Study Guide for ASTR 104 - Final Test

General comments:

The final test is comprehensive. The class presentations have been posted at <https://www.phy.olemiss.edu/%7Ettorma/Astro/Presentations/ASTR104/Presentations104.html>; they may be visible without sophisticated software, but for full view Microsoft PowerPoint must be used. The correct way of viewiing these is (i) downlodaing the files on a computer, (ii) Once openend in PowerPoint, SlideShow->PlayFromStart should be clicked. Printing out the files is very ineffective and does not show all the features.

The correct answers to the class quiz questions are marked red in the presentations.

The questions (and answers to them) in the in-semester tests cannot be posted for copyright reasons - they come from a proprietary test bank. The quiz questions are mostly the instructor's own making, so these can be posted, and they have been within the presentations.

Note that none of this is exclusive. There are more things and details, and these can be learned only by reviewing all the presentations in detail. This is meant for a guidance for the main issues/things only.

How to use this guide:

This guide is long, and it still does not repeat all the class (which would be, ofcoruse, impossible in a few pages). Use it as a list to guide your studying. You'll be skipping a lot of the items - those where you are sure you already know it.

(*If you think you need to learn now each of these items, that means you did not do a good job during the semester keeping up with the course; that is why the large amount of work. I am only hoping this isn't happning to you.*)

Concepts to understand: You should be able to explain each item for another student or a layperson in about ten sentences on average. If you think you can do that, you may skip the item, otherwise look it up on the presentations and/or in the textbook.
Mechanisms:
Ask yourself, for each item, how does it work? Why is it so? Give an explanation to yourself (or to someone who is willing to listen to you). This needs more than pure memorization!
Facts/numbers to remember: some of these item on the list includes the answer, for others you need to look it up.

Basic concepts :

Concepts to understand:
Astrology and astronomy
Solar System, Solar Neighborhood, Galaxy, galaxy,
Sun is a star, solar system objects reflect sunlight, stars don't
Light year (ly) is distance, definition
Interstellar matter
The Milky Way (in the sky) + the 'Milky Way Galaxy'
Deep sky object
What are each+how large+how old+where in the Galaxy:
- Star clusters (globular and open)
- Nebulae (planetary and diffuse)

Constellations - what are they, how many

Mechanisms (how does it work?) :
Stars are dots (no detail in telescope) - reason?
All stars of the sky are part of the Galaxy

Facts/numbers to remember:
Diameter of Earth (km,miles); AU
Solar System objects: planets, moons, asteroids, comets
Solar System is < 100 AU
Closest star, Proxima Centauri, 4 ly
Stars are a few ly apart
Brightest star, Sirius, -2 mg
Size of Galaxy: ~100,000 ly
Andromeda Galaxy: 2 million ly distance
Big Bang is established science
Age of Sun, Earth, Universe (Big Bang)
~ 5000 stars brighter than 5.0 mg

Magnitudes, parallax and stellar distances:

Concepts to understand:
Naming scheme of bright stars
Magnitude - means brightness (not size)
Absolute magnitude (M) - definition
Distance modulus and relation to distance
Parallax (concept; unit is arc second; < 1 as for stars)
Parsec (pc)

Mechanisms (how does it work?) :
Brightest strs 0 mg, faintest naked eye stars 5 mg
Telescope visually 10~15mg, photo <21 mg, pushing to ~ 27 mg
Known M and mesured m -> how to determine distance
Parallax (why the tiny circle)

Facts to remember:
Naked-eye stars are 95% within the Solar Neighborhood
The Solar Neighborhood is ~ 1000 ly (compare size of the Galaxy)
'Magnitude' without qualification means apparent magnitude (m)
Each magnitude difference means 2.5 times brighter
Larger magnitude = fainter object
Sun is M=5 mg
Parallax[as] = 1 / distance [pc]
1 pc = 3.26 ly
Solar neighborhood is where parallax >> 1 mas (=1/1000 as), still measurable

Telescopes :

Concepts to understand:
Light collection and magnification
Refractors and reflectors
Angular sizes and its units
Resolution
Seeing (unit: as)
Equatorial mount
Tracking
Size and price range for large telescopes and tax impact per taxpayer per year
CCD camera
X-ray/gamma-ray astronomy - what objects - from space only
IR astronomy - no dust absorption - dust radiates far IR - what objects

Mechanisms (how does it work?) :
Planets don't twinkle - why
How seeing is produced - how large
How to calculate magnification
Adaptive optics (incl. price and achieved amount of 'seeing' reduction)
Artificial guide star
Radio telescopes
Difference between radar and radio telescope
Radar is not used in radio astronomy outside the Solar System - why?

