🟣 **See Chandru Grading Comments from 11/4/23 below**

1. Nice work!

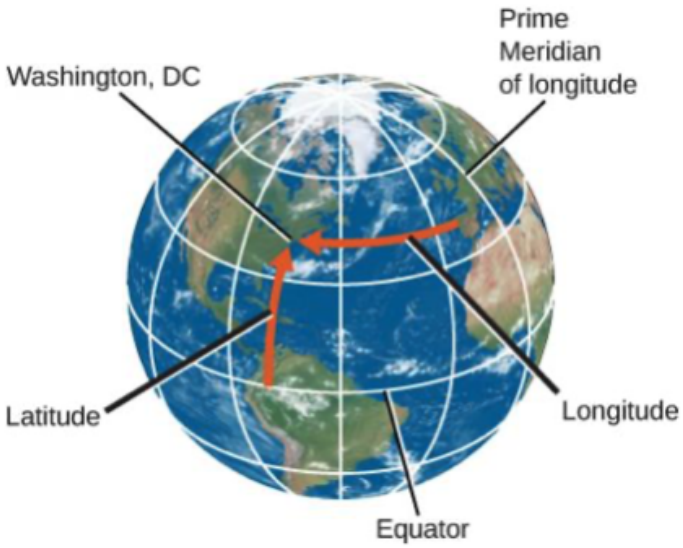
✅ **You have a 100% grade on this notebook**

✅ **Correct Any Errors identfied above for an improved grade**

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

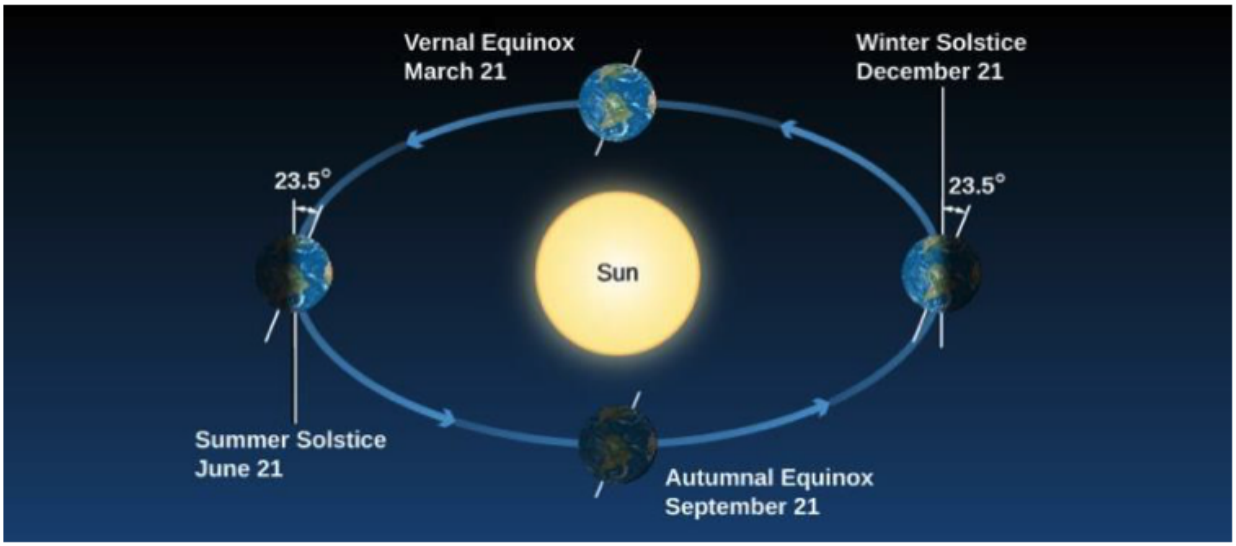
FIGURE 4.2

openstax™



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.

