

- See Chandru Grading Comments from 11/4/23 below

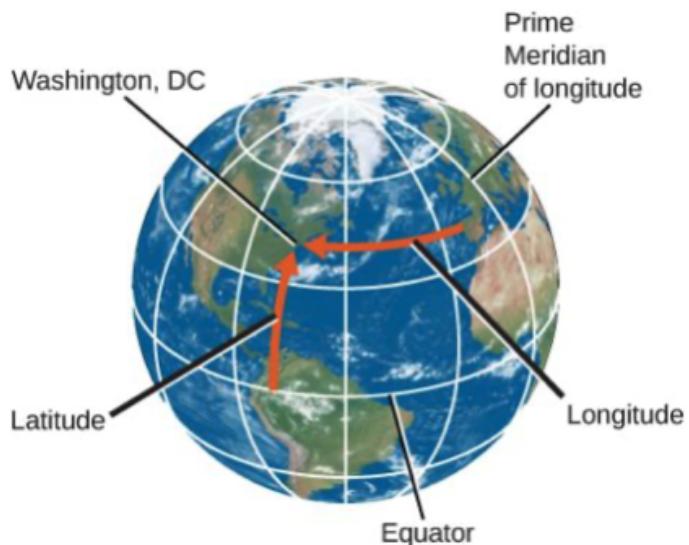
1. Nice work!

You have a 100% grade on this notebook

Correct Any Errors identified above for an improved grade

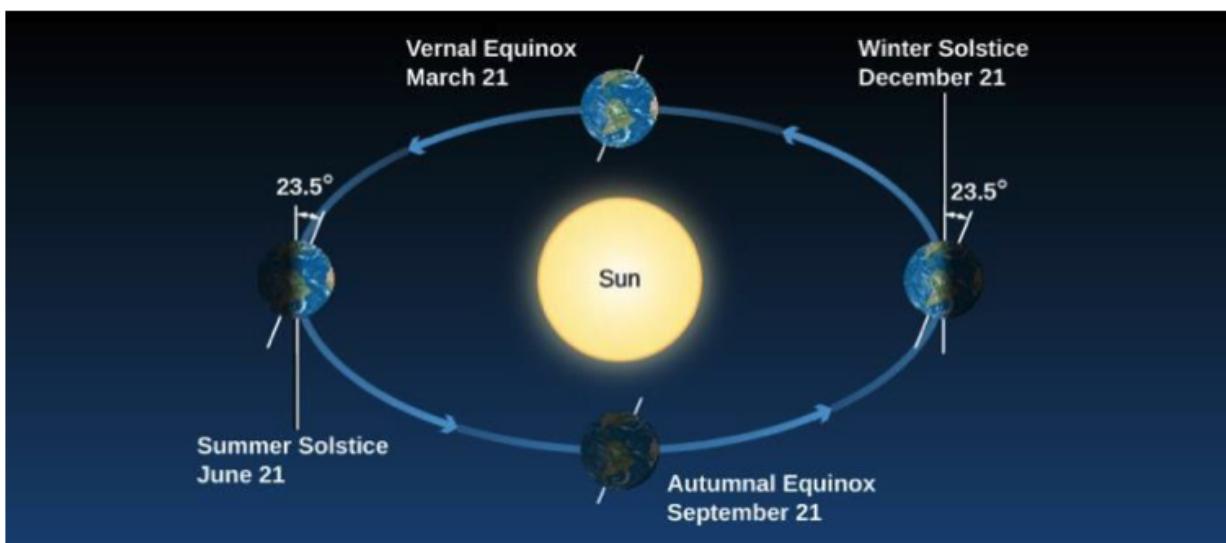
## Earth Seasons and Sun Angle Calculations for Seattle and other cities for a given date

**FIGURE 4.2**

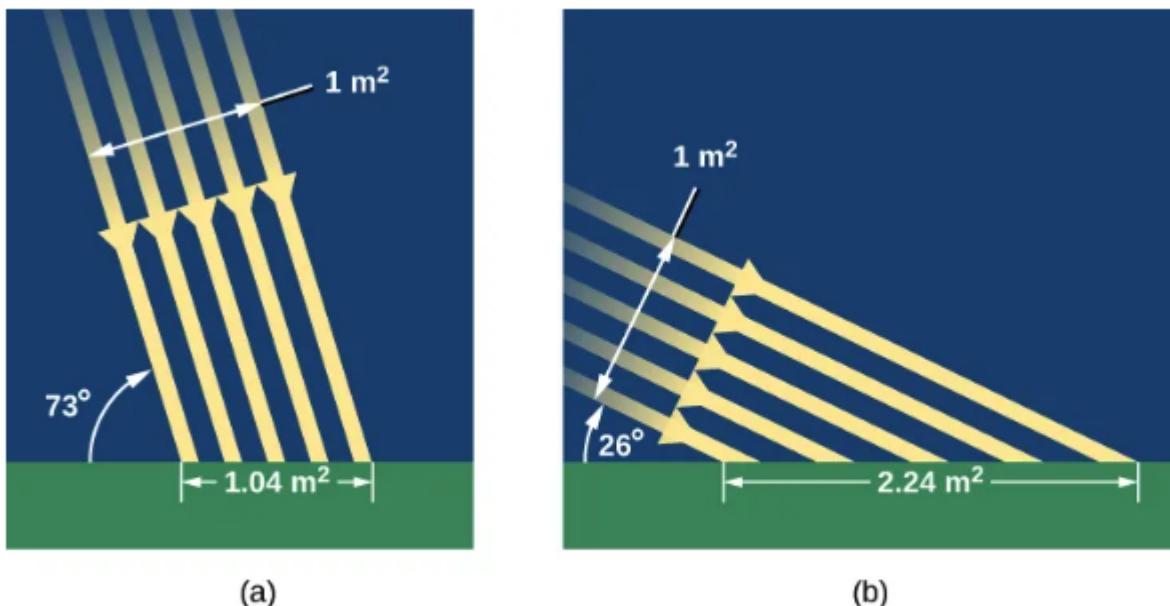


**Latitude and Longitude of Washington, DC.** We use latitude and longitude to find cities like Washington, DC, on a globe. Latitude is the number of degrees north or south of the equator, and longitude is the number of degrees east or west of the Prime Meridian. Washington, DC's coordinates are 38° N and 77° W.

