

**ASTRONOMY 120/GEOLOGY 120**  
**STUDY GUIDE and COURSE CONTENT**  
 (Revised Fall 2011)

**Recommended Text: Any introductory Solar System textbook that has less than a 5 year copyright date.**

**Required Lecture Notes: Palomar College Astronomy 120 Lecture Notes, J. Pesavento, 2009. (Located at Off Campus Books)**

I. Scientific Method

CONCEPTS: We try to understand and explain the Universe and its activities. We can be deceived in our observations.

A. Three steps of the Scientific Method

1. Observation, Theory and Test
2. Facts can change due to lack of proper observations

B. Model, theory and fact

1. Using computers to model and/or predict an event of phenomena
2. The relationship between theory and fact

C. Communication of ideas

APPLICATION: Method of solving any problem in our lives, in society, government, etc., first use of the “internet” to share data dealing with Particle Physics.

REVIEW QUESTIONS:

1. What are the three steps of the Scientific Method?
2. What is the basic problem that we humans have when we “observe” something?
3. How does computer modeling help in understanding a phenomenon?
4. What is the difference between theory and fact?

II. Benefits of Space Exploration

REVIEW QUESTIONS

1. What are some of the ways that exploring other objects in our Solar System helps us now and in the future by improving our lives on Earth?

III. Celestial Sphere

CONCEPTS: Using the Earth’s orientation in space, i.e., orbital plane, spin axis and equator, we set up references in the sky. We use the references to track the positions of objects, like the sun. We discover that the sun has a regular motion which causes seasons. The noon position of the sun in the sky is low or high depending on the time of year.

A. Earth centered (Geocentric)

B. Dome of the sky

C. Common references on the sky

1. Zenith and Horizon
2. North Celestial Pole
3. North, East, South & West (Cardinal points) on Horizon
4. Meridian
5. Celestial Equator
6. Ecliptic

#### D. Tilt of Earth's axis

1. Concentration of solar energy
2. Cause of Seasons (Equinoxes and Solstices)
3. Perihelion and Aphelion

#### REVIEW QUESTIONS

1. What is the Zenith and how does the definition of the Horizon relate to it?
2. What is the relationship between the north pole of the Earth and the North Celestial Pole?
3. Does the North Celestial Pole remain in the same place in the sky for everyone on the Earth?
4. What is the Meridian, what points in the sky does it go through and what is its purpose?
5. How does the Equator of the Earth relate to the Celestial Equator?
6. What are two definitions of the Ecliptic and how do we use it in relationship to other objects in our Solar System?
7. For a planet to have seasons what must take place as it orbits the sun?
8. If a planet has seasons, what is the relationship between the spin axis of the planet and its orbital plane?
9. What is the angle between the Ecliptic and the Celestial Equator and what does this have to do with seasons of the Earth?
10. Where is the sun's location in the sky at noon at the Summer Solstice and the Winter Solstice with respect to the Celestial Equator? Where on the horizon with respect to East does the sun rise and set at these two times of the year? Where does the Celestial Equator intersect the Horizon? How does that affect the length of the daylight hours?
11. Why isn't the hottest day of the year on the Summer Solstice and the coldest on the Winter Solstice in the Northern Hemisphere of the Earth? What does this have to do with the incoming and outgoing of energy that originated in the Sun - Solar Energy?
12. Where is the sun located with respect to the Celestial Equator at the two Equinoxes? Where does the sun rise and set at the Equinoxes?
13. Given the latitude and longitude of the Earth, where must you be located to have the sun at the Zenith at the Summer Solstice and then the Winter Solstice? If you were located on the Equator of the Earth, where would the sun be in the sky at noon, at sunrise and at sunset during the Equinoxes? Why?
14. Why are the seasons just the opposite when you compare the northern and southern hemispheres?
13. What are the Perihelion and Aphelion points of an orbiting object? Why doesn't the Perihelion and Aphelion of the Earth have anything to do with the cause of seasons?

