ASTR 101 Final Exam Review

VOCABULARY BASED

Textbook: Look at Concept Quiz Questions from Chapter 17 and 18 (He put a lot of them on the test)

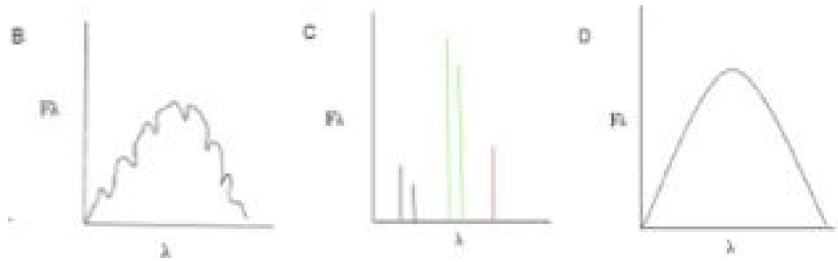
History of Astronomy

- Kinetic Energy
    - Kinetic Energy = ½ m v^2
    - Higher kinetic energy means higher total energy
    - Examples: Falling rocks or orbiting planets
    - The amount of kinetic energy depends on the orbital speed
- Gravitational Potential Energy
    - Potential Energy: $PE = mgh$ (the answer is written in Joules "J")
    - This is the potential energy for raising an object on Earth above a certain reference level. For a planet orbiting the Sun the potential energy varies with distance. Where the kinetic energy is maximum (perihelion) the potential energy is a minimum. At aphelion the potential energy is a maximum.
        - m = mass of the object
        - h = 2
        - g (gravity) = $9.8\ m/sec^2$ [local acceleration of gravity on Earth; on the Moon it is ⅙ as big]
        - Energy stored for later conversion into kinetic energy
        - Impact on planets orbiting the Sun
        - Chapter 3 of supplementary reading
        - Depends on its mass and how far something can fall as a result of gravity
            - It increases when the object moves higher and it decreases when the object moves lower
        - The amount of energy depends on the orbital distance

- Planet’s Total Orbital Energy = The sum of its kinetic and gravitational potential energy
    - Stays the same as long as no other object makes it gain or lose orbital energy
- Moon
    - Phases
        - New Moon
            - Rises: 6 AM [well, at sunrise]
            - Sets: 6 PM [at sunset]
        - Waxing Crescent
            - Rises: 9 AM
            - Sets: 9 PM
            - Visible in the West or Southwest after sunset
        - First Quarter
            - Rises: Noon (12 PM)
            - Sets: Midnight (12 AM)
            - High in the South at sunset
        - Waxing Gibbous
            - Rises: 3 PM
            - Sets: 3 AM
            - Visible in the East or Southeast after sunset
        - Full Moon
            - Rises: 6 PM
            - Sets: 6 AM
        - Waning Gibbous
            - Rises: 9 PM
            - Sets: 9 AM
        - Third Quarter
            - Rises: Midnight (12 AM)

            - Sets: Noon (12 PM)
        - Waning Crescent
            - Rises: 3 AM
            - Sets: 3 PM
            - Visible in the East or Southeast before sunrise
    - Tides
        - Tidal forces decrease with $(\text{distance})^3$
        - $T_{sun} = GM_{sun} (M_{water}) (2R_{earth}) / D_{moon}^3$
        - Full Moon and New Moon
            - Highest high tides and lowest low tides
        - 1st Quarter and 3rd Quarter
            - Lowest high tides and highest low tides
        - Spring Tides: When the tidal forces of the Sun and Moon work together (Full and New Moons)
        - Neap Tides: When the tidal forces of the Sun and Moon counteract each other (First Quarter and Third Quarter Moons)
        - Example: If high tide was 8 feet and the Moon suddenly is half its previous distance, then tides are 2-cubed = 8 times higher, or 64 feet. Goodbye beach house.
        - Tidal Force: Stretches the entire Earth to create two tidal bulges
            - One faces the the Moon and the other one faces opposite the Moon
- Basic physics
    - Spectrum
        - What kind of spectrum you get depends on the density of the material and what extra gas might be along the line of sight
        - Hot solid, liquid, or dense gas (Hot= anything above absolute zero) gives off a continuous spectrum
        - Emission Line Spectrum: Low density gas that is excited to emit

