ASTR-1200-01: Stars & Galaxies (Spring 2019) . . . . . Study Guide for Midterm 1

The first midterm exam for ASTR-1200 takes place in class on **Wednesday, February 13, 2019.** The exam covers the parts of Chapters 1, 2, 3, 4, 5, and 6 in *The Cosmic Perspective* that were assigned as readings. The exam draws on the readings, lecture material, clicker questions, and concepts in the homework. Please come to office hours, the Astronomy Help Room, and/or the extra pre-exam HELP SESSIONS if you need assistance with this material.

The exam will consist mainly of multiple-choice questions, and a few (probably three) short-answer questions that require you to write a couple of sentences for each. The midterm exams are closed-book and closed-notes. You can bring a calculator, but you should not need one. Of course, no phones or laptops (or any device that connects to the outside world) are allowed.

Some of the questions will involve memorization, but these ought to be concepts that we have highlighted and/or repeated as being major topics. Other questions will involve you taking what you know and applying it in a slightly different way.

Below is a list of sources for study aids, followed by a "birds-eye-view" list of topics that we covered. If you review and understand every item in those lists (along with where they appear in the lecture-note PDFs), you should be in good shape for the exam. Also, for only the FIRST midterm, we're including a brief selection of example questions similar to those that will appear on the exam. We won't do this for subsequent exams, because by then you will already have had a chance to see how we craft exam questions from the course material.

SOURCES FOR STUDY ASSISTANCE

- **Textbook**
  - "Learning Goals" (start of every chapter)
  - "Big Picture" and "Summary of Key Concepts" (end of every chapter)
  - "Common Misconceptions" and "Think About It" boxes
- **Canvas**
  - All lectures notes are posted in PDF format
  - Review the clicker questions from lectures
  - Solutions to the homeworks will be posted, too
  - Feel free to use the "Discussions" tab to chat online, post questions, find study partners, etc.
- **Study Groups**
  - You are encouraged to study with classmates, but be sure to take turns asking and answering questions. When done right, this can be one of the best ways to learn.
- **Office Hours & Help Sessions**
  - Times/dates will be posted. Come with questions!

TOPICS/CONCEPTS FOR MIDTERM EXAM 1

Chapter 1 (sections 1.1, 1.2, 1.4)

- Scientific notation, powers of ten, and how they are manipulated.
- Ratios and scaling relations. Understand how to work with expressions that use the "proportional-to" symbol ($\propto$) below.
- Our place in the Universe. Ranking various major classes of objects (planets, stars, galaxies, clusters) in size and distance.
- Common distance units: AU and light-year (know their meanings, *not* their exact values). For the light-year, know where it comes from: *speed = distance / time,* so *distance = speed* $\times$ *time.*
- Understand that when we look deeper into space, we're looking further back in time. Since the Big Bang was 14 billion years ago, that means the "Observable Universe" extends only 14 billion light-years from us in any direction.

Chapter 2 (section 2.1)

- What is the celestial sphere? Can we see all of it from one vantage point on the Earth? Why do objects in the sky rise in the east and set in the west?
- Understand how & why the Earth's tilt causes the seasons.
- We use angles (degrees, arc-minutes, arc-seconds) to measure the apparent sizes & distances of objects on the celestial sphere. However, angles alone cannot tell us the *distances* to these objects.

Chapter 3 (sections 3.1 [first page only], 3.2)

- Ancient Greek astronomy: Understand their geocentric & heliocentric models of the universe. The observed *retrograde* motion of some planets required them to add *epicycles.*
- Astronomy in the 1500s-1600s: Understand the general roles played by Copernicus, Tycho, Kepler, and Bruno.
- Know how Galileo's use of the telescope provided much more evidence for the heliocentric model. However, he couldn't prove it conclusively because he could not measure the *parallax* motion of stars.
- All of this resulted in the development of the modern Scientific Method.

Chapter 4 (sections 4.1, 4.3 [pages 119-123 only])

- Motion is measured with distance (d), time (t), velocity ($v = d/t$), and acceleration ($a = v/t$). Any change in velocity (including just changing direction of motion) counts as acceleration.
- Know how Newton's three laws of motion describe the concept of *force:* (1) If no force, velocity is constant. (2) Forces cause acceleration ($F = ma$). (3) If X exerts a force on Y, then Y exerts an equal/opposite force on X.
- Any two massive objects (masses m_1 & m_2) separated by a distance (d) exert a gravitational force on one another that scales as $F \propto m_1 m_2 / d^2$.
- On Earth, the acceleration due to gravity is about 10 m/s^2, and it's independent of the mass of the falling object. If you drop something, its speed increases at a rate of 10 m/s every second.
- An *orbit* is just a falling body with enough sideways speed to keep falling "around" a spherical object, perpetually.
- Understand the main types of energy (kinetic, radiative, potential). The total energy of a system is always conserved, but energy can change from one type to another.

