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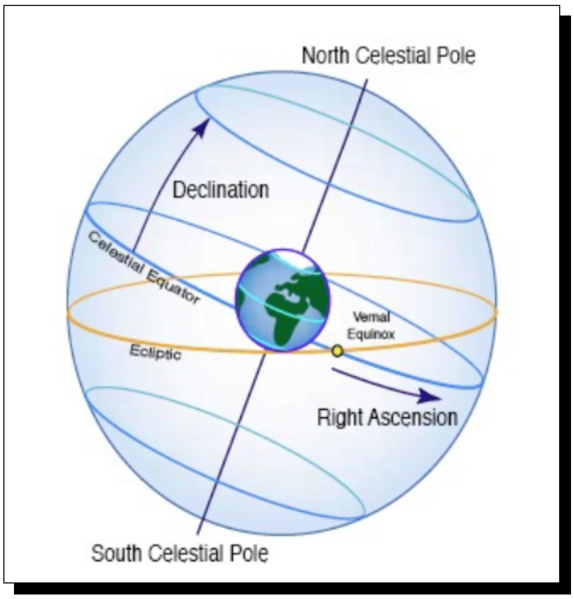
The Equatorial System

In this experiment, you will learn about the equatorial system and the orbits of the Planets.

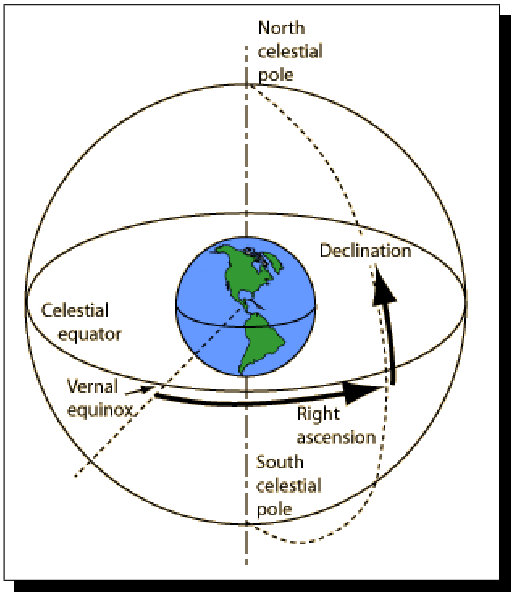
Contents

Introduction

The equatorial coordinate system is a widely used method of mapping celestial objects. It functions by projecting the Earth's geographic poles and equator onto the celestial sphere. The projection of the Earth's equator onto the celestial sphere is called the celestial equator. Similarly, the projections of the Earth's north and south geographic poles become the north and south celestial poles, respectively. The equatorial coordinate system allows all earthbound observers to describe the apparent location in the sky of sufficiently distant objects using the same pair of numbers: the **right ascension** and **declination**.



(a) The celestial equator of the earth is tilted by 23.8^0 with respect to the ecliptic plane.



(b) Right Ascension is defined relative to the Vernal Equinox point. Declination is altitude relative to the celestial equator.

Declination is the latitudinal angle of the equatorial system (Dec for short). It measures the angle of an object above or below the celestial equator. Objects in the northern celestial hemisphere have a positive declination, and those in the southern celestial hemisphere have a negative declination. For example, the north celestial pole has a declination of $+90^o$.

Right ascension is the longitudinal angle (RA for short). It measures the angle of an object east of the apparent location of the center of the Sun at the moment of the March equinox, a position known as the vernal equinox point or the first point of Aries. The vernal equinox point is one of the two points where the ecliptic intersects with the celestial equator. Unlike geographic longitude, right ascension is usually measured in sidereal hours instead of degrees, because an apparent rotation of the equatorial coordinate system takes 24 hours of sidereal time to complete. There are (360 degrees/24 hours)=15 degrees in one hour of right ascension.

The path that the Sun takes across the sky changes every day, see Fig. 1. The path is lowest in the sky at the Winter solstice, Dec. 21'st, and highest at the summer solstice, June 21'st. Only on the exact day of the Vernal and Autumnal equinoxes does the Sun rise in the direction due East, and set due West.

