Astro / EPS C12 Midterm 1 Review Sheet

1. Scale of the cosmos

Solar system - sun, planets, etc.
Milky Way Galaxy - 100 billion stars (incl. Sun)
Local Group - Milky Way + neighboring galaxies
Local Supercluster - 1000's of galaxies (incl. Milky Way)
Universe - everything there is : 100 billion + galaxies

mostly empty space:
distance between planets >> size of individual planet
" " stars >> " " " star
galaxies >> " " " galaxy

Can't see the entire Universe : only out to 14 billion light years ← light year : distance light travels in 1 year
(Universe is 14 billion years old, takes 14 billion years for light to reach us)
speed of light : $c = 3 \times 10^8$ m/s

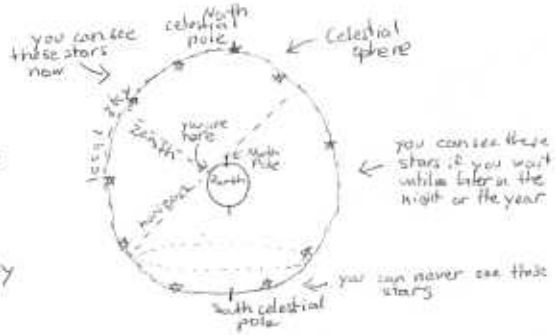
Study history of the Universe by looking far away
Origin of universe : Big Bang (14 billion years ago)
only H and He at first, other elements formed by stars

sun ← 1 AU → earth
Astronomical Unit:
distance from Earth to Sun
(= 8.3 light-minutes
= 150 million km)

2. Everyday astronomy

Celestial sphere

Local sky : visible half of sphere
Zenith : straight up (overhead)
Horizon : boundary of sky & earth
Earth spins around axis once in 1 day



Seasons

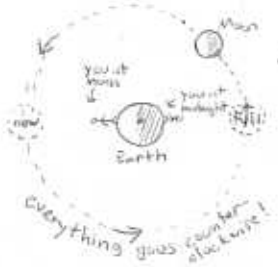
Result of tilt of Earth's axis
most sunlight: summer solstice
($^6/_{21}$ in northern hemisphere)
least sunlight: winter solstice
($^{12}/_{21}$ in north)
Earth orbits Sun once in 1 year

Moon Phases

Depends on moon's position relative to the Sun as Moon orbits Earth

Time of moonrise / moonset depends on phase

(Moon is not always up at night!)



← Seen from above north pole

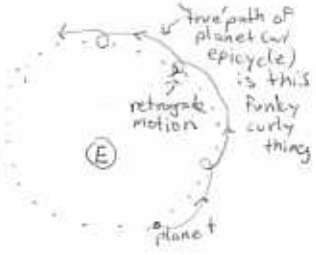
example: waning gibbous (just past Full)

overhead ~ 3 AM
rises ~ 9 PM
sets ~ 9 AM

3. Planetary motion

Geocentric model

Sun / planets orbit Earth
Ptolemy: planets have "epicycles"
(a sort of secondary orbit)
→ retrograde motion
Best model until Copernicus / Kepler

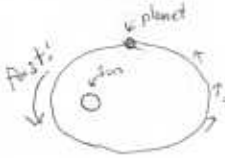


Heliocentric model:

Planets orbit Sun
Retrograde motion due to planets "passing" (at closest approach)
- like passing a car on the freeway

Kepler's Laws:

I. Orbit of a planet is an ellipse.
Sun is at a focus.



← this is a highly exaggerated example, actually, the true orbits are nearly circular

II. Planet travels faster nearer the Sun.

III. $P^2 = kA^3$
P : period
A : semimajor axis (average distance from Sun)
↑ constant = 1 ONLY if P in years and A in A.U.