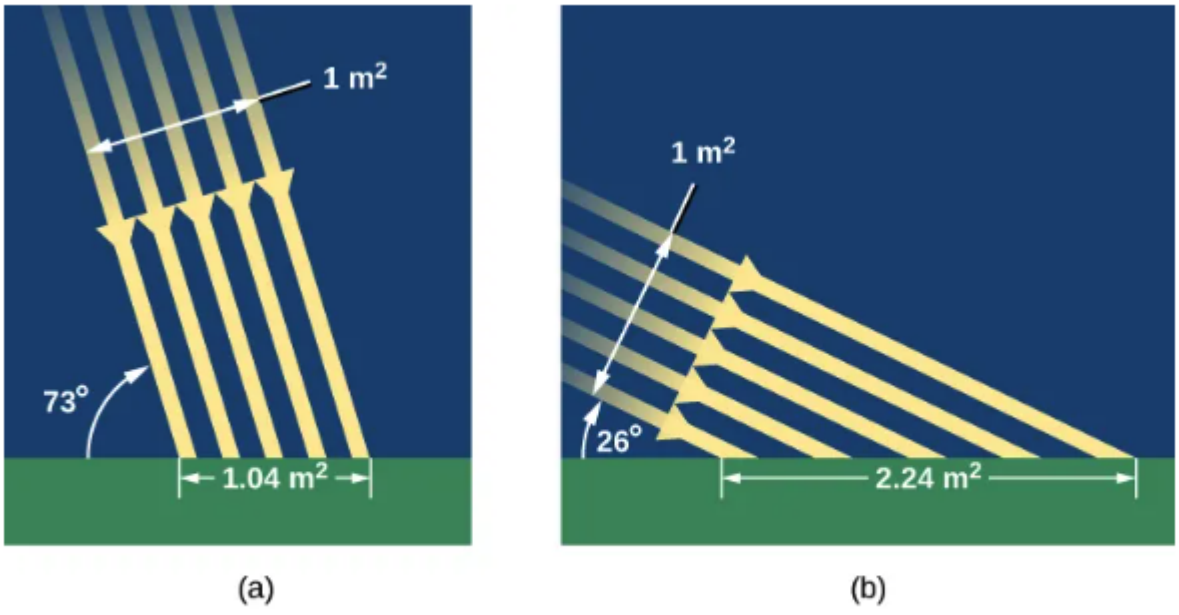
