Phys 10293 Lab #1:
The Sun and the Constellations

Introduction

Astronomers use a coordinate system that is fixed to Earth's latitude and longitude. This way, the coordinates of a star or planet are the same everywhere on Earth. This coordinate system is called the "Celestial Sphere".

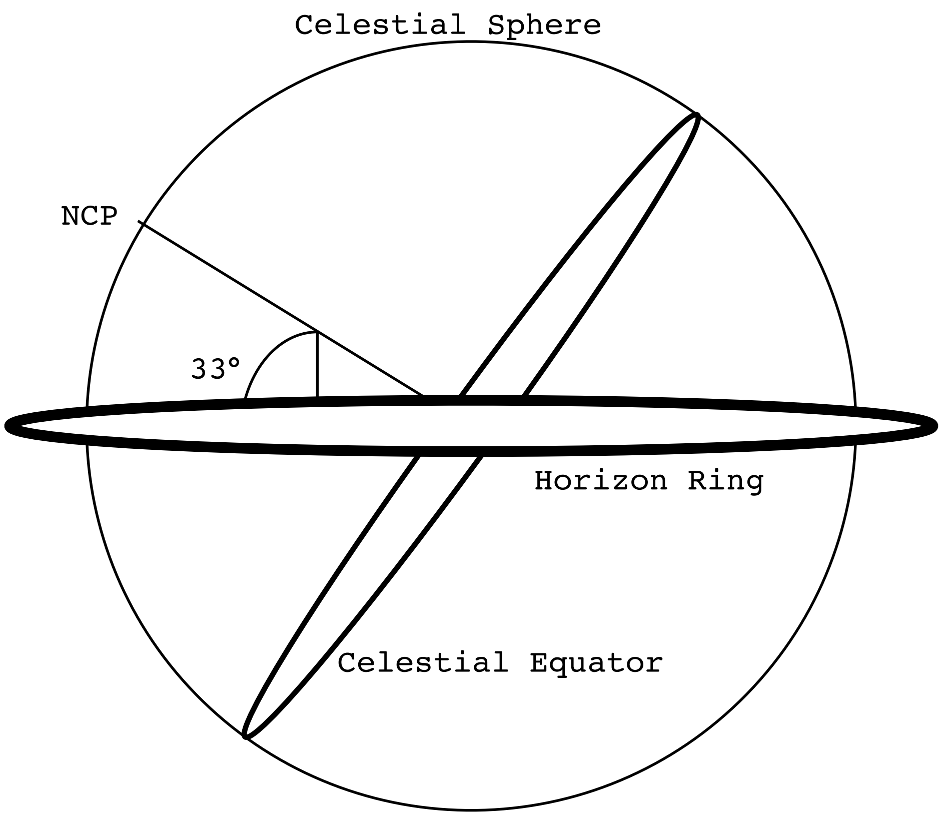
The celestial sphere can be represented by a small model (we assume the little Earth is represented at the center). On each model, you can see a grid-like coordinate system on the surface. The Celestial Sphere coordinate system assumes all the stars and planets in the sky are at an equally large distance, "painted" somewhere on the surface of the sphere.

The major circle on each model is the Celestial Equator (see if you can locate this line on your sphere). The Celestial Equator is just a projection of Earth's equator onto the night sky. You can easily see in the clear models that the Celestial Equator lies directly over Earth's equator. The grid circles that run around the globe parallel to the Celestial Equator are a measure of Celestial Latitude (also called **Declination**). The lines perpendicular to Declination lines are Celestial Longitude lines (also called **Right Ascension**).

Since the latitude of the Earth's equator is 0 degrees, we can also say that the Declination of the Celestial Equator is 0 degrees. Likewise, the North Celestial Pole (NCP) is just the projection of the North Pole onto the sky (the NCP has a Declination of 90 degrees North). The ring that surrounds the Celestial Sphere and is parallel to the tabletop is meant to represent the observer's horizon (we'll call it the **Horizon Ring**), but it will only make sense if the Celestial Sphere is set up properly. So that will be our first step...

Step 1

From lecture, you should recall that the altitude of the North Celestial Pole above the Northern horizon is equal to your latitude. We can use this information to set up the Celestial Sphere model as shown on the next page. Go ahead and set up your Celestial Sphere as shown for a latitude of +33° (our latitude in Fort Worth). The vertically oriented ring is the Meridian Ring, and since the NCP is at 90 degrees on this ring, you will want to line up your northern horizon with the 57 degree mark to ensure there are 33 degrees between the horizon and the NCP.



Also marked on your sphere is another circle, tilted 23.5° from the Celestial Equator. This is the Ecliptic, the apparent annual path of the Sun in the sky. Along the **Ecliptic**, you will see a series of month labels (e.g. "January, February, ..."). This is so you know where exactly the Sun is located on different days during the year. The stars do not move around on the celestial sphere, but the Sun does!

Look along the Ecliptic to find the current location of the Sun (based on today's date). In the space below, write down the Right Ascension of the Sun (to the nearest hour) and the Declination of the Sun (to the nearest degree). Use a tiny sticker on your sphere to denote the current location of the Sun or use the little yellow sphere in your model. Or you can just keep your finger on it while you proceed through the next steps.

Coordinates of the Sun today:

RA = __________ hours, Dec = ___________°

Step 2

Let's start this lab by looking at how the night sky changes over the course of a year. Today, when the Sun sets, you can tell what constellations will be up in the sky by simply looking around at the part of the celestial sphere above the horizon. We define the zenith to be the highest point above the horizon (so it would be the point on your sphere that is furthest from the table-top, or furthest from the horizon ring).

Spin your celestial sphere to a position for which the Sun is just setting below the Western horizon, then look to find out which constellations are close to the zenith point (and will therefore be high overhead tonight at sunset) as well as which bright stars are close to the zenith point. Write down the names of these objects in the space below.

Name two zodiacal constellations close to zenith at sunset tonight:

_______________, _________________

At sunset tonight, what direction along the horizon should you look to see the constellation Orion?

____

At sunset tonight, what direction along the horizon should you look to see the constellation Lyra?

____

Step 3

The galaxy Andromeda (also called the M31 nebula) is located within the constellation Andromeda. See if you can locate this on the North Celestial Hemisphere. At what time of day (sunrise, noon, sunset, midnight) does this galaxy pass close to our zenith point from Fort Worth? Answer this and other related questions below.

When does M31 (Andromeda galaxy) pass close to our zenith, as viewed from Fort Worth (sunrise, noon, sunset, midnight)?

____

When is the constellation Gemini closest to zenith (sunrise, noon, sunset, midnight)?

____

When is the bright star Arcturus (within the constellation Bootes) closes to zenith?

____

Step 4

Now let's see how the constellations change over the course of a year. On your sphere, first locate the Sun on September 21, the date of the autumnal equinox. In the space below, write down the Right Ascension (to the nearest hour) and the Declination (to the nearest degree) of the Sun on September 21.

Sep. 21 solar coordinates:

RA = ___________ hrs, Dec = ____________°

Name two constellations close to zenith at sunset on Sep. 21:

________________, _________________

When is Andromeda (M31) closest to zenith (sunrise, noon, sunset, midnight)?

____

When is Gemini closest to zenith (sunrise, noon, sunset, midnight)?

____

Step 5

You may notice as the Sun moves along the ecliptic during the year, it moves through a series of 13 constellations. These constellations therefore have special significance to some people. Your astrological sign is supposed to be the constellation the Sun is in on the day of your birth (time of day doesn't matter ... as you can see, the sun doesn't move much during one day relative to the background stars and constellations).

Find out what sign the Sun is in on your birthday. The position of the ecliptic relative to the constellations does wobble over thousands of years, which can cause the dates associated with certain constellations to change. We will explore this phenomenon in a later lab.

What is the month and day of your birthday? ___________________

In what constellation is the Sun on this day? __________________

Step 6

Now let's focus on the daily motion of the Sun on a few different days during the year. First, return your Sun marker to today's date and let's analyze the Sun's motion through the sky. We want to find out the Sun's setting azimuth as well as its noontime altitude above the horizon.

The Sun's azimuth at sunset can be found by measuring along the horizon ring. With the Sun located on the ecliptic on today's date, rotate your sphere so that the Sun is on the Western horizon.

When the entire Sun dips completely below the horizon ring, that is the time of sunset. Due West on your ring is at an azimuth of 90 degrees, but your setting sun is likely somewhat north or south of this point, depending on the time of year. If your setting Sun is south of West, then you might see a degree measure along the horizon of, say, 110 degrees. That is equivalent to 20 degrees South of West. By contrast, if the Sun is at an azimuth of 75 degrees, that would be the same as saying 15 degrees North of West.

You can find the Sun's noontime altitude above the horizon in the same way you set up the North Celestial Pole. Look at what degree mark is on the Southern horizon and count off degrees along the vertical Meridian Ring until you reach the Sun's location. For example, if the meridian ring says 55 degrees on the Southern horizon and 23 degrees where the Sun crosses it today, then the Sun's altitude is (55 - 23 =) 32 degrees.

Now let's estimate the day length. You can do this by starting with the Sun on the Eastern horizon. Now, keep your eye on the Western horizon and slowly turn the sphere so that the sky passes down through the Western horizon (objects set in the West). As each hour on the Celestial Equator passes below the horizon, one hour of time passes. Count off the hours until you see the Sun drop below the Western horizon...that's how long the Sun is above the horizon during the day: the day length.

Finally, repeat these measurements for a different latitude on Earth: Fairbanks, Alaska, which has a latitude of 60° North.

Today as seen from Fort Worth....

the Sun rises __________ degrees South of East.

the Sun sets ___________ degrees South of West.

the Sun's altitude above the Southern horizon at noon is

____________ degrees.

the length of the day (to the nearest hour) is about

_____________ hours.

Today as seen from Alaska (latitude 60° North)...

the Sun rises __________ degrees South of East.

the Sun sets ___________ degrees South of West.

the Sun's altitude above the Southern horizon at noon is

____________ degrees.

the length of the day (to the nearest hour) is about

_____________ hours.

Essay

In your essay, use the results of your lab to explain why the constellations overhead at midnight change over the course of a year. A simple diagram may help. In the next paragraph, explain why winters in Alaska are colder than winters in Fort Worth (if you are doing this lab in January). Use the results from step 6 to support your answer.

(space for diagram)

Physics 10293 Lab #2:
Learning Starry Night, Part 1

Introduction

In this lab, we'll learn how to use the Starry Night software to explore the sky, and at the same time, you'll get a preview of many of the topics that will be covered in lecture and lab this semester. Starry Night has a large number of features and options, and we will learn about some of the most useful ones for our purposes.

Using the Skyguide

First, start up the program. When the program first starts up, you may be asked to update data or the software. Just hit "later" for these and ignore them. TCU is responsible for keeping the software updated, so we don't need to worry about it. You will need to tell it where you are viewing from, which should be Fort Worth. The tutorial we will work through can help you with this.

When you open the application, the left sidebar will likely be open to the SkyGuide. If it is not, type "Skyguide" into the search box in the upper right corner and follow the instructions that appear. We are going to walk through the Tutorial in this lab, so click on that link. It should open a pane on the left side of the application labeled "Tutorial".

Occasionally, to check your understanding, the Skyguide will ask a multiple choice question. The same questions appear on your worksheet for this lab, and you should answer them as you go along.

In "2: The Toolbar - Cursor Tools"

Q1. How far away from Earth is Antares? ___________ light years.

Q2. What is the approximate angular separation between the star Antares and the Moon? _______ degrees.

In "3: The Toolbar - Time and Date Controls"

Q3. On the date July 5, 2009, what is the approximate angular separation between the star Antares and the Moon? ________ degrees

In “4: The Toolbar - Time Flow Controls”

Q4. Write below the statement in question 5 that is INCORRECT.

____

____

In “7: The Toolbar - Gaze”

Be sure to close to right-hand-side search pane so you can see correctly where the center of the view is when you are scrolling across the sky. The gaze display only shows the altitude and azimuth of your gaze while you are “grabbing the sky” and changing your viewing direction.

Q5. What compass direction corresponds to an Azimuth (Az) of 315 degrees? __________________

In “8: The Toolbar - Zoom Controls”

Q6. What is the angular diameter of the Moon? ________________

In “10: Finding Objects”

Q7. What is the best time for viewing Jupiter from Toronto, Canada on the night of July 4/5, 2009?

____

After you have finished the tutorial, proceed to the Student Exercises entitled “Unit A: Earth, Moon and Sun,” which are buttons on the main sky guide pane. Answer the associated questions for these exercises on your worksheet for exercises A1 through A7.

Unit A: Earth, Moon and Sun

In “A1 part 1: Diurnal Motion”

Q8. The Sun, Moon, planets and stars rise in the ____________

and set in the __________.

In “A1 part 2: Diurnal Motion Rate”

Q9. What is the rate of the Sun’s diurnal motion across the sky?

____

In "A1 part 3: The Cause of Diurnal Motion"

Q10. What do we observe diurnal motion from the surface of the Earth?

____

____

____

In "A1 part 4: Diurnal Motion and Location"

Q11. What appears to be the relationship between the angle that the track of the Sun makes with the horizon and the latitude of the observer?

____

____

____

In "A2 part 1: Night sky changes daily"

Q12. From your observations of the position of Vega, what can you conclude about the rising of stars from night to night?

____

In "A2 part 2: Constellations shift throughout the year"

Q13. Which of the statements given is NOT true?

____

____

In "A2 part 3: The cause of shifting constellations"

Q14. Which of the statements given in this section is correct?

____

____

Q15. What causes the slow shift of the stars and constellations from one night to the next?

____

In "A3 part 1: Altitude and Azimuth"

Q16. What are the approximate coordinates of Regulus as shown in the Main Window for the specific date and time in the exercise?

Altitude = ___________ Azimuth = ______________

Q17. After the time has been advanced by two hours, which of the statements given is correct?

____

____

In "A3 part 2: The meridian"

Q18. Select the statement from this section that correctly describes how Minkar's altitude changes over time.

____

____

Q19. At what time of day is the Sun most likely to be at its highest altitude, on the local meridian? ____________________

In "A3 part 3: Altitude and latitude"

Q20. What effect does changing an observer's latitude have on the altitude of Antares?

____

____

In "A3 part 4: Earth's circumference"

Q21. What fraction of a circle does the difference in the Sun's altitude as measured from the two cities represent?

____

Q22. What is the circumference of the Earth using Eratosthenes' method? _________________________

In "A4 part 1: Angular distance"

Q23. The angular distance between Merak and Dubhe is:

____

Q24. From this location in Toronto, Ontario, Canada, the angular distance between Polaris and the zenith is approximately:

_________ degrees

In "A4 part 2: Angular size"

Q25. The Moon's apparent angular diameter is approximately: __________ arc minutes

In "A4 part 3: Calculating diameter"

Q26. The calculated diameter of Mars is ______________ km

In "A5 part 1: The celestial equator"

Q27. Which of the given constellations does the celestial equator not pass through?

____

Q28. Where would the celestial equator appear to be located for an observer standing directly on one of the Earth's poles?

