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: 1000s of galaxies (incl. Milky Way)
- Universe: everything there is (100 billion + galaxies)

- Mostly empty space:
  - Distance between planets >> size of individual planets
  - Stars >> 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)
- Study history of the universe by looking for away
- Origin of universe: Big Bang (14 billion years ago)
  - Only 27 and 32 at first, other elements formed by stars

2. Everyday astronomy

- Celestial sphere
  - Local sky: visible half of sphere
  - Zenith: straight up (overhead)
  - Horizon: boundary at sky/Earth
  - Earth spins around axis once in 1 day

- Seasons
  - Result of tilt of Earth's axis
  - Most sunlight: summer solstice
    (June 21 in northern hemisphere)
  - Least sunlight: winter solstice
    (December 21 in north)
  - Earth orbits Sun once in 1 year

- Moon phases
  - Depends on moon's position relative to the Sun/Earth
  - Moon orbits Earth
  - Time of moonrise/moonset depends on phase
  - (Moon is not always up at night)

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

- Kepler's laws:
  I. Orbit of a planet is an ellipse
  II. Planet travels faster near the Sun
  III. \( P^2 = k A^3 \)

- Hypothesis vs. Theory (see homework)
4. Laws of Matter and Motion

- Speed: rate at which an object is moving
- Velocity: speed in a certain direction
- Acceleration: change in speed or direction
- Momentum: mass x velocity
- Force: change in momentum

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

Conservation of angular momentum
- Spins quickly with arms in (more mass near the center) close to the axis
- Spins slowly with arms out (less mass near the center) close to the speed

Law of Gravitation:
- Force is proportional to the product of the masses over the distance squared

5. Light

- Light is a wave
- Speed of light: $c = \lambda f$
- Wavelength: distance between crests
- Frequency: # crests passing per second

EM Spectrum:
- Radio: low frequency (long $\lambda$)
- Infrared: low frequency (long $\lambda$)
- Visible: medium frequency (medium $\lambda$)
- UV: high frequency (short $\lambda$)

- Power: rate at which energy is absorbed or emitted

Doppler Shift
- Change in $\lambda$ and $f$ due to motion along line of sight (towards or away)
- Object approaches: $\lambda$ shorter, $f$ higher
- Object retreats: $\lambda$ longer, $f$ lower

8. Origin of Solar System

"Solar Nebula Theory": collapse of cloud of gas
- Initially: giant cloud of gas
- Protoplanetary disk
- Heating: 5 paths: inward: high energy thermal, outward: spin-up, spin-down
- Spinning: matter falls inward: conservation of angular momentum, spin-up, spin-down
- Collisions: form all orbits to be in same plane and nearly circular orbits
- Result: 4 planets, diameter of disk is 1/10 of center
- Sun forms in center, planets in the disk

- Types of energy:
  - Kinetic energy of motion
  - Radiant energy of light
  - Potential energy:
    - Chemical energy
    - Thermal energy of heat

- Tides:
  - Gravitational pull of Moon and Sun on oceans
  - Forbidding of Earth away from water
  - Highest tide when Sun's pull and Moon's pull work together (Full moon)

- Matter can:
  - Absorb light (absorb energy)
  - Scatter light (change direction)

Spectrum:
- Plot of wavelength vs. amount of light observed (light with that wavelength)

- Important types of spectra:
  - Blackbody (continuous)
  - Spectrum: energy distribution of an idealized object

- Emission lines: peak energy at shorter $\lambda$
- Absorption lines: downward spikes

"Fossil Line":
- Most heating is in center (Sun's Braking) > temperature in outer disk too high cannot form ice
- Only rocky objects form solids, cannot retain hydrogen/helium
- Ice in outer disk, $H_2O$ can condense as ice $\rightarrow$ much faster cooling of $H_2$.

- Rocky planets closer to Sun
- Gas giant planets, icy means further

- If $H_2$ and $H_2O$ cool, stir $\rightarrow$ gas giant planets
- If $H_2$ or $H_2O$ cool, stir $\rightarrow$ rocky planets

- The pattern/wavelengths of lines tells you the composition of the gas, thus doing the emitting/absorbing, like a "fingerprint" of the atom.