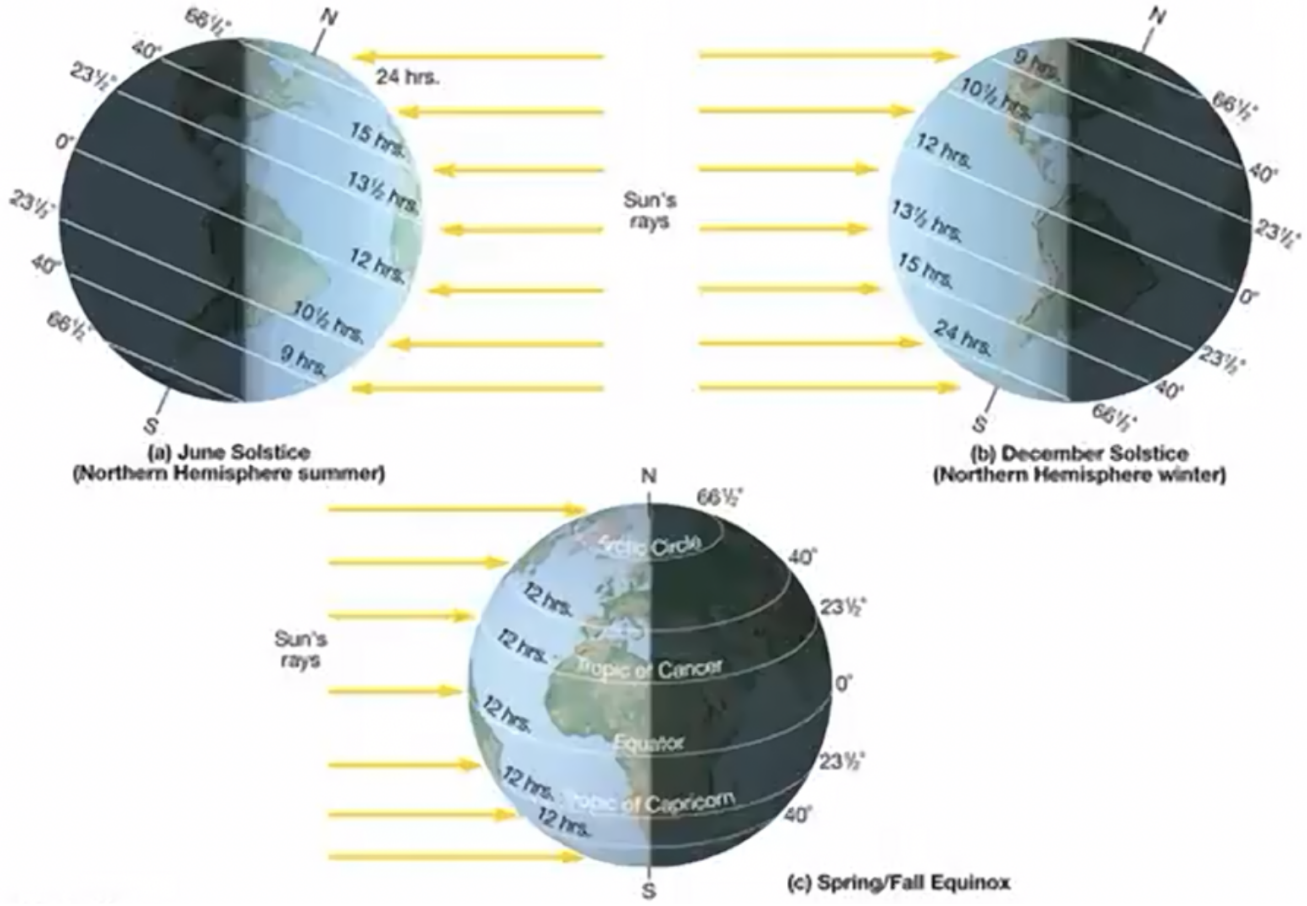
