Introduction to Astronomy
Fall 2024
Review for Final Exam

Major Topics:

I. The Celestial Sphere -- appearance and motions in the sky
- Constellations
- Coordinate Systems (horizon, RA & Dec, etc.)
- Daily motion
- Annual motion of the Sun & Stars
- Motion and phases of the moon

II. Stars
- The nature of light and structure of matter
- The properties of the stars
- Stellar evolution

III. Solar System
- The order, sizes and distance of planets
- Some properties of planets and moons
- Earth as a planet

IV. Galaxies and Cosmology
- Types of galaxies, including the Milky Way`
- Data and interpretation leading to the Big Bang theory of the evolution of the universe
- History of the universe as currently known

Sky Stuff to Know:
Constellations: UMa, UMi, Dra, Boö , CrB, Her, Lyr, Cyg, Aql, Sgr, Cap, Peg, And, Cas, Per, Psc, Ari, Cep, Aur, Tau, Gem, Ori, Cet
Motions
Solstices & Equinoxes
Know their definitions!
Know their α, δ, PL, date, & constellation
Know how to find the Atlas Chart of Each

I. The Celestial Sphere (you can't forget stuff!)

A. Constellations: *Field Guide* Ch. 4
- Origin and organization, asterisms
- Constellation names, abbreviations, genitives (*FG* pp. 440-441)
- Star names ("other" and Bayer designation)
  Know how to find them!

B. Coordinate systems: *Field Guide* Ch. 15, Fraknoi et al. Ch. 4
- horizon – horizon, zenith, nadir, meridian, etc.
- celestial – RA, Dec, NCP, SCP, Celestial Equator

C. Motions in the sky
- daily motion *Cycles* pp. 1-10, Fraknoi et al. Ch. 4.3
  stars, sun, moon, planets, comets, etc. circle NCP once per day
- annual motion *Cycles* pp. 20-32, Fraknoi et al. Ch. 4.2
  equinoxes and solstices: right ascension, declination, constellation, date
  Review the Celestial Coordinates Lab!
  the sun's motion along the ecliptic, and in declination (the analemma), the Zodiac
  sidereal and solar day and the analemma
- motion and phases of the moon *Cycles* pp. 11-19, Fraknoi et al. Ch. 4.5
  phases, elongations, times of rising, transit,
  and setting (MOON WORKSHEET!!)
- motion and positions of the planets
  planetary longitudes, elongations,
  times of rising, transit, and setting
  (PLANETS WORKSHEET!!)

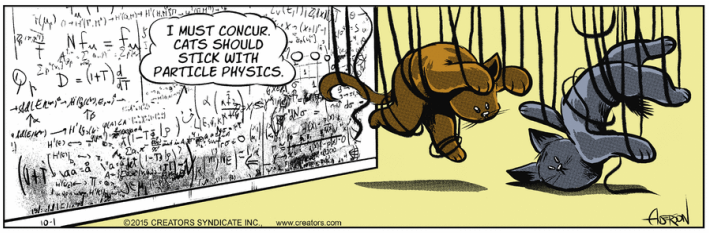
Review all the Labs
All the Calculations!

REVIEW THE POWERPOINTS & LABS!

KNOW HOW TO DO WHAT YOU DID ON THE LABS

A. The Sun ***FIELD GUIDE*** Ch. 14
Fraknoi et al. Ch. 14 - 16

- Nuclear Fusion
- Sunspots



B. Spectroscopy

- Light is a wave: $c = \lambda f$, $E = hf = hc/\lambda$
- Inverse square law: luminosity and flux
  absolute & apparent magnitude

$$\text{Flux} = \frac{\text{Luminosity}}{4\pi r^2} \sim \frac{1}{(\text{distance})^2}$$

γ-rays	HIGH ENERGY	
X-rays	HIGH FREQUENCY	SHORT WAVELENGTH
Ultraviolet (UV)		
Visible: blue		
Visible: green		
Visible: yellow		
Visible: orange		
Visible: red		
Infrared (IR)	LOW FREQUENCY	LONG WAVELENGTH
Radio	LOW ENERGY	

- electromagnetic spectrum Fraknoi et al. Ch 17
  - types of spectra and their sources (continuum, emission line, absorption line)
- atomic structure, source of emission and absorption lines
- Hydrogen Balmer spectrum
- Spectral Classes: **O B A F G K M** (… extra credit for a good mnemonic)
  order (A – N): Willamina Fleming
  order (O – M), subclasses & classification: Annie Jump Cannon
  temperature association: Cecillia Payne Gaposchkin
  Cepheid variables: Henrietta Swan Leavitt
  star luminosity classes from spectra: Antonia Maury

C. Star Properties (how do we measure or calculate … any needed equations will be given), Fraknoi et al. Ch 18

- temperature
- distance
- size
- flux and luminosity

Know the **Images of objects** … be able to explain what's happening & what stage of star formation they show!

