a lightning tour through our understanding of the universe and a bit of the history of how we came to know this. Our primary interest will be to gain an understanding of the nature of astronomical objects: planets, stars, stellar remnants, galaxies, clusters, and ultimately the universe as a whole. To do this we will need to become familiar with some aspects of modern physics, starting with Newtonian mechanics and moving through waves, electromagnetism, elementary statistical physics, atomic physics and quantum mechanics, special and general relativity, and particle physics. Those that are not familiar to students already will be introduced at a level adapted to students' command of physics and the relevant mathematics.

Unit 1: Positional Astronomy

We will begin with a quick survey of the apparent motions of the sky, the way we designate the position of celestial objects and the observations we can understand from these concepts: lunar phases, eclipses, seasonal variations, and precession of the equinoxes.

1. Introduction to Positional Astronomy
2. The Celestial Sphere and Spherical Coordinates
3. The Local View and Observer Coordinates
4. Sidereal Time and Finding a Star
5. The Sun's Apparent Motion
6. Tilt and Seasons
7. Precession of the Equinoxes
8. The Moon's Motion and Phases
9. Eclipses
10. Summary

Unit 2: Newton's Universe

Newtonian physics revolutionized the way we understand our Universe. We will discuss Newtons laws of mechanics, the conservation laws that follow from them, as well as his theory of gravity and some applications to Astronomy. Exactly how we do this unit will depend on what students alreadt know about physics, as well as their command of calculus and multivariate calculus.

1. Motions of Planets

2. Brahe and Kepler
3. Some Kinematics
4. Newton's Laws
5. Conservation Laws
6. Newtonian Gravity
7. Newtonian Orbits
8. More About Gravity
9. Tides

Unit 3: Modern Physics

We will look at some properties of radiation and the features of quantum mechanics relevant to our course. This will be a particularly busy and challenging unit, but hard work here will pay off later. Again, how much we assume and how deep we go will depend on students' previous experience.

1. Matter and Atoms
2. Waves
3. Heat and Radiation
4. Light
5. Electromagnetism
6. Blackbody Radiation
7. Light and Matter
8. Line Spectra
9. Atomic Structure
10. Quantum Mechanics
11. Constituents of Matter

Unit 4: Solar Systems

We will not have time in this course to do any justice to the broad and exciting field of planetary science. We will spend some time on a general review of the properties and structure of our Solar System and our understanding of its origins and history. We will end with some discussion of the exciting discoveries over the past decade of many hundreds of extrasolar planets.

1. Inventory of the Solar System
2. Radioactive Dating and the Age of the Solar System
3. The Solar Nebula

4. Terrestrial Planet Formation
5. Beyond the Snow Line - Giants
6. A Little Bit of Planetary Science
7. The Atmosphere and the Greenhouse Effect
8. Asteroids and Comets
9. Other Solar Systems: Detection, Properties

Unit 5: Stars

What we know about stars and a bit about how we found out. We will begin with a quick review of the best-studied star of all, our Sun. We will then talk about classifications; H-R diagrams and main sequence stars; distance, mass, and size measurements; binaries; clusters; and stellar evolution through the main sequence.

1. Solar Energy
2. Nuclear Physics
3. Solar Fusion
4. Neutrinos
5. Solar Structure
6. Solar Weather
7. Astrometry
8. Classification and the H-R Diagram
9. Binary Stars
10. Properties of Main Sequence Stars

Unit 6: Stellar Evolution

Early and final stages of stellar evolution and stellar remnants. Giants, white dwarves, novae, variable stars, supernovae, neutron stars and pulsars.

1. Pre-Main Sequence Stars
2. Post-Main Sequence Sun
3. Clusters and Population Studies
4. Instability - Variable Stars
5. White Dwarfs
6. Evolution of Massive Stars
7. Core Collapse
8. Neutron Stars

Unit 7: Relativity and Black Holes

We will spend most of this unit acquiring an understanding of the special theory of relativity. We will then discuss the general theory in a qualitative way, and discuss its application to black holes, gravitational lensing, and other phenomena of interest.

1. Relativity and Spacetime
2. Maxwell and c
3. Lorentz Transformations
4. Relativistic Spacetime and Invariant Interval
5. Relativistic Conservation Laws
6. The Equivalence Principle
7. Gravity as Geometry - General Relativity
8. General Relativity in Astronomy
9. Black Holes

Unit 8: Galaxies

Galactic structure and classification. Active galactic nuclei, quasars and blazars. Galactic rotation curves and dark matter. Galaxy clusters and large-scale structure.

1. The Milky Way
2. Weighing the Galaxy
3. Other Galaxies?
4. Dark Matter
5. Galactic Structure
6. Galactic Evolution
7. Hubble's Law
8. Active Galactic Nuclei
9. Galaxy Clusters

Unit 9: Cosmology

What we can say about the universe as a whole. Hubble Expansion. Big bang cosmology. The cosmic microwave background. Recent determination of cosmological parameters. Early universe physics.

1. Kinematics of Expansion and Redshift
2. Dynamics of Newtonian Expansion
3. Cosmic Microwave Background
4. Relativistic Cosmology

5. The Big Bang
6. Precision Cosmology - Measuring the Parameters
7. Evolution of Structure
8. Early Universe and Inflation