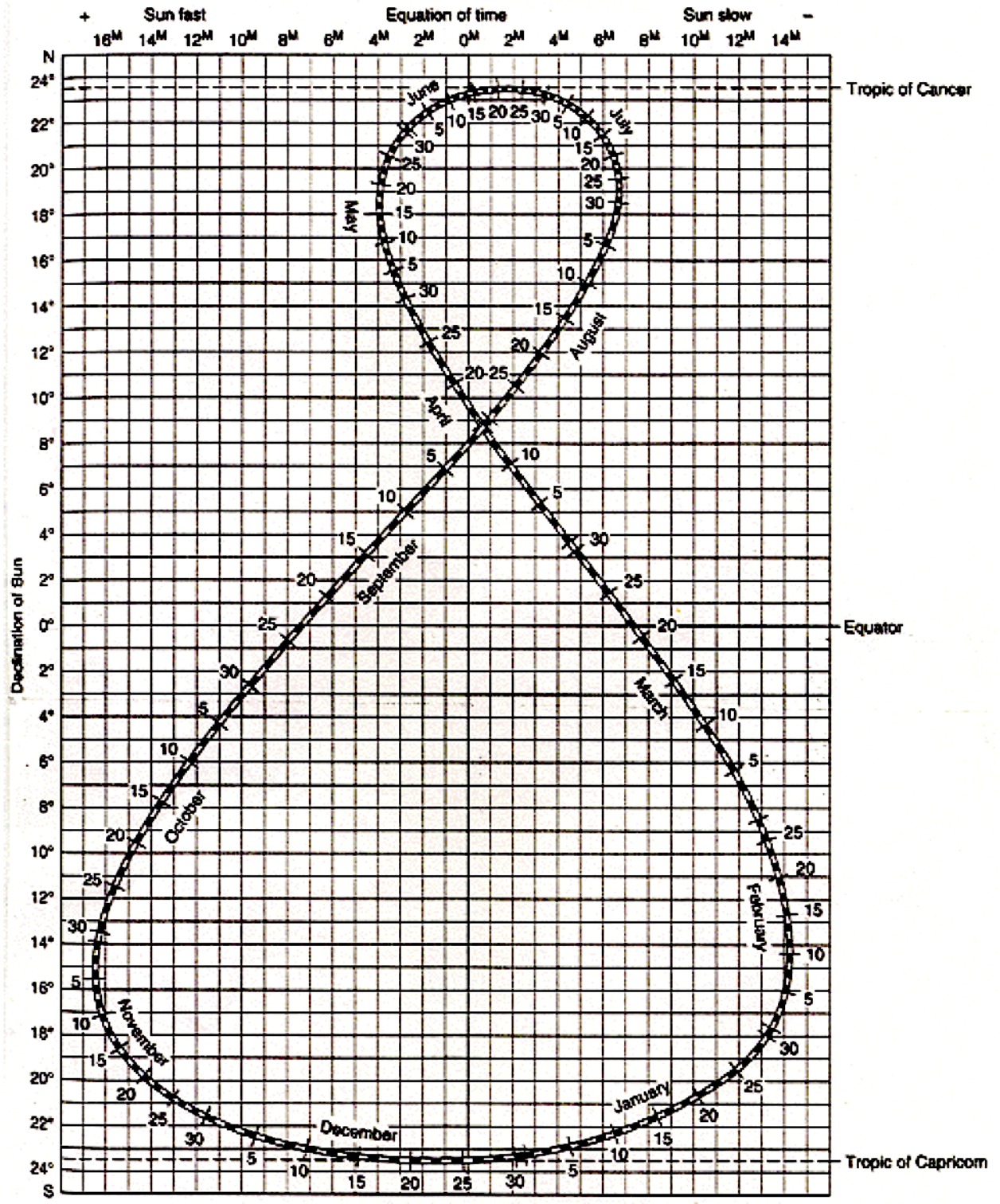