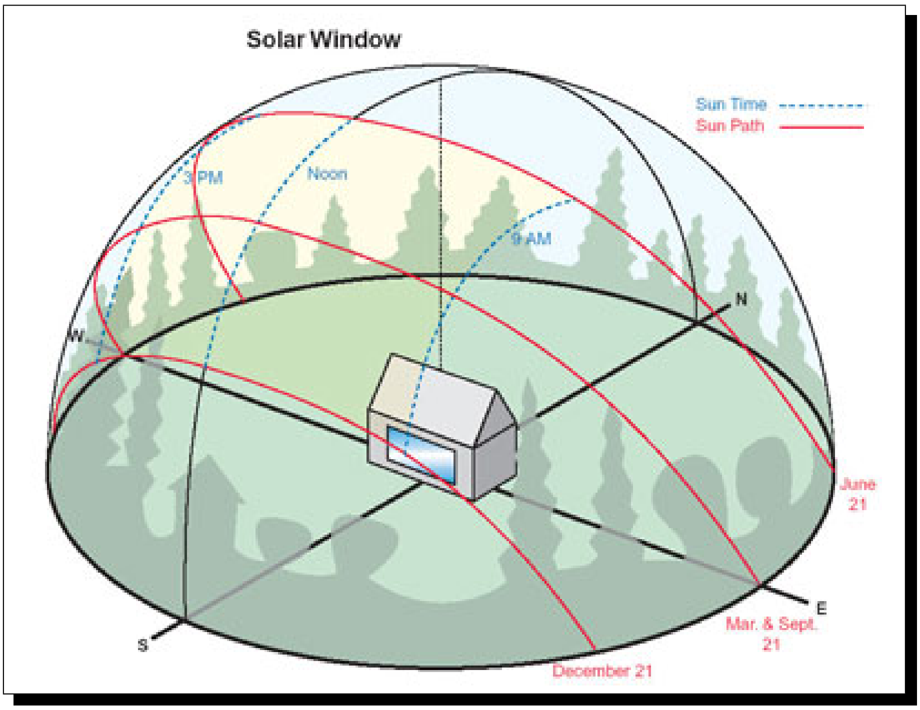


Figure 1: Paths of the sun across the sky.

References:

[1] Wikipedia page: http://en.wikipedia.org/wiki/Equatorial_coordinate_system

1. Observations of the Sun

In this part you will examine the sun's position relative to the background stars (equatorial coordinates), it's rising time and time above the horizon throughout the year. You will be observing from Atlanta. The set up is as follows.

- **Chart→Set Location**. Choose **Atlanta** from list cities and **OK**.

Set up for tracking the sun's changing position.

- **Display→Reference Lines→Show Reference Lines and Points**

  Make sure **Horizon Line, Celestial Equator, Ecliptic, Meridian** are checked, and **Galactic Equator** is not checked. Click **OK**.

- Click on **Display→Constellations** and check the boxes exactly as shown in Fig. 2.

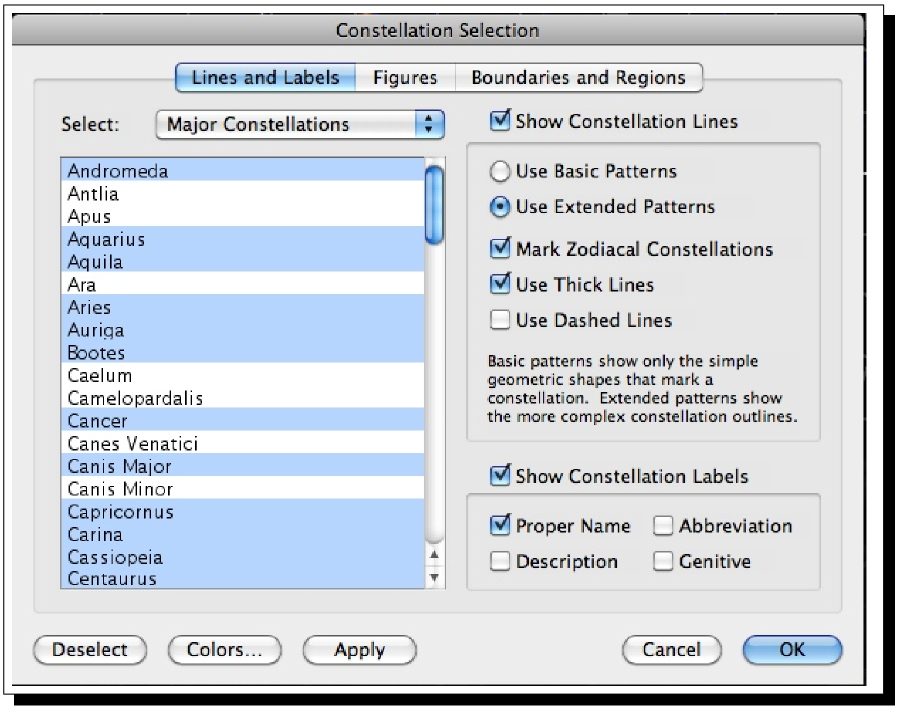


Figure 2: Settings to show the major constellations in the **Display→Constellations** dialog box.