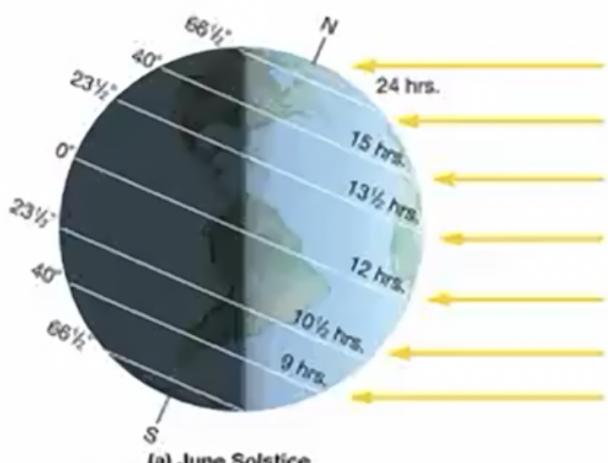
## FIGURE 4.5



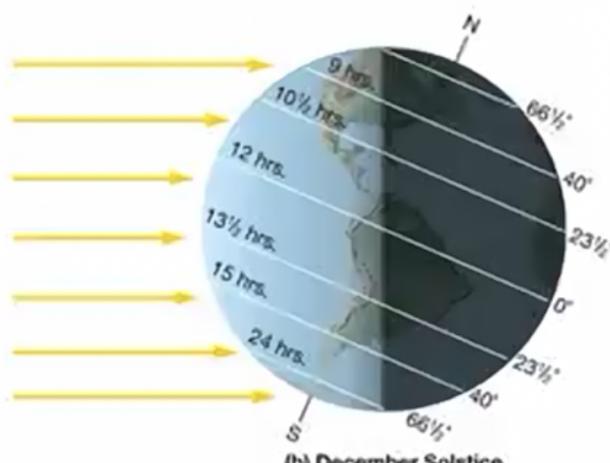
**Seasons.** We see Earth at different seasons as it circles the Sun. In June, the Northern Hemisphere “leans into” the Sun, and those in the North experience summer and have longer days. In December, during winter in the Northern Hemisphere, the Southern Hemisphere “leans into” the Sun and is illuminated more directly. In spring and autumn, the two hemispheres receive more equal shares of sunlight.



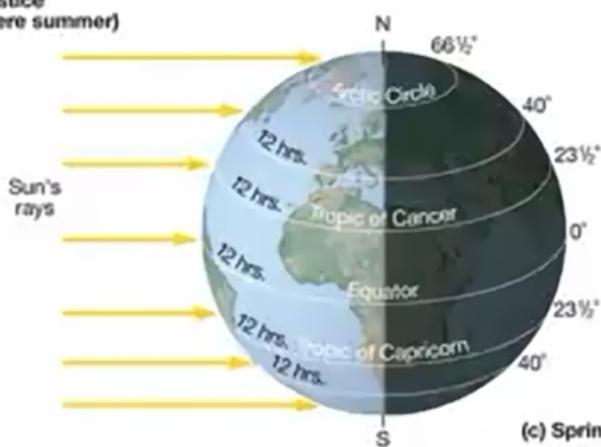
**Figure 4.6 The Sun's Rays in Summer and Winter.** (a) In summer, the Sun appears high in the sky and its rays hit Earth more directly, spreading out less. (b) In winter, the Sun is low in the sky and its rays spread out over a much wider area, becoming less effective at heating the ground.



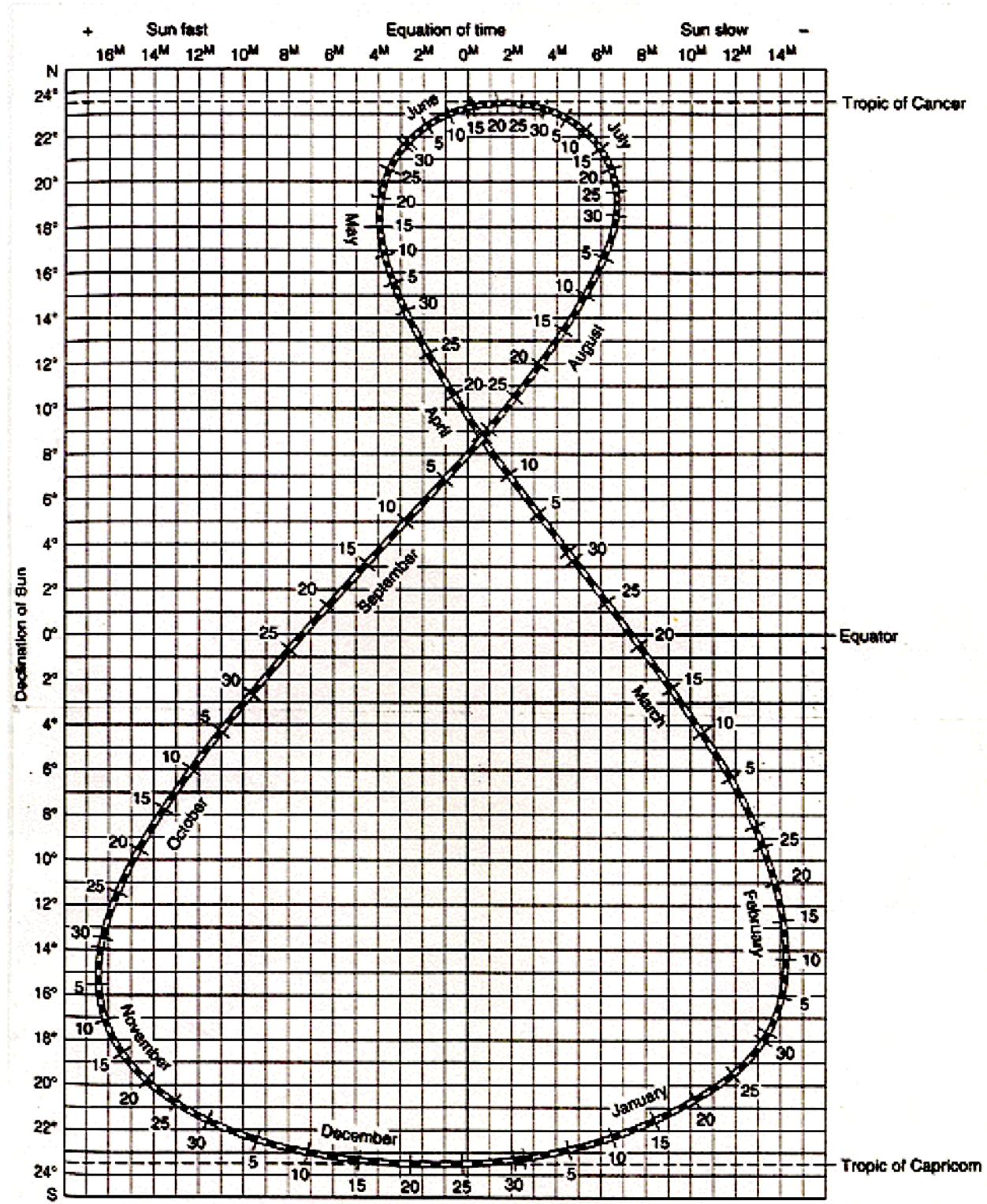
(a) June Solstice  
(Northern Hemisphere summer)