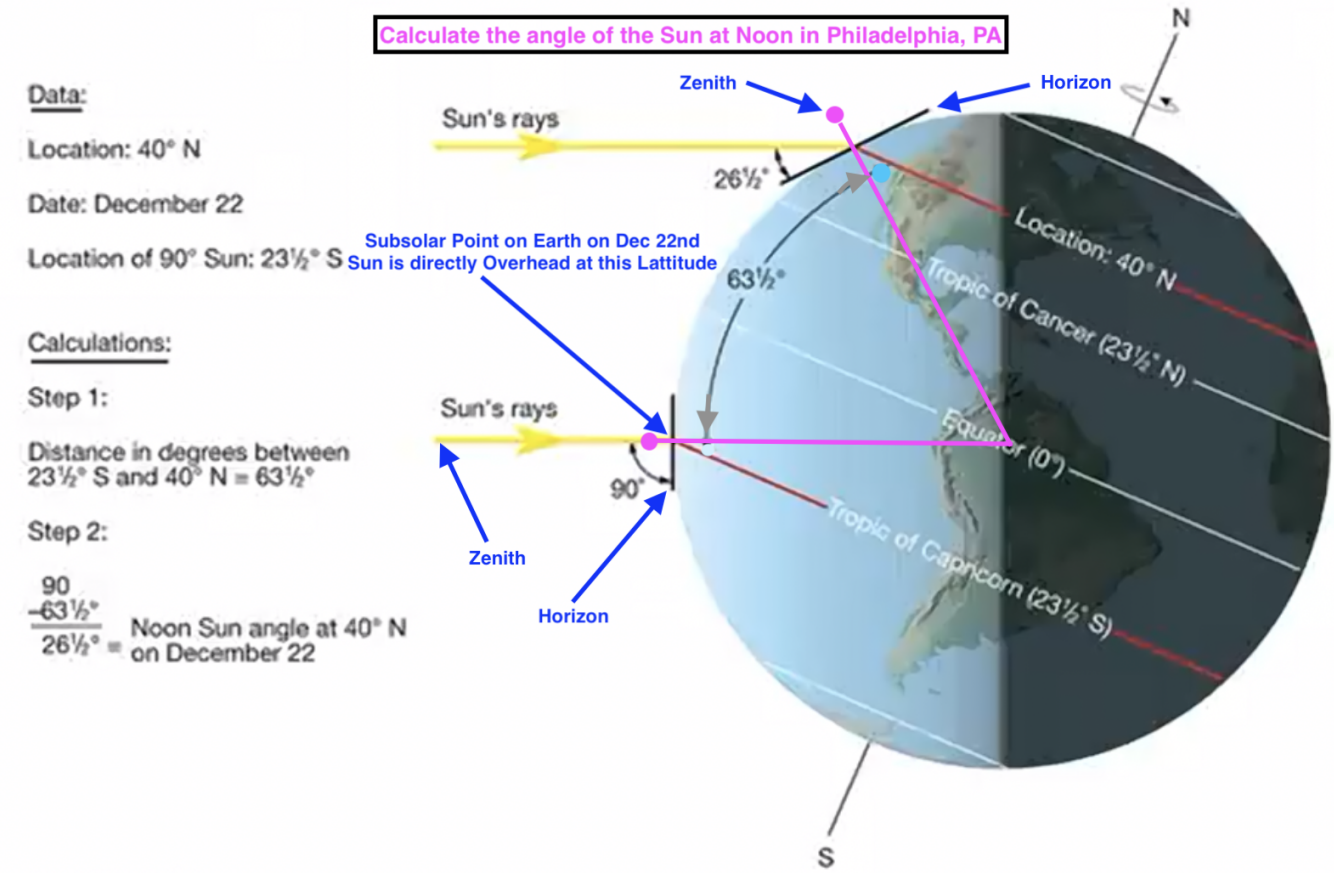
Figure 4.6 The Sun's Rays in Summer and Winter. (a) In summer, the Sun appears high in the sky and its rays hit Earth more directly, spreading out less. (b) In winter, the Sun is low in the sky and its rays spread out over a much wider area, becoming less effective at heating the ground.


