# Study Questions for Astronomy 101

**These questions are meant to guide your reading, test overall comprehension, and highlight the main points of each chapter. It is also recommended that you know the definitions of all of the bold terms in the chapter summaries and try the "Self Test" questions at the end of the relevant chapters prior to each test.**

- **Prologue**
    - What are the main quantities we measure in physics, and why do we choose to use metric units to measure them?
    - Given the fact that the speed of light is finite, what connection does this imply between the distances to, and perceived ages of, astronomical objects?
    - How do the apparent motions of the sun and the stars depend on the actual motions of the Earth?
    - Why does the Earth have seasons?
    - How can simple geometry be used to measure the sizes and distances of faraway objects? How does the observed parallax vary with distance to the foreground object? How does the observed parallax vary with the size of the baseline?
- **Chapter 1**
    - Why does the moon have phases?
    - Why do eclipses occur, and why are there different kinds?
    - What were the two biggest problems with the geocentric model of the universe?

- What observations did Galileo perform that supported Copernicus' heliocentric model, and what was the supporting evidence? Discuss in the context of the “scientific method”.

- What are the shapes and important characteristics of the planetary orbits?

- Describe Newton's laws and the law of gravity.

- What force governs the motions of astronomical bodies, and what factors determine how strong this force is?

- In what sense is it correct to consider the Moon to be continually “falling” towards the Earth and missing? Does this reasoning extend to the Earth (or any other planet) in its orbit around the Sun? Why or why not?

- **Chapter 2**

  - What is a wave? What are the main properties of a wave? What two things do all waves transport?

  - What is the basic difference between different regions of the electromagnetic spectrum?

  - What are the important characteristics and laws associated with objects that have a black-body spectrum?

  - Describe the basic structure of the hydrogen atom.

  - Explain how absorption and emission lines are produced and discuss their dependence on atomic structure.

  - What are photons? What role do they play in absorption/emission? What two things do they transport? How are they related to electromagnetic waves?

  - Why is spectroscopy a useful tool in astronomy?

- How and why does the observed frequency and wavelength of a wave change when the source of the wave moves towards or away from you? How about when you are moving towards or away from the source? What about motion perpendicular to the line-of-sight?

- **Chapter 4**

  - List the nine planets and briefly describe their layout in the solar system using the sun as a reference point. Where does the asteroid belt lie?

  - What properties distinguish the terrestrial planets from the Jovian Planets?

  - Where do comets originate? Describe the appearance of a comet when it is far from the sun and when it is very close to the sun?

  - What is the main reason for studying solar system debris?

  - Briefly outline the nebular and condensation models of solar system formation. How do these models account for the different properties of the inner (terrestrial) and outer (Jovian) planets?

  - Explain conservation of angular momentum and discuss its role in solar system formation.

  - What two important roles do dust play in the condensation model of solar system formation? What is accretion?

- **Chapter 5**

  - What causes the tides? Why do tidal forces tend to stretch things out?

  - Where did the water that exists on the surface of the Earth today come from?

- Explain how heat is transferred from a hot region to a cool region by convection.

- How does the Greenhouse Effect work? What are the most important greenhouse gases in the Earth's atmosphere?

- Describe the basic structure of the Earth's interior in terms of: whether the temperature and density increase as you go outwards or inwards, the different layers, and which regions are solid and which are molten. What is our main source for this type of information?

- What does the differentiation exhibited by the Earth suggest about its early history?

- What causes continental drift? What kinds of surface activity tend to occur at plate boundaries?

- Using the concept of escape speed, explain why the Earth has an atmosphere while the moon does not.

- What are the two main kinds of terrain on the Moon and what are their important properties?

- Explain how counting craters can be used to estimate the age of a surface.

- What is currently the prevailing theory for the origin of the Moon? What are the problems with the competing theories?

- Explain why the Moon always has the same face pointed towards Earth. Does this mean that the Moon is not rotating?

- **Chapter 6**

  - How is Mercury's solar day related to its solar year? How does this relationship compare to that of our Earth-Moon system? How do we measure the rotation rate of a planet?

  - Describe the two anomalous features of Venus' rotation.

- What technique was used by the Magellan probe to make surface maps of Venus and how does it work?

- Describe the runaway greenhouse effect and its consequences? What would happen if the Earth was suddenly moved to an orbit the same distance from the sun as Venus?

- Compare and contrast the surface temperatures and atmospheres of Mercury, Venus, Earth, and Mars.

- What are the different indicators that liquid water used to flow on Mars? Where is that water thought to be now and in what form (solid, liquid, gas)?

- Where did Mars' two moons come from?

- **Chapter 7**

  - Describe the discovery of Neptune in terms of the scientific model and Kepler's and Newton's laws.

  - What is differential rotation and how is it related to the composition of the Jovian planets?

  - What process(es) explain the zone and belt patterns on the Jovian planets? Describe the differences (temperature, pressure, wind direction, etc.) between the zones and belts? What causes these bands to stretch all the way around the planets?

  - Why are storms (like the great red spot) so long-lived on the Jovian planets?

  - Explain the effect of Uranus' extreme axial tilt on that planet's seasons.