(b) December Solstice  
(Northern Hemisphere winter)

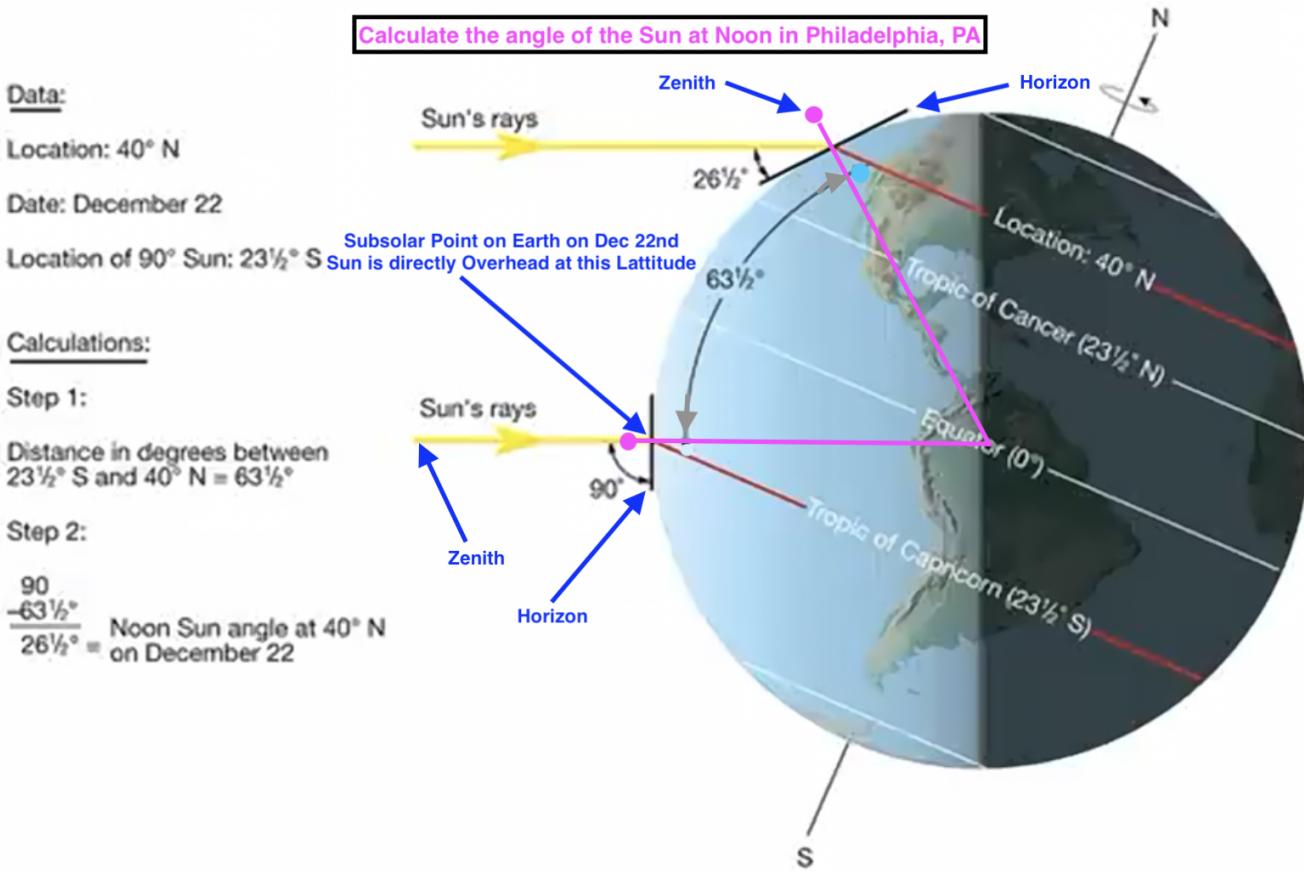


(c) Spring/Fall Equinox



The analemma. Data courtesy of U.S. Coast and Geodetic Survey.

