

Course Goals & Learning Outcomes for Astronomy 2022A, 2014

Course goals: At the end of this course, students will be able to:

- describe the science of cosmology: its goals, methods and current state
- explain and use quantitative arguments in cosmology
- identify and describe cosmology's current unanswered questions

Learning outcomes for specific topics — students will be able to:

1. Scale of the universe (Chapter 2, 12)

- (a) define and use the terms star, planet, galaxy, universe
- (b) define light year, astronomical unit and relate these to the size of the above objects
- (c) do order-of-magnitude calculations with scientific notation
- (d) compare human scales of space and time to astronomical scales
- (e) define parallax, Cepheid, supernova and explain how these are used to measure distances

2. Forces in the universe (Chapters 3, 9)

- (a) define equivalence principle and explain what it has to do with Einstein's theory of general relativity
- (b) explain how general relativity is used in understanding the structure and evolution of the universe
- (c) compare and contrast the possible types of spacetime curvature
- (d) identify the 4 fundamental forces and describe their role in the past and present universe
- (e) explain the meaning of quantum as applied to forces in physics

3. The expanding universe (Chapters 4, 5)

- (a) describe the Cosmological Principle and its consequences
- (b) explain the meaning of scale factor and the different possible expansion histories for the universe
- (c) explain the effects of gravity, matter and energy on the expansion
- (d) describe the observational evidence for the expanding universe
- (e) define redshift and Hubble constant
- (f) explain Hubble's Law and interpret a Hubble diagram
- (g) describe the relation between the universe's expansion rate and its age

4. The early Universe (Chapter 6)

- (a) explain what is meant by Big Bang theory and list some evidence for it
- (b) define and use the terms cosmic microwave background and recombination
- (c) give the relationship between time, average energy, and temperature in the universe
- (d) explain the concept of thermal equilibrium and its importance in cosmology
- (e) describe what happened (and approximate timescales) for the various eras in the early universe

5. Matter in the Universe (Chapters 7–9)

- (a) define nucleus, element, isotope
- (b) list and correctly order the most abundant elements in the universe and explain where and how these elements are formed
- (c) describe how the abundances of elements changes with time
- (d) summarize the life cycle of stars
- (e) define anti-matter and explain why it is uncommon in the present-day universe

6. Dark matter and dark energy (Chapters 10–13)

- (a) define these two terms
- (b) describe the constituents of the universe and their approximate proportions
- (c) list and explain at least 2 pieces of observational evidence for dark matter and dark energy
- (d) compare and contrast the candidates for dark matter and dark energy, and the prospects for directly detecting them
- (e) explain how the possible fates of the universe relate to the matter and energy densities
- (f) explain the relations between the cosmological constant, vacuum energy and accelerating universe

7. Structure and scale (Chapters 14, 15)

- (a) define homogeneity and isotropy and their use in the context of cosmology
- (b) explain the idea of the cosmological horizon
- (c) define inflation in the cosmological context and explain what it means
- (d) explain how the cosmic microwave background relates to the distribution of matter in the universe
- (e) explain what measurements of structure in the cosmic microwave background tell us about the early universe

8. Galaxies in the universe (Chapter 16)

- (a) describe the general size and shape of the Milky Way galaxy
- (b) list the different types of galaxies and their properties
- (c) explain the relationship between galaxies and supermassive black holes
- (d) explain the roles of gravity and angular momentum in the formation of galaxies and stars

9. Beginning (Chapter 18)

- (a) explain what it means to talk about the ‘beginning’ of the universe
- (b) define the idea of the multiverse and discuss its implications
- (c) explain what quantum gravity and string theory have to do with the beginning of the universe