#### IV. Early Understanding of the Solar System

CONCEPTS: Over 4000 years ago, people in Great Britain had an understanding of the movement of the sun and moon in the sky with respect to the horizon and direction. They also may have used this knowledge to predict eclipses. Their motivation may be the belief that the sun and the moon were gods that affected the Earth. The belief that any astronomical body and its position in the sky influences man's activities on the earth is called astrology. It has no scientific foundation, therefore it is called a pseudoscience. The early Greeks used astrology as a motivation to predict the movement of celestial bodies. In the process of doing this, they started to make careful observations and measurements. The Science of Astronomy began to be developed with many misconception of how the universe worked.

##### A. Stonehenge - German (5000BC) and British (3000BC)

1. Movement of the sun and the moon
2. Eclipse predictor????

##### B. World Cultures, Beliefs and the Sky

1. Tracking the annual motion of the Sun
2. Orientation of structures

- 3. Link between the sky and religion
- C. Pseudoscience of Astrology
- D. Greek Astronomers
  - 2. Aristotle
    - a. Shape of the earth
    - b. Phases of the moon
    - c. Eclipses
  - 3. Aristarchus of Samos
    - a. First to consider Heliocentric Solar System
    - b. Attempted to find relative distances of Moon and Sun
  - 4. Eratosthenes - size of the Earth
  - 5. Hipparchus
    - a. Eclipse Prediction
    - b. Sizes and distances
  - 6. Ptolemy
    - a. Almagest
    - b. Retrograde Motion
    - c. Epicycles

#### REVIEW QUESTIONS

1. How did we come up with the conclusion that the Stonehenges were used as Solar Observatories? Why do we think the people that built these were so interested in the Sun and Moon?
2. What evidence do we have that certain ancient structures in the world were used for Solar observations and as part of many civilizations belief systems?
3. What is the difference between Astrology and Astronomy?
4. What are the two methods that Aristotle used to determine the shape of the Earth?
5. From the Earth, why do we see the Moon going through phases?
6. What are the eight phases of the Moon as seen from the Earth and what are the angles of the Sun, Earth and Moon associated with the phases?
7. Does the moon kept one side facing the Earth as it orbits the Earth and what is this called? Why does this occur for many of the satellites of other planets? What did we realize about the energy configuration of all dynamic systems in our universe?
8. What is local time and how does it work? Does it change throughout the year?
9. Why don't we have eclipses every new and full Phase of the Moon?
10. What are the importance of knowing the Nodes of an orbiting Body?
11. What are the two conditions necessary to have an eclipse of any type?
12. Why don't we have an eclipse exactly six months apart?
13. There are three shadow regions caused by the Earth or Moon. What are the names of these regions and what can you see of the sun if you were located in each of them?
14. What are the names of the three types of Solar Eclipses and what do they look like from the Earth?
15. What is meant by the "path of totality" during a Total Solar Eclipse?
16. What are the names of the three types Lunar Eclipses and what do they look like from the Earth?
17. Explain the two reasons that the Moon during a Total Lunar Eclipse turns a red-orange color.
18. Who was the first Greek Astronomer to propose the Heliocentric Theory and was the first to attempt to measure and calculate the relative distance to the sun?
19. Explain how Eratosthenes not only determined that the Earth was spherical but was also able to measure and calculate it size.
20. Who wrote a "book" called the Almagest that recorded all of the Astronomical knowledge of the time? In the "book" he may have borrowed an idea from Hipparchus called epicycle to explain

Retrograde Motion. What is Retrograde Motion and how do epicycles work to explain it? Were epicycles meant to describe the reality of the Solar System? What actually causes Retrograde Motion in the Solar System that we now understand?

## V. Copernican Revolution

CONCEPTS: As humans learn more about our Universe, we find that one person makes a discovery, then another person learns about that new information and builds on that making further discoveries. Thus, our understanding improves. Newton would not have been able to arrive at the law of gravity without those who went before him.