Facts to remember:
Diameter as measure of telescope - ranges
Largest magnification ~ 500 times - seeing-limited
Resolution of the eye ~ 1am
Resolution of telescope - order of 1 as due to seeing
Meaning of 8x50 for binoculars
Smallest object seen on the Moon is ~1mile (=1as)
List of telescopes at Ole Miss
Hubble space telescope - how large, how good
Best seeing on Earth - Mauna Kea Hawaii, 0.4 as
Modern telescopes - no looking, no film - only CCD

Spectroscopy :

Concepts to understand:
The three types of spectra
Frauenhofer lines
Narrowband filter (e.g. H-alpha)
Spectroscope/spectrograph - one color is one ‘line’

Mechanisms (how does it work?) :
Strength of H lines vs. temperature
Strength of metal lines vs. temperature
Doppler effect
Examples of physical effects showing on spectral lines:
  radial velocity, rotation, temperature,
  magnetic field. (Zeeman effect), stellar wind (P Cygni profile), microturbulence
  pressure (i.e. surface gravity) - tell giant star from main sequence one
  rotation of a galaxy
Spectroscopic binaries
  incl. what is their separation/period in practice?
  incl. mass determination
Narrowband filters (e.g. H-alpha) bring out regions with emission lines

Facts to remember:
Stars (normally) have absorption spectra
Emission spectrum from rarified gas excited by UV
How large is the Doppler effect (tiny)
Doppler shift in % of wavelength = speec in % of speed of light
Spectroscopy requires large telescopes (light-starved)

Electromagnetic waves:

Concepts to understand:
Electromagnetic waves, their types vs. wavelength
Wavelength is color
Which EM wave penetrates the atmosphere
Difference between chmistry and nuclear physics
eV and MeV
How small is a nucleus vs. size of atom
Isotopes, nuclear charge and mass number
Chemical elements vs. nuclear charge
Photon and its energy vs. wavelength
Fluorescence, thermal glow, synchrotron radiation
Ionization; metal (astronomical sence)
Solar wind and (deep space) cosmic rays - interaction with the atmosphere

Mechanisms (how does it work?) :
Speed of light - discovery
How to change nuclei and how to change molecules
Formation of absorption spectra - cold gas in front
Excitation of atoms by UV and by collisons (temperataare)
Formation of emission spectra - de-excitation

Facts to remember:
Conversion between meter, millimeter, micron, nanometer
Wavelength of visible light (ballpark number)
Speed of light is ~ 300,000 km/sec
Laser is light
Atom is not a mix of protons-neutrons-electrons
Atoms constituents are: nucleus (+) and electrons (-)
Chemistry is ~ 1 eV level, nuclear is ~ 1 MeV level
Energy of a photon E=1240/wavelength (units eV and micron)
At what temperature do molecules fall apart
At what temperature are H/He atoms ionized, are metals partially ionized

The Sun:

Concepts to understand:
Photosphere, convection, sunspots, granules, corona, prominence, flare, CME
Mechanisms (how does it work?) :
Plasma motion / magnetic field lines
Magnetic reconnection
Formation of sunspots
Limb darkening
Aurora - where to see?

Facts to remember:
Chemical composition
Photospheric temperature
When is the corona visible
Length of solar cycle

Astrophysics:

Concepts to understand:
Stellar spectral types
Double star, binary star
HRD - what plotted vs. what, variations
Main sequence stars + red giants and white dwarfs
 - on the HRD + physical reasons
Burning and chemical reactions vs. nuclear reactions
The 3 types of nuclear reactions (compare to fire, A-bomb, reactor, H-bomb)
Coulomb barrier
The Chandrashekar limit
The case of Sirius B (include history of discovery)

Mechanisms (how does it work?) :
The sequence of calculations to tell the size of stars
The sequence of calculations to tell the mass of binary stars
Stars are born in clusters (open clusters or loose associations)
but leave the cluster soon
The method of spectroscopic parallax
Cluster HRD's turnoff point - physical explanation and age relation
How to use a cluster HRD for main sequence fitting: tell distance
Large difference in luminosities but not in masses explain why large stars live short lives
Nuclear reactions: 'missing' mass turning into heat (details for 4H->He)
Nuclear reactions: Fe is lightest nucleus per atomic mass number
no heat produced by fusing byond iron
Coulomb barrier: electric repulsion of nuclei
The mechanism of balancing a star - pressure gradient vs. gravity
Evolutionary sequence (on the HRD) of the Sun - specify endstage
Evolutionary sequence (on the HRD) of a heavy star - specify endstage
Cosmic recycling and the origin of chemical elements