You should now be ready to collect data for **Table 1 - OBSERVATIONS OF THE SUN**. Make sure your screen is correctly set up before proceeding. You are to collect Sun data for each of the eight dates throughout a year.

1. Go to the Time panel (the one with the clock). Click on the ▷ symbol to the right of the "3" on the dial, and click **Set Date and Time**. Enter the first date in Table 1, March 21, 2011. Set the time to 12:00:00 PM.
2. On the Time Panel, click on the Time Step button (button under start). Select **1 day** as the time step.
3. To obtain the desired data for each date in Table 1, the Sun's rising time, setting time, right ascension and declination, click on the Sun and bring up the Sun's Data Panel.

4. To progress to the next date in Table 1, use the forward or reverse arrows next to the **START** button on the Time Panel window. Stop and record Sun data on all the dates given. Remember to write times using a 24 hour clock, i.e. 7:48 pm is 19:48.
5. The amount of time between sunrise and sunset goes in the column labeled "Above Horizon". (i.e. 12 hrs 48 min.)
6. Notice the progression of the Sun through the zodiacal constellations. Record for each date the Sun's constellation on the right side of Table 1.

2. Motions of the Planets

In this section you will collect information on the the Sun, the Moon, and six orbiting planets, Mercury, Venus, Mars, Jupiter and Saturn. For each of these objects, you are to record data in Table 2 for two different dates - April 1, 2011 and June 1, 2011. It will be easiest to observe the Sun and planets directly in Equatorial coordinates. This will be the same observation view as in part 1 above, that is viewing from Atlanta, except now we just remove the earth (!) so that we can see both above and below the horizon. To do this, do the following,

Chart→Coordinates→Star Atlas-Equatorial.

The following recipe procedure is suggested.

1. Record all the data for all objects for one date and then repeat for the second date. Do the following.
   Chart→Set Time and Date, enter April 1, 2011.
   Set the time to 11:59 pm.
2. To obtain data for the first object in Table 2, find and click on each of the planets and the Sun and record the rising time, setting time, right ascension and declination as listed in the **Info** panel windows.
3. Repeat series of measurements in part 2 for the second date, June 1, 2011.

3. Conjuctions and Oppositions

This section is concerned with conjunctions and oppositions of the planets in their orbits around the sun. Study carefully Fig. 3 for the relevant definitions.

The Sky Chart is set up as follows:

1. **Chart→Coordinates→Solar System - Ecliptic Coordinates**.
   On the **Location** panel window, click on the **Solar System** tab, then set Longitude = 0 degrees, and Latitude = 90 degrees. You are now looking down on our solar system, i.e. the ecliptic plane is in the plane of the flat screen. Set the Time Step to **1 day**, click Start, and watch the planets orbit the Sun. You're now ready to find when the conjunctions and oppositions of the planets occur.

Part 1: Mercury and Venus

Observe and report on your observations of the motions of the planets Mercury, Venus and the Earth, as seen from a point above the Sun.

1. On the **Location** panel window, set distance from the Sun to 1 A.U.
2. On the **Time** panel window, click **NOW** button to reset to today's date.
3. Use the arrows next to the **Start** button to advance time in **1 day** increments.
4. Observe **Mercury** and **Venus**, making note of the first inferior and superior conjunctions occurring starting from today's date. You can use the edge of a sheet of paper to see if the planets, Earth and Sun are all aligned.
5. Fill in all data in part 1 of the CONJUCTIONS AND OPPOSITIONS data sheet.

