

Astronomy 1 — Descriptive Astronomy

Study Guide

1 How To Study For This Class

Studying for this class — not to understate the value of attendance — should include the following three main components:

1. reading the text,
2. reviewing your notes and the key concepts list,
3. reviewing the definitions and questions in this study guide.

If you do these you will have mastered the bulk of the material required to receive a *good* grade in this class. Below I describe how you can benefit from each of these.

1.1 Reading

Since we will be covering nearly all of the textbook, there is admittedly a lot of reading to do. However, the material is interesting and presented in a straightforward, readable manner. Although I will not follow the structure of the textbook strictly, I will go through it roughly in order and I will cover most of its material. I urge you to read in advance of the presentation in class if possible (see the tentative class schedule in the syllabus). If not, at least try to read the material soon after the class discussion of that topic. Don't try to do all the reading the day before the exam.

Pay particular attention to the figures since on an exam I will often ask you to draw a figure to demonstrate a particular phenomenon. Even if I don't ask you to draw it on an exam, it is still helpful since it is much easier to grasp an idea if you can visualize it. Although numbers are often important, I will not expect you to be responsible for memorizing masses of planets, or other numerical facts. I am much more interested in you developing an understanding of the broader concepts and themes. Also pay attention to the *Big Picture* and *Time Out To Think* parts of the book. By working with a concept — trying to draw a broader conclusion by combining it with other ideas — you get familiarity with it and greater confidence in your learning.

1.2 Notes

Try to take good notes. The best way for you to remember what happened in class is by writing it down, it simply helps you to process the material as you are hearing it. You don't need to write down everything that is on a given slide, in fact I discourage this. Rather try to capture the most important points, by picking out what I emphasize and using a bit of your own editing and thinking. Then, soon after each class, review your notes. Often you may find that you have forgotten a particular explanation, or something that seemed clear in class you now can't quite put together afterwards. By reviewing your notes regularly these difficulties can be identified and you can then take steps to clear up the problem, either by looking it up in the textbook (hint: make use of the index), or by asking a question in class or during my office hours (see below).

1.3 Key Concepts

Included in this study guide is a list of Key Concepts (the same list appears in the syllabus). These are important specific ideas or overarching principles that serve as grand themes in astronomy and also as benchmarks for my teaching goals in this class. They are the essential big ideas that in the course of any introductory astronomy class, will appear at several points in the class. Get familiar with them early and take note of them as they reappear.

1.4 Definitions and Questions

On the following pages are lists of terms to be defined and questions to be answered, associated with each exam. These will be used to make up the exams and I will often use a question from the study guide directly for a long answer question on the exam. As you go through your notes and the reading, check the list to see if a definition or question can be answered from the material that we have covered. Write down a *detailed* answer in your notes. It should include not simply a definition but also an explanation regarding the astronomical significance of the term or question. Then come back later and re-read and evaluate your answer. Don't just take the answer as done, but instead ask yourself if it makes sense to you as if you were judging someone else's answer, i.e. be self-critical. If it doesn't make sense then re-read the material in the book or double check your notes to try and resolve the issue. You can easily do this with another student by simply trading your answers and critiquing their responses as they critique yours.

1.5 Other Resources

If after reviewing your notes or the study guide, you are in doubt about a concept please come by and talk to me during my office hours (see the syllabus) I am also around my office at other times so it is fine to come knock on my door, or phone or e-mail and ask if I'm available.

There is a web site associated with the textbook that you might also find helpful:

<http://www.astronomyplace.com>

A web search for a topic using Google or another search engine, may also turn up a site with good explanations. Another good resource is your fellow classmates. Ask a friend if they understand something and see if they can help you figure it out. This can help both of you. Explaining a topic to someone else can reinforce your learning and is a good way to see if you understand it yourself.