D. HR diagram Field Guide Appendix 3, Raymo March 15 –22, Fraknoi et al. Ch 18.4

- axes (what's plotted against what? What are the scales)
- regions (and Luminosity Classes)

E. Stellar evolution ***FIELD GUIDE*** (p. 144-167), Fraknoi et al. Ch. 21 - 23

- Star Birth (*e.g.* Orion & Eagle Nebulas)
- Main Sequence Stars
  What process defines a STAR?
  What is a star's source of energy?

$E=mc^2$

Know name, position & constellation of examples of each stage

- Red Giant Stage
  starts & end in low-mass stars (Sol)
- Star Death
  Planetary Nebula and White Dwarf
  Supernova and Neutron Stars
  Supernova and Black Hole

Know the death processes for Sun-sized (low-mass stars) and high-mass stars. How do they differ? How will the Sun age and die?

III. The Solar System Fraknoi et al. Ch. 7 - 14

- worlds (**expect images** … study the power points and your Field Guide Ch. 8 - 14)
  Eight planets, the Galilean Moons, Titan, Enceladus, Mimas, Miranda, Triton, and Luna.
- arrangement, size, and formation of the solar system

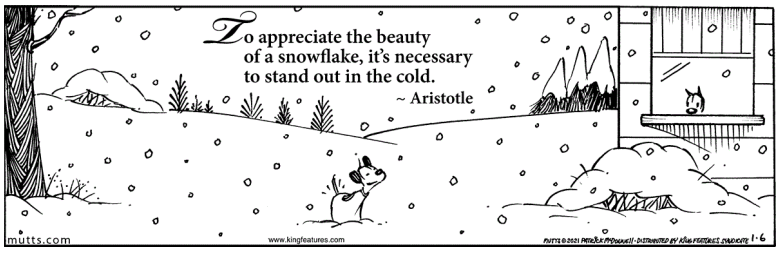
The Astronomical Unit (AU)

1 *AU* = mean Earth-Sun distance
= 150,000,000 km (150 million km)
= 93,000,000 mi (≈ 100 million miles is close enough)

NAME	SYMBOL	SIZE	DISTANCE FROM SOL	LENGTH OF DAY	LENGTH OF YEAR
MERCURY	☿	0.4 $R_\oplus$	0.4 AU	60 $d_\oplus$	$\frac{1}{4}$ $y_\oplus$
VENUS	♀	0.95 $R_\oplus$	0.7 AU	243 $d_\oplus$ (R)	0.6 $y_\oplus$
EARTH	⊕	1.0 $R_\oplus$	1.0 AU	1$d_\oplus$	1 $y_\oplus$
MARS	♂	0.5 $R_\oplus$	1.5 AU	1.03 $d_\oplus$	2 $y_\oplus$
ASTEROIDS		0.1 $R_\oplus$	3 AU	-----	5 $y_\oplus$
JUPITER	♃	11 $R_\oplus$	5 AU	10 $h_\oplus$	12 $y_\oplus$ (≈ ONE CONSTELLATION OF THE ZODIAC PER YEAR)
SATURN	♄	9.5 $R_\oplus$	10 AU	10.25 $h_\oplus$	30 $y_\oplus$
URANUS	♅	4.1 $R_\oplus$	20 AU	17 $h_\oplus$ (R)	85 $y_\oplus$
NEPTUNE	♆	3.9 $R_\oplus$	30 AU	16 $h_\oplus$	165 $y_\oplus$

- Earth as a planet Fraknoi et al. Ch. 8

-- interior
-- surface
geology:
cratering, volcanism, plate tectonics & continental drift
-- oceans: Jet Stream: The Ocean
importance of water in the evolution of the atmosphere & life
Heat Capacity (definition, importance, water's value)
Latent heat (definition, importance, water's value)
Heat transfer (3 ways)
-- atmosphere Jet Stream: The Atmosphere
composition [N_2 (78%), O_2 (21%), Ar (1%), CO_2 (0.037%)]
evolution of composition
oceans condensed, absorbed CO_2, locked it into rocks, life released O_2
forces on air
pressure gradient force (air moves from high to low pressure)
coriolis force (acts only on *moving* objects)
global circulation Jet Stream: Global Circulations
greenhouse effect NASA
ground heated by sunlight
ground radiates IR
IR heats atmosphere
climate change data in cores
air bubbles
isotopes