→ result:
inner planets move really fast
outer " " " slow

Hypothesis vs. Theory : see homework

4. Laws of Matter and Motion

motion:
- speed - rate at which an object is moving
- velocity - speed in a certain direction
- acceleration - change in speed or direction
- momentum - mass × velocity
- force - change in momentum
- angular momentum - mass × velocity × distance from spin axis

Newton's laws of motion:
- I. Object moves at constant velocity if no net force acts on it (inertia)
- II. Force = mass × acceleration
- III. For any force, there is an equal & opposite reaction force

Conservation of angular momentum

Spins quickly with arms in (more mass near the center)

Spins slowly w/ arms out (mass towards the outside slows down the speed)

types of energy
- kinetic - energy of motion
- radiative - energy of light
- potential - stored energy
- thermal - energy of heat

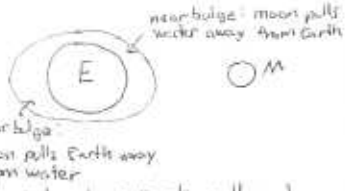
Law of Gravitation:

$$F_g = G\frac{M_1 M_2}{d^2}$$

$G = 6.7\times10^{-11}\ \frac{N\,m^2}{kg^2}$

force is proportional to the product of the masses over the distance squared.

Tides:
- gravitational pull of Moon and Sun on oceans



highest tide when Sun's pull and moon's pull work together (new and full moon)

5. Light

Light is a wave.

$c = \lambda f$
- c: speed of light
- λ: wavelength (distance between crests)
- f: frequency (# crests passing per second)

matter can:
- absorb light (absorb energy)
- emit light (release energy)
- reflect light (bounce off surface) & scatter in air/water

EM spectrum:

categorize light according to frequency:
- radio: very low frequency (very long λ)
- infrared: low frequency (long λ)
- visible: medium frequency (med λ)
- UV: high frequency (short λ)
- x-ray
- gamma ray
- etc

divide visible into colors:
- red: lower frequency (longer λ)
- orange
- yellow
- green
- blue
- violet: higher frequency (shorter λ)

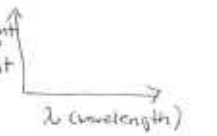
energy varies with frequency:

$E = hf$ — higher frequency ⇒ higher energy

$h = 6.6\times10^{-34}\ \frac{m^2 kg}{s}$ (J·s)

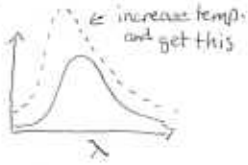
Power:
- rate energy is absorbed or emitted

Spectrum:
- plot of wavelength vs. amount of light observed with that wavelength



Important types of spectra:

blackbody - continuous
- "bump": size and position of bump (i.e. wavelength and total amount of energy) depend on temperature.
- higher T → more energy emitted, peak moves to shorter λ
- normally in infrared part of spectrum



Doppler shift

change in λ and f due to motion along line of sight (towards or away)

object approaches: ()
- λ shorter
- f higher
- "blueshift"

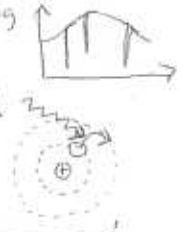
object retreats: ()
- λ longer
- f lower
- "redshift"

$$\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$$

Δλ: shift in wavelength; v: velocity along line of sight; c: speed of light; λ_0: rest wavelength

emission lines - "spikes" or visually colorful lines against background, due to electron jumping from high energy level to lower one:

absorption lines - downward "spikes" where light is missing from a continuous spectrum. Due to photons hitting atoms to boost an electron to a higher level:



the pattern/wavelengths of lines tells you the composition of the gas that's doing the emitting/absorbing, like a "fingerprint" of the atom

8. Origin of Solar System

"Solar nebula theory": collapse of cloud of gas

initially: giant cloud of gas

↓ contracts due to gravity

protoplanetary disk
- heating → matter falls inward: heats up (potential (conservation of energy) → kinetic → thermal)
- spinning → matter falls inward: conservation of angular momentum says it must spin faster
- flattening → collisions force all orbits to be in same plane and nearly circular orbits
  - ↳ result: flat, spinning disk that is hot in the center

↓

Sun forms in center, planets in the disk

"Frost line":
- most heating is in center (Sun is blazing) ⇒ temperatures in the inner disk are high: cannot form ice
- only rocky objects can solidify. Cannot retain hydrogen/helium
- in outer disk, H_2O can condense as ice → much faster accretion of H/He

→ rocky planets closer to Sun
gaseous planets & icy moons further