____

____

In "A5 part 3: Finding the north celestial pole"

Q29. The relatively bright star near the north celestial pole is: _____________________

Q30. An observer in Earth's northern hemisphere is looking directly toward Polaris. In what direction is this observer facing?

____

In "A5 part 4: North celestial pole and an observer's latitude"

Q31. How does the altitude of the north celestial pole relate to the observer's geographic latitude on the surface of Earth?

____

____

In "A5 part 6: The inclination of the ecliptic"

Q32. The ecliptic is inclined at 23.5 degrees to the celestial equator. This is the result of:

____

____

In "A5 part 7: The equinoxes"

Q33. On what date of the year does the Vernal Equinox occur, and on what date does the Autumnal Equinox occur?

______________________________, ______________________________

In "A5 part 8: The solstices"

Q34. On what date does the Sun reach the most northerly point (the summer solstice) along the ecliptic? On what date does the Sun reach the most southerly point (the winter solstice) along the ecliptic?

______________________________, ______________________________

Q35. An observer notices that the Sun is directly overhead at midday during the Summer Solstice. What is the observer's latitude upon the Earth?

____

In "A6 part 2: Declination"

Q28. What is the declination of an object that lies directly on the Celestial Equator?

_______________ degrees

Q36. What is the declination of an object that lies equidistant between the celestial equator and the south celestial pole?

_______________ degrees

In "A6 part 3: Right Ascension"

Q37. What is the right ascension of an object exactly on the vernal equinox?

____

In “A6 part 4: Measuring Coordinates”

Q38. Locate the star Altair in the sky. What are its approximate celestial coordinates?

RA = ______________________, Dec = ________________________

Q39. Which bright star has the following celestial coordinates? RA = 3h 59m, Dec = -13° 28′

____

In “A6 part 5: Celestial Coordinates and an Observer’s Location”

Q40. Which of the given statements in this section is correct?

____

____

____

____

In “A6 part 6: Precession”

Q41. How do the coordinates of Vega change between 3009 and 2009?

____

In “A7 part 1: Apparent Solar Day”

Q42. What is the approximate length of an apparent solar day from June 21, 2020 to June 22, 2010?

____

Q43. What is the approximate length of an apparent solar day from September 21, 2010 to September 22, 2010?

____

In “A7 part 4: Sidereal Day”

Q44. What is the approximate length of a sidereal day from September 21, 2010 to September 22, 2010, when measured in the units of mean solar time?

____

Q45. Which of the following statements comparing a mean solar day of exactly 24 hours to a sidereal day is correct?

____

____

Next week, we will pick back up starting with section A8. There will be no essay for your lab this week!

Physics 10293 Lab #3:
Learning Starry Night, Part 2

Introduction

In this lab, we'll learn how to use the Starry Night software to explore the sky, and at the same time, you'll get a preview of many of the topics that will be covered in lecture and lab this semester. Starry Night has a large number of features and options, and we will learn about some of the most useful ones for our purposes.

Continue with Skyguide

Once you start the program, if the left sidebar is not already open to the SkyGuide, just type "Skyguide" into the search box in the upper right corner and follow the instructions. We will continue walking through the tutorial to learn more about the features of Starry Night and to learn more about naked eye astronomy that we are covering in lecture.

Proceed to the Student Exercises entitled "Unit A: Earth, Moon and Sun," which are buttons on the main sky guide pane. Answer the associated questions for these exercises on your worksheet for exercises A8 through A13.

Unit A: Earth, Moon and Sun

In "A8 part 1: Earth's orbit"

Q1. The Earth is closer to the Sun on June 21
and further from the Sun on December 21: True / False

Q2. What is the approximate percentage change in the Earth-Sun distance between June 21 and December 21?

_____________ percent

Q3. Which of the given statements is correct in Question 3 of this section?

____

____

____

In "A8 part 2: Earth's rotation axis"

Q4. Which of the given statements is correct in Question 4 for June 21?

____

____

Q5. Which of the given statements is correct in Question 5 for December 21?

____

____

Q6. Observe the tilt of the Earth's equator with respect to the orbital plane and the direction in which the Earth's rotation axis points in space as it orbits around the Sun. Which of the given statements in Question 6 is true?

____

____

____

Q7. Which of the given statements in Question 7 is true based upon your observations of the Earth revolving around the Sun?

____

____

____

____

In "A8 part 3: Concentration of sunlight"

Q8. How long is the day in New York City (the time between sunrise and sunset) at this time of year and how high does the Sun get in the sky?

____

____

Q9. How many hours of daylight does New York City receive in December and how high does the Sun get in the sky at this time?

____

____

Q10. Which of the statements given in question 10 explains why we experience the annual cycle of seasons in the Northern Hemisphere?

____

____

____

____

In "A8 part 4: Spring and Fall"

Q11. Which of the given statements in question 11 is **incorrect**?

____

____

In "A8 part 5: Seasons on Mars"

Q12. Which of the given statements in question 12 about seasonal variations on Mars is correct?

____

____

____

Before moving on to section A9, you may wish to review some of the content you covered in last week's lab in section A7.

<u>In "A9 part 1: The shape of the analemma"</u>
Q13. What is the shape of the analemma? ______________________

<u>In "A9 part 2: Analemma and Earth's orbital eccentricity"</u>
Q14. The variable velocity of the Earth in its orbit is responsible for the Sun's changing apparent motion as it traces the analemma. The Earth's variable velocity is caused by:

____

____

<u>In "A9 part 3: Analemma and Earth's tilt"</u>
Q15. The vertical extent of the analemma, in angular measure, is equal to…"

____

Q16. Which of the given statements in Question 4 for this section is correct?

____

____

Q17. What would be the observed shape of the analemma seen from a body whose orbital eccentricity and axial tilt are both zero?

____

<u>In "A9 part 4: Analemma and the equation of time"</u>
Q18. Which of the given statements in Question 6 of this section concerning the Equation of Time is correct?

____

____

<u>In "A9 part 5: Mars' Analemma"</u>
Q19. What is the shape of the Martian analemma? _______________

Q20. What is the approximate tilt of Mars' spin axis? _______°

Q21. The shape of the analemma on Mars suggests that…

____

____

In "A10 part 1: The Moon's rotation"

Q22. The rotation period ("day") of the Moon is

____

In "A10 part 2: The Moon's revolution"

Q23. How long does the Moon take to complete one orbit around the Earth with respect to the stars?

____

Q24. We always see the same side of the Moon from the Earth because:

____

____

Q25. How many degrees of arc does the Moon move across Earth's sky every day?

_____________ degrees

In "A10 part 3: The Moon's libration"

Q26. The Moon appears to grow successively larger and smaller during the libration cycle. Which of the given statements in Question 5 of this section correctly explains this phenomenon?

____

____

____

In "A11 part 1: Synodic Month"

Q27. How long does it take the Moon to cycle once through all of its phases, a period known as the synodic month?

____

In "A11 part 2: New Moon"

Q28. At what time of day would you expect the New Moon to rise? ____________________________

In "A11 part 3: Waxing Crescent"

Q29. Which side of the Moon do we see illuminated by the Sun during the waxing phase?

____

In "A11 part 4: First Quarter"

Q30. Select the Moon and use the Info view to determine which of the given statements is correct, then write that statement below in the space provided.

____

____

In "A11 part 6: Full Moon"

Q31. The Full Moon is opposite the Sun in the sky, and rises as the Sun sets. What is the approximate angular separation of the Sun and the Full Moon?

___________________ degrees

In "A11 part 7: Waning Gibbous"

Q32. Which side of the Moon appears illuminated by the Sun during the waning phase?

____

In "A11 part 8: Last Quarter"

Q33. Select the Moon and use the Info view to determine which of the given statements is correct, then write that below:

____

____

In "A11 part 10: Phases are caused by the Moon's orbit…"

Q34. Which phase of the Moon do we see on Earth at this particular position in the Moon's orbit?

____

Q35. What is the phase of the Moon 7 days later?

____

Q36. What is the phase of the Moon after another 7 days?

____

Q37. What is the phase of the Moon after another 7 days?

____

In "A12 part 1: Line of nodes"

Q38. An eclipse is not possible at the time show in the simulation because…

____

____

In "A12 part 2: Eclipses and the phase of the Moon"

Q39. What is the phase of the Moon during a solar eclipse?

____

Q40. What is the phase of the Moon during a lunar eclipse?

____

In "A12 part 4: Partial lunar eclipses"

Q41. The lunar eclipse of June 26, 2010 is only partial because…

____

____

In "A12 part 5: Solar eclipses"

Q42. The date of the total solar eclipse in the simulation is:

____

In "A12 part 7: Solar eclipse seen from the Sun"

Q43. Which one of the given statements is correct?

____

____

In "A13 part 1: Precession of the Earth's spin axis"

Q44. What is the precession period of Earth's spin axis?

_________________ years

Q45. What is significant about the diameter of the precession circle?

____

____

In "A13 part 2: Shifting Celestial Pole"

Q46. AT what time in the past could Vega have been considered the North Star?

______________ BC

In "A13 part 3: Precession of the Equinoxes"

Q47. In which constellation was the Vernal Equinox when Hipparchus made his observations in the 2nd century BC?

____

In "A13 part 5: Nutation Period"

Q48. What is the period of nutation (note that each time step is one year, so the dots are separated by two-year intervals)?

___________________ years

Next week, we will cover a broader variety of topics within Starry Night, including planetary motion, star finding and the zodiac. There is again no essay for this week.

Physics 10293 Lab #4:
Learning Starry Night, Part 3

Introduction

In this lab, we will continue using Starry Night to explore some of the most important concepts we will cover in lecture.

Continue with Skyguide

Once you start the program, if the left sidebar is not already open to the SkyGuide, just type "Skyguide" into the search box in the upper right corner and follow the instructions. We will continue walking through the tutorial to learn more about the features of Starry Night and to learn more about naked eye astronomy that we are covering in lecture.

Proceed to the Student Exercises entitled "Unit A: Earth, Moon and Sun," which are buttons on the main sky guide pane. Answer the associated questions for these exercises on your worksheet for exercises B1-B4, C1-C3 and E1-E4.

Unit B: Solar System

In "B1 part 3: The Heliocentric Model"

Q1. Which of the given statements is NOT a feature of the Copernican heliocentric model?

____

____

In "B1 part 4: Heliocentric explanation for retrograde motion"

Q2. How does the heliocentric model explain retrograde motion?

____

____

____

In "B2 part 1: The inferior planets"

Q3. The sidereal period of Mercury is ____________ days.

In "B2 part 2: Conjunctions and elongations"
Q4. Examine the current date in the Main Window. When will the next superior conjunction of Venus occur?

____

In "B2 part 3: Synodic period"

Q5. The synodic period of Mercury is ____________ days.

In "B2 part 5: Sidereal and synodic period of Jupiter"

Q4. The length of Jupiter's sidereal period is __________ days.

Q5. The length of Jupiter's synodic period is __________ days.

In "B3 part 1: Kepler's first law"

Q6. The length of the major axis of Mars' orbit is ________ AU.

In "B3 part 3: Kepler's third law"

(you will need a calculator for these questions…)

Q7. The sidereal period of Mars is __________ years.

Q8. At what distance would a planet have to orbit the Sun on average in order to have a sidereal period of 10 years?

_______________ AU

In "B4 part 1: The phases of Venus"

Q9. What is the phase of Venus in the simulation shown?

____

In "B4 part 2: Apparent size of Venus"
Q10. What is the approximate angular diameter of Venus when it is a very slim crescent? ______________

Q11. Which model is supported by your observations?

____

In "B4 part 3: The moons of Jupiter"

Q12. Why did the observations described in the text persuade Galileo that the geocentric view of Ptolemy was wrong?

____

____

Unit C: The Planets

Note: Not all questions asked in Starry Night will appear here for this section.

In "C1 part 1: Orbits of the inner planets"

Q13. Which of the inner planets has the most eccentric orbit? ________________________

In "C1 part 2: Mercury"

Q14. What is the length of a Mercury solar day in Earth days? _________________ days

There are no further questions from C1, although you are encouraged to read through the last few parts.

In "C2 part 1: Orbits of the outer planets"

Q15. The eccentricity of the outer planets' orbits is close to zero: True / False (circle one)

Now skip ahead to Unit E.

Unit E: Star Finding

In "E1 part 1: The Big Dipper"

Q16. What is the orientation of the Big Dipper asterism in winter?

____

In "E1 part 2: Star Hopping"

Q17. Polaris is part of which constellation?

____

In "E1 part 3: Polaris and Latitude"

Q18. What happens to the position of Polaris in your sky as time advances over a period of a year?

____

____

Q19. What is the relationship between the altitude of Polaris and the latitude of the observer?

____

____

In "E1 part 4: The south star?"

Q20. What is the nearest star to the south celestial pole, shown in the main window? ____________________

In "E2 part 1: Apparent magnitude"

Q21. A magnitude 2 star is ____________ times brighter than a magnitude 4 star.

Q22. Which of the four named stars from the constellation Orion is the faintest? ______________________

In "E2 part 2: Magnitudes of solar system objects"

Q23. What is the apparent magnitude of the Sun? ______________

Q24. What is the 2nd brightest object in our sky? ______________________________

In "E2 part 3: Comparing brightness of objects"

Q25. How much brighter is the planet Venus than the planet Mars on January 24, 2015?

____________ times brighter

In "E2 part 4: Absolute magnitude"

Q26. What is the absolute magnitude of the star Deneb? _______

In “E3 part 1: The diurnal cycle of stars”

Q27. Virgo is considered to be a spring constellation in the northern hemisphere because…

____

____

In “E3 part 2: The zodiac”

Q28. Which of the listed constellations is not a part of the zodiac? _____________________

Q29. Which of the listed celestial objects is NOT always found near the zodiac? ____________________

In “E3 part 3: Circumpolar constellations”

Q30. Which of the given statements regarding celestial objects seen at the poles is false?

____

____

Q31. What is the maximum angular measure that a star at this latitude could possess in order to be considered a circumpolar star?

___________________ degrees

In “E4 part 1: Sun signs”

Q32. Over what time period is the Sun actually in the constellation Sagittarius?

____

Q33. How well do astrologer’s dates agree with Starry Night’s dates for the passage of the Sun through Sagittarius?

____

____

In "E4 part 2: Comparison over time"

Q34. How closely do the dates of the Sun's passage through Leo in the year 1 CE match the dates assigned by astrologers to the Leo horoscope sign?

____

Q35. How closely do the dates of the Sun's actual passage through Capricorn in the year 2000 BCE match with astrologers' Sun sign dates?

____

Q36. When was the last time that the Sun sign positions from astrology accurately reflects the true location of the Sun in the celestial sphere?

____

In "E4 part 3: Precession of the equinoxes"

Q37. The vernal equinox is presently in the constellation Pisces. In what constellation was the vernal equinox located in the year 2500 BCE?

____

In "E4 part 4: The 13th constellation"

Q38. What is the additional constellation through which the Sun now moves, aside from the 12 standard zodiacal constellations?

____

Q39. Astrology has kept pace with our present knowledge of the changing sky: True / False

Unit F: The Stars

In "F2 part 1: Measuring stellar parallax"

Q40. What is the parallax of Alpha Centauri?