- **Chapter 8**

  - Discuss the different ways in which the Galilean moons orbiting Jupiter resemble a miniature solar system.

- What are the rings of Saturn (and of the other Jovian planets) made of? How did they form? (Include a discussion of the Roche limit.)

- Explain why Triton is slowly spiraling towards Neptune. What is the ultimate fate of this moon?

- What is a shepherd moon and what does it do?

- Explain the mechanism by which the interiors of Io and Europa are heated.

- What are Kuiper belt objects and how is Pluto related to them?

- **Chapter 9**

  - Briefly outline the internal structure of the Sun. In what part of the Sun is energy produced? What part of the Sun do we see from Earth?

  - Briefly describe the energy production mechanism that powers the sun. How is the law of conservation of mass-energy involved? Why are such high temperatures needed for this process?

  - In what two ways is energy transported within the Sun? In what way can we think of the solar wind as the evaporation of the Sun? What is hydrostatic equilibrium?

  - Describe sunspots in terms of their relationship to “loops” in the Sun's magnetic field. What causes these loops to form? How hot are sunspots in relation to the rest of the surface of the Sun?

- **Chapter 10**

  - List and define the properties of stars which we need to measure in order to understand their structure and evolution.

- What two methods are used to measure stellar temperatures? Explain how they work.

- Explain the difference between apparent brightness and luminosity.

- Explain the radius-luminosity-temperature relationship. Which ONE of these three properties is the relationship usually used to determine?

- What two quantities are plotted on an H-R diagram? Define the “Main Sequence”.

- Explain how the distances to stars can be determined using spectroscopic parallax. What key assumption needs to be made when using this technique? Why is this generally a safe assumption?

- **Chapter 11**

  - How does the typical density of interstellar gas compare to that of stars or planets?

  - What are the possible observational effects of looking through interstellar dust? Why does 21-centimeter line radiation remain unaltered by these effects?

  - What important roles does interstellar dust play in the formation of stars?

  - For a typical star, briefly outline the steps leading from (i) a cold cloud of molecular gas to (ii) nuclear fusion at the core of the newborn star and finally (iii) a star settling on the main sequence. In what ways would this sequence differ for a VERY massive star?

- **Chapter 12**

  - How does the rate of fusion vary with temperature? What does this imply about the evolution of a post-main sequence star?

- Briefly describe the events leading up to the end of a low mass star's lifetime. How does this differ for a very high mass star?

- What process results in a Nova?

- What are the two different types of supernova and what are there causes?

- Describe how the main sequence turnoff mass can be used to determine the age of a star cluster.

- Why are star clusters useful for studying stellar evolution?

- **Chapter 13**

  - How is a neutron star formed? What role does the Pauli exclusion principle play?

  - What is a pulsar? List some important properties.

  - Einstein's equivalence principle relates what two phenomena?

  - In general relativity, what effect does matter have on the background of space? How is this related to black holes?

  - What are the Schwarschild radius and the event horizon and how are they related? List some of the strange phenomena that can occur near the event horizon of a black hole (including: tidal forces, effects on photon frequency, and the behavior of clocks).

- **Chapter 14**

  - What are the three main components of the Milky Way? List the important properties of each.

  - What is thought to reside at the very center of our galaxy? Where is our Sun (and the Earth) located and how do we know?

- Explain how variable stars are used to determine distances.

- Describe the orbits of stars in the disk and the halo.

- Briefly explain why galaxies like our own have a spiral structure. What is this theory called?

- What is the main evidence that the Milky Way contains a great deal of dark matter?

- **Chapter 15**

  - Briefly outline the "nearby" structure of our universe. Start with the local cluster and end with superclusters.

  - Explain how the Tully-Fisher relation is used to measure distances out to ~200 Mpc. What two properties of galaxies does this method rely on?

  - Explain how a Type I supernova behaves like a "standard candle" and how this can be used to measure distances out to ~1 Gpc.

  - Compare and contrast the Blackbody spectra of Normal and Active Galaxies. List the different types of AGN and some of their properties. What is the power source behind all AGNs?

- **Chapters 16 and 17**

  - What is Hubble's law? Explain how it can be used to determine distances to the most distant objects in the visible universe.

  - Describe the structure of the universe on the largest scales. How does this compare with the structure seen at or below the level of superclusters?

  - How can gravitational lensing be used to detect dark matter?

  - What two assumptions make up the cosmological principle? Describe each.

- What is Olbers' Paradox and how was it eventually solved?

- What quantity determines the ultimate fate of the universe? What is the single biggest contributor to this quantity? According to the best available data, what is the predicted fate of the universe?

- Describe the cosmic microwave background radiation. How is it related to the Big Bang? To the horizon problem? What does it imply about the conditions in the early universe?

- What is primordial nucleosynthesis and why did it eventually stop?

- What are the horizon and flatness problems and how does the theory of inflation solve them?

- **Chapter 18**

  - List and describe the main characteristics of “life as we know it”.

  - Briefly describe the point of view expounded by the “assumptions of mediocrity”.

  - Describe the Miller-Urey experiment. What did they show?

  - What is the Drake equation? Discuss the relative difficulty in assigning values to each term.

  - What is the “cosmic watering hole”? Why is it important? Where in the EM spectrum does it lie?