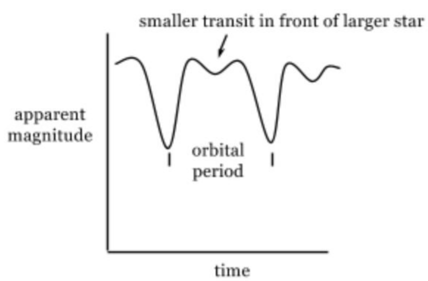
        - Absorption Line Spectrum: Cooler gas between the observer and source of continuous radiation



Absorption   Emission   Continuous

- Basic information
    - Radial velocity: Monitors the brightness of the stars
        - Radial velocities of stars: Measured from the Doppler shift of the lines in the star's spectrum
    - Doppler's Formula: $v / c = (\lambda_{obs} - \lambda_o) / \lambda_o$
        - v = radial Velocity
        - c = speed of light (300,000)
        - λ_{obs} = observed wavelength of a spectral line from some cosmic source
        - λ_o = lab wavelength of the sample line
    - Doppler Shift
        - Frequency- Change of frequency equals the speed of the object and the angle of the object
            - Frequency is higher when something is coming towards you
            - Frequency is lower when something is going away from you
        - Light waves and sound waves can be Doppler Shifted
            - Light waves: $v = \Delta\lambda / \lambda_0 \times 300{,}000$ km/s
            - So, if object is receding from you at 4% of the speed of light, then all the spectral lines are observed at wavelengths 4% longer than in the lab
    - Proper motion

- The number of arcseconds per year (or century) that a star moves with respect to the distant background of stars or galaxies
- Binaries
  - Spectroscopic binaries
    - Revealed by the Doppler shifts of the two stars in a close binary system
  - Eclipsing binaries
    - Revealed by the mutual eclipses of two stars
    - To see this from Earth the observer must be close to the plane of the orbit of the two stars. Here's a light curve:
  - Close Binary Stars



    - Have different evolution than single stars
    - Mass can be passed from one star to the other
    - As the more massive star swells to become a red giant
      - A lot of mass can be transferred to the formerly less massive star
- Star Clusters
  - Evolution of stars
    - Giants and supergiants
  - A single interstellar cloud can contain enough material to form many stars- stars usually form in groups
  - All of the stars in a cluster formed at about the same time
    - Within a few million years of each other

- Open star clusters: have approximately 100 - 1000 stars
    - Found in the disks of galaxies and often contain young stars
- Globular star clusters: have approximately 100,000 - 500,000 stars
    - Found primarily in the halos of galaxies and contain only very old stars

- Law of Gravity
    - $F_g = G\frac{M_1 M_2}{d^2}$
        - F_g = the force of gravitational attraction
        - M_1 & M_2 = masses of the two objects
        - d = distance
        - G = gravitational constant
            - $6.67 \times 10^{-11}\ m^3 / (kg \times s^2)$

- Kepler's Third Law (simplest version, for object orbiting 1 solar mass star)
    - $p^2 = a^3$
- Magnification
    - M = Fo / Fe
        - Focal length of the primary mirror/focal length of the eyepiece
- Optical Telescope
    - Gather as many photons as it can (light gathering power)
    - How much light a telescope can gather depends on the area of the primary light gathering element
- Absolute magnitude
    - A measure of an object's luminosity
    - $M_v = m_v + 5 - 5 \log d$
        - M_v = absolute visual magnitude (derived)
            - Apparent magnitude of a star would have if it were at a distance of 10 pc
        - m_v = apparent visual magnitude (observed)

