Disclaimer: Below is a list of important concepts that you will be responsible for on Midterm 2. As you go through the list, make sure you can answer the questions as well as understand and explain the concepts. This is a study guide, not a comprehensive list. I have tried to give a complete review, but may have missed things - in the end, you the students are responsible for going over the material: you should not depend solely on this guide. Some of the questions have short answers to lead you in the right direction, but your understanding of the answer should extend beyond the simple one or two word answers given here.


The Solar System and Exoplanets

Planets

• Terrestrial versus Jovian planets - general characteristics
• The Greenhouse effect - how it works and it’s role on Venus and on Earth
• Tidal forces and their role in:
  – the Roche limit - how does this apply to Saturn’s rings?
  – Mercury’s orbit around the Sun (rotation period = 2/3 orbital period)
  – the Moon’s orbit around Earth (same face of the Moon always faces the Earth)
  – Io’s volcanism
  – the asteroid belt
• Know the important moons and what is interesting about them:
  – the 4 Galilean moons of Jupiter
  – Saturn’s moon Titan (good place for life perhaps? Why?)
  – Mars’ moons Phobos and Deimos (likely captured asteroids - why?)
• Evidence for water on Mars
• How was Neptune discovered?
• How were the faint rings of gas giants (other than Saturn) discovered?
• How does cratering (or lack thereof) tell you about the age of the surface of a planet or moon?

Asteroids

• Why is there an asteroid belt?
• What are asteroids like? (composition, size)
• Why are they interesting? (refer back to homework 7 solutions)
Comets

• Where do they come from? (Kuiper belt and Oort cloud)

• How do the Kuiper belt and Oort cloud compare? (location, spherical or disk-like and how do we know?)

• What are comets made of?

• Comets have 2 tails - explain what forms each of them. Do they have tails when they are far from the Sun?

• Why are comets interesting to astronomers?

Meteroids

• What are meteroids? (chunks of rock in space) Where do they come from?

• When they enter Earth’s atmosphere, they are called meteors. They burn up (and light up) - we often call them ”shooting stars”.

• If a meteor makes it all the way to the ground, we call it a meteorite.

Solar System Formation

• What are the main points of the ”nebular hypothesis” (see lecture notes)?

• Why does a spinning cloud of gas and dust collapse easily into a disk but it is difficult for the material in the outer parts of the disk to move inward? (angular momentum!)

Exoplanets

• What are the main ways of detecting exoplanets? (Doppler shift and transits)

• Which method is the recently launched Kepler satellite going to use to look for exoplanets? (transits)

• How does the Doppler shift method work? Why does the star wobble? (refer back to the worksheet we did in section for more clarification)

• What kind of exoplanet systems have been found? (mainly hot Jupiters - what do we mean by ’hot Jupiter’?)

• Does this mean that our solar system is strange? (Not necessarily - we are not yet sensitive to solar systems like ours - why?)

The Sun

• Structure: how do we study the interior structure of the Sun? (helioseismology - what is this?)
  - core - nuclear reactions happen here, very hot: $\sim 10^7$ K!
  - photosphere - this is the part we see
  - chromosphere - pinkish, hotter than photosphere, but very thin
corona - white, hotter still. Also very thin. Expands into space.

- Why are the chromosphere and corona only visible during eclipses?
- What is the Solar activity cycle? How long is it? (22 years) What happens every 11 years? How frequently is there a minimum number of sunspots?
- What is a sunspot? Why do they look dark? Is the magnetic field stronger or weaker?
- What are prominences, solar flares and coronal mass ejections?
- Why did humans likely evolve to see visible light?

Stars and Stellar Evolution

Properties of Stars

- Distance: how do we measure the distance to stars? (parallax: \(d(\text{pc}) = \frac{1}{p(\text{arcsec})}\)) How does this work?
- Brightness: what are the units of brightness? How is it related to the luminosity and distance? (check out the midterm 2 math review worksheet!)
- Luminosity: what is it? (what are the units?) How do we calculate it?
- Temperature: How do we measure the temperature of a star? (Wien’s law, colors) What part of the star is this the temperature of?
- Radius: How do we calculate the radius of a star?
- Chemical Composition: How do we find out the chemical composition of star? (absorption lines)
- Mass: How do we find the mass of a star? (eclipsing binaries) Can we do this for any star in the sky?
- Proper Motion: What is the proper motion of a star?
- Spectral Type: What are the spectral types of stars? How do astronomers decide what spectral type a star is? How does the temperature of stars change as you move through the spectral types?

