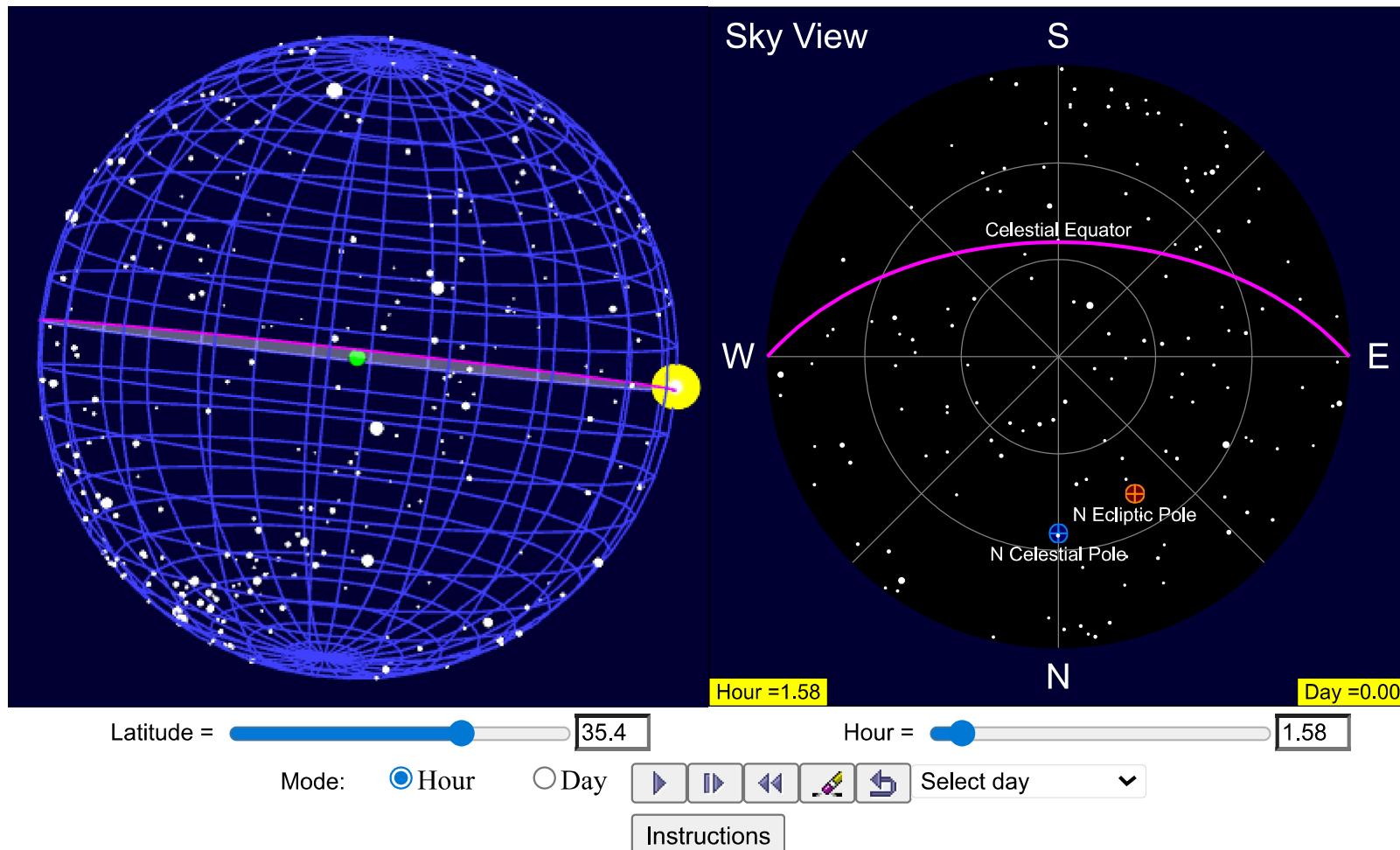


Celestial Sphere and Analemma

 Trace Sun Celestial Grid Ecliptic Horizon Equator Extra Opt.

The simulation models the motion of Sun (yellow sphere) and stars on the surface of a [Celestial Sphere](#) as seen from Earth (green sphere) which is at the center of this sphere. Two views are shown: one from outside the Celestial Sphere and the other showing a Sky View of an observer on Earth facing north and looking up at the sky.

Questions

Setup: Set latitude to your latitude, set time to 12 hours (noon), set day to Vernal Equinox.

1. Look at the Sky View. Is the Sun exactly on the meridian (north-south) line? If not, is it slightly east or west of that line? On average, the “mean Sun” is always on the meridian at (local) noon. Recall that the Sun moves eastward relative to the stars. On the vernal equinox, is the “true Sun” ahead of, behind, or nearly even with the mean Sun?
2. Use the Select Day the control panel to change the day to the summer solstice. Is the Sun exactly on the meridian (north-south) line? If not, is it slightly east or west of that line? On the summer solstice is the true Sun ahead of, behind, or nearly even with the mean Sun?
3. Repeat these steps for the autumnal equinox and the winter solstice.
4. Compare your answers. From the vernal equinox to the summer solstice does the true Sun move faster, slower, or at the same speed as the mean (average) Sun? Answer the same question for the other seasons: summer solstice to autumnal equinox, autumnal equinox to winter solstice, and winter solstice to vernal equinox.
5. During each season the Sun moves through a 90 degree arc of the ecliptic. Which seasons will be longer than average? Which seasons will be shorter than average?
6. We can visualize the variation in the true Sun’s local noon position throughout the year by tracing its path. Select Trace Sun to Show the Sun’s path. Set the Advance option to Day start the animation to trace the location of the local noon Sun throughout the year. (You can also use the time slider but the trace may not be smooth.) The path that is displayed is known as the analemma.

Advanced

7. The variations in the Sun’s local noon position throughout the year has two causes: the tilt between the ecliptic and the equator, and the actual change in the Sun’s apparent speed as it moves along the ecliptic. We now know that the changing apparent speed of the Sun along the ecliptic is really due to the changing speed of the Earth as it moves along its orbit around the Sun. To understand the different effects produced by these two causes we can examine a model in which the Sun moves at a uniform speed along the

ecliptic (but the ecliptic is still tilted relative to the equator by 23.5 degrees). In the Extra Options menu, select Uniform Sun. Then trace out the path of the local noon Sun as before. Notice that this version of the analemma looks different. Compare the two anomalies to answer the following questions:

- Which effect is responsible for the general figure-8 shape of the analemma: the tilt of the ecliptic or the non-uniform speed of the Sun along the ecliptic?
 - Which effect is responsible for the asymmetry of the analemma?
 - Which effect is responsible for the difference in the length of the four seasons?
8. You can further explore the effects of the tilt of the ecliptic and the non-uniform motion of the Sun/Earth by selecting the Extra Options menu in the Celestial Globe frame. The Axial Tilt slider can be used to control the tilt of the ecliptic. The Eccentricity slider can be used to control the non-uniformity in the Sun's apparent speed along the ecliptic (larger eccentricities lead to more variation in speed). You can adjust these sliders and then trace out the path of the local noon Sun throughout the year to see how the adjustment alter the shape and size of the analemma.

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