- A. Copernicus
  - 1. Heliocentric Theory
  - 2. Positions of the planets
  - 3. Sidereal and Synodic periods
- B. Tycho Brahe
  - 1. Sighting instruments
  - 2. Observed comets
  - 3. Accurate planet positions
  - 4. His view of the Solar System
- C. Johannes Kepler
  - 1. Studied Brahe's data
  - 2. Three laws of planetary motion
- D. Galileo Galilei
  - 1. Made telescope to observe the sky
  - 2. Studied the Moon
  - 3. Discovered four moons of Jupiter
  - 4. Discovered the phases of Venus and proved that it went around the sun

## REVIEW QUESTIONS

1. Why did Copernicus consider that the Heliocentric Theory best fit the reality of the Solar System?
2. Draw and label the planetary positions of Opposition and Conjunction of the outer planets; and Inferior and Superior Conjunction, and Greatest Western and Eastern elongations of the inner planets.
3. What is the difference between Sidereal and Synodic Periods of the planets? Can you observe both Periods? Which one must be calculated of the planets? Why can the Sidereal and the Synodic Periods of our Moon be observed and why do they differ?
4. What was Tycho Brahe major contribution to our understanding of the Solar System? Did his view of the Heliocentric Theory differ from Copernicus? Why?
5. Explain Kepler's three Laws of Planetary Motion?
6. What feature did Galileo discover when he observed the Moon with his telescope? How did this contradict the present thinking as presented by Aristotle?
7. What was the significance of Galileo's discovery of four of the Satellites of Jupiter?
8. Explain how Galileo used the phases of Venus to prove that it orbited around the Sun and not the Earth like our Moon.

## VI. Laws Governing the Dynamics of the Solar System

CONCEPTS: Using the discoveries of others, Newton synthesized the essential properties of moving objects in his three Laws of Motion. What was so magnificent about the laws was that they worked for all the objects in the universe. This led him to derive the law of gravity that explains the movement of the planets, etc. in our Solar System. Gravity can also be used to explain the movement of water on the

surface of the Earth that we call tides. It should be noted here that Einstein further explained movement of objects that were not measurable until the latter part of the nineteenth century.

- A. Three laws of motion
  - 1. Law of Inertia
    - a. Velocity vs. Speed
    - b. Force needed to change velocity
    - c. Difference between Weight and Mass
  - 2. Relationship between Force, Mass and Acceleration
  - 3. Equal and Opposite Forces
- B. Law of Gravity
- C. Tides

#### REVIEW QUESTIONS

1. Explain the Law of Inertia and how this relates to the orbits of planets.
2. What does Newton's Second Law say about making a mass move? How does this Law relate to the Law of Inertia?
3. What does Newton's Third Law say about the force of the Sun and the Earth?
4. Explain how Newton was able to realize an object could be put into orbit around the Earth?
5. How is the force of Gravity affected by changes of mass and distance?
6. How does Gravitational Assist increase the velocity of a spacecraft so it can move further from the sun?
6. In general, how do tidal interactions involve gravitational forces? Does just liquids, like water, respond to tides? Why not?
7. Explain why there are two high water tides on the Earth, i.e., one facing the Moon the other in the opposite direction? What does the center of the Earth have to do with this?
8. Why does the Moon have a greater effect on Earth tides than the Sun?
9. What are Spring and Neap Tides? Why do they depend on the phase of the Moon?

#### VII. Earth as a Comparison

CONCEPTS: In order to understand other objects in our Solar System, we must understand our own planet. On the other hand, as we learn about other objects; we become more aware of the Earth's systems. By seismic activity we can determine the sections and state of the Earth's interior. This enables us to formulate a theory of planetary magnetic field production. The top layers of the Earth are constantly being reformed and modified over millions of years by many different processes. A general theory, Plate Tectonics, emerged to explain many of the features on the Earth's surface. The atmosphere of any object plays an important part in the evolution and modification of the planets surface.

- A. Formation of Earth
- B. Interior Structure
  1. Method of probing - Seismic waves
  2. Core
    - a. State and type of material
    - b. Production of magnetic field
    - c. General magnetic field of the Earth
  3. Mantle - state of material
- B. Crust as part of Lithosphere
  1. Rock types - Igneous, Sedimentary and Metamorphic
  2. Chemical composition
  3. Dating techniques
  4. Original condition
  5. Later modifications

## 6. Weathering and Erosion

### C. Plate Tectonics

#### 1. Early ideas

- a. Alfred Wegener's Theory
- b. Pangaea - Laurasia and Gondwanaland
- c. Paleoclimates, fossils, geological features as evidence
- d. Lack of mechanism for movement

#### 2. Revival of theory

- a. Magnetic field of Earth stored in rock
- b. Proof of movement - N. American Terrains
- c. Problem of sea floor
- d. Resolution of problem by Hess in 1962