Multiple-star Systems

- Know what each of the following are: optical doubles, visual binaries, spectroscopic binaries, eclipsing binaries and astrometric binaries.
- How do binary star systems help astronomers? (determine mass of stars as well as radius in the case of eclipsing binaries)
- What is the difference between an open cluster and a globular cluster? (ie. which one has more stars and are the stars in them young or old?)
Variable Stars

- What are variable stars and why are they useful to astronomers?
- How can astronomers use their variability to figure out the distance to the star?

Temperature-Luminosity Diagram or H-R Diagram

- What is the H-R Diagram?
- Where does each of the stages of stellar evolution in the next section lie on the H-R diagram?
- How does plotting all the stars in a cluster on an H-R Diagram tell you about the age of the cluster? (think about stellar evolution)

Stellar Evolution

Pre-Main Sequence

- How does a star form from a cloud of gas and dust?
- What do we mean when we say a star is 'born'? (nuclear reactions start in the core which supports the star against gravitational collapse - this is 'hydrostatic equilibrium')

Main Sequence

- Stars spend most of their 'active' life on the main sequence (meaning not passively cooling white dwarf or neutron star)
- Main sequence stars are steadily fusing hydrogen into helium in their cores to support the star against gravitational collapse (maintain hydrostatic equilibrium)
- Why do main sequence stars lie in a line in the HR diagram? (think about people’s height versus weight exampe)
- How does the amount of time spent on the main sequence depend on the mass of the star?
- Nucleosynthesis: what is this?
  - How is the $E = mc^2$ important in nucleosynthesis?
  - What is a neutrino?
  - What are the two basic fusion processes for fusing hydrogen into helium? (proton-proton chain in low mass stars and CNO cycle in high mass stars) Note - you don’t need to know the steps in the p-p chain or CNO cycle!

Post-Main Sequence

- How do low and high mass stars evolve when they leave the main sequence? When do they leave the main sequence? (when they run out of hydrogen to fuse in their cores)
- Lower mass ($< 8-10 \, M_\odot$)
- Red Giant star: What is supporting the star against gravitational collapse in this phase? (fusing heavier elements in the core like helium and carbon) What happens to the star? (core contracts and the outer layers expand)

- Planetary nebula: How is this created? Why does it glow?

- White Dwarf:
  * What are white dwarfs made of?
  * What supports white dwarfs against gravitational collapse?
  * What is the maximum mass a white dwarf can have?
  * White dwarfs do NOT fuse anything in their cores - they just slowly cool, eventually becoming so dim that some astronomers call them black dwarfs.

- Novae and Type 1a Supernovae
  * If a white dwarf is in a binary system with a red giant star, the red giant may expand so much that some of it’s outer layer material gets close enough to the white dwarf that it gets pulled onto the white dwarf.
  * This accreted material on the white dwarf can fuse quickly creating a small burst of energy: a nova
  * If the accreted material gives the white dwarf enough mass so that it’s mass becomes greater than 1.4 M$_\odot$, it will explode in a Type 1a supernova. Why?

- Higher mass (> 8-10 M$_\odot$)
  
- Supergiant star
  * The core keeps contracting, making the temperature higher so that heaver elements can be fused to support the star against collapse. This fusion keeps going to higher elements until which element? (Iron)
  * Why don’t stars fuse elements heavier than Iron?
  * What is the structure of a supergiant star just before supernova? (think onion)

- Core-Collapse Supernovae
  * The iron core can’t fuse, so there is not enough energy being produced in the core to support the star against collapse → core collapses, rebounds and star explodes → Core-collapse or Type II supernova!
  * Why are these supernovae important for life?
  * What are the two possible supernova remnants? (neutron stars and black holes)

- Neutron Stars
  * What are they made of? (neutrons!)
  * What supports neutron stars from gravitational collapse?
  * What is a pulsar? What is the lighthouse model?

- Black Holes will not be covered on this exam