____

Q41. What is Alpha Centauri's approximate distance from Earth?

____

In "F2 part 2: Proper motion"

Q42. Which of the given stars has the greatest proper motion?

____

In "F2 part 3: Barnard's Star"

Q43. What is the average annual proper motion of Barnard's Star?

______________________ arc seconds

In "F2 part 4: Effects of proper motion – Gamma Caeli"

Q44. When will Gamma Caeli because a star located within the boundaries of the constellation Columba?

__________________ CE

Finally, let us consider the zodiacal signs. If you read your horoscore in the newspaper, you may find the following "official" dates apply:

Aries (Mar 21 - Apr 19)	Libra (Sep 23 - Oct 22)
Taurus (Apr 20 - May 20)	Scorpio (Oct 23 - Nov 21)
Gemini (May 21 - Jun 20)	Sagittarius (Nov 22 - Dec 21)
Cancer (Jun 21 - Jul 22)	Capricorn (Dec 22 - Jan 19)
Leo (Jul 23 - Aug 22)	Aquarius (Jan 20 - Feb 18)
Virgo (Aug 23 - Sep 22)	Pisces (Feb 19 - Mar 20)

For your essay, address the following questions:

In the first paragraph, state your birth day and then use Starry Night to determine your "correct" astrological sign for the date of your birth. State whether this is different from the sign found using the common, mistaken dates above.

In the second paragraph, explain whether your opinion about the validity of horoscopes has changed. Assuming you have the opportunity in the future to check your horoscope, explain whether you will check your "correct" sign or your sign based on the dates given above? Which would you give preference to and why? If you don't believe horoscopes are valid in the first place, explain why you think this. You may write your essay in the space below.

Physics 10293 Lab #5: Starry Night – Observations of the Sun and Moon

Introduction

Today, we are going to use the Starry Night software to learn about motion of the stars, sun and moon on the celestial sphere. At each step along the way, I will ask you a few simple questions to check your understanding of what you are seeing.

First, start up the program and make sure your location is set to Fort Worth for today's date and time. Turn your view toward the West, then we will make a few changes to what you are seeing so that it more closely resembles one of the celestial sphere models we worked with during the first week.

Step 1

Type "options" in the search box in the upper right corner, and this will make the options sidebar appear beneath it. Once that is open, do the following...

- Under "Guides", click the arrow next to "Alt-Az guides" to open a dialog box on screen.

- Check the Local Equator (Horizon line) option
  Then hit "ok" to close the dialog box.

- Under "Guides", look for the heading "Celestial Guides"
  Under this heading, check the following boxes:
    - Equator
    - Grid
    - Poles

- Under "Guides", look for the heading "Ecliptic Guides"
  Under this heading, check "The Ecliptic"

- Under "Local View"
    - Uncheck the Daylight option
    - Uncheck the Local Horizon (lake) option

- Under "Solar System"
    - Uncheck the Asteroids option
    - Uncheck the Comets option

- Uncheck the Satellites option
  - Uncheck the Space Missions option

- Under "Constellations"
  - Check the Boundaries option
  - Check the Labels option

Your screen should now resemble what you would see if you could stand on the tiny Earth inside one of the transparent celestial sphere models. Zoom out and back in to see the whole sphere. Now scroll around the screen and find some information about various objects you see in order to answer the questions below.

In what constellation is the Sun today? ________________________

What time does the Sun set today? __________________

How long is the day today, to the nearest hour? ___________ hrs

What constellation will the Sun move to next as it travels along the ecliptic? _________________________

Find the North Celestial Pole (NCP) on the sky. What constellation is the NCP in? ______________________

What is the name of the bright star found very near the NCP on the sky? ______________________

Find the South Celestial Pole (SCP) on the sky? What constellation is the SCP in? ______________________

Since there is no star close to the SCP, navigators long ago used the constellation Crux, also known as the Southern Cross, to help find the location of the SCP and thus the direction true South.

Find the constellation Crux and within it, the star Acrux. How far is Acrux from Earth? _____________ ly

The "ly" units stand for "light years". The nearest star to us, besides the Sun, is Alpha Centauri, about 4 light years away.

Step 2

Next, we will study the motion of the Moon. First, use the search box to find the moon. Just enter "Moon" in the search box, double-click on "The Moon" within the results sidebar, and the program should find and center the Moon for you. Click on the Moon, and to the right of the label, you will see a little "i" button next to the blue checkmark. Click the "i" button to open up a dialog box regarding the Moon.

Within this dialog box, click on "More…" in the upper right to open a menu of options. Select "Orbit" on this menu to label the Moon's orbital path on the sky.

You should now see the Sun's apparent annual orbital path in the sky (the Ecliptic) and the Moon's apparent monthly orbital path in the sky both as green lines. We know that we can only get lunar or solar eclipses during "eclipse seasons" when the Moon's orbital path and the Sun's orbital path cross every six months.

It will help if we now find and center on the Sun so that we can keep the Sun in the center of our screen as we move time forward. Use the find sidebar to find the Sun. Type "sun" into the search box and then below that, double-click on the Sun from the list of possible objects. The program should now smoothly scroll around the sky until your view is centered on the Sun.

Take note of which constellations you can find the intersection of the Moon and Sun orbits. The intersection points are called "nodes". You may need to zoom in to see the intersection clearly in some cases. Answer the associated questions below.

In which two constellations do the orbital paths of the Sun and Moon intersect this year?

_________________, ___________________

What days of the year (this year) does the Sun cross the Moon's orbital path? You may need to run time forward/backwards to see this. These are the dates around which lunar and solar eclipses are possible.

Earlier crossing on __________________________

Later crossing on _________________________

Minimize Starry Night for the time being and open up a browser window. Visit the web site http://eclipse.gsfc.nasa.gov and find out the dates closest to the two dates above (should be within 4-6 wees) on which we see solar eclipses somewhere on Earth.

______________________ and _______________________

Access Starry Night again and set time forward to January, three years from this year. During the new year you have set, find the crossing dates (they have moved to different constellations):

Earlier crossing on _________________________

Late crossing on _________________________

Again, using NASA's eclipse web page, find the two dates closest to the above dates on which we will see solar eclipses. You can find this using the Decade Solar Eclipse Tables under the large heading Eclipses of the Sun.

_______________________ and _______________________

Step 3

The motion of this intersection of orbits (the node) through the sky is due to the fact that the Moon's orbit wobbles. Each year, the Moon's orbital plane, which is tilted 5° with respect to the Ecliptic, wobbles. This causes the nodes to shift positions on the sky by about 20 degrees in Celestial Longitude (Right Ascension). So each year, the eclipse time table moves by about 20 days forward. In Step 2, your dates for eclipses three years from now should be about 60 days later than the dates for this year.

It takes approximately 18 years for the nodes to return to their original location. This time period is called a Saros Cycle. Ancient astronomers recognized this motion of the Moon and Sun and could thus predict eclipses with some accuracy by measuring the precise location of the Full Moon as it would set along the horizon.

Let's do an example together. We will use the functions of Starry Night to gather data on the positions of the Sun and Moon on certain days of the year. To begin, find the date of the first full moon of this calendar year. Now look to the Western horizon and set the time to sunrise on that day (the menu to the left of the date in the top info bar shows this). You should see the full moon near the horizon. Adjust the time minute-by-minute until the full moon sets (when the top bit of the moon is just dipping below the horizon).

To find the azimuth of the Moon, select the Moon, then click on the "i" button to open its information box. There, on the left side, click "Position in Sky" and the box will now show the altitude and azimuth of the Moon, among other things. The small continuous changes in numbers can be distracting, so you can hit the "stop" button for time flow on the top menu bar just to the left of the search box.

Now start filling in your data table on the last page of the lab. Note the date and the azimuth of the full moon (info tab on the sidebar) at moonset (which is near sunrise but not exactly at sunrise most of the time). Now switch the time to sunset. Your screen should now show the Sun dipping below the Western horizon. Now just like you did for the Moon, find the Sun's azimuth at sunset and record this in your data table.

Now repeat for each of the 12 or 13 full moons that will occur during this calendar year. Each full moon date should be separated by about 29-30 days (you can set your time step to "lunar months" and increment one step at a time in the top menu bar). Note that the moon is technically full sometimes on two different days, and it doesn't matter which of those two you choose for our purposes.

Please take some time to appreciate the fact that these observations we are simulating would have taken many years to perfect for ancient peoples, and we also have perfect weather and precise angular measuring tools that weren't easily available.

Step 4

There is a good possibility of eclipse when the Sun, Earth and Moon are precisely lined up, so how can you tell when they are lined up? You may notice from your observations that when the Full Moon sets North of West, the sun tends to set South of West and vice versa.

Suppose the full moon sets 20 degrees South of West. We are likely to get an eclipse of the sun sets equally far (20 degrees) North of West. So on this table, I've included some columns for you to do simple calculations. For each line of recorded data, fill in the relative azimuths of the Sun and Moon, where West is 270 degrees.

For example, if the Moon sets at an azimuth of 293 degrees, that is (293-270 =) +23 or 23 degrees North of West.

On the same day, if the Sun sets at an azimuth of 242 degrees, that is (242-270 =) -28 or 28 degrees South of West.

Since these numbers aren't the same, there is no chance of an eclipse.

On a different day, if you get -11 for the Full Moon set and +11 for the sunset, then an eclipse is likely. Even if the numbers are only different by 1-3 degrees, an eclipse is likely since there is some margin for error.

Step 5

Based on your table, during which months of this year are we likely to get eclipses? Write down this answer below and then go online to http://eclipse.gsfc.nasa.gov and find out during which months of the year lunar or solar eclipses are actually occurring.

Based on your table in step 4, during which months are eclipses likely?

____

Compare your answer to the published eclipse dates listed above in step 2 for this year. They should be pretty close (within a month or two for sure).

There will be no essay with this week's lab.

Date	Azimuth of Full Moon Set (near sunrise)	Azimuth of Sun Set	Moon Azimuth - 270	Sun Azimuth - 270

Physics 10293 Lab #6:
Mercury

Introduction

Today we will explore the motions in the sky of the innermost planet in our solar system: Mercury. Both Mercury and Venus were easily visible to the naked eye near sunrise and sunset, and their distinctive patterns of motion were studied closely by many cultures.

Step 1

Start by opening the Skyguide tab on the sidebar, then select "Unit C: The Planets".

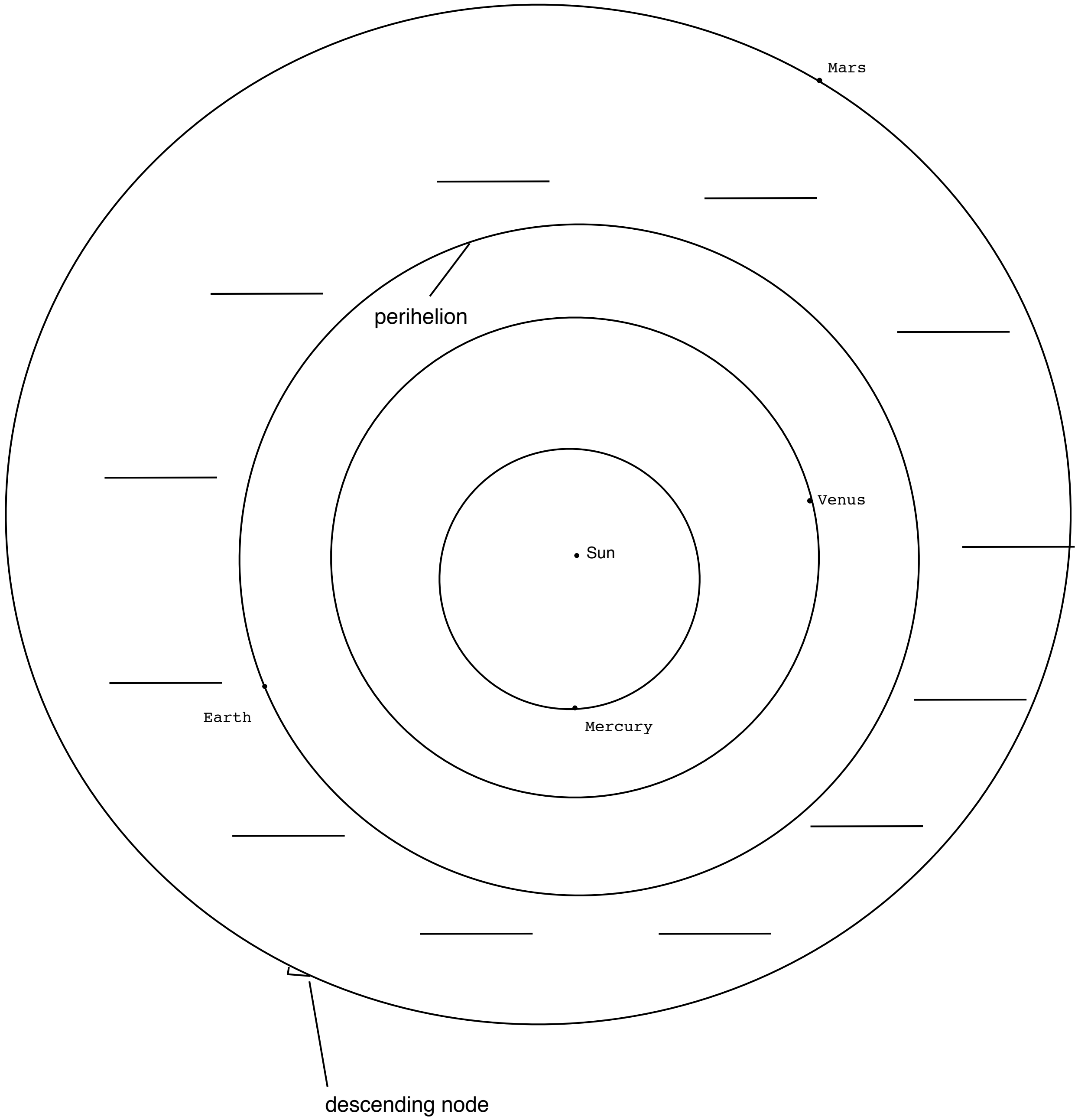
Select "C: The Planets". This will open a list of exercises. Within this module, select "C1: The Inner Planets of the Solar System" and "Part 5: Mars". This should give you a bird's eye view of the orbits of the four inner planets.

Time

On your diagram on the following page, the figure on your screen has been reproduced as a negative and a few features labeled.

Notice on the diagram twelve blanks surrounding Earth's orbit. By watching the motion of the planets on your screen, write in three letter abbreviations in each blank corresponding to the month when Earth is in that position in its orbit around the Sun.

Label the months in the diagram below.



<u>Conjunctions</u>

Next, notice the locations of Mercury and Venus in the diagram above. The location of Venus is on the far side of the Sun, almost exactly opposite of the Earth. We call this position "superior conjunction". Conjunction means "joining", so this is a time when the Sun and Venus are apparently joined on the sky. When a planet is between the Earth and Sun, we call this position “inferior conjunction.” During conjunctions, a planet is not easily visible since it is so close to the Sun in our sky.

