Midterm 2 – Wed. March 2

On the day of the midterm:
SIT IN YOUR ASSIGNED ROW!
TAKE ONLY THE TEST WITH *YOUR* NAME PRINTED ON THE FRONT COVER!

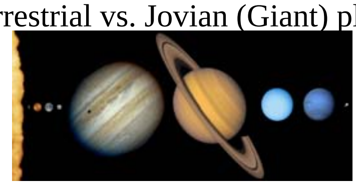
Have photo ID.
Closed book… No calculators, notes, etc.
Multiple choice questions

What to Know

- You should know about *all* of the things I have discussed in class since Midterm 1.
  - This study guide just gives some of the high points.
- Study your lecture notes first, then use your textbook to help you understand your notes.
  - Add pgs 332–335 "Star Birth" to the reading suggestions given in the syllabus.
  - We may not get all the way through "Comets" and "Pluto" before the midterm. The test will only cover material that we actually have gotten to.
- There will be a number of questions about facts about the various planets, etc,.
- There are also a few more general ideas that you should understand, including the following examples:
  - What is the general layout of the solar system?
  - Why does it have those properties?
  - What led to the great difference between the terrestrial and the Jovian (Giant) planets?
  - How do the processes of *differentiation*, *tidal locking*, and *orbital resonances* work?
  - Why is Venus so hot? Mars so cold?
- Some specific numbers to know (there are very few of these):
  - Age of solar system. And how is it measured?
  - Fraction of solar system's mass that is in the Sun. Fraction of remaining mass that is in Jupiter.
  - Plus you should have an idea of *relative* sizes, distances, etc.

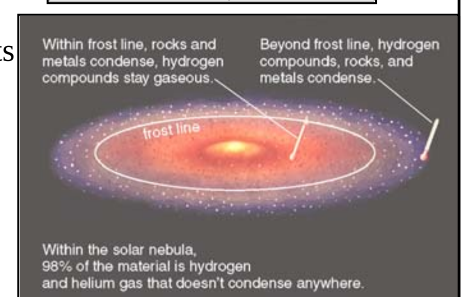
Overview of Solar System

- The solar system is a disk
  - Rotation of sun, orbits of planets all in same direction.
  - Most planets rotate in this same sense. (Venus, Uranus are exceptions).
  - Angular momentum of pre-solar gas cloud.
- Terrestrial vs. Jovian (Giant) planets



  - High vs. low density
    - Rocks vs. mostly gas
  - Composition
    - heavy elements vs. primarily H/He
  - Difference due to distance from Sun.

Object	% Total Mass
Sun	99.8
Jupiter	0.1
Comets	0.05
All other planets	0.04
Satellites & rings	0.00005
Asteroids	0.000002
Cosmic dust	0.0000001



During planet formation in Solar Nebula: Presence of ice
➔ more material for core
➔ could gravitationally attract large masses of hydrogen & helium gas.

Terrestrial Planets

- Earth
  - Differentiated:
    - Iron/nickel core
    - Mantle of lighter rock
    - Thin crust on top
  - Evolution of atmosphere
    - Thick CO_2 ➔ life ➔ N_2, O_2
    - Current global warming
      - Greenhouse effect
      - Man-made CO_2

- (Moon)
  - Impact craters as clocks
  - Old highlands (4.1-4.4 billion yrs)
    - Heavily cratered
  - Maria (3.3- 3.8 billion yrs)
    - Fewer craters
  - Rocks from each brought back by Apollo astronauts.
    - Age dating
    - Chemical composition
  - Tidally locked to Earth
  - Formation of Moon
    - Giant Impact is current favorite theory… collision between Earth & Mars-sized object.
- Mercury
  - Closest to Sun, eccentric orbit.
  - Airless, heavily cratered.
  - Same density as Earth: iron-nickel core.
  - Geologically dead (probably)
    - But cliffs ➔ shrinkage at early time.
  - Rotates in 2/3 of its orbital period
    - Tidal locking with a twist.

Terrestrial Planets (continued)

Venus
- Same size, density as Earth.
- Differentiated like Earth
- Surface mostly studied by radar
  - Large volcanoes
  - “Continents” pushed up by tectonic flows in mantle.
  - Recent lava flows, constant resurfacing.
  - Crater density ➔ very young surface
    - only 750 million yrs old.
- Thick CO_2 atmosphere
  - Result of runaway greenhouse effect.
  - Keeps surface very hot (900F).
    - Lead is molten.
- Retrograde (backward) rotation
  - Probably due to giant impact.