- d = distance in parsecs
  - = 1/p”
    - Parallax angle
- Apparent magnitude
  - A measure of the apparent brightness of an object in the sky
    - Based on the ancient system that was developed by Hipparchus
  - Declines with the square of its distance
    - Doubling the distance to an object (such as a star) would decrease its apparent brightness by a factor of 2^2 or 4
- Cosmology: The study of the evolution and structure of the universe
  - Axion
    - (very light particle) is also a possibility
  - Neutralino
    - The lightest neutralino is a good candidate for COLD DARK MATTER (neutral little thing)
  - Cosmological Distance Ladder
    - By measuring stellar parallaxes we can determine the distance to the nearby stars
- Meteorites/Meteors
  - Meteor- Not a “falling star”
    - A piece of sand that vaporizes in the Earth’s atmosphere due to friction
  - Meteorite- An asteroid can collide with Mars and a chunk of Mars can be ejected from its surface, orbit the Sun for some time, and collide with the Earth
- Asteroids
  - There are 400,000 to 1 million asteroids in the solar system with sizes greater than 1 KM
  - Most asteroids are solid bodies

    - How destructive are they? - This is determined by mass and velocity of the asteroid
        - ½ mv^2
        - Roughly 1,000,000 times more destructive than nuclear bombs
- Dwarf planets
    - Kuiper Belt: Contains many dwarf planets as well as many km-sized objects
    - A potential planet is considered a dwarf planet if it does not meet ALL three of these criteria:
        1) Orbit a star
        2) Roughly spherical
        3) Have cleared out the ring of volume in which it exists
- Terrestrial planets: Mercury, Venus, Earth, and Mars
    - Rocky, thin atmospheres
        - Mars has a small one
        - Mercury really doesn't have an atmosphere anymore
    - Much remaining evidence of bombardment by asteroids and meteors
    - Contain live volcanoes or evidence of past lava flow
    - Few moons
- Jovian planets: Jupiter, Saturn, Uranus, and Neptune
    - "Gas giants"
    - Low average density (compared to the terrestrial planets)
    - Ring systems
    - Many moons
    - Interior = Composed of metallic hydrogen
- Brown dwarf stars
    - 20-80 Jupiter masses
    - Compared to the Sun ~ 0.02 to 0.08 solar mass
- Star masses

- Lower Mass Limit: 0.08 $M_\odot$
- Upper Mass Limit: $\sim 60 - 100\, M_\odot$
- Star with 8 or more solar masses:
    - Ends up with a many-layer structure
    - Eventually ends up with an iron core
- Dwarf galaxies
    - Get eaten by more massive galaxies
- Types of Galaxies:

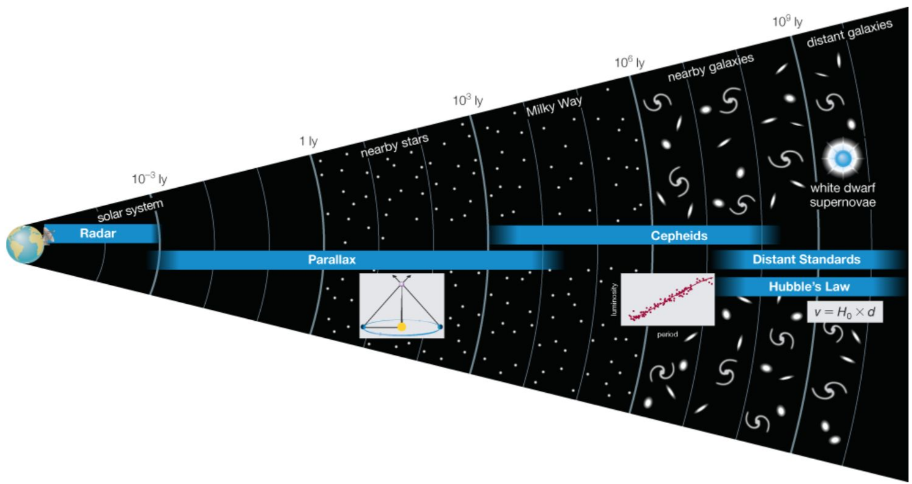
Type:	Mass:	Star Formation:
Ellipticals (no spirals) - You can't make new stars here	Very little dust and gas (<1% of mass)	$\sim$No
Spirals (Milky Way) - Stars can form here - 1 main sequence star/year	5-10% gas	Yes
Irregulars lots of star formation b/c lots of gas	10-50% gas	YES