Perihelion

On your screen, a small tick mark perpendicular to a planet’s orbital path denotes the perihelion for each planetary orbit (shown for Earth on the diagram on the previous page). Since all planetary orbits are elliptical, there will be a point in the orbit at which the planet is closest to the Sun (perihelion) and furthest from the Sun (aphelion).

Nodes

Next, notice on your screen the small half-arrows attached to each orbital path. Like the Earth’s moon, the orbital planes of the planets do not exactly match up with the Earth’s average orbital plane, also known as the plane of the Ecliptic.

There are two places where the planets cross through the Ecliptic plane: the ascending node and the descending node. The descending node is marked with a hollow half-arrow for each planet (this has been reproduced on the diagram on the previous page for Mars’ orbit). This is where the planet is plunging down through the plane of the Ecliptic. On the opposite side of the planet’s orbit (on the screen but not shown on paper) is the solid half-arrow which marks the ascending node.

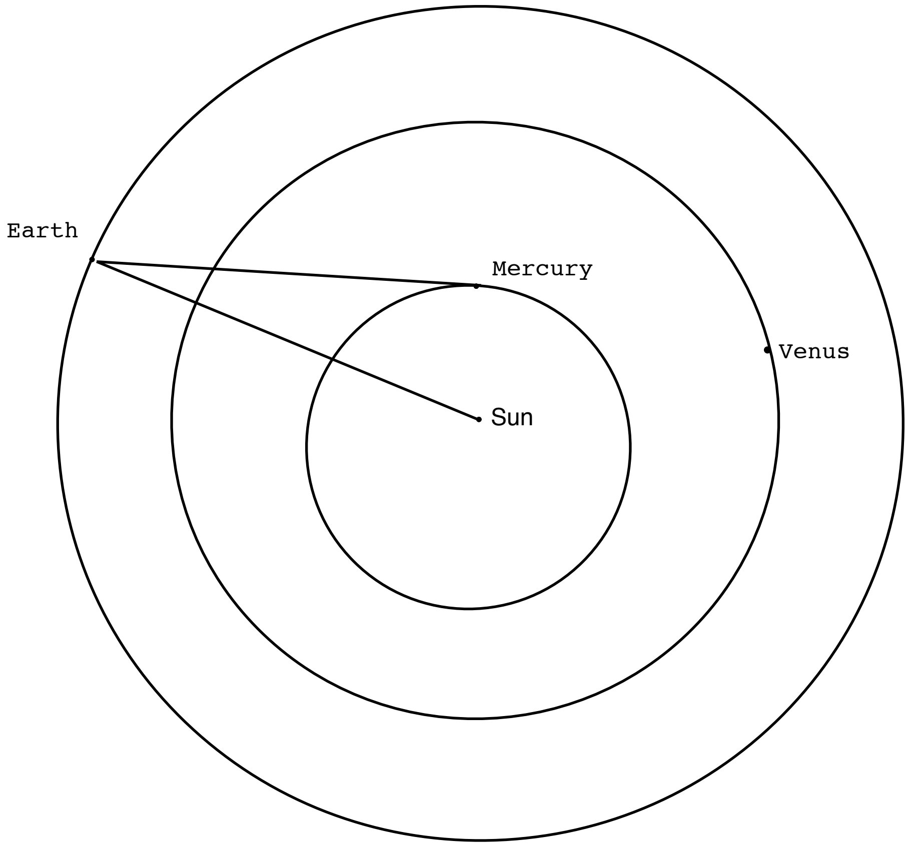
When an inner planet moves in front of the Sun like our Moon occasionally does, we do not call it an eclipse. Instead, we call it a transit. Planetary transits can occur when the planet is at a node at the same time it is lined up with the Earth and the Sun. Below, for the planet Mercury, write down which months of the year it is possible to see a transit of this planet from the Earth. This answer doesn’t depend on the year.

Mercury transit is possible in which two months?

______________ and ________________.

Step 2

Below, Figure 1 shows Mercury at its perihelion point. A line has been drawn from Earth's orbit to Mercury's perihelion point.



Elongations

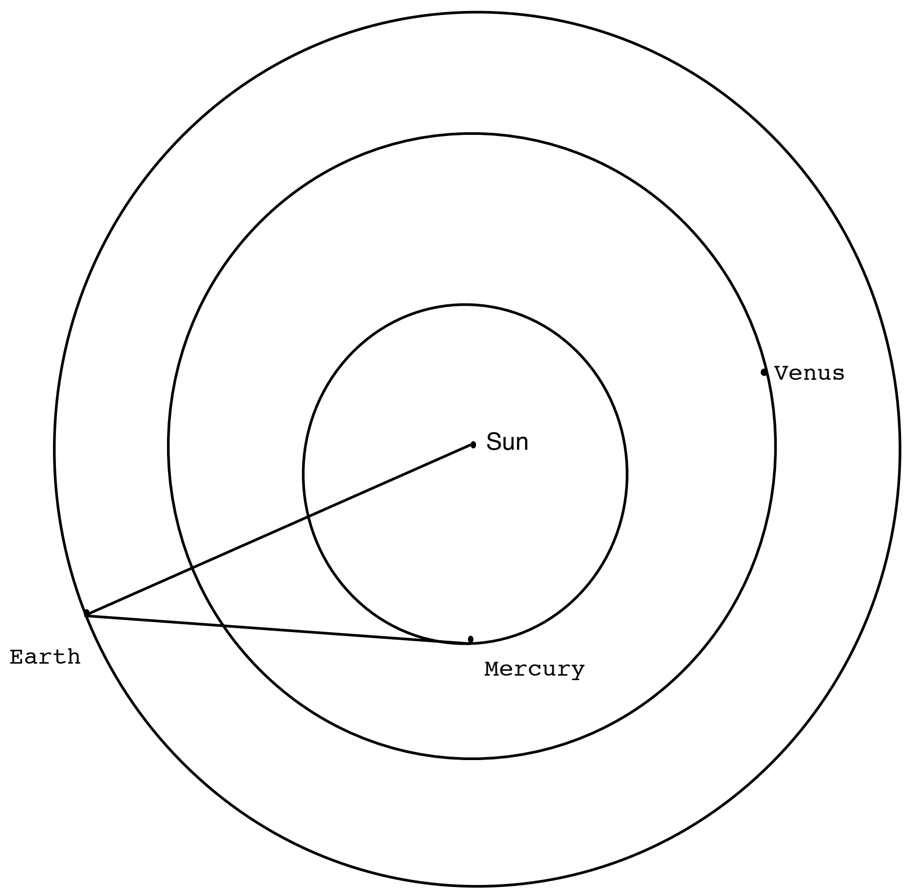
When the Earth is here, we see Mercury at one of its greatest elongations, or furthest angular distances from the Sun. This is possible four times during Earth's orbit, but only one example is shown in Figure 1.

When Mercury is at perihelion, its greatest elongation is 18°. That means the angular distance in the sky between Mercury and the Sun is 18°. That's about the same angular distance as exists between Rigel and Betelgeuse (the two brightest stars) in the constellation Orion. That's also about the same as the angular length of the handle of the Big Dipper.

Below, a diagram shows Mercury at aphelion, its furthest distance from the Sun. This is the second of four possible orientations where Mercury can be seen at a maximum elongation. Again, a line has been drawn from Mercury's aphelion to the Earth's orbit, showing where the Earth is located when Mercury experiences its greatest elongation at aphelion, which is 28°. That's about the distance from the tip of the handle to the tip of the bowl of the Big Dipper.

From Earth's perspective, as Mercury orbits the Sun, it can be seen either to the left or the right of the Sun periodically, and the maximum angle from the Sun along this apparent path is always somewhere between about 18° and 28°. Obviously, the most favorable time for naked eye observations of Mercury occurs when its angular distance from the Sun is maximized.

Notice that if a planet is at maximum elongation, if you draw a line from the planet to Earth, that line will make a right angle with a line from the planet to the Sun.



Monitor the motion of the Earth and Mercury, changing the date when necessary, and answer the associated questions below.

Set the date in the simulation for January 1 of next year.

What is the first day after this date that...

Mercury will be at inferior conjunction? ______________________

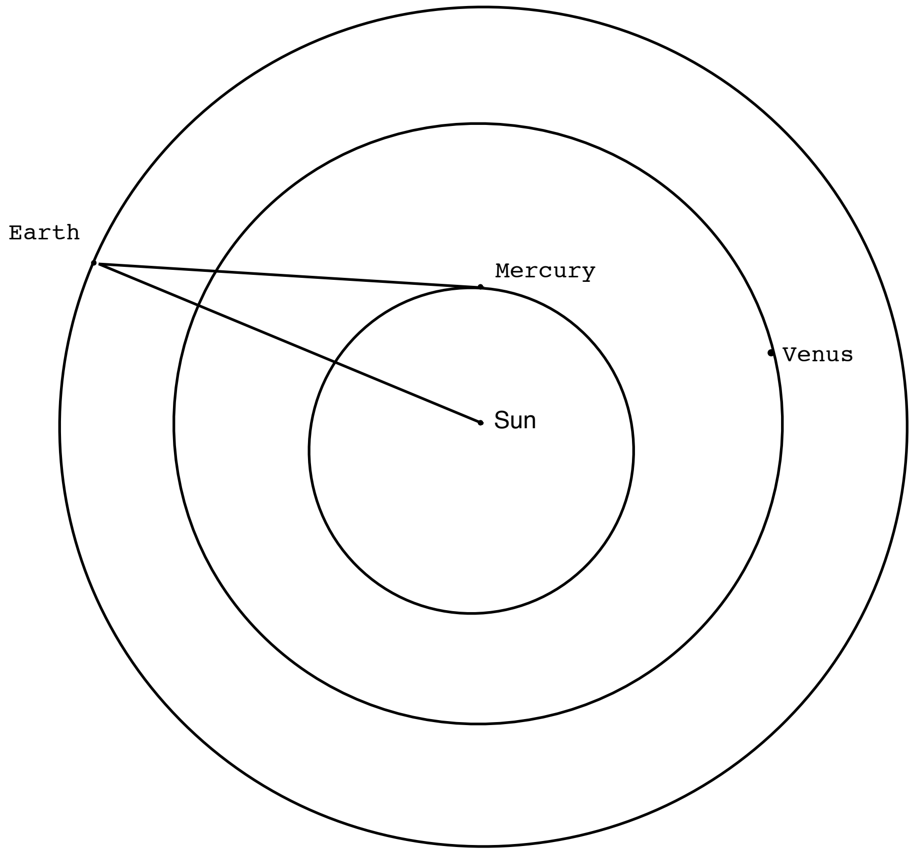
Mercury will be at maximum elongation? _______________________

Mercury will be at superior conjunction? _______________________

What is time interval (in days) between consecutive inferior conjunctions? This is Mercury's synodic period. _________________________

What is the time interval (in days) of Mercury's orbit? For example, how long is the time interval starting from perihelion to its next appearance at perihelion? This is the sidereal period. ______________________

On the diagram below, show all four possible Earth-Mercury configurations that result in elongations at either perihelion (18°) or aphelion (28°). Ask your TA for help if necessary, but it is better if you try (in pencil) first to see if you understand.



Next, think about the direction of orbital motion and rotation (both counterclockwise) for the Earth. For each of your four configurations, label whether Mercury would appear in the morning (before sunrise) or in the evening (after sunset). To get you started, the first configuration shown would be "evening".

Finally, use the mouse to drag on the screen so that it rotates downward. This has the effect of rotating your view of the planetary orbits until you get an edge-on view. Notice the orbits are all nearly coplanar. Mercury's orbit (red) is tilted with respect to Earth's orbit (green) by an angle of 5°. That's coincidentally the same angle our Moon's orbit is tilted compared to the Ecliptic!

Step 3

Now we will study the apparent motion of Mercury in the sky as seen from the Earth. Although Mercury's maximum possible elongation of 28 degrees seems like a pretty big angle on the sky, Mercury can be difficult to see.

First of all, it is only visible to the naked eye when the sun is just below the horizon (before sunrise or after sunset), and so the sky in that direction is still fairly bright. The longer you wait, the darker the sky gets, but also the lower in the sky Mercury goes so that atmospheric effects (which make Mercury dimmer and redder) increase.

Also, just because the angular separation of Mercury and the Sun is as much as 28°, that does not mean Mercury is 28° above the horizon at sunrise or sunset! To help you understand why, we need to set up Starry Night in a certain way.

- Hit the "Home" button in the left corner of the top bar,

- Close the SkyGuide tab (tab controls left of search box).

- Open the Options tab by typing "options" into the search box.

- Under "Guides," select "Ecliptic Guides", then check "The Ecliptic".

- Under "Local View", uncheck "Daylight".

- Under "Solar System", uncheck "Asteroids", "Comets", "Satellites" and "Space Missions"

- Under "Solar System", click on the words "Planets-Moons" to open a dialog box. In this box, near the bottom, activate the "Labels" option.

- At the bottom of this "Planets-Moons" dialog box, check "Label only planets bright than" and move the slider to a magnitude of about 4.

- Now close the dialog box and drag the sky around until you are looking at the Western horizon.

- Under the "Local View" tab, click on the words "Local Horizon" to open a dialog box. Near the top of this box, select "Flat" so we have a perfectly flat horizon to make measurements easier.

- Set the time to sunset on January 1 of next year.

At this point, you may want to ask your TA to double-check your screen to ensure your settings are all correct.

The green line that passes through the Sun and has monthly labels on it is the ecliptic. It serves as the apparent annual path of the Sun in the sky. On your screen, the Sun is in the "Jan" part of the ecliptic. As the year progresses, it will move to the "Feb" part, the "Mar" part, etc.

But it also marks out the plane of Earth's orbit. Remember that Mercury's orbit is tilted with respect to Earth's orbital plane by 5° (we saw that in the edge-on view of planetary orbits). That means Mercury will always be found close to the ecliptic.

Now pay attention to the angle the ecliptic makes with the horizon. Set the time flow rate to "1 day" and run time forward, watching the angle the ecliptic makes with the horizon throughout the year. In the space below, note during which month the ecliptic makes the steepest (largest) angle with the horizon and which month the ecliptic makes the shallowest (smallest) angle with the horizon.

During which month does the ecliptic make its steepest angle with the horizon?

____

During which month does the ecliptic make its shallowest angle with the horizon?

____

The best time to see Mercury will be during a month when the ecliptic makes a steep angle with the horizon, as shown in below in Figure 3.