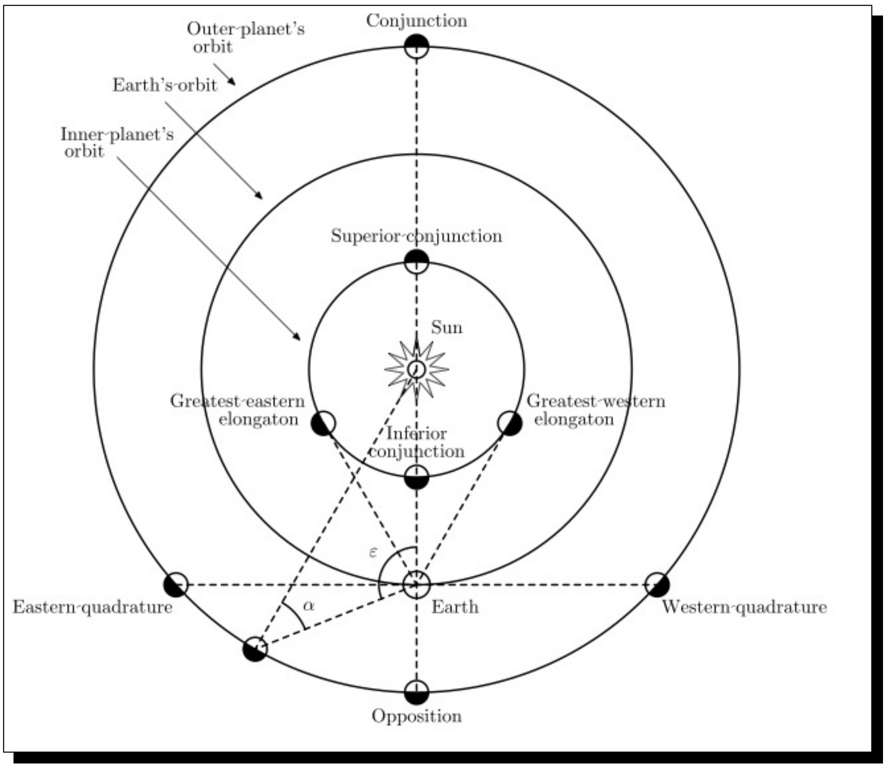


Figure 3: Conjunction and Opposition Diagram.

Part 2: Mars

1. On the **Time** panel window, click **NOW** button to reset to today's date.
2. Adjust the **Distance** on the **Location** panel window so that you can see all of **Mar's** orbit.
3. Observe **Mars**, making note of the date of the first conjunction and first opposition, as well as that of the second opposition.
4. Fill in all data in part 2 of the CONJUCTIONS AND OPPOSITIONS data sheet for Mars.

Part 3: Jupiter and Saturn

1. On the **Time** panel window, click **NOW** button to reset to today's date.
2. Adjust the **Distance** on the **Location** panel so that you can see the orbits of **Jupiter** and **Saturn**.
3. Find the dates of the next conjunction and opposition for both **Jupiter** and **Saturn**.
4. Fill in part 3 of the CONJUCTIONS AND OPPOSITIONS data sheet for **Jupiter** and **Saturn**.

Part 4: Outer Planets

1. On the **Time** panel window, click **NOW** button and set the time step to **1 month**.
2. On the **Location** panel window, set the distance from sun large enough so that you can see the outer planets **Pluto, Neptune** and **Uranus**.
3. On the **Location** panel window, set the **Latitude** to **0 degrees** so that you can view the solar system from the side.
4. Advance time to watch the outer planets orbit the Sun. Answer the questions in Part 4 of the CONJUCTIONS AND OPPOSITIONS data sheet.

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Table 1: OBSERVATIONS OF THE SUN

Date	Rising Time	Setting Time	Time Above Horizon	Right Ascension	Declination	Constell.
March 21, 2012						
May 1, 2012						
June 21, 2012						
Aug. 1, 2012						
Sep. 21, 2012						
Nov. 1, 2012						
Dec. 21, 2012						
March 21, 2012						

1. Describe the change in declination of the sun through the year.

2. Describe the relationship between the Sun's declination and its rising time.

3. Describe how the total time above the horizon depends upon its declination.

4. How does the rising time of the Sun change throughout the year?

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Table 2: MOTIONS OF THE PLANETS

Object	4/01/11 Rising Time	4/01/11 Setting Time	Time Above Horizon	4/01/11 RA	4/01/11 DEC.	6/1/11 RA	6/1/11 DEC.
Sun							
Mercury							
Venus							
Mars							
Jupiter							
Saturn							

1. Do the (+) declinations stay above the horizon longer than the (-) declinations?

2. Which objects had the most change in position between the two times?

3. Why is the change in position greater for some objects then it is for others?

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CONJUCTIONS AND OPPOSITIONS

Part 1 - Mercury and Venus

Date of Inferior Conjunction of Mercury. ____________
Date of Superior Conjunction of Mercury. ____________
Date of Inferior Conjunction of Venus. ____________
Date of Superior Conjunction of Venus. ____________

Part 2 - Mars

Date of Conjunction of Mars ____________
Date of Opposition of Mars ____________
Date of next Opposition of Mars ____________

Part 3 - Jupiter and Saturn

Date of Conjunction of Jupiter ____________
Date of Opposition of Jupiter ____________
Date of Conjunction of Saturn ____________
Date of Opposition of Saturn ____________

Part 4 - Outer Planets

(A) Do the outer planets orbit the sun in the ecliptic plane and if not, which orbital plane is tilted the most?

(B) Do the planets orbit the sun CW or CCW as seen from above?

** END **