- Distance Information
    - Nearest stars are several light-years away
    - Size of the Milky Way
        - 75,000 light-years
    - Earth's Diameter
        - 8,000 miles
    - Distance from Earth to Moon
        - 60 Earth radii

        - 240,000 miles
    - Distance from Earth to Sun
        - 150 million km (93 million miles)
    - Light-Year
        - How far light travels in a vacuum in a year
        - 6 trillion miles
    - Parsec
        - Short for parallax of a second of arc
        - 1 pc ~ 3.26 light-years
        - Distance in pc is the reciprocal of the parallax in arcsec
            - d = 1/p
- Kepler's Second Law
    - Based on the conservation of angular momentum
    - Angular momentum stays the same, but the speed changes
    - Kinetic Energy + Gravitational Potential Energy stays the same
- Sun: Interior / Atmospheric Temperatures
    - Solar Core: 15,000,000 degrees K
        - Where fusion takes place
    - Radiative Zone: 10,000,000 degrees K
    - Convection Zone: 2,000,000 degrees K
    - Photosphere: 6,000 degrees K
        - Sunspots: 4,500 degrees K
            - Sunspots are magnetic fields
                - That is why they are cooler in temperature
    - Chromosphere (colored layers): 4,500 degrees K at the bottom, 10,000 degrees K at the top
        - Hydrogen gas emits light
    - Corona: 1,000,000 degrees K
        - X-rays and visible light

- Supernova
    - There are two basic ways to make a supernova:
        1) Explosion of a single mass star
        2) Mass transfer to a white dwarf star
            - If the mass of the WD approaches 1.4 solar masses, the star explodes
    - Two Types of Supernovae
        - Type II Supernovae
            - Supernovae with hydrogen emission in their spectra
            - They are explosions of single, massive stars
        - Type Ia Supernovae
            - Supernovae without hydrogen emission, but with silicon absorption
            - They are explosions of C-O white dwarf stars
- Milky Way Galaxy
    - 75,000 light-years in diameter
        - Several million light years gets you to the Andromeda galaxy (It is 2 million light years away)
    - Located in the local group in the local cluster
        - Only three major galaxies located here
        - Some galaxy clusters have only 20 galaxies, while others may have more than 1000
    - Not expanding because they have enough density
- Dark Matter
    - The visible Galaxy we know that gives off most of the light is embedded in a halo of invisible Dark Matter
    - Not sure what exactly this Dark Matter is
        - Relic (leftover) particles from the Big Bang?
        - Lots of 3 solar mass black holes?

- Evidence for Dark Matter
    - Rotation curves of large spiral galaxies
    - Arcs of light in the direction of rich clusters of galaxies, caused by gravitational lensing
    - Analysis of the motions of galaxies in clusters



- Classifying Stars
    - OBAFGKM (spectral types)
        - 0-9 (hottest to coolest)
    - O: helium lines, weak H lines
    - B: weaker He line, stronger H lines
    - A: strongest H lines
    - F: weaker H lines, some metallic lines
    - G: weaker still H lines, strong lines of calcium, iron, sodium
    - K: even stronger lines of Ca, Na
    - M: molecular bands such as TiO, VO
- Carbon Dioxide Cycle
    - Four greenhouse gases involved:
        - Carbon Dioxide: CO_2

- Water Vapor: H_2O
- Nitrous Oxide: N_2O
- Methane: CH_4

- When it rains, carbon dioxide gets dissolved in the water, then the water becomes mildly-acidic, that water allows for erosion, this material gathers on the ocean floor and becomes rocks like limestone, then plate tectonics carry these carbonate rocks (like limestone) to subductions zones, subduction pushes them down into the Earth's mantle, as they are pushed into the mantle, some of the carbonate rocks melt, then releasing carbon dioxide which then outgasses back into the atmosphere through volcanoes.

- Aristotle
    - Concluded that the Earth must be a sphere because only a sphere could always cast a shadow that was circular
- Hipparchus
    - Observed the 1000 brightest stars
        - Classified stars' brightness (invented magnitude scale)
        - Discovered precession of the equinoxes
- Copernicus
    - Founder of modern astronomy
- Galileo
    - Discovered the Sun had some imperfections
- Newton
    - Laws of gravity