

# Homework 4 Solutions

## 1. Properties of Planets I:

- a. *Orbit size* is measured as the length of the semi-major axis, which is half the long diameter of the ellipse (pg. 69). It is measured by observing the position of the planet in the sky and fitting the sightings to an ellipse which has the Sun at one focus, as per Kepler.
- b. *Orbital eccentricity* is a measure of how far an ellipse is from being a circle. It is defined as the distance between focal points, divided by the length of the major axis (pg. 69). It is measured by observing the position of the planet in the sky and fitting the sightings to an ellipse which has the Sun at one focus, as per Kepler, and then computed from the parameters of that ellipse.
- c. *Orbital period* is the time it takes the planet to move once around the sun (pg. 90). It is also called the Siderial period (pg. 71). It is measured by observing the planet or comet. For long period comets we find the orbital path (the “orbital elements”) and then calculate the period, since it would take too long to wait for a full revolution around the sun.
- d. *Orbital inclination* is the angle between the plane of the planet’s orbit and the plane of the ecliptic (which is the plane of Earth’s orbit). It is measured by determining the orbital path of the planet in three dimensions based on observing the planet’s position in the sky at various times.
- e. *Rotation axis* is an imaginary line about which an object rotates. A planet rotates about a line from it’s north pole to its south pole. Measured by observation.
- f. *Direction of rotation* is the direction an object rotates about it’s rotation axis. If viewed from celestial north (from the North Star) it will be counterclockwise for all planets except Venus and Uranus. Measured by observation.
- g. *Length of day* is the time it takes for the planet to rotate and return to facing the same direction – either toward the Sun for a solar day, or toward the same star for a Siderial Day. Measured by observing the surface of the planet as it rotates, (which was not possible for Venus until recently).
- h. *Mass* is a measure of the total amount of material that makes up the planet. It can be measured by observing the orbit of a satellite and applying Kepler’s third law, eq (5.4) on pg. 90, and solving for  $M$ .
- i. *Density* is the total amount of material, the mass, divided by the total volume, which for a sphere of radius  $r$  is  $\frac{4}{3}\pi r^3$ .

- j. *Temperature range* is the difference in temperature between the highest temperature observed on the planet and the lowest temperature observed. The temperatures can be determined by observing a region of the planet in the Infrared (IR) spectrum.
- k. *Composition* means what the planet is made of. For the inner planets the composition will be silicates and metals, basically rocks, while for the outer planets the composition will be light gases and liquids, such as helium, hydrogen, methane, and ammonia. Can be measured by spectroscopy.
- l. *Atmosphere* is the gas which envelops a planet. Not all planets have an atmosphere. Data about a planet's atmosphere can be obtained when the planet passes in front of a star (or the Sun).
- m. *Radius* is the distance from the center of a sphere to the surface. Planets may not be exact spheres, but they are close. The diameter is the largest distance from one side to the other, and is twice the radius. You cannot measure the radius directly. You can measure the diameter by observation, and then take half the value to be the radius.
- n. *Number of moons* means the number of natural satellites around the planet, which can be either "regular" moons or "irregular" moons. Measured by observation.
- o. *Number of rings* is determined by observing the rings and the divisions between them.

## 2. Properties of Planets II:

- a. *Mercury* has the largest temperature difference between night and day.
- b. *Venus* has high temperatures and pressure and clouds of sulphuric acid, and Venus rotates in retrograde.
- c. *Earth* has liquid water, and life.
- d. *Mars* is red in color due to high iron oxide content in surface material.
- e. *Jupiter* is the largest planet, and it has a long-lived storm known as the Great Red Spot.
- f. *Saturn* has multiple visible rings.
- g. *Uranus* rotates on its side.
- h. *Neptune* has a moon, Triton, which has a retrograde orbit.
- i. *Pluto* has an orbit which is more elliptical than the planets, to the point that it sometimes is closer to the Sun than Neptune, and the plane of the orbit is inclined  $17^\circ$  from the ecliptic, which is a lot.