Analemma by US Coast and Geodetic Survey



## A. Calculate Sun's Altitude in Philadelphia, PA on Dec 22nd which is the Winter Solstice in Northern Hemisphere

**TASK 1:** Let's store the Latitude and Longitude of Philadelphia below in decimal degrees for computing

**Philadelphia Latitude:**  $39^{\circ} 57' 9.3''$  N    **Philadelphia Longitude:**  $75^{\circ} 9' 54.8''$  W

- Note: North Latitudes are considered Positive and South Negative
- Note: East Longitudes are considered Positive and West Negative

Philadelphia Latitude =  $39.95$  degrees

Philadelphia Longitude =  $-75.17$  degrees

## **TASK 2:** Let's calculate the altitude of the Sun above the horizon in Philadelphia at Winter Solstice in the Northern Hemisphere

1. To do this we first need **Philadelphia's latitude which is calculated above to be  $+39.95$**
2. We then need the **latitude of the sub-solar point** on Earth on Dec 22nd. In other words, this is the latitude at which the Sun is directly overhead.
3. At Winter Solstice in NH, Sun is directly overhead any city on the Tropic of Capricorn. At other dates, we can refer to the Analemma chart above.
4. The **latitude of the sub-solar point is  $-23.5$  deg** as read from the Analemma chart

5. We then find the ***angular separation or angular distance between these two lattitudes***
6. Finally the ***Sun Altitude*** or Sun Elevation above the horizon on Dec 22nd is calculated to be ***90 - angular distance***

Philadelphia Latitude = 39.95 degrees

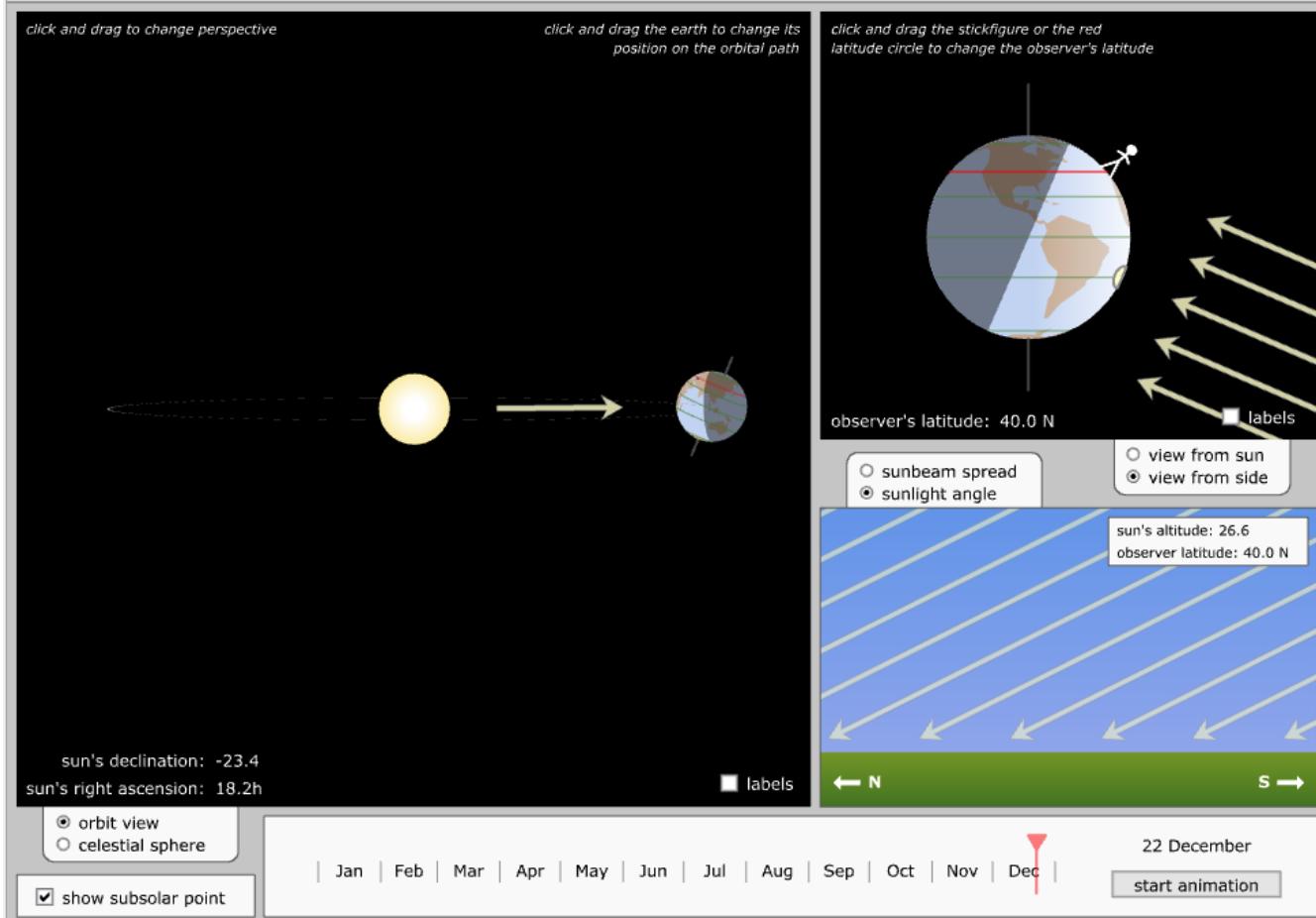
Philadelphia Longitude = -75.17 degrees

## TASK 2: Let's calculate the altitude of the Sun above the horizon in Philadelphia at Winter Solstice in the Northern Hemisphere

1. To do this we first need ***Philadelphia's latitude which is calculated above to be +39.95***
2. We then need the ***latitude of the sub-solar point*** on Earth on Dec 22nd. In other words, this is the latitude at which the Sun is directly overhead.
3. At Winter Solstice in NH, Sun is directly overhead any city on the Tropic of Capricorn. At other dates, we can refer to the Analemma chart above.
4. The ***latitude of the sub-solar point is -23.5 deg*** as read from the Analemma chart
5. We then find the ***angular separation or angular distance between these two lattitudes***
6. Finally the ***Sun Altitude*** or Sun Elevation above the horizon on Dec 22nd is calculated to be ***90 - angular distance*** for locations in NH and ***90 + angular distance*** for locations in SH

Sun Altitude in Philadelphia at Winter Solstice (Dec 22nd) = 26.55 deg

## TASK 3: Using the [Seasons Simulator linked here](#) snapshot a picture of the summer solstice in the Northern hemisphere. Validate the computer Sun Altitude with your calculation above within 5% accuracy.