2 Key Concepts

- **Seasons** — changing temperature, length of the day and the position of the Sun in the sky, are influenced by your latitude, the tilt of the Earth's rotation axis and its direction relative to the Sun, **not** the Earth's distance from the Sun.
- **Lunar Phases** — rising and setting times and the relative orientations of the Earth, Moon and Sun are linked to the apparent shape of the moon in the sky.
- **Copernican Principle** — there is nothing unique or special about the position of the Earth in the cosmos.
- **Newtonian or Classical Dynamics** — the laws of mechanics and gravity as synthesized by Isaac Newton, accurately determine the motions of nearly all astronomical objects.
- **Electromagnetic Radiation** — optical light is just one part of the electromagnetic spectrum. Most of what we know about astronomy is from observing the radiation, ranging from γ -rays to radio waves, from stars and other astronomical objects.
- **Quantum Mechanics** — the physics of the very small, quantities which appear continuous on the relatively large scales of our senses come in tiny discrete units, or quanta. The consequences for physics and astronomy are profound.
- **Astronomical Observation** — our means of learning about celestial bodies is through a few basic types of observations, whose strengths and weaknesses shape the progress of research in astronomy.
- **Astronomical Instrumentation** — telescopes, satellites and their detectors make up the tools of the trade.
- **Theoretical Astronomy** — astronomical observations must be interpreted in terms of the laws of physics through construction and application of detailed models.
- **Planetary Systems** — our solar system, composed of planets, asteroids, comets and debris, is one of many inside the Milky Way Galaxy.
- **Stellar Evolution** — the birth, life and death of a star and how it is different for stars of different masses, is an important branch of astronomical research.
- **Nucleosynthesis** — all elements heavier than hydrogen and helium, including those required for the chemical evolution of life on Earth (and presumably elsewhere), were produced in nuclear reactions in the centers of stars or in supernova explosions.
- **Special and General Relativity** — Einstein's revisions of Newtonian dynamics which applies at high velocities and large accelerations.
- **Extra-galactic Astronomy** — Galaxies are large assemblages of stars, gas and dust, bound by gravity, like the Milky Way and its neighbor the Andromeda galaxy. They are the basic building blocks of the Universe at large.
- **Cosmology** — the study of the large scale structure, origin and fate of the Universe.
- **Expansion of the Universe** — the universe is expanding such that the more distant a galaxy is the faster it recedes from all other galaxies. This is the basis of Hubble's Law, and has consequences for the origin and fate of the Universe.
- **Hierarchy and Scales of the Universe** — which astronomical objects are components of other larger objects, and what physical principles play a role on a given length scale or time scale.
- **Scientific Revolutions** — changing the interpretations of observed facts to match a new fundamental principle or paradigm.

3 Exam #1

3.1 Definitions (for historical figures list their major accomplishments)

- Scientific Notation
- Winter/summer solstice
- Latitude
- Right ascension
- Retrograde motion
- Nicolaus Copernicus
- Semi-major axis
- Isaac Newton
- Kinetic energy
- Frequency
- Emission line
- Photon
- Pixel
- Hubble Space Telescope
- Light Year
- Vernal/autumnal equinox
- Longitude
- Declination
- Epicycle
- Copernican principle
- Astronomical unit
- Force
- Potential energy
- Wavelength
- Absorption line
- Doppler effect
- Keck Telescopes
- Chandra Telescope
- Constellations
- Ecliptic
- Paleoastronomy
- Circumpolar stars
- Ptolemy
- Johannes Kepler
- Galileo Galilei
- Momentum
- Angular momentum
- Electromagnetic radiation
- Energy level
- CCD
- VLA
- Spitzer Telescope

