Name: _____
Partner(s): _____
1101 or 3310: _____
Desk # _____
Date: _____

Motion of the Inner Planets

Purpose

- Identify and describe the motions of the inner planets
- Explain conjunction, elongation, synodic period and sidereal period
- Describe the transit of Venus
- Draw and describe the phases of Venus
- Describe the retrograde motion of Mars

Equipment

- Starry Night College

Question 1: General Motions.

a) List the planets in the night sky as seen from Vancouver tonight.

b) Hide daylight. View the zodiac. Play time with a step of 1 sidereal day so that you keep looking at the same portion of the celestial sphere. Do all the planets seem to be moving at the same speed? Describe what you observe.

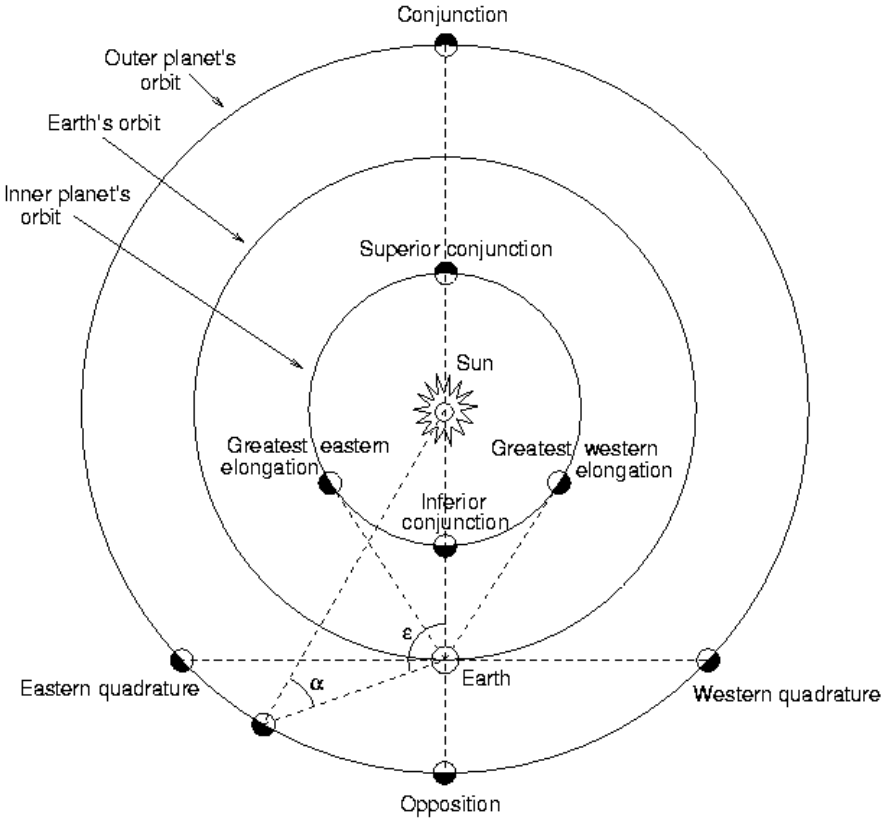
c) Do the planets mostly move East or West?

d) Which planets sometimes move backward?

e) How long does it take for the Sun to be back to its original position against the background of the stars (i.e. to the same RA and Dec)?

Mercury: Find Mercury. Play time with a step of one sidereal day.

Question 2: Orbit. Since we know that the Earth is orbiting the Sun, we can draw the following diagram. Note the terms Conjunction and Elogation.



a) Is the angular diameter of Mercury changing? (Check the "Show Info…" option).

b) Track the celestial path of Mercury. Imagine you are an ancient Greek. What would you conclude about the motion of Mercury relative to the Sun?

c) Show the orbit of Mercury. Using the Angular Separation Tool, what is the greatest angle between the Sun and Mercury to the nearest degree? Provide the greatest angle when Mercury is to the west of the Sun and when it is to the east of the Sun. This angle is called elongation.

Question 3: Conjunction. Observe the conjunction on May 2, 2007. Right-click the Sun and Go there.

a) Where is Mercury with respect to the Earth and Sun?

b) Is it an inferior or superior conjunction?

c) Observe the conjunction on October 23rd, 2007. Is it an inferior or superior conjunction?

Question 4: Period. There are two kinds of periods for objects orbiting the Sun.

- The **sidereal** period is the time that it takes the object to make one full orbit around the Sun, relative to the stars. This is considered to be the true orbital period of an object.
- The **synodic** period is the time that it takes for the object to reappear at the same point in the sky, relative to the Sun, as observed from Earth; i.e. returns to the same elongation. This is the time that elapses between two successive (inferior or superior) conjunctions with the Sun. The synodic period differs from the sidereal period since Earth itself revolves around the Sun.

a) Show the orbit of Mercury and Centre/Lock on the Sun. Play time and watch for the time it takes Mercury to go through two successive superior conjunctions. What is the synodic period of Mercury (in days)?

b) Measuring the synodic period of Mercury from Earth is relatively straightforward, but in the time it took Mercury to go from conjunction to conjunction, Earth has moved some fraction of its own orbit around the Sun. You'll now go through the steps to find the sidereal period of Mercury with observations from Earth. You know the Earth goes through 360° in 365.25 days. How many degrees did the Earth travel in the amount of time you found in (a)?

c) In one synodic period, Mercury traveled 360° plus the number of degrees you found in (b) because it went all the way around once, plus a bit. How many degrees did Mercury travel in one synodic period?

d) With your answer from (c), how long does it take Mercury to travel 1°?

e) With your answer from (d) how long does it take Mercury to travel 360°? This is the sidereal period of Mercury which you can measure from Earth with this method.