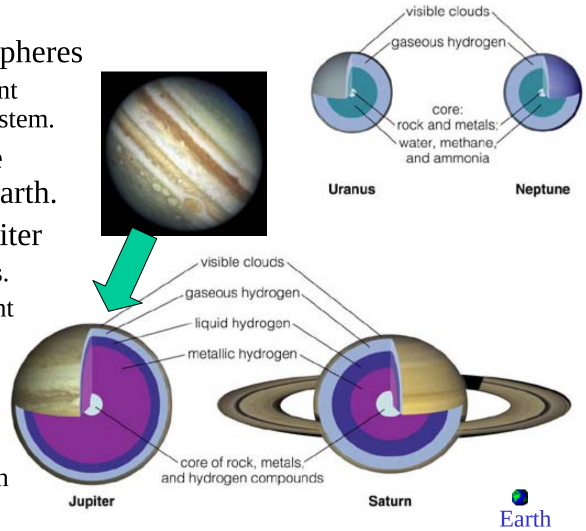
Mars
  - 50% smaller diameter than Earth
  - 1.5 times further from Sun.
  - Gigantic volcanoes.
  - 50% highland “continents”
    - Tharsis bulge.
    - Cracked open to form Valles Marineris.
  - 50% low-lying lava plains.
- Atmosphere
  - CO_2, like Venus, but very thin.
  - Liquid water currently impossible. *Why?*
- Climate change
  - Loss of atmosphere
    - Low escape velocity
    - Solar wind
  - Could not retain heat
  - Water froze out
    - even less heat retained
  - 2 Rovers found evidence of past water.
- Life?
  - Viking landers found no sign.
  - Questionable data in meteorite.

The Giant Planets

Jupiter – Saturn – Uranus - Neptune

- 14-300 x more massive than Earth.
- Massive H + He atmospheres
  - By far the most abundant elements in the solar system.
- On top of rock/ice core with 10-15 x mass of Earth.
- Lots of weather on Jupiter
  - Ammonia (NH_3) clouds.
  - Strong winds at different latitudes.

    (differential rotation)
  - Cyclonic storms
    - Great Red Spot
      - 2 x size of Earth
      - 400 yrs so far



Some planets and moons (and Pluto)

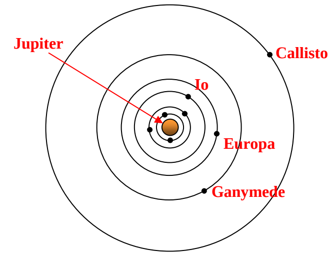
shown in correct relative sizes

Planets:
orbit around Sun

Dwarf Planets:
also orbit Sun

Moons:
orbit around planets

Moons



- Jupiter's Galilean moons, as we get closer to Jupiter:
  - Callisto – ice, geologically dead.
  - Ganymede – ice, but geologically active.
  - Europa – rock, but covered by ice pack over liquid water.
  - Io – rock, extreme volcanic activity.
- Gradient of properties due to increased tidal effects & heating from Jupiter.
- Jupiter's 59 other moons are much smaller.
- Saturn: over 30 known moons
  - largest is Titan
    - N_2 atmosphere.
    - Carbohydrate smog.
    - Similar to Earth's, but very cold (methane lakes).
    - Cassini/Huygens visit.

Rings

- All 4 giant planets have rings.
- Jupiter, Uranus, Neptune have very thin rings. Saturn has much larger rings.
- Gravitational resonances important for shaping details of rings
  - Mimas created Cassini Division.
  - Shepherd satellites
    - moons sweep out divisions, contain rings through gravitational resonances.
- Rings made of ice and small bits of dust.

Asteroids

- Small rocky bodies in orbit about sun.
  - Left over from formation of Solar System.
- Most, but not all, in asteroid belt.
  - Some cross Earth's orbit

Meteorites

- Asteroids that hit Earth and don't burn up in atmosphere.
- Analyzing them ➔
  - Age of solar system (4.5 billion yrs) *How do we measure that?*
  - Initial chemical composition of solar system.

Consumer Warning:
We may not get all the way through Comets before the midterm. The test will only cover however far we get.

Comets

- Mostly ice
- Some on highly eccentric orbits
  - Spectacular tails when close to Sun.
  - Melted ice is driven off by solar radiation, solar wind.
- Most come from Oort Comet Cloud at edge of solar system.
  - Some from Kuiper Belt, just beyond Pluto.