#### 3. Features of plates and plate boundaries

- a. Diverging boundaries
  - (1) Sea floor spreading
  - (2) Driving force
  - (3) Age of sea floor
  - (4) Magnetic anomalies
- b. Converging boundaries
  - (1) Subduction
  - (2) Mountain Building

### D. Atmosphere

#### 1. First atmosphere and origin

#### 2. Second atmosphere

- a. T-Tauri Phase
- b. Impacts of asteroids and comets
- c. volcanic activity
- d. Lack of Oxygen Gas
- e. Removal of Carbon Dioxide

#### 3. Photosynthesis - BlueGreen Algae

## REVIEW QUESTIONS

1. Draw and describe with words how the energy is expressed in P-waves, S-waves and surface waves (L and R waves), and what these look like on the seismogram.
2. What is the relationship between P-waves and S-waves in terms of their speed and the state of the material that they can travel through?
3. What happens to the seismic waves as they pass through material that has a gradual change of density? Does the energy travel in straight lines? What happens to the waves if they "hit" material with a large change in density?
4. Why are there "shadow zones" from direct S-waves?
5. What were the two "anomalies" that Inge Laymann discovered in studying seismograms that enable her to conclude that there is a solid Inner Core of the Earth?
6. What are the states of matter (solid or liquid) of the Inner and Outer Core?
7. What elements do we think the Inner and the Outer Core is composed? What piece of information allows us to come up with reasonable candidates?
8. What is the state of matter and chemical composition of the Lower Mantle?
9. What are the two conditions that an object must have to produce a magnetic field?
10. Using a simple model, in term of moving hot material; what is the Outer Core doing to produce a magnetic field?

11. Is the magnetic field of the Earth oriented along the spin Axis? Does the North and South Magnetic Poles remain in the same position over a long period of time?
12. Using a compass, the needle will orient itself with the Magnetic North Pole in the horizontal plane; but will it move in the vertical plane depending on where you are located in Latitude? Why?
13. Draw, name and describe the parts of the Upper Mantle along with the change of speeds of the seismic waves?
14. How thick is the Upper Mantle compared to the Lower Mantle?
15. What are the layers of the Lithosphere?
16. Is there a difference in the thickness of the crust? Where?
17. What is the Mohorovicic Discontinuity?
18. What is the present theory of the formation of the continents? Why do they have a higher elevation than other parts of the crust?
19. How did we determine the relative age of sedimentary layers, such as sandstone, shale, limestone, etc. What do we use to make the comparisons?
20. When an element is radioactive, what property does it have that make it different from a stable element?
21. What is meant by the "half -life" of a radioactive sample?
22. Is the rate of decay affected by the environment of the sample? Is this dating technique accurate? Can the radioactive process to determine age of a sample be "reset"?
23. What is the difference between weathering and erosion?
24. What are the two types of Weathering?
25. What are the agents of erosion?
26. Who was Alfred Wagener and how did he come up with "Continental Drift"?
27. What types of evidence did Wagener use for his theory?
28. What is the name of the super-continent and what it broke into?
29. What was the main reason that his theory was not accepted?
30. What proof of the movement of rock material do we have that eliminates the possibility of polar wondering?
31. If the continents are moving, there should be evidence on the ocean floor. What did Harry Hess discover? What was his solution to the problem?
32. What evidence do we have that the "Ridge System" on the ocean floor is a divergent boundary?
33. How did the "rift valley" form?
34. What could be the driving mechanism for divergence?
35. The Hawaiian Islands are a good example of a "hot spot". What are plumes or hot spots and why do we think the Hawaiian Islands are a good example?
36. Given the distribution of the age of the sea floor, how does this help prove that ridge zones are divergent plate boundaries?
40. After sampling the rock on either side of the ridge zones, what conclusion was made about the magnetic field of the Earth over time?
41. If there are divergent plate boundaries, why must there be convergent boundaries?
42. Describe subduction zones and the structural activities (faulting, magma, volcanoes, etc.) associated with it.
43. Explain the formation of the Himalayan Mountians.
44. What do we think was the chemical composition of the first atmosphere of the Earth and what was the origin of the material?
45. What happened to that first atmosphere?
46. What are the two possible processes that caused the formation of second atmosphere? What was the chemical composition of the second atmosphere.