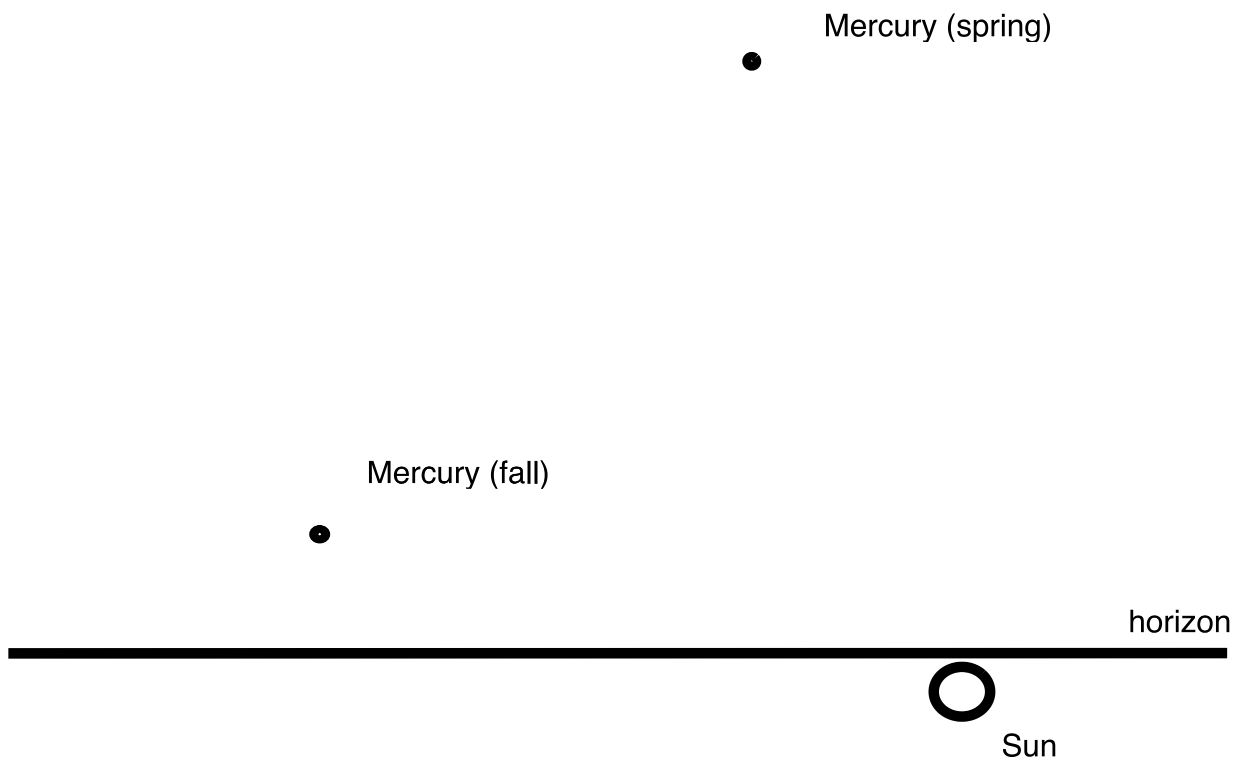


Figure 3

During Spring, when the ecliptic makes a steep angle with the horizon, it is possible for Mercury to appear very high in the Western sky at sunset. During Fall, when the ecliptic makes a shallow angle with the horizon, even if Mercury is at a large angular distance from the Sun, it won't be very high above the horizon and so not very easy to see.

Thus, the best time to view Mercury is during the Spring.

Now a few more quick steps so we can see another interesting effect.

- First, under the “Options” menu above the top bar, select “Orbit/Path Options...”.

- On this screen, check the box near the top marked “Use infinite path length”

- There is a slider below the “Show circular markers” box. Slide this to the smallest value possible (1).

- Uncheck the box near the middle that says “Show date/time”. Then close the box.

- Set the time to sunset on March 21 of next year.

- Make sure the time flow rate is set to “1 day”

Now run time forward. As soon as the planet Mercury is visible above the horizon, stop the time flow and right click on Mercury. This brings up a long menu, and about 2/3 of the way down, select “Local Path”.

This will show Mercury’s day-to-day path across the sky, as though you were observing and carefully marking its position on a star chart every day at sunset, just like the ancient Mayans, Egyptians or Babylonians once did. You will notice Mercury’s path across the sky has two very distinct shapes, a shorter path and a longer path. Stop the simulation after Mercury has completed each of the two paths once.

<u>Sketch the shapes of these two paths on the next page</u>.

Sketch the longer path of Mercury across the sky after sunset in the space below.

horizon

Sketch the shorter path of Mercury across the sky after sunset in the space below.

horizon

After you are finished, you may want to see the simulation run for a while so that you can see the patterns of these two paths over the course of many years.

Physics 10293 Lab #7:
Venus

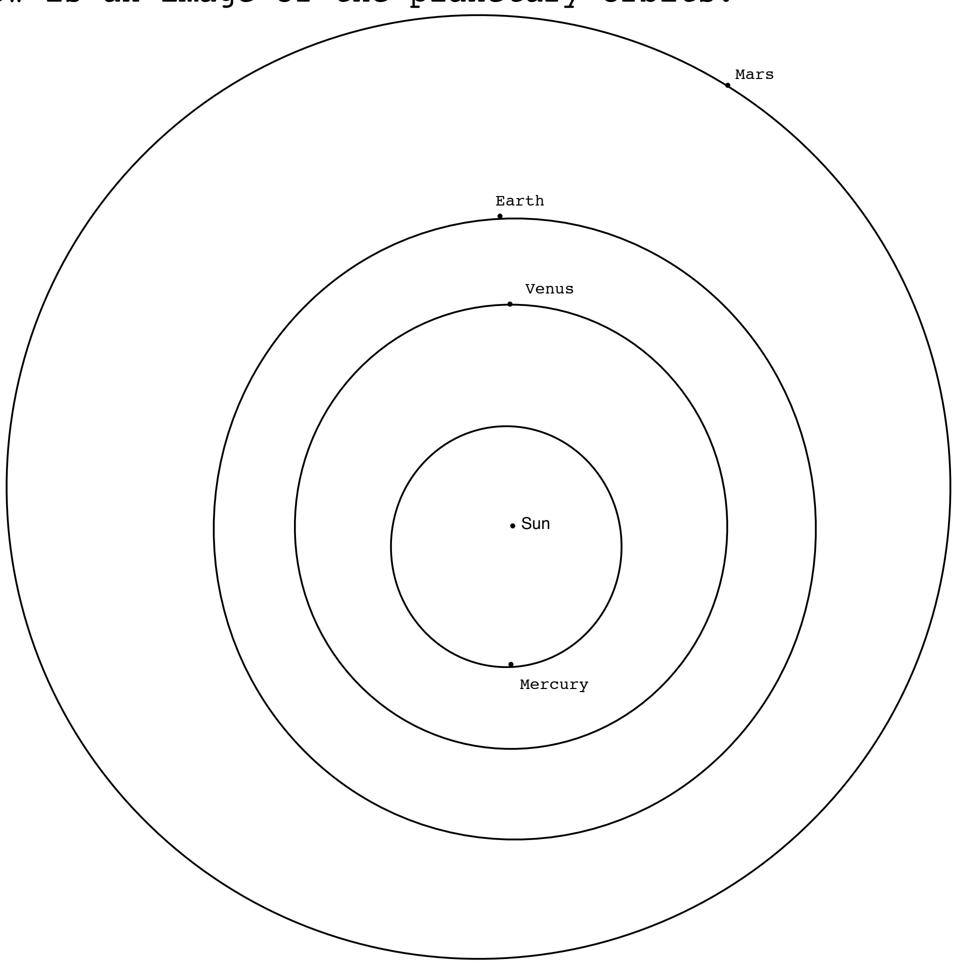
Introduction

Today we will explore the motions in the sky of the brightest planet in our sky: Venus. Because of its brightness and easy visibility near sunrise and sunset, Venus played an important role in the mythologies of many cultures.

Start by opening the Skyguide tab on the sidebar, then select "Unit C: The Planets". Select "C: The Planets". This will open a list of exercises. Within this module, select "C1: The Inner Planets of the Solar System" and "Part 5: Mars". This should give you a bird's eye view of the orbits of the four inner planets.

Conjunctions

Below is an image of the planetary orbits.



This image shows Venus in “inferior conjunction” between Earth and the Sun. It also shows Mercury in “superior conjunction” directly behind the Sun as viewed from the Earth.

Set the date for January 1 of next year. Find the first day after this date that...

Venus at inferior conjunction: _____________________________

Venus at superior conjunction: ___________________________

Venus inferior conjunction (2nd time): ________________________

To find Venus’ synodic period (in days), we need to count the days between inferior conjunctions, but this is difficult using the month and day system. Instead, we will use the Julian calendar, which just counts the days from Jan 1, 4713 BC.

Stop the clock from running and set the date back to the first inferior conjunction of Venus, then use the drop-down menu next to the date display on Starry Night. You will see a menu function “Set Julian Day...”. Select this, and a box will appear showing you the Julian date corresponding to this day on the calendar. Don’t worry about the fraction after the decimal.

Julian Day for 1st inferior conjunction: ______________________

Julian Day for 2nd inferior conjunction: ______________________

Difference = synodic period (in days): ______________

Step 2

Recall from our study of Mercury’s orbit, there are two places where the planets cross through the Ecliptic plane: the ascending node and the descending node. The descending node is marked with a hollow half-arrow for each planet. This is where the planet is plunging down through the plane of the Ecliptic. On the opposite side of the planet’s orbit (on the screen but not shown on paper) is the solid half-arrow which marks the ascending node.

Set the date for January 1 of next year, and run time forward until Venus first reaches a node.

Planetary transits can occur when the planet is at a node at the same time it is lined up with the Earth and the Sun. Below, for the planet Venus, write down which months of the year it is possible to see a transit of this planet from the Earth. This answer doesn't depend on the year.

What are the next two dates on which Venus will be at a node?

_______________________ and ________________________

The closest transit to our date occurs from our perspective during the afternoon of June 5, 2012. To view this from TCU, make the following changes to the settings:

- In the top left corner of the menu bar, select "Home", and close the Skyguide tab.

- Change the date and time to 3pm on June 5, 2012

- Scroll around the sky to find the Sun and zoom in until you can see the surface features clearly.

- Right-click on the Sun and select "Centre".

- Open the options sidebar by typing "options" into the search box in the upper right corner.

- Under "Solar System", click on the words "Planets-Moons" to open a dialog box. Near the bottom of this box, click to activate Labels for the planets, then hit "OK" to close the box.

- On the top menu bar, increase the time flow rate to 300x and run time forward until the transit of Venus begins, when the disk of Venus first touches the solid disk of the Sun (not the yellow halo part around the Sun).

- Note the time of this below, to the nearest minute.

Beginning of 2012 Venus transit from TCU: ___________________

What time is this in "Universal Time"?
(see dropdown menu next to time box): ___________________

- On the very top menu bar, under "Options", select "Viewing Location". Use this to change your viewing location to Papeete, French Polynesia, also known as Tahiti.

- Again, find and center on the Sun and determine the time (in Universal Time) of the beginning of the transit.

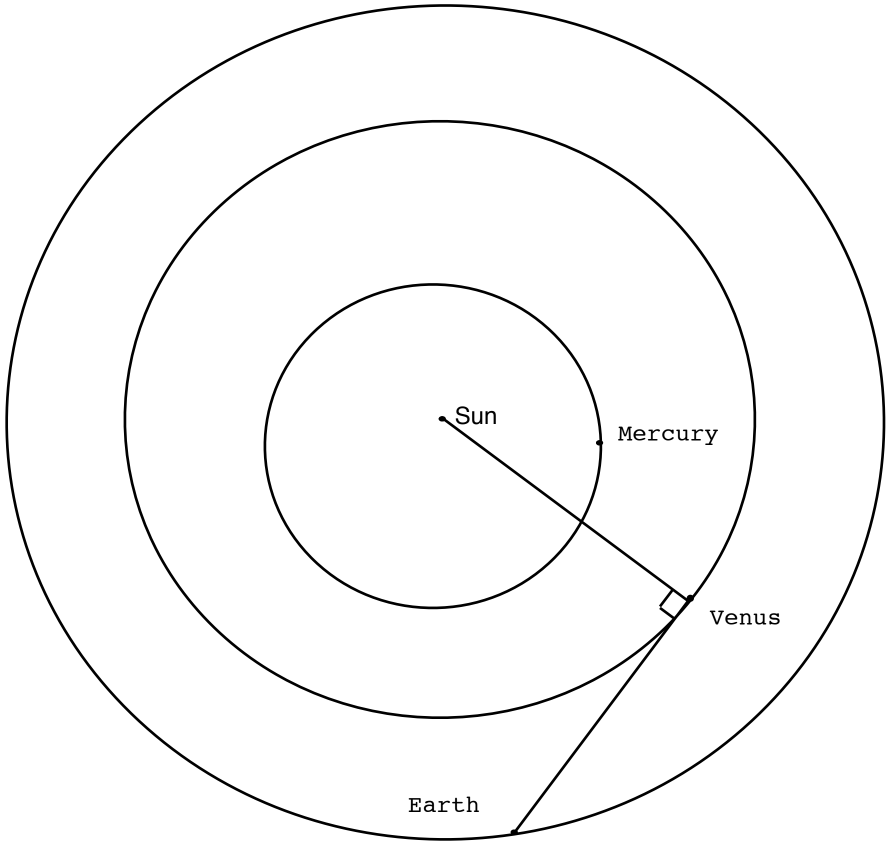
What time is the beginning of the 2012 Venus transit in Papeete, French Polynesia (UT)? ________________

The reason for this difference is parallax. Because these two places on Earth are separated by thousands of miles, they see this event at different times. This time difference proved to be important in establishing the size scale of our solar system for the first time in 1769, a historical event we will return to later.

Step 3

As with Mercury, we will study the maximum elongations of Venus. Since the orbit of Venus is roughly circular, like Earth's orbit, the maximum elongation angle that Venus experiences does not vary much like Mercury's elongation angle. Also, since Venus is further from the Sun, it can appear further away (in an angular sense) in the sky. Thus, before sunrise or after sunset, Venus can be found much higher in the sky compared to Mercury.

We will now explore some upcoming elongations, times when Venus will be easily visible in the morning or evening. On the next page is an example of a planetary configuration where we on Earth are seeing Venus at a maximum elongation.



Notice at this time, that a line from Earth to Venus forms a right angle with a line from Venus to the Sun. Reopen the skyguide simulation and look for the next occurrence of maximum elongation after June 5, 2012.