3.2 Questions

- What is the cosmic calendar and on what dates and times do the first stars, dinosaurs, humans and human civilizations appear?
- What phenomena on the Earth and in the sky are associated with the change of seasons and what ultimately causes them?
- What determines the altitude (that is the height above the horizon) of the north or south pole in the sky?
- What are the phases of the moon? How do they depend on the relative positions of the Sun, Moon and Earth? How are they tied to the rising and setting times of the Sun and Moon?
- Describe an eclipse of the moon (lunar eclipse) and an eclipse of the Sun (solar eclipse)?
- How did Eratosthenes determine the circumference of the Earth?
- Describe the heliocentric and geocentric universes.
- What conflicts with Aristotle's view of physics were created by the introduction of the heliocentric universe?
- What was Tycho Brahe's contribution to the development of astronomy in the late Renaissance?
- What are Kepler's three laws of planetary motion?
- Describe the first observations that Galileo made with a telescope. How did they serve to support Copernicus' heliocentric model?
- What are Newton's laws of motion and the law of gravity? How do they alter or incorporate Kepler's laws?
- Why doesn't the force of gravity cause the Moon to collide with the Earth?
- What is the origin of tides in the ocean?
- What is meant by conservation of energy? What is meant by conservation of angular momentum? Give examples of each.

- List the colors of the visible spectrum in order from longest wavelength to shortest wavelength.
- List the regions of the entire electromagnetic spectrum in order from longest wavelength to shortest wavelength.
- The intensity or brightness of light follows an inverse-square law with distance. What does that mean?
- What is meant by the term thermal radiation and how does the shape of a thermal spectrum change with temperature?
- Describe the Bohr model of the atom, including its constituents, and how it can be used to explain absorption and emission lines?
- Draw the optical path of a reflecting telescope and a refracting telescope? Describe the advantages and disadvantages of each?
- What are the three things that a telescope does to improve the quality of an image over that produced by the human eye?
- What are the advantages of telescopes in space over their ground-based counterparts?
- What are the particular strengths of the Hubble Space Telescope, the Chandra Observatory and the Spitzer Telescope?

4 Exam #2

4.1 Definitions

- Comparative Planetology
- Terrestrial planets
- Greenhouse effect
- Great red spot
- Asteroid
- Extra-solar planets
- Ionized plasma
- Parallax
- Apparent brightness
- Binary star
- Radial velocity
- Hydrostatic equilibrium
- White dwarf
- Nebular Hypothesis
- Jovian planets
- Plate tectonics
- Cassini's division
- Comet
- Natural selection
- Solar prominence
- Transverse motion
- Intrinsic brightness
- Variable star
- Spectral type
- H-R diagram
- Giant
- Protoplanetary disk
- Kuiper Belt
- Differentiation
- Roche Limit
- Meteor
- Mass extinctions
- Sunspot
- Parsec
- Magnitude
- Nova
- Luminosity class
- Main sequence
- Supergiant

4.2 Questions

- List the planets in order from closest to the Sun to farthest away. List the planets in order of size from largest to smallest.
- How does the Nebular Hypothesis explain the differences between the terrestrial and jovian planets?
- What physical and geological processes influence the surfaces of terrestrial planets?
- Explain the role played by the greenhouse effect (or lack of it) in determining the characteristics of the atmospheres of Earth, Venus and Mars.
- What is the origin of the oxygen in the Earth's atmosphere?
- What is the origin of the water on Earth?
- What phenomenon is responsible for the craters on the moon? What do we know about the history of this process?
- Briefly describe the four main theories for the origin of the moon. Which one is currently in favor by scientists and why?
- What are the four Galilean moons of Jupiter? Why is one of them considered a possible site for the evolution of life? How is volcanic activity sustained on the Jupiter's innermost moon?
- Where do comets come from? Where in the solar system are you likely to find asteroids? How do they fit into the picture of the Nebular Hypothesis?
- What properties of extra-solar planets make them difficult to understand, in the context of the Nebular Hypothesis? How might these problems be explained?
- What is the composition of the Sun? How does it compare with the composition of the terrestrial and Jovian planets?
- Draw and label a cutaway diagram of the Sun and its extended atmosphere. Indicate the temperature at key points in its structure.
- How is energy produced from the thermonuclear reactions at the center of the Sun? How are the strong nuclear force, the electromagnetic force and the temperature involved?
- How does the parallax of a star allow us to determine its distance?