Percent Error in calculating Sun Altitude = -0.20%

## Sun Angle Calculator: Repeat tasks 1, 2 & 3 above for calculating Sun Elevation at:

- Philadelphia at Winter Solstice in the Northern Hemisphere (See above)
- Seattle on Autumnal Equinox in the Northern Hemisphere (Complete in-class)
- An Equatorial city of your choice at Autumnal Equinox
- Stockholm at Winter Solstice in the Northern Hemisphere
- Sydney at Summer Solstice in the Southern Hemisphere
- A city of your choice in the Tropic of Capricorn at Vernal Equinox

## B. Calculate Sun's Altitude in Seattle, WA on Sep 21

**TASK 1:** Let's store the Latitude and Longitude of Seattle below in decimal degrees for computing

**Seattle Latitude: 47° 7' N Seattle Longitude: 122° 2' W**

- Note: North Latitudes are considered Positive and South Negative
- Note: East Longitudes are considered Positive and West Negative

Seattle Latitude = 47.12 degrees

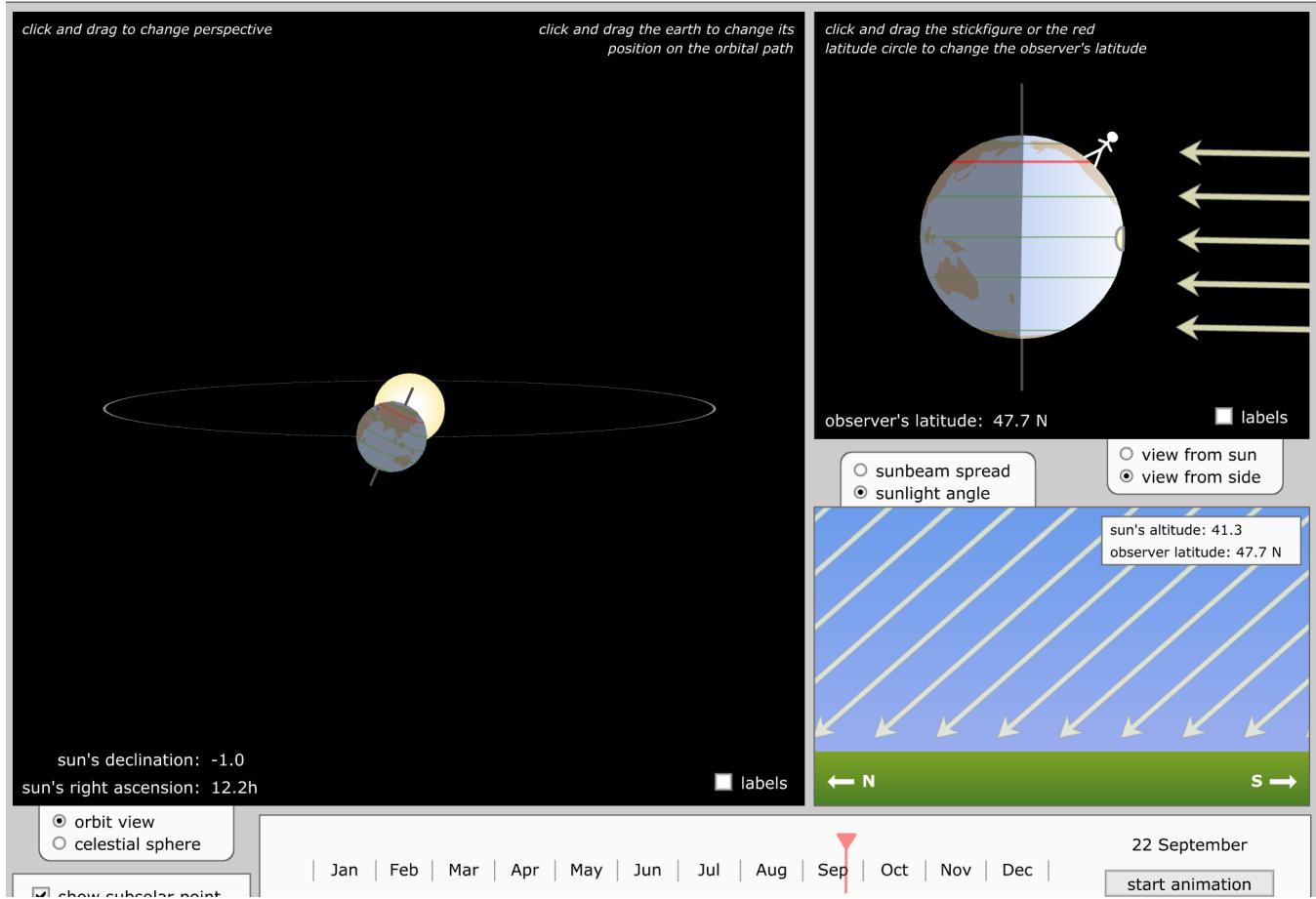
Seattle Longitude = -122.03 degrees

## **TASK 2: Let's calculate the altitude of the Sun above the horizon in Seattle at Autumnal Equinox in the Northern Hemisphere**

1. To do this we first need **Seattle's latitude which is calculated above to be +47.12**
2. We then need the **latitude of the sub-solar point** on Earth on Sep 21st. In other words, this is the latitude at which the Sun is directly overhead.
3. Let's refer to the Analemma chart above for the subsolar point on Sep 21st.
4. The **latitude of the sub-solar point is +1 deg** as read from the Analemma chart
5. We then find the **angular separation or angular distance between these two latitudes**
6. Finally the **Sun Altitude** or Sun Elevation above the horizon on Dec 22nd is calculated to be **90 - angular distance** for locations in NH and **90 + angular distance** for locations in SH