IV. Galaxies and Cosmology *FIELD GUIDE* (p. 168-170), Fraknoi et al. Ch. 25 - 29

- Types of galaxies (be able to recognize images from the Power Points!)
  - details about the Milky Way (dimensions, contents, interactions)
  - details about dark matter (what indicates it's there?)
- The DATA of Big Bang Cosmology Fraknoi et al. Ch. 26

  all galaxies are redshifted

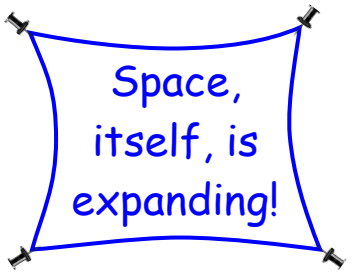
  ⇒ evidence that they are all moving away from us

  more distant galaxies are redshifted more

  ⇒ evidence that more distant galaxies are moving away faster

  ⇒ evidence that the universe is EXPANDING

  the observed cosmic background radiation (CBR) fits the model of the universe just before atoms formed and it was opaque at the predicted redshift



- The expansion of the universe Fraknoi et al. Ch. 29

  ⇒ how is the universe like a raisin bread? A gas? how is expansion changing?
  - what were the rolls of Einstein, Hubble, Lemaître, Gamow (& Alpher), Hoyle, Guth
- The four fundamental forces and what they do:

	NAME	RELATIVE STRENGTH	RANGE	PHENOMENON	SUSCEPTIBLE PARTICLES	CARRIER PARTICLES	SEPARATION ΔBT
weakest	***GRAVITATIONAL FORCE***	1	∞	KEEPS US ON THE GROUND, MAKES STARS & GALAXIES	all matter	gravitons	10^{-43} s
	WEAK NUCLEAR FORCE	10^{25}	10^{-17} m	RESPONSIBLE FOR RADIOACTIVE DECAY	nuclear particles	weak bosons	10^{-10} s
	ELECTROMAGNETIC FORCE	10^{36}	∞	MAKES CAT HAIR CLING TO ANYTHING EXPENSIVE	charged matter	photons	10^{-10} s
strongest	***STRONG NUCLEAR FORCE***	10^{38}	10^{-15} m	HOLDS QUARKS & BARYONS TOGETHER IN NUCLEUS	nuclear particles	gluons	10^{-38} s

- The history of the universe … after t = 0 seconds … know what happened at …

TIME	ERA	EVENT OR CONTENTS
t = 0		Time Begins … the beginning of the universe
	Planck	Quantum foam … nature unknown
t ≈ 10^{-43} sec.		Gravity separates from the other three forces
	GUT	Elementary particles of matter and antimatter (leptons & quarks) forming out of energy
t ≈ 10^{-38} sec.		The strong force separates from electroweak
	Inflation	Universe undergoes HUGE, RAPID expansion (due to separation of strong force or gravity)
	Electroweak	Elementary particle (leptons & quarks) soup
t ≈ 10^{-10} sec.		Electromagnetic & weak forces separate
	Particle	Quarks bind into protons & neutrons (1 n^0 for each 7 p^+). Ends with matter/antimatter annihilation … only matter left
t ≈ 10^{-3} sec.		Last matter-antimatter annihilation
	Nucleosynthesis	Nuclei of He (and some others) formed by fusion
t ≈ 3 min.		Fusion ends … matter is 75% H nuclei, 25% He nuclei
	Nuclei	Plasma of H and He nuclei and leptons.
t ≈ 500,000 yr.		The universe cools enough for atoms to start forming from nuclei and electrons.
	Atoms	Nuclei capture electrons to form atoms, the universe becomes transparent … origin of CBR
t ≈ 1,000,000 yr.		First galaxies form
	Galaxies	Stars, galaxies, Earth, trees, puppies, and us!

- Think about the origin of the protons, neutrons, and electrons in your body and the elements made from them in the cores and explosions of stars, and ponder the Desiderata:

Desiderata

Go placidly amid the noise and haste, and remember what peace there may be in silence. As far as possible, without surrender, be on good terms with all persons.

Speak your truth quietly and clearly, and listen to others, even the dull and ignorant; they too have their story. Avoid loud and aggressive persons; they are vexations to the spirit.

If you compare yourself with others, you may become vain and bitter, for always there will be greater and lesser persons than yourself.

Enjoy your achievements as well as your plans. Keep interested in your career, however humble; it is a real possession in the changing fortunes of time.

Exercise caution in your business affairs; the world is full of trickery. But let this not blind you to what virtue there is: many persons strive for high ideals, and everywhere life is full of heroism.

Be yourself. Especially do not feign affection. Neither be cynical about love, for in the face of all aridity and disenchantment it is perennial as the grass.

Take kindly the counsel of the years, gracefully surrendering the things of youth.

Nurture strength of spirit to shield you in sudden misfortune. But do not distress yourself with imaginings. Many fears are born of fatigue and loneliness. Beyond a wholesome discipline, be gentle with yourself.

You are a child of the universe, no less than the trees and the stars; you have a right to be here.

And whether or not it is clear to you, no doubt the universe is unfolding as it should. Therefore, be at peace with God, whatever you conceive God to be, and whatever your labors and aspirations, in the noisy confusion of life, keep peace with your soul.

With all its sham, drudgery and broken dreams, it is still a beautiful world. Be careful. Strive to be happy.

Max Erhmann, 1927.