## ASTR 310 Tutorial 3: Sunrise and Sunset

The Sun, stars and planets cross our sky in complicated patterns that depend on the Earth's daily rotation around its tilted axis and its annual revolution of the Earth around the Sun.

For thousands of years, astronomers have watched the sky, figured out the patterns and built "computers" like these so they could predict when and where the Sun, stars and planets rise and set each day.


In this tutorial, you'll use your 21st Century computer to explore the motion of the Sun.

1. Open your browser to astro.unl.edu
2. On the NAAP Labs tab, select Labs - Motions of the Sun.
3. Click the "Paths of the Sun Simulator" link to launch the sim.

## Part 1: The Path of the Sun Simulator

Explore the sim with your partners and answer these questions:
An object's altitude tells you how high an object is in the sky, from $0^{\circ}$ on the horizon to $90^{\circ}$ at your zenith. What is the altitude of the Sun at 12:00 noon on Canada Day (July 1), as seen by observers in Vancouver (latitude $49.0^{\circ} \mathrm{N}$ )?

Challenge question: An object's azimuth tells you its direction, like on a compass, from angle $0^{\circ}$ (due North) to $90^{\circ}$ (due East) to $180^{\circ}$ (due South) to $270^{\circ}$ (due West) and back to $360^{\circ}$ or $0^{\circ}$ at North again. How many degrees North of East is the most northerly sunrise for observers in Vancouver?

## Part 2: The Path of the Sun Across the Sky

If you were able to answer both those questions, you've probably figured out how to

- drag the Sun
- grab and move the sphere
- find the time
- set the time
- set the latitude
- set the date
- measure the altitude
- measure the azimuth
- animate the daily motion
- what the white, gray, yellow and blue circles are

If you haven't figured these out yet, don't worry. Watch your TA use the simulation to collect data tracking the path of today's Sun. Record the data in the Table:

|  |  | Today | Autumnal Equinox <br> Sep 22 |
| :--- | :--- | :--- | :--- |
| Time of sunrise <br> (time when the Sun is at altitude $0^{\circ}$ ) |  | Winter Solstice <br> Dec 22 |  |
| Sun's location on horizon at sunrise, <br> in degrees North or South from East <br> (azimuth $90^{\circ}$ ) |  |  |  |
| Sun's highest altitude of the day, <br> in degrees above Southern horizon |  |  |  |
| Time of sunset <br> (time when the Sun is at altitude $0^{\circ}$ ) |  |  |  |
| Sun's location on horizon at sunset, <br> in degrees North or South from West <br> (azimuth $270^{\circ}$ ) |  |  |  |
| Draw the Sun's path on diagram. <br> Label path with date, time of sunrise, <br> time of sunset. |  |  |  |

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If you haven't figured these out yet, don't worry. Watch your TA use the simulation to collect data tracking the path of today's Sun. Record the data in the Table:

|  |  | Today | Vernal Equinox <br> Mar 20 |
| :--- | :--- | :--- | :--- |
| Time of sunrise <br> (time when the Sun is at altitude $0^{\circ}$ ) |  | Summer Solstice <br> Jun 22 |  |
| Sun's location on horizon at sunrise, <br> in degrees North or South from East <br> (azimuth $90^{\circ}$ ) |  |  |  |
| Sun's highest altitude of the day, <br> in degrees above Southern horizon |  |  |  |
| Time of sunset <br> (time when the Sun is at altitude $0^{\circ}$ ) |  |  |  |
| Sun's location on horizon at sunset, <br> in degrees North or South from West <br> (azimuth $270^{\circ}$ ) |  |  |  |
| Draw the Sun's path on diagram. <br> Label path with date, time of sunrise, <br> time of sunset. |  |  |  |

Name $\qquad$ ID No. $\qquad$ Tutorial Day/Time $\qquad$

Part 3: Questions Please hand in this worksheet when you are finished.

1. Use the sunrise and sunset times you collected and from your sky diagram to find the length of the day (the number of hours the Sun is up) throughout the year. Put the values on this graph and draw a smooth curve between them. Be sure to include today, too.

2. Shade in the region of the graph in Question 1 that represents the hours of darkness when the Sun is down. What fraction of the graph did you shade in? Answer: $\qquad$
3. Change the latitude to $90^{\circ} \mathrm{N}$ so the sim shows the motion of the Sun for observers at the North Pole.

When does the Sun rise today? $\qquad$
When does the Sun rise on Jun 20? $\qquad$
When does the Sun rise at the North Pole? $\qquad$
4. There's something wrong with the equinoxes. In class, we say the Sun rises at 6:00 a.m. and sets at 6:00 p.m. but that's not what you found. Set the simulation for Vancouver again. Write the observations you made earlier and add another observation: the time when the Sun crosses the meridian (at azimuth $180^{\circ}$.) This is what we usually call "noon."

| Date | sunrise | noon | sunset |
| :--- | :--- | :--- | :--- |
| Vernal Equinox |  |  |  |
| Autumnal Equinox |  |  |  |

On the Vernal Equinox, the day is $\qquad$ hours long but it's shifted $\qquad$
On the Autumnal Equinox $\qquad$

This unexpected shift will be explained in upcoming classes about Kepler's Laws and the analemma.
Path of the Sun simulator: astro.unl.edu/naap/motion3/animations/sunmotions.html