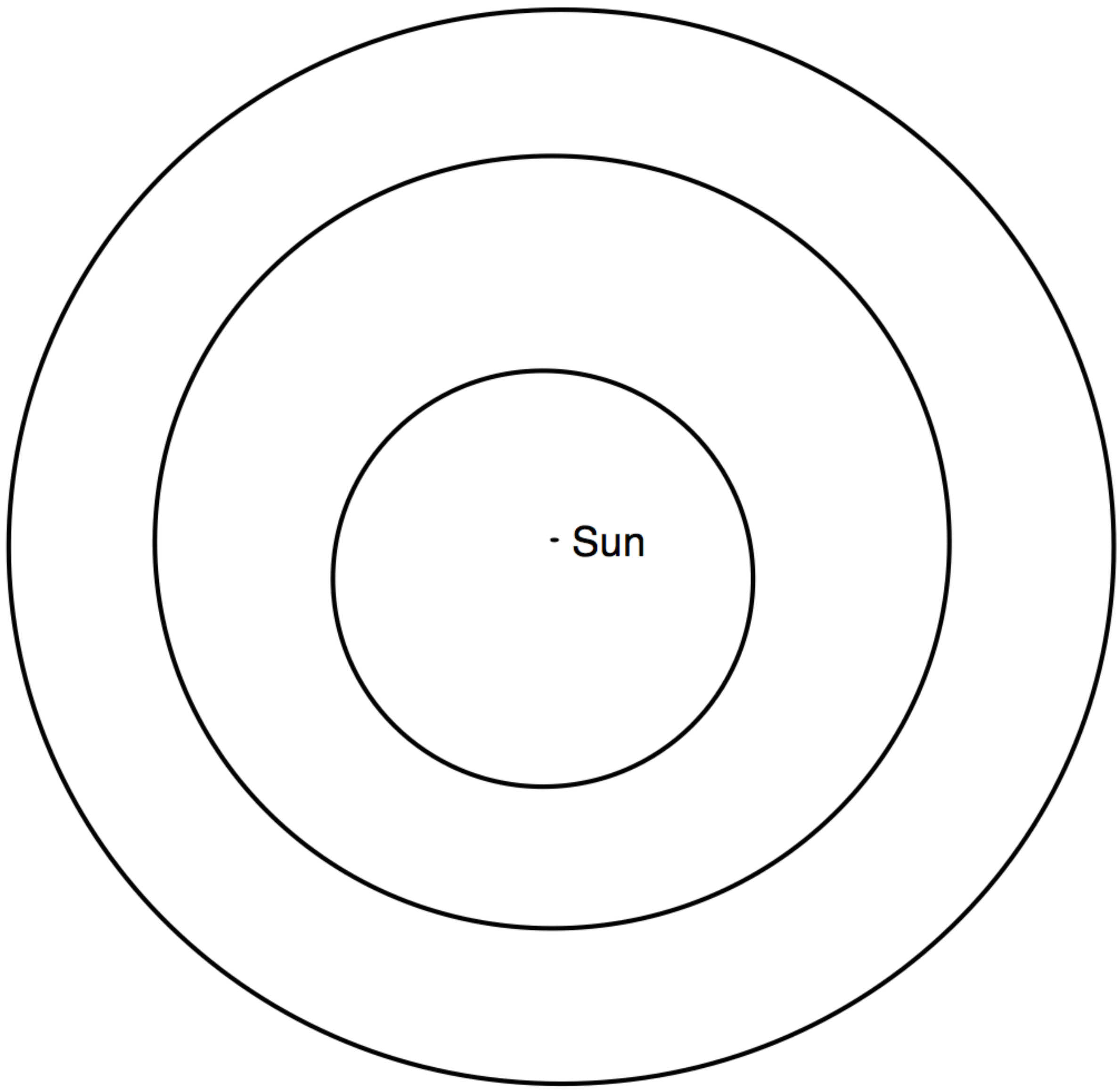
Open the Skyguide tab on the sidebar, then select “Unit C: The Planets” then “C1: The Inner Planets of the Solar System”, then “5: Mars”

Under the Time control box on the top bar, select “Now”.

In the “Options” sidebar, under “Solar System”, click on the words “Planets-Moons” and activate “Labels” near the bottom of the dialog box that opens.

Run time forward (1 day time steps) until the next occurrence of maximum elongation (use a piece of paper to help establish when there is a right angle). <u>Sketch the location of the planets on your worksheet and note the date</u>.

On the chart below, mark the locations of Earth and Venus during the next occurence of maximum elongation.



What is the date of this elongation? ____________________________

Keeping in mind that Earth orbits and rotates in a counterclockwise direction, will Venus be visible before sunrise on this date or after sunset? ____________________________

Now use the "Home" button on the top bar to return to our standard sky view from TCU.

Set the date for the maximum elongation date you already determined and the time to sunrise or sunset, depending on when you think Venus will be visible above the horizon. Now determine Venus' altitude above the horizon by right-clicking on Venus and selecting "Show Info" at the bottom of the drop-down menu.

What is Venus' altitude above the horizon
at sunrise or sunset on this date? ________________________

The next time Venus will have its maximum elongation at this time of day will be one synodic period later. You calculated the synodic period of Venus in step 1. <u>Use the "Julian Day" setting for the date to add one synodic period to today's date and again determine Venus' altitude at sunrise or sunset on this new date</u>.

What is Venus' altitude above the horizon
at sunrise or sunset one synodic period
after its first maximum elongation? ________________________

<u>Step 4</u>

You probably found that your two altitude answers weren't quite the same. That's because Venus doesn't follow the same apparent path in the sky at every elongation. It varies because the orbits of Earth and Venus are not exactly circular, and their perihelion points don't quite match up.

The Mayans noticed this, but they also noticed that while the appearance of Venus in the sky differs from year-to-year, there is a point at which it begins to repeat. We are going to try to recreate these observations to deduce when the cycle of Venus repeats itself. This cycle was recognized by not only the Mayans but also several other early cultures, as indicated by their writings and artwork.

Take the following steps to view the motion of Venus in the evening sky.

- Scroll around to view the Western horizon

- Set the date to the Vernal Equinox (March 21) of this year.

- Set the time to sunset.

- In the options sidebar, under “Local View”, click on the words “Local Horizon” to open a dialog box. Near the top of this box, select “Flat” for the horizon style.

- Under “Local View”, uncheck “Daylight”.

- Under “Solar System”, uncheck “Asteroids, “Comets”, “Satellites” and “Space Missions”

- Under “Solar System”, click on the actual words “Planets-Moons” to open up a dialog box. At the bottom of this box, check to activate “Labels” and also check “Label only planets brighter than” and move the slider to a magnitude of -2 (brightest choice).

- Zoom in or out as necessary until the SW and NW labels on your horizon are at either edge of your screen, with any sidebars (skyguide or options) closed.

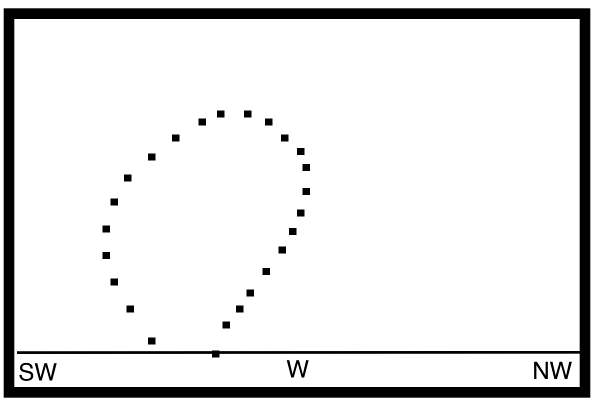
- Set the time step to one day.

- If Venus is already visible, take note of its position. If not, run time forward until Venus is visible above the horizon at about sunset.

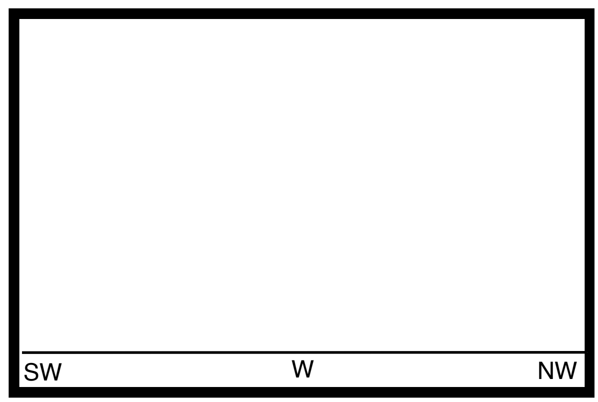
Your goal here will be to map out the day-to-day location of Venus after sunset. You will find it makes a distinctive path in the sky with each cycle. Below, there are several blank diagrams where you should draw the path of Venus through the sky. One example, showing the path of Venus in the sky starting on Feb 11, 2010, has been done for you. You may wish to check this one yourself to see Venus’ motion on the screen and how that translates to your diagram.

Starting from the next time after Feb 11, 2018 that Venus appears above the Western horizon at sunset, plot the apparent day-to-day path of Venus in the Western sky at sunset until you notice a repetition of the cycle. I recommend a dot on your diagram about every 10 days, then draw a line through the dots when you are done. You should start to notice a repetition before you run out of diagrams! Once you notice a repetition, you only need to draw the first two diagrams of the next cycle.

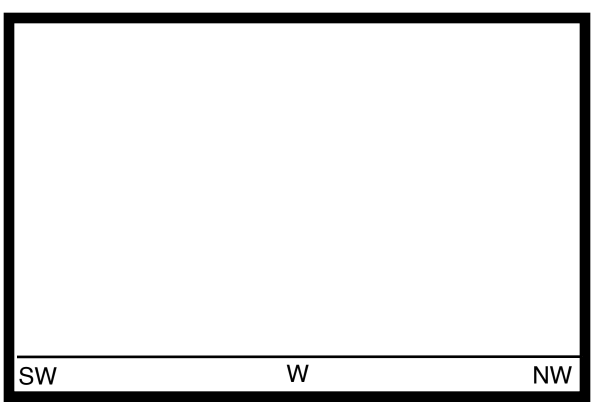
On the diagrams below, plot the day-to-day path of Venus in the Western sky at sunset. The first one has been done for you. Below each diagram, note the start date for your path. These dates should be roughly one synodic cycle apart.



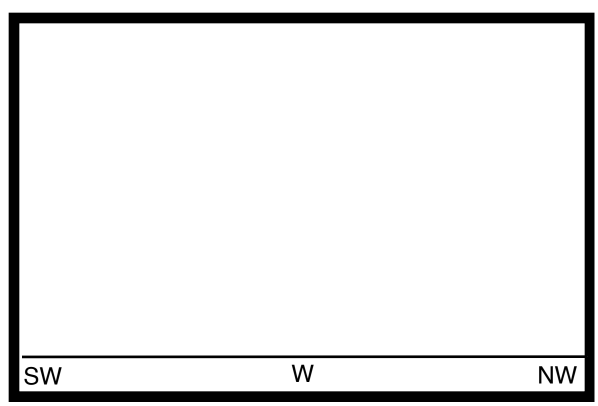
Start date: _Feb 11, 2018________



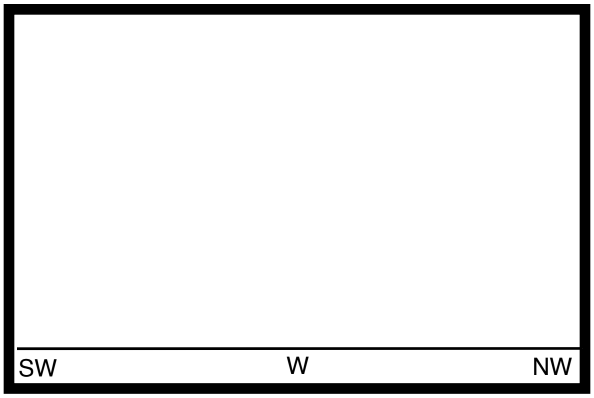
Start date: ____________________

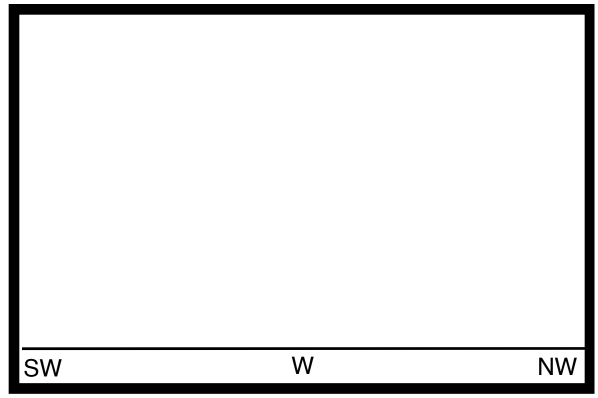


Start date: ____________________

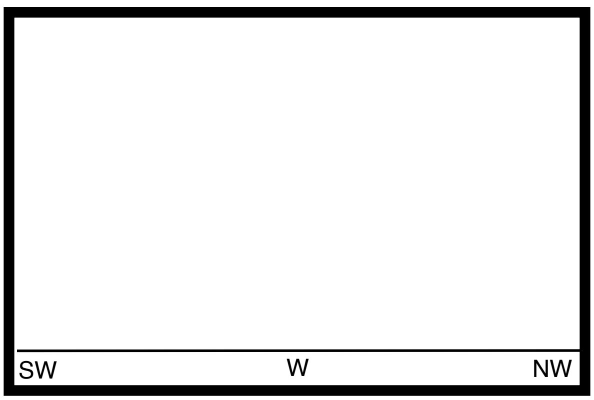


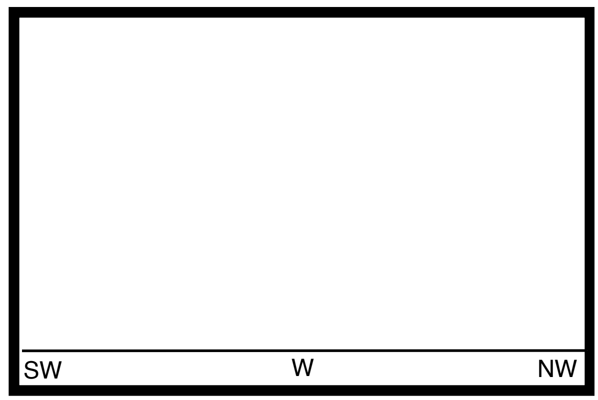
Start date: ____________________





Start date: ____________________ Start date: ____________________





Start date: ____________________ Start date: ____________________

Based on your charts, how many times does Venus appear before its path cycles back to the first path in the cycle? ________

How many years passes between the beginning of these two cycles? ________

How many days are in this number of years? ________

How many synodic cycles is this (previous answer / 584)? _______

Step 5

Like Mercury, Venus shows phases. When Galileo first noticed this through his telescope, he used it to bolster his argument that the planets orbit the Sun rather than the Earth. If you would like to center and zoom in on Venus at some point in its motion in the sky, you can see these phases for yourself as Galileo saw them through his telescope.

Later, Johannes Kepler would expand on this idea, as well as the work of Nicholas Copernicus and Tycho Brahe, to formulate his Three Laws of Planetary Motion. For the first time, planetary motions were starting to make sense to scientists and, most importantly, they were predictable through mathematics with remarkable precision.

The final piece of the planetary motion puzzle, the actual distance between the planets, was established with the help of Captain James Cook's observation of a transit of Venus in 1769. Google "James Cook Venus Transit" and read the first article that comes up (from NASA Science News) to answer the questions below for this final section of the lab.

If Cook's mission had failed in 1769, when would the next transit of Venus have occurred? ________

Explain why it is difficult to precisely determine the time of the beginning (or the end) of the Venus transit.

Did Cook make it back to England? What happened to his crew?

Physics 10293 Lab #8:
<u>The Outer Planets</u>

<u>Introduction</u>

Today we will explore the motions in the sky of the outer planets that are easily visible to the naked eye: Mars, Jupiter and Saturn.

<u>Step 1</u>

Start by opening the Skyguide tab on the sidebar, then select the "Unit C: The Planets". Then choose "Exercise C1: The Inner Planets of the Solar System" and from here, exercise "Part 1: Orbits of the inner planets."

When one of the outer planets is directly on the opposite side of the Earth from the Sun, we call this <u>opposition</u>. During this time, the planet and the Earth are at their smallest distance from one another, and the planet is therefore at its brightest in our nighttime sky, high overhead at midnight.