47. How was the second atmosphere modified? What happened to the Carbon Dioxide?  
 48. How did the Oxygen Gas develop in the Atmosphere? Has this atmosphere fluctuated in chemical composition in the past and is still changing? How?

**A 150 POINT MID-TERM EXAM WILL NOW BE GIVEN COVERING ALL THE MATERIAL THROUGH TOPIC “VII”.**

VIII. Methods and Instruments to Gather Information

CONCEPTS: All forms of matter produce electromagnetic radiation of some type. By carefully analyzing the spectrum from the object; we can determine various properties, for example, chemical composition and temperature. Earth bound telescopes are limited as to what we can learn about the objects in our Solar System. The advent of spacecraft’s ability to fly to other planets gave us a phenomenal increase of information about our Solar System.

- A. The Domains of Electromagnetic Radiation
- B. Types of Spectra
  - 1. Continuous, absorption and emission
  - 3. Not limited to the optical domain
  - 2. Uses
    - a. Chemical composition of atmospheres
    - b. Chemical composition of solid material
    - c. Temperatures
    - d. Movement of object
- C. Limits of Earth-bound or Earth-orbit instruments
- D. Spacecraft, atmospheric/surface probes and rovers
  - 1. Solar System object that they had visited, are visiting or will visit
  - 2. Some instruments on board to make various kinds of observations
    - a. how they work
    - b. what they measure

REVIEW QUESTIONS

1. What are the domains of Electromagnetic Radiation from Radio to Gamma Rays?
2. What are the three different types of spectra and what is the condition of the material to produce that spectrum?
3. How is the chemical composition of the atmosphere of a planet or satellite determined by the spectrum?
4. If an object is not producing optical radiation, how can we determine its chemical composition? What domain or domains of EM Radiation can be used?
5. What domain of EM Radiation is used to determine the temperature of the top region of the atmosphere and the surface of a planet or satellite?
6. How do we determine the rotational velocity or the period of rotation of a planet?
7. Given the lists of spacecrafts, what are their names and what object or objects in our Solar System did they visit?
8. What are some of the instruments used on the spacecraft and what type of data do they collect?

IX. The Moon

CONCEPTS: Our view of the moon evolved as our methods of measurement evolved from simple to complex. We ultimately physically visited the moon. The exploration of this object helped explain the highlands and maria regions. One of the most common features on the surface of solid objects in our Solar System are craters, their formation involves a complex process of accretion, ejecta and planetary evolution. There are many theories of how the moon originated. By using computer modeling and better

understanding of the Moon, the collision hypothesis seems to be the most likely at this time.

A. Theories of Formation

1. Must explain high angular momentum
2. Must explain orbit inclination
3. Must explain high mass compared to Earth
4. Must explain unusual isotopes of elements

B. Early study and discovery

1. Galileo's Observations
2. Size and density
  - a. Uncompressed Density
  - b. Gravitational force on the surface
  - c. Escape Velocity
3. Surface temperature
4. Lack of an atmosphere

C. Lunar exploration by men and spacecraft

D. Interior Structure

E. Surface features

1. Highlands
  - a. Origin
  - b. Regolith
  - c. Chemical composition
2. Maria
  - a. Origin
  - b. Regolith
  - b. Chemical composition
3. Rays and Rilles
4. Far Side
5. Craters
  - a. Volcanic or impact origin
  - b. Process of impact cratering
  - c. Dating cratered worlds

E. Evolution of the surface

REVIEW QUESTIONS

1. Who was the first person to study the Moon and what did he find?
2. What is meant by Escape Velocity? How does this relate to the energy required to leave the Earth and that needed to leave the Moon?
3. What is the size of the Moon relative to the Earth? In general, what are the sizes of other satellites relative to their planet?
4. When comparing Densities of bodies it is helpful to use the Uncompressed Densities. What does this mean and why is it so helpful in understanding the interior of the body? Why can't we just use the average Density?
5. Did the Moon have an atmosphere? How did it form? What happened to it? Before we sent men to the Moon, how did we know that it had little or no atmosphere?
6. What are the temperature ranges on the Moon's surface?
7. What country was the first to photograph the "far-side" of the Moon?
8. What did the spacecrafts called Ranger, Lunar Orbiter and Surveyor do to help us land men on the Moon?
9. What were some of the accomplishments of the Apollo Program? What type of measurements did the automated surface lab called ALSEP (Apollo Lunar Surface Experiments Package) perform?