Facts to remember:
Wien's law (for thermal glow)
- precise form of law, in language and associated formula

Stephan-Boltzman law (for thermal glow)
- precise form of law, in language and associated formula

Stellar spectra (OBAFGKM) - related to temperature (color)
Sun is G spectrum at 6000 K
O and B stars at >20,000K radiate UV; very few such stars
Most stars are M dwarfs at <3000K
Mass determines location on HRD and evolutionary timeline
Heavy stars live short lives (~ a few million yrs), light stars long lives (~ trillions of yrs)
Stellar masses range 0.07 M_sun to 100 M_sun
Stellar luminosities range much more (10^-5 to 10^+6 solar)
The Coulomb barrier restricts nuclear fusion to:
- (H->He)> a few MK
- (He->C)> 100 MK

Compact objects:

Concepts to understand:
what is it; how large; density; when is it produced:
- white dwarf
- neutron star
- pulsar
- stellar-mas black hole

supernova - core-collapse and type Ia
where are core-collapse SNe located in a galaxy
novae

Mechanisms (how does it work?) :
origin of type-Ia SNe and why are they identical
origin of heavy elements (heavier than iron)
how does an SN look in the sky, how bright
how are pulsar's 'pulses' formed - relation to rotation

Facts to remember:
type-Ia supernova absolute magnitude -19 mg
how often is there a SN in a galaxy (20 to 500 years)
what powers the exploding SN shell
pulsar rotation periods (10 millisec to 10 sec)
most pulsars are only radio sources (not optical or X-ray)

The ISM and starbirth:

Concepts to understand:
Interstellar matter - composition (H,He+little else)
ISM - portion of dust (always <<1%)
ISM - molecular clouds
- size,density,temperture,dust content
- location in galaxies
- when O,B stars nearby, visible (emission sp)

T Tauri star
Protoplanetry disk

Mechanisms (how does it work?) :
Dust absorbs starlight and reddens stars
Dust is ice/graphite(carbon)/silicates(sand)
Collapse of cloud cores is stopped if no cooling
coolant: CO (radiates away heat in IR)
small pieces collapse faster ->fragmentation
Why are stars born in company
Infalling matter of forming star forms accretion disk
Proof of SN at the time of the birth of the Sun: Xe^129 in meteorites

Facts to remember:
Infrared penetrates dust
Molecular cloud cores of ~1ly size, 10^8 atoms/cm^3 form stars
Planets are in one plane (ecliptic)

Galaxies and the Universe:

Concepts to understand:
The Hubble Fork
Elliptical, spiral (barred and non), irregular galaxies
Proper motion
Population I, II, III:
- where in a galaxy
- chemical composition

Disk, halo and relation to populations
The supermassive black hole in the center of the Galaxy
Starburst galaxies
Quasars and their jets

Mechanisms (how does it work?) :

Which population:
- interstellar dust
- O,B stars
- open clusters
- globular clusters
- spiral arms
- halo stars
- diffuse nebulae
- core collapse SNe

The mechanism of disk formation
- conditions (central gravity + orbiting ‘particles’ which can collide)
- examples (Saturn’s ring, star formation - accretion disk, disk of galaxies, ‘radiating’ black holes)

How do active galactic nuclei radiate

Facts to remember:

Proper motion is usually < 1 as/year (and often much less)
Stars orbit the center of the Galaxy
The Sun is not in the center of the Galaxy, not in a spiral arm

The Universe and the Big Bang:

Concepts to understand:

Cepheids-what are they
Hubble’s law
Expansion of the Universe - no center
CMB (Cosmic Background Radiation)
Critical density of the Universe (= 1 atom/cm^3)
Dark matter
Dark energy

Mechanisms (how does it work?) :

Period-Luminosity relation of Cepheid variables
How far can Cepheids be used and why
Type-Ia SN distance determination
Linearity of Hubble’s law implies one Big Bang
The cosmic distance ladder
Hubble’s law applies only to far-away galaxies - why?
Early Universe was hot - now radiation cooled to 3K
Matter density in the Universe determines fate of Universe - how?
Effects of Dark Matter: keeps galaxy clusters together, affects rotation of galaxies

Facts to remember:

Cepheids can be used to determine distances to close-by galaxies
All Type-Ia SNe are peak M=-19.3 mg
Redshift is shift in spectral lines, not in overall color
Big bang was 14 billion yrs ago
Constitution of the Universe (visible matter 5%, dark matter 25%, dark energy 70%)