The simulation "<u>Part 1: Orbits of the inner planets</u>" begins in 2009. Let's instead set the starting time to "Now" and the time step to 1 day. Starting from now and going forward, find the approximate dates of the next five oppositions of Mars. Remember, during opposition, you should be able to draw a straight line from the Sun, through the Earth, to Mars.

Opposition #1 date: ______________________________

Opposition #2 date: ______________________________

Opposition #3 date: ______________________________

Opposition #4 date: ______________________________

Opposition #5 date: ______________________________

What is the approximate average interval, in years and months, between successive Martian oppositions? This is the Martian synodic (solar) period.

_________ years __________ months

Step 2

You may have noticed that during Opposition #1, the Earth and Mars were much closer together than during later oppositions. Since Mars has an elliptical orbit, such close approaches will occur when Mars is near perihelion (the little notch marked in its orbit), its closest approach to the Sun.

In fact, the closest approach recently occurred on August 27, 2003. Set the date to this day to see where Mars was with respect to the Earth on that day. You may need to zoom in a bit to make sure Mars appears.

Every time Mars has an opposition (especially back in August 2003), we are typically bombarded with messages about Mars being “huge” or “the size of the full moon” as if this is some sort of amazing record or incredible and unprecedented visual phenomenon, but actually, Mars doesn’t look all that different at various oppositions. Its brightness and apparent size depend on the distance from Earth to Mars at the time of opposition.

Use the “Home” button to return to Fort Worth and set the date for the first opposition date recorded above. Set the time to 11pm, then use the “Find” sidebar to find Mars. Once you see Mars on your screen, hover your cursor over it to determine the distance from Earth (observer) to Mars.

Repeat this for each of the opposition dates we studied in Step 1 and record the information below (round off to three digits). Note that “au” for distance means “astronomical unit” which is the Earth-Sun distance, approximately 93 million miles.

Earth-Mars distance for Opp. #1: ________________ au

Earth-Mars distance for Opp. #2: ________________ au

Earth-Mars distance for Opp. #3: ________________ au

Earth-Mars distance for Opp. #4: ________________ au

Earth-Mars distance for Opp. #5: ________________ au

Earth-Mars distance for Aug 27, 2003: ________________ au

% difference between Aug 27 and other close opposition: ________

The 1st opposition represents a “typical” minimum opposition. The Earth-Mars opposition occurs near the Martian perigee about every 9th or 10th opposition. The August 27, 2003 opposition was heralded by many as something incredibly special, but in reality, it wasn’t much different from an ordinary opposition near perigee.

On your worksheet, calculate the percentage difference in distance 100 * (difference) / closest distance, which shows in percentage terms, this opposition wasn’t much different than most other oppositions of this kind.

In order for Mars to truly appear to be “the size of the full moon” in the sky, its distance from Earth would have to be about 0.004 au, not 0.372 au!

Step 3

For this part of the lab, we will go to another Skyguide exercise. Open the Skyguide, then open “Unit C: The Planets” and “C3: Direct and Retrograde Motion” and “1: Direct Motion”.

Step time forward one sidereal day at a time (if you let it run, it goes too fast) so that you can watch the motion of the planets. You will notice the planets moving right to left (West to East) along the Ecliptic. Most of the time, planets tend to travel at a roughly uniform speed along the ecliptic toward the East. That means if we map the planets against the background stars, they will seem to move a tiny bit further east each day.

Right-click on Saturn and select “Local Path” from this menu. On the very top, select the Options menu, then select “Orbit/Path options…”. In this dialog box, click “infinite path length”, then slide the circular markers slider all the way to the left, then uncheck “show date/time”.

Run time forward until you see Saturn complete a few retrograde loops, a short time interval where it seems to reverse course and go opposite of its normal easterly motion along the ecliptic.

In what three constellations are these loops located?

____________________, ___________________, ____________________

Step 4

In the Skyguide sidebar, return to “Unit B: Solar System”, then select “B1: Geocentric to the Heliocentric Model” and finally “2: The Geocentric Model”. Run time forward to see how the geocentric model explains the retrograde loops of the outer planets (in this case, Mars).

Notice that in this model, when Mars is undergoing a retrograde loop, it is closest to Earth and therefore brightest, which matches the observations they were able to make at that time.

For the last part of the lab, we will explore the geocentric vs heliocentric debate a little further by reading a Scientific American article with a more detailed history of the issue. Read the article “Astronomy in the Age of Columbus” at the link:

http://personal.tcu.edu/dingram/Astronomy_Columbus.pdf

Answer the questions below, which are asked in the same order as they are covered in the article.

Q1. The author asserts that most scientists of Columbus’ era (late 15th century) agreed that the Earth is round. Why did many people abandon this belief in the United States after the American Revolution? Explain.

<u>Q2</u>. Columbus himself agreed that the world is round. Explain how he justified his voyage to the king and queen of Spain, to make them believe it was possible.

<u>Q3</u>. Although Columbus wasn't much of an astronomer, he did make use of "Ephemerides," a reference book for timing astronomical phenomena such as lunar phases and eclipses. Explain how.

Q4. Explain why Ptolemy's original geocentric model of the solar system was doubted by scholars of Columbus' era.

Q5. Explain why Copernicus' original heliocentric model of the solar system was no more accurate that Ptolemy's geocentric model.

Q6. Name and explain three different arguments or lines of evidence that helped prompt the revolutionary change in consensus from Ptolemy's geocentric model to a Copernican heliocentric model.

There is no essay with this week's lab.

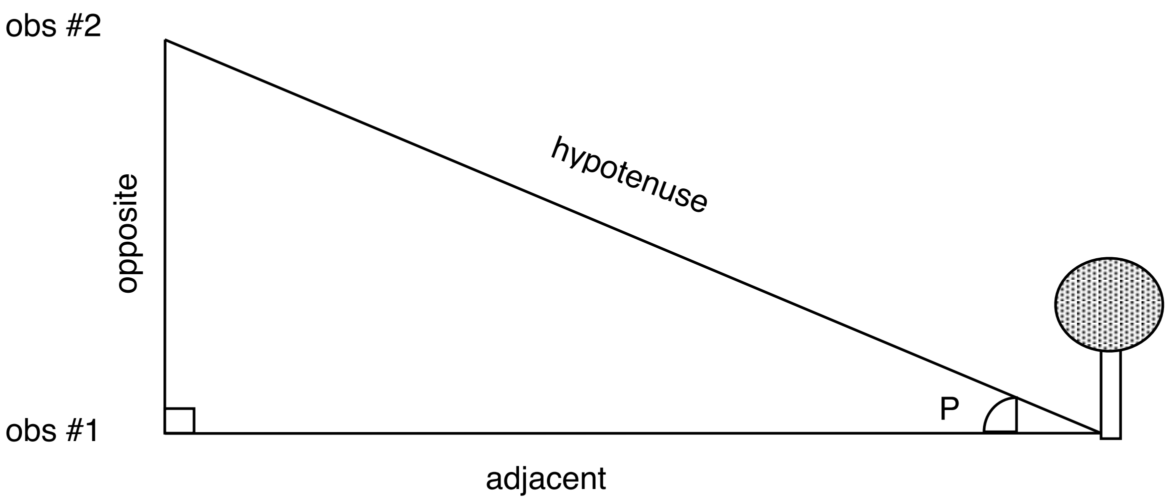
Physics 10293 Lab #9:
Stellar Parallax

Introduction

Parallax is a distance determination technique that uses geometry to measure the distance to some object when other means (such as a ruler or tape measure) won't suffice. On Earth, surveyors call this technique triangulation.

Part 1

In the diagram below, we want to measure the distance to a tree that we cannot walk to (perhaps a river is in the way). So we measure its position from two different observation points, drawing a line from each point to the tree and a line connecting our two observation points as shown below.

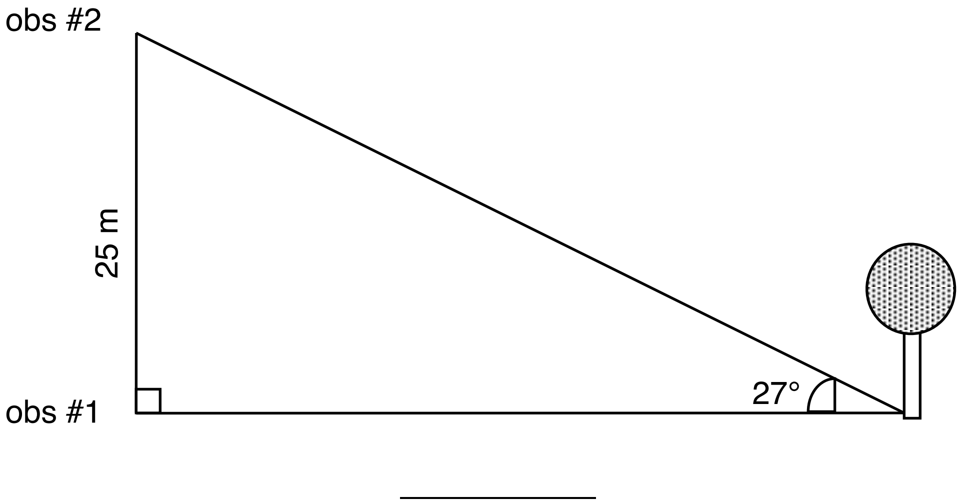


If we physically walk from observation point #1 to observation point #2, then we know that distance. Let's assume it is 25 meters. Using a protractor or other angular measuring device, we can also determine angle P. Let's assume that angle P is 27 degrees.

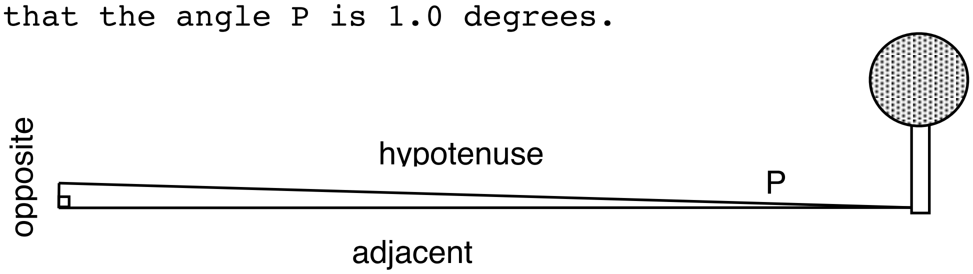
Basic geometry tells us that for angle P,

sin (P) = opposite / hypotenuse
cos (P) = adjacent / hypotenuse
tan (P) = opposite / adjacent

Determine the lengths of the hypotenuse and adjacent side of this triangle and write those values next to the corresponding sides on the diagram below.

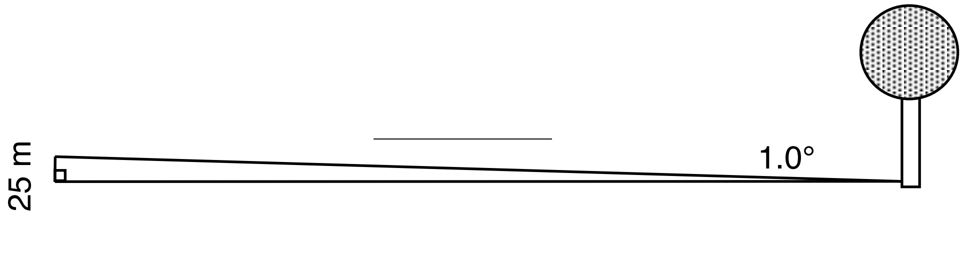


In Astronomy, the angles we measure are much smaller. On the diagram below, assume the opposite side is 25 meters and that the angle P is 1.0 degrees.



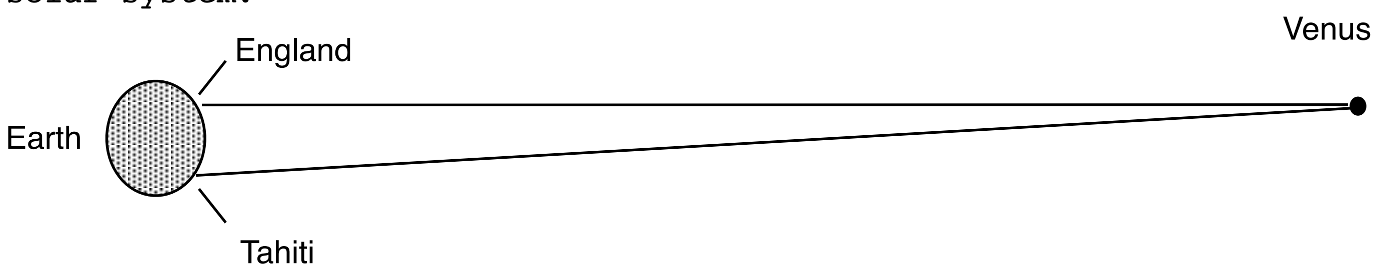
Notice that in the second case, the values for the adjacent side and the hypotenuse are nearly identical. For very small angles, this will always be the case, so it doesn't really matter in our triangle which of the two sides we calculate.

Determine the lengths of the hypotenuse (upper) and the adjacent side (lower) and fill these values in next to the corresponding sides on the diagram below.



Part 2

Historically, parallax played a significant role in our study of the solar system and our galaxy. In the earlier Venus lab, we learned about the story of Captain Cook's expedition to Tahiti. Part of his mission was to measure the timing of the transit of Venus across the Sun. While Cook was making his measurements, astronomers were also timing the transit from England. We know the staight-line distance (through the Earth) between England and Tahiti. We can also calculate the angle P (**the parallax angle**) based on the time delay between transits. We then use this information to deduce the distance from Earth to Venus and, for the first time, establish the scale of our solar system.



Prior to this, Astronomers couldn't reliably use parallax to measure the distances to planets because the positions of the planets could not be measured precisely enough from two different locations simultaneously. Even if one person tried to do both measurements with the same instruments, it took time to travel across the Earth from one observation point to another, and in that time, the planet would inevitably move on its own against the starry background, making the parallax measurement impossible.

The stars themselves, however, do not move significantly in the sky over time, and so there was some hope we could use parallax to determine how far away the stars are. Sirius is the brightest star in the sky, and astronomers (correctly) deduced that one reason for its brightness is that it is closer to the Earth than most other stars.

A quick aside about angular measurements: for small angles, we do not use degrees but instead arcminutes and arcseconds.