Sun Altitude in Seattle at Autumnal Equinox = 43.38 deg

## **TASK 3: Using the [Seasons Simulator linked here](#) snapshot a picture of the summer solstice in the Northern hemisphere. You can also get a more accurate value from the US Naval Observatory [here](#). Validate the computer Sun Altitude with your calculation above within 5% accuracy.**



Percent Error in calculating Sun Altitude = 1.84%

## E. Calculate Sun's Altitude in Sydney, WA on Summer Solstice in the SH (Dec 21)

**TASK 1:** Let's store the Latitude and Longitude of Sydney below in decimal degrees for computing

**Sydney Latitude: 33° 52' 11" S Sydney Longitude: 151° 12'30" E**

- Note: North Latitudes are considered Positive and South Negative
- Note: East Longitudes are considered Positive and West Negative

Sydney Latitude = -33.87 degrees

Sydney Longitude = 151.21 degrees

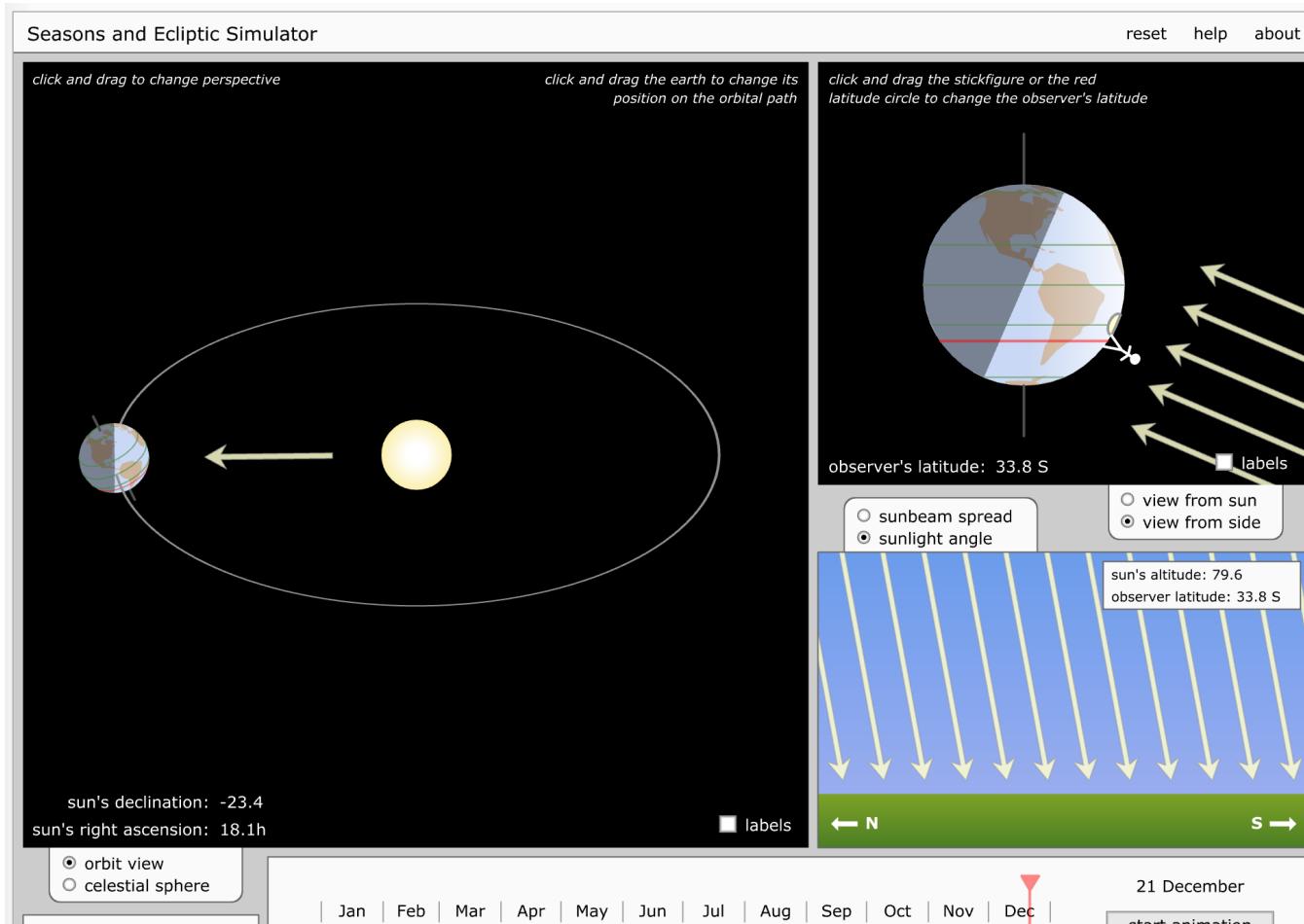
**TASK 2:** Let's calculate the altitude of the Sun above the horizon in Sydney at Summer Solstice in the Southern Hemisphere

1. To do this we first need **Sydney's latitude which is calculated above to be -33.87**

2. We then need the **latitude of the sub-solar point** on Earth on Dec 21st. In other words, this is the latitude at which the Sun is directly overhead.
3. Let's refer to the Analemma chart above for the subsolar point on Dec 21st.
4. The **latitude of the sub-solar point is -23.5 deg** as read from the Analemma chart
5. We then find the **angular separation or angular distance between these two latitudes**
6. Finally the **Sun Altitude** or Sun Elevation above the horizon on Dec 22nd is calculated to be **90 - angular distance** for locations in NH and **90 + angular distance** for locations in SH

Sun Altitude in Sydney at Summer Solstice in SH = 79.63 deg

**TASK 3: Using the [Seasons Simulator](#) linked here** snapshot a picture of the summer solstice in the Northern hemisphere. [You can also get a more accurate value from the US Naval Observatory here](#). Validate the computer Sun Altitude with your calculation above within 5% accuracy.