Venus: Show daylight.

Question 5: Observing. What are the best times of the day to observe Venus?

Question 6: The transit of Venus. This occurs when Venus passes directly between the Sun and the Earth, obscuring a small portion of the Sun's disc. During a transit, Venus can be seen from the Earth as a small black disc moving across the face of the Sun.

Transits of Venus are the rarest of all predictable astronomical phenomena and currently occur in a pattern that repeats every 243 years, with pairs of transits eight years apart separated by long gaps of 121.5 years and 105.5 years.

Before 2004, the last pair of transits of Venus were in December 1874 and December 1882.

The first of a pair of transits of Venus in the beginning of the 21st century took place on June 8, 2004 and the next in this pair was on June 6, 2012.

a) Was the transit of Venus on June $5^{th}/6^{th}$ 2012 visible from Vancouver?

b) Observe the transit of Venus from 2012. Remove the horizon if needed. How long did the transit of Venus last? (round off to the nearest hour)

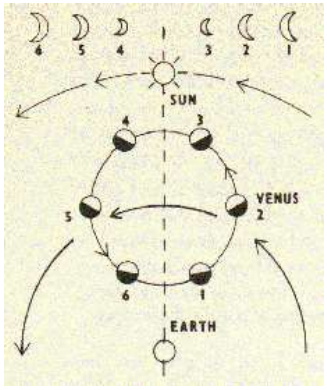
c) When is the next transit of Venus?

Question 6: The phases of Venus. At the beginning of the Renaissance, the geocentric model developed by the ancient Greeks was still taught in all western universities: the Earth was the centre of the universe and the Sun was orbiting it. Copernicus, a German priest, proposed the heliocentric model: the Sun was the centre of the solar system. This model was used for calculations but nobody could prove that it was an actual representation of the solar system.

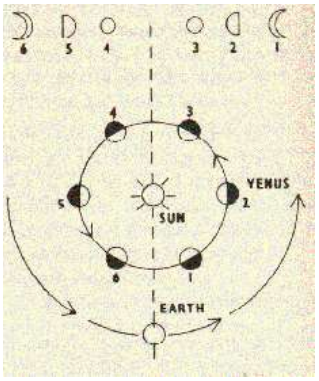
Go to Earth Centric and play time. Observe the motion of the planets and the Sun around the Earth.

Galileo (1564-1642) was the first to study the sky with a telescope. He speculated:

"If the Sun were orbiting the Earth, then the phases of Venus as seen from the Earth should look like:"



"However, if the Sun was the centre of the solar system, them they should look like:"



a) Still in Earth Centric view, right-click on Venus and select Show Orbit. Play time and to the nearest day, find the length of a year on Venus (how long it takes for Venus to return to the same position in its orbit).

b) Observe Venus from Earth. Remove the horizon if needed. Play time (1 sidereal day). Observe the changing phases of Venus (zoom in). Go over one synodic period. Record the phase and angular size of Venus for three different positions of Venus. Draw four phases of Venus **TO SCALE** using 1mm for 1 arc second (1″).

c) Which of the two models of the solar system do your drawings from (b) support?

d) Draw a diagram showing the Sun, Venus, Earth and the phase of Venus at greatest western elongation.

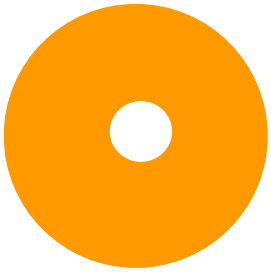
Mars:

Question 7: View the sky from the surface of Mars.

a) Find the name of the two moons of Mars.

b) How long is a day on Mars from noon to noon (rounding off to the nearest Earth minute)?

c) Go "Home" and find Mars in the sky. Right click on Mars and select "Go There" and adjust your view to see the Northern polar cap from above. The diagram on the right is a top view of Mars' polar cap. Draw the dark side of Mars on an equinox.



d) How long does it take between two successive equinoxes in Earth days?

e) How long is the cycle of the seasons on Mars (i.e. a Martian year)?

Question 8: Opposition. Mars is a superior planet. Look at the diagram page 2.

a) Name the superior planets of the solar system.

b) Name the four possible configurations for an outer planet.

c) On October 26th 2006, was Mars in opposition or conjunction, as seen from Earth?

d) When was the opposition of planet Mars in 2007, as seen from Earth? Explain the method you used.

Question 9: Retrograde motion. Go home. Remove the horizon. Track the celestial path of Mars and Centre/Lock Mars. Play time (1 sidereal day). Observe the retrograde motion of Mars.

a) How long does it take Mars to go over a full loop? Once you see the path of the loop on the screen, determine the number of days Mars spends making that loop.

b) What date will the retrograde motion of Mars be observed again?

With one partner playing the part of Mars and the other the part of the Earth, use your arm to symbolize the line of sight of somebody standing on the Earth and looking at Mars. Reproduce the orbital motion of the two planets to explain the retrograde motion of Mars.

c) Explain the retrograde motion of Mars to your instructor. Check: _____
Beware: do not skip this question!

d) Explain the retrograde motion of Mars using a diagram and a few words.