- What provided the electrical power for ALSEP?
10. Does the Moon have a Core, Mantle and Crust? Is there any evidence of movement of the crust, e.g., faulting? What are the features on the Moon indicating volcanic activity? Is the crust the same thickness all the way around? Why not? Does the Earth have anything to do with it?
  11. What is the difference between a Crater and a Caldera?
  12. Before the 1890's, craters were considered to what geological feature? Who was the first person to present arguments against the initial theory? What did he propose how craters formed? What was his proof?
  13. Why are large craters always round?
  14. What is the process of crater formation? How is the energy expressed? What are the energy transfers involved? What is the difference between "High Speed Ejecta" and the "Ejecta Blanket"?
  15. What are lunar Rays? What are Rilles?
  16. What is the shape of the inner wall of a large crater?
  17. What often forms in the middle of large crater? Why? Why do some craters have a very smooth and even bottom?
  18. Is there a relationship between crater density and the age of the surface that has these features? What is meant by Crater Density? What assumptions had to be made about the number of objects in our Solar System over the past 4.6 billion years? How did the radioactive dating of the rocks on the Moon help our understanding? How did the Maria and the Highlands play a part in this conclusion? Can this crater density and surface age relationship be used throughout the Solar System?
  19. What is the difference between the Highlands and the Maria? What is the difference in surface features, chemical composition, depth of regolith(soils from impacts), geological history and age?
  20. What are some of the possible Origins of our Moon? What is wrong with some of these theories? Explain the one that is accepted as a plausible theory today.
  21. Explain the stages of the formations and evolution of the Moon as we understand it today?

## X. Mercury

CONCEPTS: Mercury is very difficult to study from the Earth, since is so close to the Sun. We did manage to resolve some misconceptions about the Planet. Mercury has an unusual tidal coupling, where it keeps one of two sides toward the sun at perihelion. We are now learning much more about Mercury due to the Messenger Spacecraft in orbit around the planet.

### A. Orbit and rotational relationship

1. Expected surface temperature if in synchronous orbit
2. Actual surface temperature different
3. 2 to 3 orbital-rotational relationship due to high eccentricity of orbit

### B. Density and inferred interior structure

### C. Surface features

1. Craters
2. Rough mare regions
3. Formation of Lobate Scarps

### D. Magnetic field

### E. Not that much of an atmosphere (mostly Solar Wind material)

## REVIEW QUESTIONS

1. From the Earth can we observe any features on the planet? We did we assume about the rotation about its axis?
2. What did we discover about the temperature on the "dark side" of the planet? Did this make sense given the assumption made about the rotation? What did we discover with a Radio

Telescope and the Doppler Effect about the rotation? What is the relationship between the Rotational Period and the Orbital Period? Does this have to do with the high Eccentricity of its orbit and the tidal influence of the Sun?

3. What is the approximate surface temperature of the night side and the day side? In comparison to the Earth How quickly does the temperature change?
4. What is the size of the Planet relative to our Moon?
5. What is the uncompressed density of Mercury with respect to the Earth's? Does this indicate something about the chemical composition of interior? What would our guess be about the composition?
6. Does the surface look like the Moon? What are the differences? What are Lobate Scraps and how do we think they formed?
7. What is the strength of the Magnetic Field of the Planet and what does it tell us about the interior structure today?
8. Is there any atmosphere? Why?
9. What Spacecraft is now in orbit around Mercury and what can it measure about the planet?