Percent Error in calculating Sun Altitude = -0.20%

**Sun Angle Calculator: Repeat tasks 1, 2 & 3 above for calculating Sun Elevation at:**

- a. Philadelphia at Winter Solstice in the Northern Hemisphere (See above)

- b. Seattle on Autumnal Equinox in the Northern Hemisphere (Complete in-class)
- c. An Equatorial city of your choice at Autumnal Equinox
- d. Stockholm at Winter Solstice in the Northern Hemisphere
- e. Sydney at Summer Solstice in the Southern Hemisphere
- f. A city of your choice in the Tropic of Capricorn at Vernal Equinox

## B. Calculate Sun's Altitude in Seattle, WA on the Autumnal Equinox in the Northern Hemisphere

**TASK 1:** Let's store the Latitude and Longitude of Philadelphia below in decimal degrees for computing

**Seattle Latitude: 47° 7' N Seattle Longitude: 122° 2' W**

- Note: North Latitudes are considered Positive and South Negative
- Note: East Longitudes are considered Positive and West Negative

Seattle Latitude = 47.12 degrees

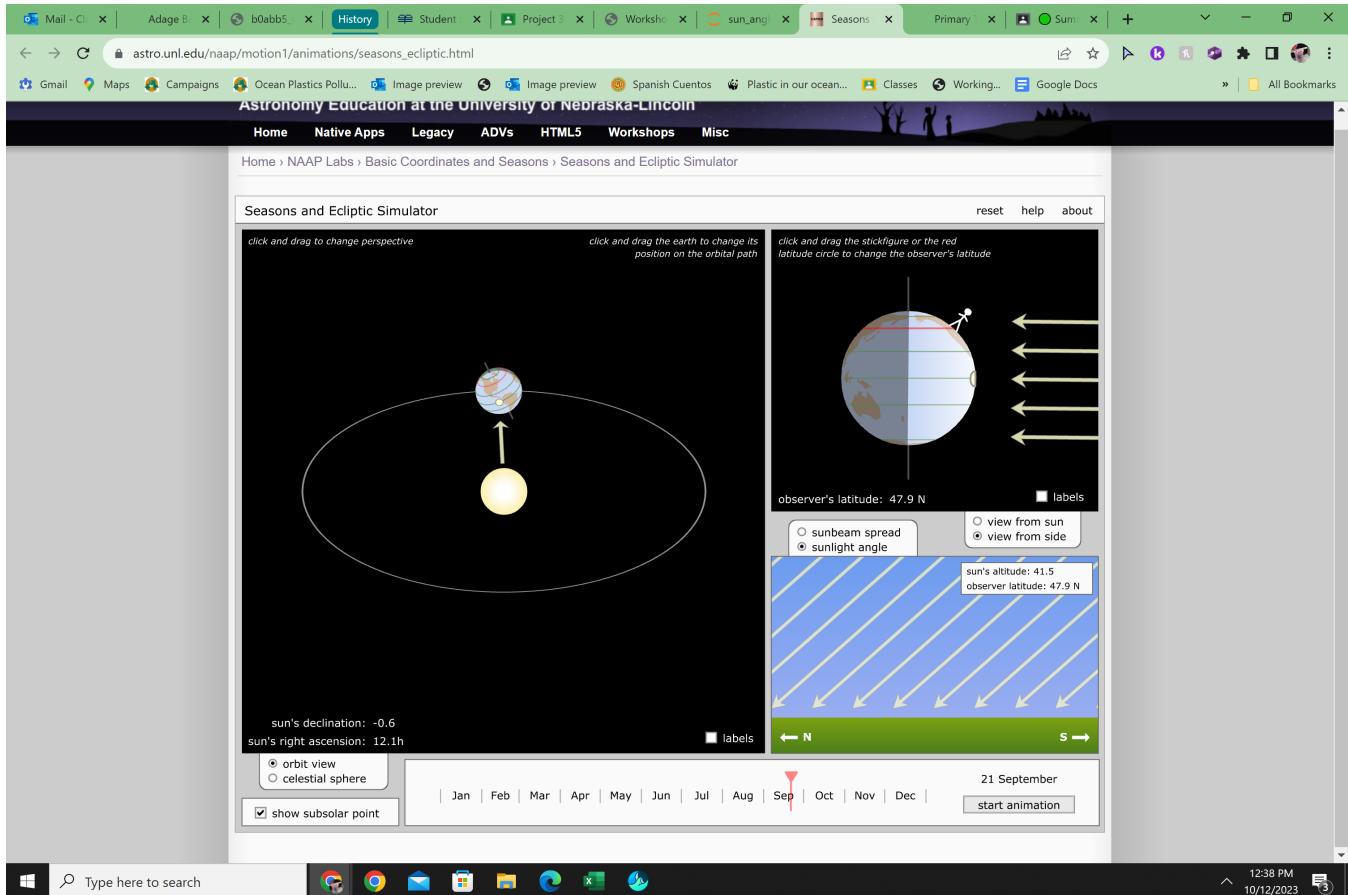
Seattle Longitude = -122.03 degrees

**TASK 2:** Let's calculate the altitude of the Sun above the horizon in Philadelphia at Winter Solstice in the Northern Hemisphere

1. To do this we first need ***Philadelphia's latitude which is calculated above to be +39.95***
2. We then need the ***latitude of the sub-solar point*** on Earth on Dec 22nd. In other words, this is the latitude at which the Sun is directly overhead.
3. At Winter Solstice in NH, Sun is directly overhead any city on the Tropic of Capricorn. At other dates, we can refer to the Analemma chart above.
4. The ***latitude of the sub-solar point is -23.5 deg*** as read from the Analemma chart
5. We then find the ***angular separation or angular distance between these two latitudes***
6. Finally the ***Sun Altitude*** or Sun Elevation above the horizon on Dec 22nd is calculated to be ***90 - angular distance***

Sun Altitude in Seattle at Winter Solstice (Sept 21nd) = 43.68 deg

**TASK 3:** Using the [Seasons Simulator linked here](#) snapshot a picture of the summer solstice in the Northern hemisphere. Validate the computer Sun Altitude with your calculation above within 5% accuracy.