1 degree = 60 arcminutes = 3600 arcseconds.
1 arcmin = 0.167 degrees

1 arcsec = 0.000278 degrees

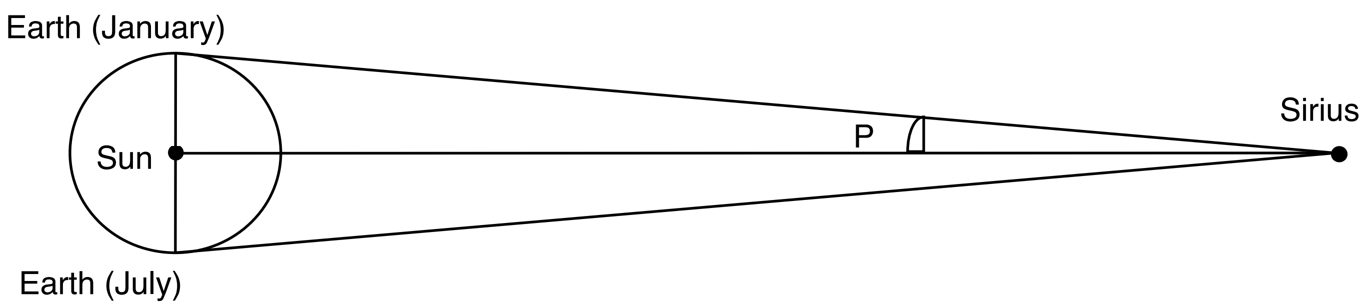
Attempts were made to accurately measure the position of the star Sirius from two different locations on the Earth. Our most accurate observations at the time, however, could only measure angles as small as 1/120th of a degree, which is 30 arcsec.

Work through the example on your worksheet to determine the parallax angle of Sirius if it is viewed from two places on the Earth approximately 3000 miles apart.

Since we could at that time only measure angles as small as 30 arcsec, you can see from your answer that the parallax angle of Sirius measured in this way is about a million times too small.

Then the Copernican Revolution happened.

According to the ideas promoted by Galileo, Copernicus and Kepler, the Earth orbits around the Sun. Astronomers realized that we could use this to our advantage in measuring parallax angles.



Instead of using 3000 miles on the Earth as a baseline, we can use the radius of Earth's orbit (93 million miles). To improve accuracy, we can even use the whole diameter of Earth's orbit so that the tiny angle we are trying to measure is twice as big, but to keep it simple, let's stick with the radius.

Use the radius of Earth's orbit as your opposite side (baseline) and the distance to Sirius as your hypotenuse to determine the parallax angle of Sirius. This is the proper way to determine parallax and the method Astronomers still use today.

The distance to Sirius is 50.5 trillion miles, or 5.05 x 10^{13} miles. Use this for your hypotenuse and 3000 miles for your opposite side (we call this the baseline) and determine the parallax angle for Sirius in degrees and arcseconds.

P = _________x $10^{\_\_\_\_}$ degrees

P = ____________________ arcsec

Notice that your calculated parallax angle for Sirius is still much smaller than our 30 arcsecond accuracy limit. In fact, Astronomers tried in vain to measure parallax angles for many stars and were completely unsuccessful at this time. We know today that the reason for this lack of success is due to the great distances to stars (hence, extremely small parallax angles).

Redo the parallax angle for Sirius using 93,000,000 miles as your baseline distance (this uses the Earth's orbit as the baseline rather than two points on Earth). Use this to determine the parallax angle for Sirius in degrees and arcseconds.

P = _________________ degrees

P = _________________ arcsec

At the time, however, many Astronomers were unwilling to accept the idea that stars were so far away. In order for the parallax angle of Sirius to be too small to measure, they calculated that it would have to be at least 5000 times further away than the most distant planet known at the time (Saturn). From a philosophical standpoint, they thought it was absurd that God would waste so much space. They felt it reasonable to assume that the stars are much closer.

The lack of an observed parallax angle, then, would be explained by the fact that <u>Earth doesn't really orbit the Sun</u>. After all, there are two reasons a parallax angle might be small: Either the distance to the object (the hypotenuse) is really big or the baseline (the opposite side) is really small. We will explore that concept more thoroughly in part 3.

Part 3

On the diagram to your right, draw a line from Earth (in January) through star A and to the distant background stars. USE A RULER FOR A STRAIGHT LINE.

You now have a narrow parallax triangle with the radius of Earth's orbit as the baseline. The small angle just below star A is your parallax angle P, the Earth's orbital radius is the side opposite, and the distance to the star is the hypotenuse of this triangle. Label the parallax angle P_A.

On this same diagram, draw a second star (star B) on the dashed vertical line farther from the Sun than star A. Now in a different color or perhaps with a dashed line, draw a line from Earth (in January) to star B. Label the parallax angle for this star P_B.

Which star, A or B, has the larger parallax angle?

____

Consider the following two statements regarding this exercise:

#1: The parallax angle of star B should be larger because star B is further away.

#2: Star B is further away, so its triangle is sharper or narrower. That means the parallax angle is smaller.

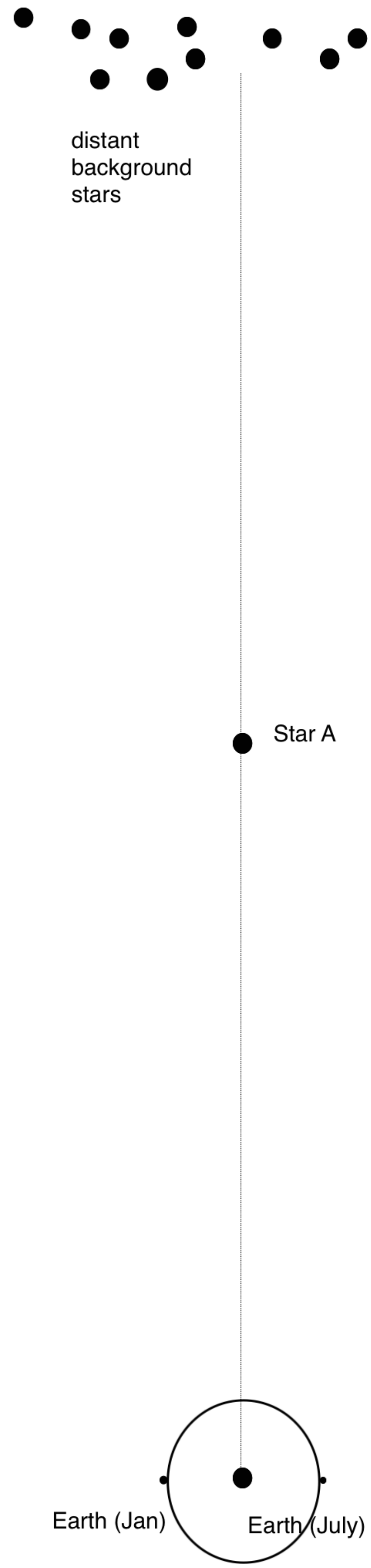
Which statement is right?

____

Consider the parallax angle of star A. If Earth's orbital radius (our baseline) were smaller, the parallax angle of star A would be

_________________.

So there are two ways to explain a star having a very small (unmeasurably small) parallax angle: either the star's distance is incredibly large or the baseline we are using is very small (about 3000 miles instead of the 93,000,000 mile radius of Earth's orbit).



In your own words, explain why Astronomers of Galileo’s era were unable to measure parallax angles for nearby stars like Sirius.

Next, in your own words, explain how they used the lack of measured parallax as a way to argue against the Copernican sun-centered (heliocentric) model in which the Earth revolves around the Sun. Instead, they used the lack of parallax to support the old Earth-centered (geocentric) model in which the Earth doesn’t move and all of the planets, including the Sun, orbit the Earth.

Physics 10293 Lab #10:
<u>Tonight's Sky</u>

<u>Introduction</u>

This week, we will take advantage of all that we have learned with the Starry Night application to answer some questions about the night sky at this time of year.

Open up Starry Night, and take the following steps in preparation:

- Type "options" into the search bar to turn on the options sidebar.

- Under "Guides", expand the "Alt/Az Guides" menu, and turn on "Labels", "Grid" and "Meridian".

- Under "Local View", click on the words "Local Horizon" to open a dialog box. Near the top of this box, select "Flat" so that the application displays a flat horizon.

- Under "Solar System", uncheck "Asteroids", "Comets", "Satellites" and "Space Missions".

- Under "Solar System", click on the words "Planets-Moons" to open a dialog box. In this box near the bottom,
    - Activate "Labels"
    - Activate "Label only planets brighter than…"
    - Move the slider to a magnitude of about 5.

- Under "Stars" and the sub-menu "Stars", activate the "Labels" button to help identify bright stars.

- Under "Constellations", select "Labels", "Boundaries" and "Stick Figures"

- Set the time to 9pm tonight.

Now close the options sidebar and use the Starry Night controls to answer the following questions.

Q1. In what constellation is the bright star Sirius?

____

Q2. At approximately what time, to the nearest minute, will Sirius cross the meridian tonight?

____

Q3. At approximately what time, to the nearest minute, will Sirius cross the meridian tomorrow night?

____

Q4. The difference between these two times is the sidereal day. How long is the sidereal day, in hours and minutes?

_________ hours ______ minutes

Q5. At what time, to the nearest minute, will the Sun cross the meridian today?

____

Q6. At what time, to the nearest minute, will the Sun cross the meridian tomorrow?

____

Q7. The difference between these two times is the solar day. How long is the solar day, in hours and minutes?

__________ hours ________ minutes

Q8. Set the time to 9pm tonight. In what constellation is the bright star Regulus?

____

Q9. How far is Regulus from the Earth, in light years?

_____________ light years

Open the options sidebar, and under “Guides” and the sub-heading “Ecliptic Guides”, turn on “The Ecliptic”. Notice that Regulus is very close to the ecliptic. That made it a useful marker star for the Persians, who considered Regulus one of the “Four corners of heaven” or “Royal Stars”, marking four bright stars along the ecliptic separated by about 90 degrees.

Q10. Another of the “Royal Stars” is Aldebaran. In what constellation is the bright star Aldebaran?

____

Q11. Now look to the North, set the time step to 1 minute, and observe the motion of the sky. If you wish, you may use the options sidebar to disable “Daylight” under “Local View”. Name six bright stars (with proper names) that are circumpolar (always above the horizon) from our location:

___________________, _____________________, ____________________

___________________, _____________________, ____________________

Q12. Find the constellation Perseus. What is the name of the brightest star in this constellation (designated Alpha Persei)?

____

<u>Reset the time to 9pm tonight</u>, and look toward the East.

Q13. Which star is at a higher altitude, Arcturus (in the constellation Bootes) or Spica (in the constellation Virgo)?

____

Q14. Which zodiacal constellation is closest to the zenith?

____

Q15. Two months from now, which zodiacal constellation will be closest to the zenith at 9pm?

____

Q16. Return to today’s date at 9pm. Which zodiacal constellation is just now rising over the Eastern horizon?

____

Q17. In the constellation Gemini, which star is brighter, Castor or Pollux? Remember that the magnitude system measures brightness backwards (so smaller apparent magnitude = brighter star)!

____

Q18. Check to see if any major, visible planets are up (Venus, Mars, Jupiter or Saturn), and if so, what constellation are they found in? List any you see above the horizon at 9pm tonight, along with their constellation (you will find them near the ecliptic).

Q19. What time today will the planet Saturn transit (cross the meridian)?

____

Q20. What time today will the planet Jupiter rise?

____

Q21. In what constellation is the planet Neptune found today?

____

Q22. Zoom in on Neptune. What is the name of Neptune's largest moon?

____

Zoom back out to a normal view. Under "Deep Space" and the sub-heading "Messier Objects", turn on "Labels".

Q23. List which Messier Objects are located within the constellation Perseus.

____

Q24. Find M45 (the Pleiades). In what constellation is M45?

____

Q25. Zoom in on the Pleiades. There are nine named stars in this small cluster. List these names below.

__________________ ____________________ __________________

__________________ ____________________ __________________

__________________ ____________________ __________________

Q26. Zoom back out to a normal view, then find M31. What kind of object is M31?

____

Q27. In what constellation is M31 found?

____

Q28. What kind of object is M13?

____

Q29. In what constellation is M13 found?

____

Q30. How far away from Earth is M13?

____

Return to today's date and locate the Moon. The best way is to type "moon" into the search box on the upper right and double-click "The Moon" below that. If the Moon is below the horizon, click "Best Time" to see the Moon when it crossed the meridian today.

Q31. In what constellation is the Moon today?

____

Q32. In what phase is the Moon today? _______________________

Q33. At what time does the Moon cross the meridian today?

____

Q34. At what time does the Moon cross the meridian tomorrow?

____

The difference between these two times, which is approximately 24 hours and 50 minutes, is called a lunar day. Since the Moon's orbital speed around the Earth varies, the lunar day length has a range of values, but the average lunar day length is 24 hrs 50 min.

Q35. Visit https://tinyurl.com/yathu5pd to watch an animation of the lunar day, and explain below with the help of a simple diagram, why the lunar day is longer than the solar day.

There is no essay with this week's lab.

Physics 10293 Lab #11: The Origin of the Constellations

Introduction

In this lab, we will study the research compiled by Ian Ridpath in his online book, "Star Tales," to help understand the origin of the modern-day constellations. I have organized several questions about the first two chapters of this reading below and included sufficient space for you to write your answers. There will be no essay with this lab.

Chapter 1, Page 1a

(http://www.ianridpath.com/startales/startales1a.htm)

The constellations we use today were first published as a set by Ptolemy in his book known as the Almagest. Explain the two lines of evidence (one of them written, one of them having to do with the gaps in the star maps) that many of the constellations in Ptolemy's book likely originated from the Babylonian civilization that existed about 800 years prior to Ptolemy's era.

Chapter 1, Page 1b
(http://www.ianridpath.com/startales/startales1b.htm)

Describe the evidence for and against the hypothesis that the Minoan civilization centered on the island of Crete was the primary source of constellations recognized by the Greeks and Ptolemy.

Describe the role of the Arabic astronomer Al-Sufi (or Azophi) in the creation of the constellation and star names we use today.

Chapter 1, Page 1c
(http://www.ianridpath.com/startales/startales1c.htm)

Explain the origin of two large constellations in the Northern celestial hemisphere: Camelopardalis and Monoceros.

What was the role of Petrus Plancius in filling in the Southern Celestial hemisphere with 12 new constellations, previously uncharted?

Chapter 1, Page 1d
(http://www.ianridpath.com/startales/startales1d.htm)

Explain the role of Johannes Hevelius in the modern set of recognized constellations.

Explain the role of Lacaille in the modern set of constellations.

Why are there so many constellations named after scientific instruments (e.g. Telescopium, Microscopium) in the Southern celestial hemisphere?

Describe how the current officially recognized boundaries for the constellations were drawn.

Chapter 2, Page 2a
(http://www.ianridpath.com/startales/startales2a.htm)

What is the Farnese Atlas? Explain its historical significance.

What is the Dunhuang star chart? Explain its historical significance.

Explain how the themes and names of Chinese constellations differed from Western constellations.

Chapter 2, Page 2b
(http://www.ianridpath.com/startales/startales2b.htm)

What is the Uranometria? Explain its historical significance.

What are Bayer letters, and how were they usually assigned to specific stars?

Chapter 2, Page 2c
(http://www.ianridpath.com/startales/startales2c.htm)

What are Flamsteed numbers, and where did they originate?

Explain the origin of simpler line diagrams connecting bright stars on published maps as opposed to the more elaborate pictures that had been the norm.

Chapter 2, Chinese Constellations (linked on page 2a)
(http://www.ianridpath.com/startales/chinese.htm)

Explain how the Chinese constellations originally organized the sky. In particular, describe lunar mansions and the four-part zodiac.

Explain two reasons why it is very difficult to determine the identifications of specific stars within constellations from Chinese star charts.