ASTRONOMY 5
Study Guide to Midterm Exam

The exam will consist of four sections:

True-false
Multiple choice
Short definitions: what it is? Why important?
Numerical problems

There will be some choice in the last two sections; all the questions in the first two sections will be required. The material will cover the material through Lecture 10 on black holes.

The exam is open notes/open book. You are permitted to use any of the reading materials and your own notes. However, in practice questions will be drawn from the lecture notes, quizzes, and homework so bring those to the exam. The textbook is considered background material. Numerical problems will look like ones you have had for homework and quizzes. Don't bother to memorize formulas---if a formula is needed, it will be provided in the question.

RECOMMENDED REVIEW PLAN:

I. Try to synthesize the big picture.

1) Concentrate on the lecture notes, quizzes, and homeworks.
2) Re-read the lecture notes with attention to the logical flow of ideas in each one. Make a brief topical outline of the main ideas in each lecture (3-5 ideas). Get a feeling for where each main idea was introduced. Note concepts that are not clear or terms that you don't understand for the review on Friday.
3) With each main idea, ask yourself why it is important and how it has been used.

II. Consolidate your understanding of vocabulary.

4) Each lecture presents a few underlined terms. Make a list of these and ask yourself if you understand their meaning. Could you write a definition if asked? Why is each of these important?

III. Consolidate your understanding of the equations.

5) Write down the principle equations from each lecture.
6) Review the meaning of the quantities in each one.
7) Most of the equations tell you how one thing varies as another thing changes. Construct an English sentence that summarizes what each equation says about the variation. Example: "The formula for the enclosed mass M(R) says that the mass

varies as the *square* of the rotation velocity V and inversely with the radius R." What does this sentence mean, physically?

8) Finally, think about how the equation is used. Why is it important for cosmology?

IV. Review the homework problems.

9) Most of the homework problems are much harder than anything on the exam. For example, we will not ask you on a midterm to estimate the number of grains of sand on Earth's beaches!
10) However, we do ask you to be familiar with the simple equations of the course, and especially how one thing varies versus another thing. See the sample questions we handed out on Wednesday to find out what the numerical problems are like. Note that equations turn up not only in the numerical problems but also in the multiple-choice part of the exam, where we ask you about the meaning or implications of an equation.

V. Finally, try the sample questions and see if you can answer them. Or, start with these and use them as a guide for filling in your knowledge.

IMPORTANT TOPICS:

Here is a list of important topics so far:

- Scientific notation
- Lookback time and the lookback onion; horizon radius
- Olber's paradox
- Electromagnetic spectrum; light; photons
- Wave-particle duality of photons
- Basic building blocks of the Universe: matter, radiation, atoms, electrons, neutrons, and protons.
- Light and its interactions with atoms; spectral lines
- Stars
  - How stars shine; nuclear reactions; $E = mc^2$
  - HR diagram: luminosity; surface temperature
  - Stellar lifetimes vs. mass; turnoff ages
  - Color of stellar population as indicator of ongoing star formation
  - Star formation from interstellar gas; hydrogen gas maps of Milky Way and other galaxies
  - Supernovae; nucleosynthesis of heavy elements; build-up of heavy elements over time by supernovae
- Distances to stars; inverse square law
- Distance ladder; Cepheid variables
- Milky Way structure
  - Disk: nature of stars, gas content, stellar ages, orbits

- Spheroid: nature of stars, stellar ages, orbits, globular clusters
- Location and orbit of Sun in Milky Way

The Doppler effect

Weighing galaxies and clusters of galaxies; rotation curves

Dark matter vs. ordinary matter:

- How we know dark matter is there
- Using gravity to detect the dark halos of galaxies
- Universal ratio of dark matter to ordinary matter

Hubble types; Hubble sequence

Galaxy collisions: destruction of disks; creation of spheroids

Why stars can orbit in both disks and spheroids but gas can orbit only in disks

Interpretation of Hubble sequence in terms of time of last major collision

Hubble's law and the expansion of the Universe

- Redshift, z
- Hubble constant
- Scale factor, a
- Why Hubble's law does not imply that we are at the center

Age of Universe from Hubble constant compared to ages of globular clusters

Properties of quasars

Basic facts about black holes:

- Event horizon, Schwarzschild radius
- Bending of light beams
- Black hole time as perceived by inside observer vs. outside observer

Processes that make black holes in nature

How quasars shine via black holes; accretion disks