Percent Error in calculating Sun Altitude = 5.26%

**A. Calculate Sun's Altitude in Philadelphia, PA on Dec 22nd which is the Winter Solstice in Northern Hemisphere**

**E. Calculate Sun's Altitude in Santiago, Chile on Summer Solstice in the SH (Dec 21)**

**TASK 1: Let's store the Latitude and Longitude of Sydney below in decimal degrees for computing**

**Santiago Latitude: -33.5**

- Note: North Latitudes are considered Positive and South Negative
- Note: East Longitudes are considered Positive and West Negative

Santiago Latitude = -33.50 degrees

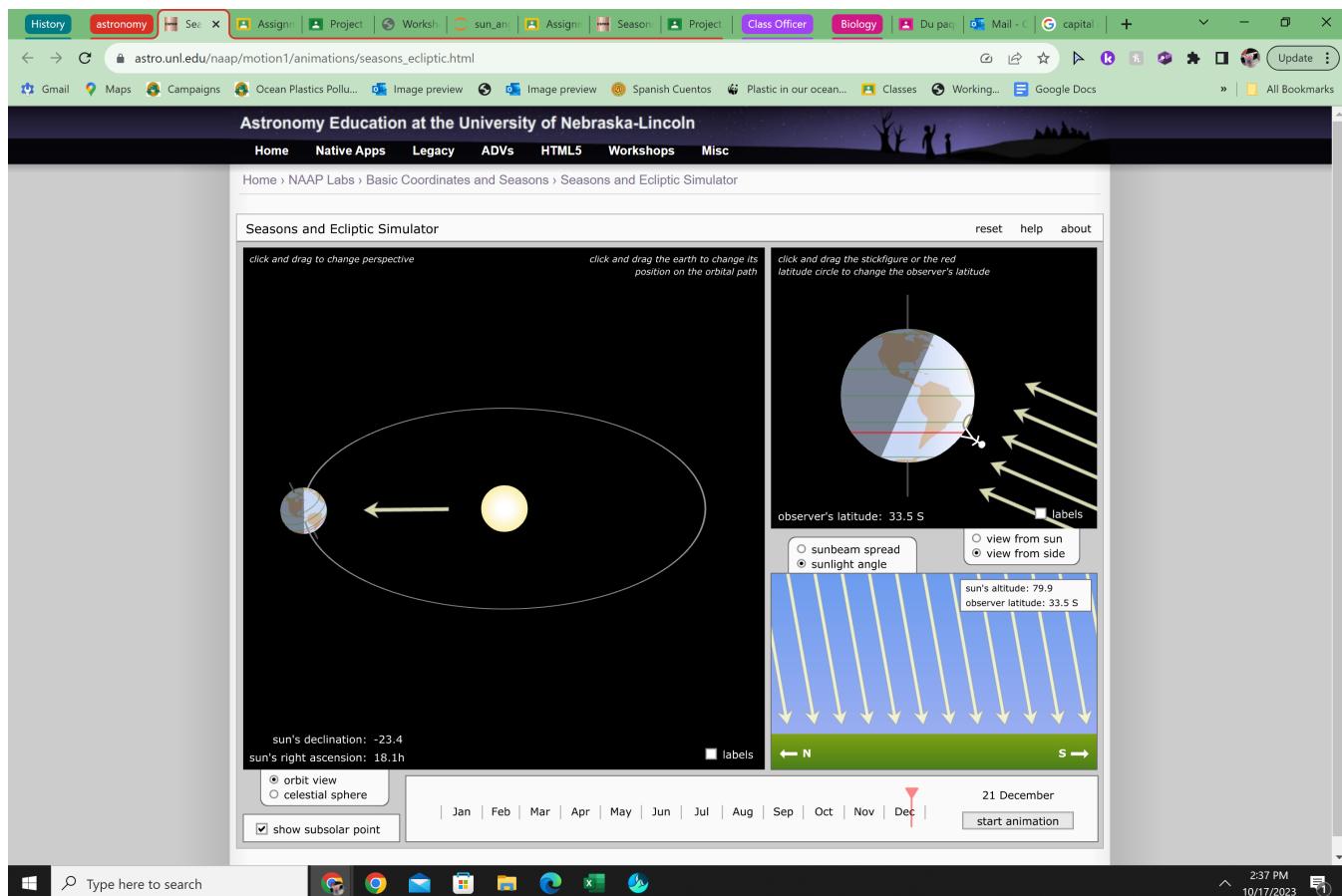
**TASK 2: Let's calculate the altitude of the Sun above the horizon in Sandiago at Winter Solstice in the Northern Hemisphere**

1. To do this we first need **Sandagos's lattitude which is calculated above to be +39.95**

2. We then need the ***latitude of the sub-solar point*** on Earth on Dec 22nd. In other words, this is the latitude at which the Sun is directly overhead.
3. At Winter Solstice in NH, Sun is directly overhead any city on the Tropic of Capricorn. At other dates, we can refer to the Analemma chart above.
4. The ***latitude of the sub-solar point is -23.5 deg*** as read from the Analemma chart
5. We then find the ***angular separation or angular distance between these two latitudes***
6. Finally the ***Sun Altitude*** or Sun Elevation above the horizon on Dec 22nd is calculated to be ***90 - angular distance***

Sun Altitude in Santiago at Winter Solstice (Sept 21nd) = 80.00 deg

**TASK 3: Using the [Seasons Simulator linked here](#) snapshot a picture of the summer solstice in the Northern hemisphere. Validate the computer Sun Altitude with your calculation above within 5% accuracy.**



Percent Error in calculating Sun Altitude = 0.13%