## XI. Venus

- A. Rotation of solid planet and its atmosphere
- B. Interior (thick or thin lithosphere controversy)
- C. Magnetic field
- D. Atmosphere
  1. Clouds
  2. Chemical composition (very dry)
  3. Greenhouse effect
  4. Structure and circulation
- E. Surface features
  1. Radar mapping
  2. Crater distribution
  3. Possible plate tectonics
  4. Possible volcanic activity
  5. Probes on the surface
  6. Evolution of Surface
    - a. Uniform erosion and mountain ( "continent" building) OR
    - b. Periodic catastrophic volcanic activity
- F. Differences between Earth and Venus

## REVIEW QUESTIONS

1. What is the size and density of Venus with respect to the Earth?
2. What is the length of the Solar Day in terms of Earth Days? What direction does Venus rotate so that the sun rises in the East or the West?
3. What is the strength of its Magnetic Field with respect to the Earth? What do we think causes this? Does the planet most likely have a liquid interior? What would be needed to determine the state of matter in the interior, thicknesses and its chemical composition?
4. How were we able to "observe" the surface of Venus? Why can't we just see it by sun light? What Spacecraft did this?
5. What features does the surface have that we have on the Earth? Volcanoes, Mountains, plains, sand dunes, etc. Are there features that we cannot explain since we don't have anything like that on our planet? What can be said about the steepness of the sides of Mountains? Are they like the Earth's? Why are they different? Does Venus have similar activity as the Earth that we call Plate

Tectonics?

6. What did we discover about the distribution of craters on the surface of Venus? What should this indicate about the age of the surface? Does this indicate that the surface is like the Earth's in that the rocks in different regions have different ages? What was suggested to explain the problem? Did this involve the thickness of the Lithosphere?
7. Does Venus have an Atmosphere? How does it compare to the Earth's in terms of Thickness, mass, pressure, chemical composition, etc.?
8. We assume that Venus did have water at one time. Why is the atmosphere so dry? Is there any water on the surface? Does it seem that the rock material on the surface should have water? How does this relate to the steepness of the mountains?
9. Why do we think there is so much Carbon Dioxide in the atmosphere? How was Carbon Dioxide produced? Didn't the Earth have the same process? Where is most of the Carbon Dioxide of the Earth? What substance was necessary to get it there?
10. What is the composition of the clouds(droplets) of Venus? What caused this substance to be present in the atmosphere?
11. What is the surface temperature of Venus? Is there any difference between the night or day side of the planet? Why is it so hot? What is this called? How does this work?

## XII. Mars

- A. History of study
  1. Canals
  2. Seasonal cycle - high eccentric orbit
  3. Temperature
  4. Satellites
- B. Size and interior structure
- C. Atmosphere
  1. Chemical composition
  2. Pressure
  3. Weather - temperature, clouds and fog
  4. Dust storms and dust devils
  5. Water
- D. Surface features
  1. Elevations compared to Earth and Venus
  2. Craters - age determinations
  3. Volcanic activity
    - a. Volcanic plains
    - b. Tharsis and Olympus Mons
  4. Canyons
  5. Tectonic activity
  6. Water channels and other evidence of water
  7. Polar region
- D. Evolution of the surface
- F. Search for life
- G. Satellites

## REVIEW QUESTIONS

1. Percival Lowell mapped "canals" on the surface of Mars. What were these features that he saw in his telescope in Flagstaff, Arizona?
2. What is the Sidereal Period of Mars with respect to the Earth's? What is the period of rotation on its axis? Does it have Seasons? Is there a tilt in its axis or rotation with respect to its orbital

plane? How long do the seasons last? Is there a feature on the planet that can be seen from Earth that indicates what hemisphere is having winter?

3. What is the average temperature on the surface of Mars? How does this compare to the average temperature of 60 degrees F on the Earth?
4. Is the daily temperature variation on Mars any different than the Earth's? Is there a large variation on Mars? Why?
5. What is the chemical composition of the Atmosphere? What is its thickness or pressure as compared to Earth's atmosphere? Given the density of the atmosphere, is the sky Black? Why not? What processes created the Atmosphere? What could have happened to the rest of the material?
6. Does Mars have clouds? What condition is the material that comprises the clouds? Does Mars have fog? What is the condition of this material? What is the chemical composition of frost we sometimes observe on the surface?
7. Does Mars have dust storms? How do we think they form? Are they localized or can they cover the entire planet?
8. What evidence do we have that water once flowed on the surface of Mars?
9. What is actually the "face" on the surface of Mars?
10. Is there plenty of evidence that rock material has moved down slope? Is this seen best in the canyon regions?
11. Why is Olympus Mons the largest volcano in the Solar System?
12. Why are sand dunes a common feature on the planets surface?
13. What evidence do we have of recent water flows?
14. What do we think is the origin of the canyons or other like depressions? What is this called?
15. What evidence do we have that the Northern Region of the planet is younger than the Southern Region?
16. How has the probes of the surface that can move around helped us in our understanding of the geological processes on the surface of Mars?
17. What evidence has the rovers found to indicate that water was once abundant on the surface of Mars? Are there certain minerals that can only form in the presence of water?
18. What are the names of the two satellites of Mars? How large are they compared to the Moon? Why are they considered to be captured Asteroids?