Chapter 5 (sections 5.1, 5.2, 5.3, 5.4)

- How does light interact with matter? Understand emission, absorption, transmission, & scattering.
- Light can be described as both waves and as particles ("photons").
- For light waves, understand how wavelength (λ), frequency (f), and the speed of light (c) are related to one another: $c = \lambda f$, and so on.
- The energy of a photon: $E \propto f \propto 1/\lambda$.
- Know the main layout of the electromagnetic spectrum: gamma-rays, X-rays, ultraviolet, visible, infrared, microwave, radio.
- Recall the roles of protons, neutrons, and electrons in atoms.
- Electrons "orbit" the nucleus with a range of possible *energy levels.* If electrons jump UP, that's an energy gain that must correspond to absorbing (destroying) a photon of that energy. If electrons jump DOWN, that's an energy loss that must correspond to emitting (creating) a photon of that energy.
- Hot, solid objects glow with a continuous thermal ("blackbody") spectrum, with $\lambda_{\rm peak} \propto 1/T$, and total intensity $I \propto T^4$.
- Understand how emission and absorption line spectra are created.
- Understand the basic reasons for the *Doppler shift* of light: motions toward the observer are blue-shifted, and motions away from the observer are red-shifted.

Chapter 6 (sections 6.1, 6.2)

- Know the 3 main reasons that we use telescopes. Compared to the human eye, (1) they collect more light, (2) they have better angular resolution, and (3) they can be made sensitive to non-visible wavelengths.
- The light-collecting power of a telescope is proportional the *Area* of its main mirror or lens. Remember that $A = \pi r^2$, and that a circle's diameter is twice its radius.
- Some wavelengths of light (all gamma-rays, all X-rays, some UV, some IR, and some radio) are absorbed totally by the Earth's atmosphere, so telescopes must be put in space in order to detect that light from distant objects.

EXAMPLE MULTIPLE-CHOICE QUESTIONS

_____ 1. Which of the following is largest?

A. the size of a typical star
B. the size of a typical galaxy
C. the size of Pluto's orbit around the Sun
D. 1 light-year
E. 1 astronomical unit (AU)

_____ 2. There are about 1 million asteriods in our solar system. There are about 100 billion solar systems like ours in our galaxy. A good estimate for the number of asteroids in our galaxy is therefore:

A. 10^{14}
B. 10^{15}
C. 10^{16}
D. 10^{17}
E. 10^{18}

_____ 3. Which of the following statements about the celestial sphere is *not* true?

A. The celestial sphere is a representation of how the entire sky looks, as seen from Earth.
B. From any location on Earth, we can see only half the celestial sphere at any one time.
C. The celestial sphere does not exist as a physical object.
D. The celestial sphere represents a belief in an Earth-centered universe, and hence is no longer considered to have any use.

_____ 4. The astronomer who discovered that Jupiter has 4 moons circling it (and, thus, *not* every object in the sky circles the Earth) was:

A. Galileo Galilei
B. Tycho Brahe
C. Johannes Kepler
D. Nicolaus Copernicus
E. Isaac Newton

_____ 5. Suppose an object is moving in a straight line at 50 miles/hour. According to Newton's first law of motion, the object will

A. continue to move in the same way forever, no matter what happens.

B. continue to move in the same way until it is acted upon by a force.

C. eventually slow down and come to a stop.

D. continue to move in a straight line forever if it is in space, but slow and stop otherwise.

E. continually slow down but never quite come to a complete stop.

_____ 6. Which of the following is *not* a type of energy?

A. Kinetic energy

B. Thermal energy

C. Radiative energy

D. Quantum energy

E. Gravitational potential energy

_____ 7. Laboratory measurements show that hydrogen produces a spectral line at a wavelength of 486.1 nanometers (nm). A particular star's spectrum shows the same hydrogen line at a wavelength of 486.0 nm. What can we conclude?

A. There must be some kind of measurement error.

B. The star is moving away from us.

C. The star is moving toward us.

D. The star is getting hotter.

E. The star is getting colder.

_____ 8. How can an electron in an atom lose energy to go from a higher energy level to a lower energy level?

A. It absorbs a photon equal in energy to its own energy drop.

B. It loses kinetic energy.

C. It loses gravitational potential energy.

D. It exchanges gravitational potential energy for kinetic energy.

E. It releases a photon equal in energy to its own energy drop.

Check answers only AFTER you've tried answering the questions first...

1. B 2. D 3. D 4. A 5. B 6. D 7. C 8. E