- Draw the light curve of an eclipsing binary. Draw a picture showing the positions of the stars during and in-between eclipses.
- How do the radial velocities of binary stars change over a complete cycle? How does the inclination of the orbit to our line of sight influence this?
- Draw and label a Hertzsprung-Russell diagram. List the spectral types in order from hottest to coolest.
- How do the properties of stars change from one end of the main sequence to the other?
- How can we use the HR-diagram and the equation $L = 4\pi R^2 \sigma T^4$ to infer the radii of stars?
- How do the variations of a Cepheid variable allow us to determine its distance?

5 Final Exam

The final exam will be part comprehensive and part covering the material since the last in-class exam. Use the previous pages to help you study for the comprehensive section.

5.1 Definitions

- Interstellar medium
- Protostar
- Helium flash
- Neutron star
- Supernova remnant
- Black hole
- Andromeda galaxy
- Distance chain
- Galaxy halo
- Elliptical galaxy
- Starburst galaxy
- Virgo cluster
- Dark matter
- Olber's paradox
- Hubble Deep Field
- Critical density
- Molecular cloud
- Evolutionary track
- Chandrasekhar limit
- Pulsar
- Supernova 1987 A
- Event horizon
- Spiral arm
- Redshift
- Galaxy disk
- Irregular galaxy
- Quasar
- Local group
- Protogalaxy
- Cosmological principle
- Gravitational lens
- Accelerating universe
- Interstellar dust
- Brown dwarf
- Planetary Nebula
- Supernova
- White dwarf supernova
- Spacetime
- Magellanic clouds
- Hubble's law
- Galaxy bulge
- Active galactic nucleus
- Radio galaxy
- Supercluster
- Galaxy interaction
- Lookback time
- Anti-matter
- SETI

5.2 Questions

- What are the differences between globular and open clusters?
- What causes a star to leave the main-sequence and form a red giant?
- Draw the evolutionary track of a low mass star from protostar to white dwarf on the HR diagram. Label the points of the most significant events in the course of its lifetime.
- What are the end states of a low mass star and a high mass star?
- How does the production of an iron core in the evolution of a high mass star result in a supernova explosion? What happens in a white-dwarf supernova?
- On what two principles did Einstein base the theory of special relativity?
- What specific case does special relativity apply to? How does general relativity expand on this?
- According to special relativity what are some of the peculiar effects of traveling at speeds approaching the speed of light?
- Draw a picture of the Milky Way galaxy as it might appear from outside and label all of its parts.
- How are globular clusters distributed within the Milky Way? How are open clusters distributed?
- How is a galaxy different from a star cluster?
- How do we know that the Milky Way is a spiral galaxy given the difficulty of determining its structure from our vantage point in its dusty disk?
- Draw and label the tuning fork diagram for galaxies.
- What are the differences between elliptical and spiral galaxies?

- Describe the different techniques for measuring distances to galaxies.
- What is the significance of Hubble's Law to the studies of galaxies? What is its significance to cosmology?
- How did the discovery of Cepheid variable stars in the Andromeda galaxy allow Edwin Hubble to conclude that galaxies were distant objects beyond the Milky Way?
- What is a standard candle? How do the Tully-Fisher method and the type Ia supernovae allow us to get distances to galaxies?
- What is the raisin bread analogy for Hubble's Law?
- Why were the conclusions about quasars were so difficult to understand for astronomers in the 1950s and 1960s?
- Describe the mechanism which produces the enormous luminosities of quasars?
- What is the Big Bang?
- What is a Hubble time?
- What are the possible fates of the Universe? What is the importance of the critical density, Ω_0 , in each of these? Draw a diagram illustrating these possibilities.
- What is the cosmic background radiation and what is its origin?
- What is the inflationary universe theory?