### XIII. Jovian Systems - Jupiter, Saturn, Uranus and Neptune

- A. Size, orbit and rotation
- B. Interior structure
  1. State of matter
  2. Chemical composition
  3. Energy output
- C. Atmosphere
  1. Trace molecules
  2. Changes due to altitude from liquid surface
  3. Belts and zones
  4. Markings in the atmosphere
- D. Magnetic field
- E. Ring systems
- F. Satellites

### REVIEW QUESTIONS

1. What are the differences between the Terrestrial Planets and the Jovian Planets?
2. What is the chemical composition of the Jovians that give them such a low density?

3. What are the properties of the Cores of these Planets? If it is so hot at the core, why do we say the part of the core is made up of Ices?
4. The interior of the Jovians are made up of a Metallic Hydrogen Layer near the core and a Molecular Hydrogen Layer above the Metallic one. What are the properties of these layers?
5. Do the Jovian Planets have a Magnetic Field? What is the strength of the Field compared to the Earth's? What causes such a strong Field?
6. The atmosphere of Jupiter appears to be segmented into belts and zones. What are the properties of these regions that make them appear so different? What is the Red Spot in the atmosphere, how big is it and how long has it been observed? What elements, compounds or conditions do we think causes all of the colors?
7. If Saturn has the same chemical composition as Jupiter, why do the colors in its atmosphere appear to be muted?
8. Why does the color of the atmospheres of Uranus and Neptune appear to be a blue-green hue? Do these planets have any cloud formations? What do they look like?
9. Do the Jovian Planets have a "surface"? What would it be like if you flew through the atmosphere and into the planet's interior? How would the temperatures change?
10. Do the Jovian Planets produce energy from the interior?
11. Is there evidence of lightning in the atmosphere of Jupiter? How did we observe this?
12. Have we observed Aurora on both Jupiter and Saturn? When does it occur? What causes it?
13. Do all of the Jovian Planets have a Ring System around them? What are some possible origins of the material that make up the rings? In general, what are the differences in the rings structures amount these planets? How thick are the rings compared to their width? What are the sizes of the ring material? Is there a mixture of sizes in a ring or is there some orderliness in the sizes relative to their location from the planet? How can we determine the sizes? What is the chemical composition of the material in the rings? Is it all ices or is there some rock material? How can we determine this?
14. Saturn has 1000's of separate rings. What are "Shepherding Satellites" and how do they form some of the ring structures?
15. What are the names of the four Galilean Satellites in order from the closest to Jupiter to the outside? How do their sizes compare to our Moon's? How do they differ in structure among themselves? Why is Io so volcanically active? What causes all of the colors on Io surface? How do we know that Io has a very young surface and how do we know that Callisto has a very old surface? What indications that Europa has water below its frozen surface? Do any of these satellites have an atmosphere?
16. What satellite of Saturn has active "Ice Geysers"? What do we think is causing this activity? What satellite of Saturn has a relatively thick atmosphere? What is the composition of the atmosphere? How were we able to "observe" the surface of this satellite? What features did we find on the surface? What is the temperature on the surface?
17. What is so unusual about Miranda, a satellite of Uranus? What is a possible theory of why it looks the way it does?
18. What is the large satellite of Neptune that has "Nitrogen Ice geysers"? What evidence do we have that some are active? Does this satellite have an atmosphere? How do we know that it has winds?

#### XIV. Kuiper Belt Objects (p 347-351)

- A. Discovery
- B. Size and mass
- C. Satellites

XV. Asteroids (p 356-362)

- A. Orbits
- B. Types
- C. Origin

XVI Comets (p 368-374)

- A. History
- B. Orbits
- C. Parts of a Comet
- D. Chemical composition
- E. Meteor relationship

XVII. Meteors (p 374-379)

XVIII. Origins and Formation of the Solar System (p 160-165, 382-399)