N
S
66½°
40°
23½°
0°
23½°
40°
66½°
24 hrs.
15 hrs.
13½ hrs.
12 hrs.
10½ hrs.
9 hrs.
Sun's rays
(a) June Solstice
(Northern Hemisphere summer)
9 hrs.
10½ hrs.
12 hrs.
13½ hrs.
15 hrs.
24 hrs.
(b) December Solstice
(Northern Hemisphere winter)
Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn
12 hrs.
(c) Spring/Fall Equinox



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

Analemma by US Coast and Geodetic Survey



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

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 Lattitude and Longitude of Philadelphia below in decimal degrees for computing

Philadelphia Lattitude: 39° 57' 9.3" N Philadelphia Longitude: 75° 9' 54.8" W

- Note: North Latitudes are considered Positive and South Negative

- Note: East Longitudes are considered Positive and West Negative

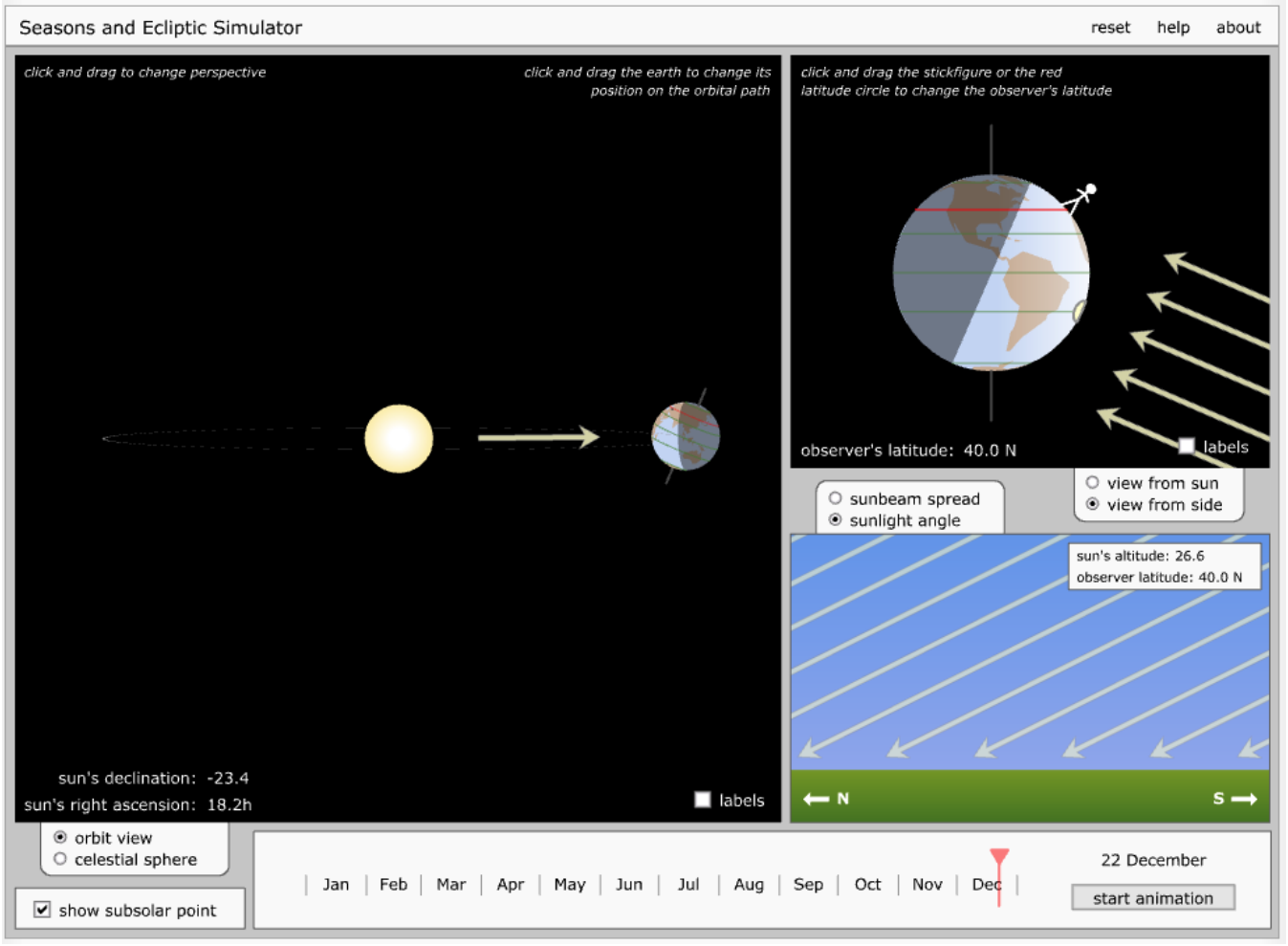
```
Philadelphia Lattitude = 39.95 degrees

Philadelphia Longitude = −75.17 degrees
```

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

1. To do this we first need ***Philadelphia's lattitude which is calculated above to be +39.95***
2. We then need the ***lattitude of the sub-solar point*** on Earth on Dec 22nd. In other words, this is the lattitude at which the Sun is directly overhead.
3. At Winter Solstice in NH, Sun is directly overhead any city on the Tropic of Caprocorn. At other dates, we can refer to the Analemma chart above.
4. The ***lattitude 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 Altitiude = 0.20%
```

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

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

Seattle Lattitude: 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 Lattitude = 47.12 degrees
```

```
Seattle Longitude = -122.03 degrees
```

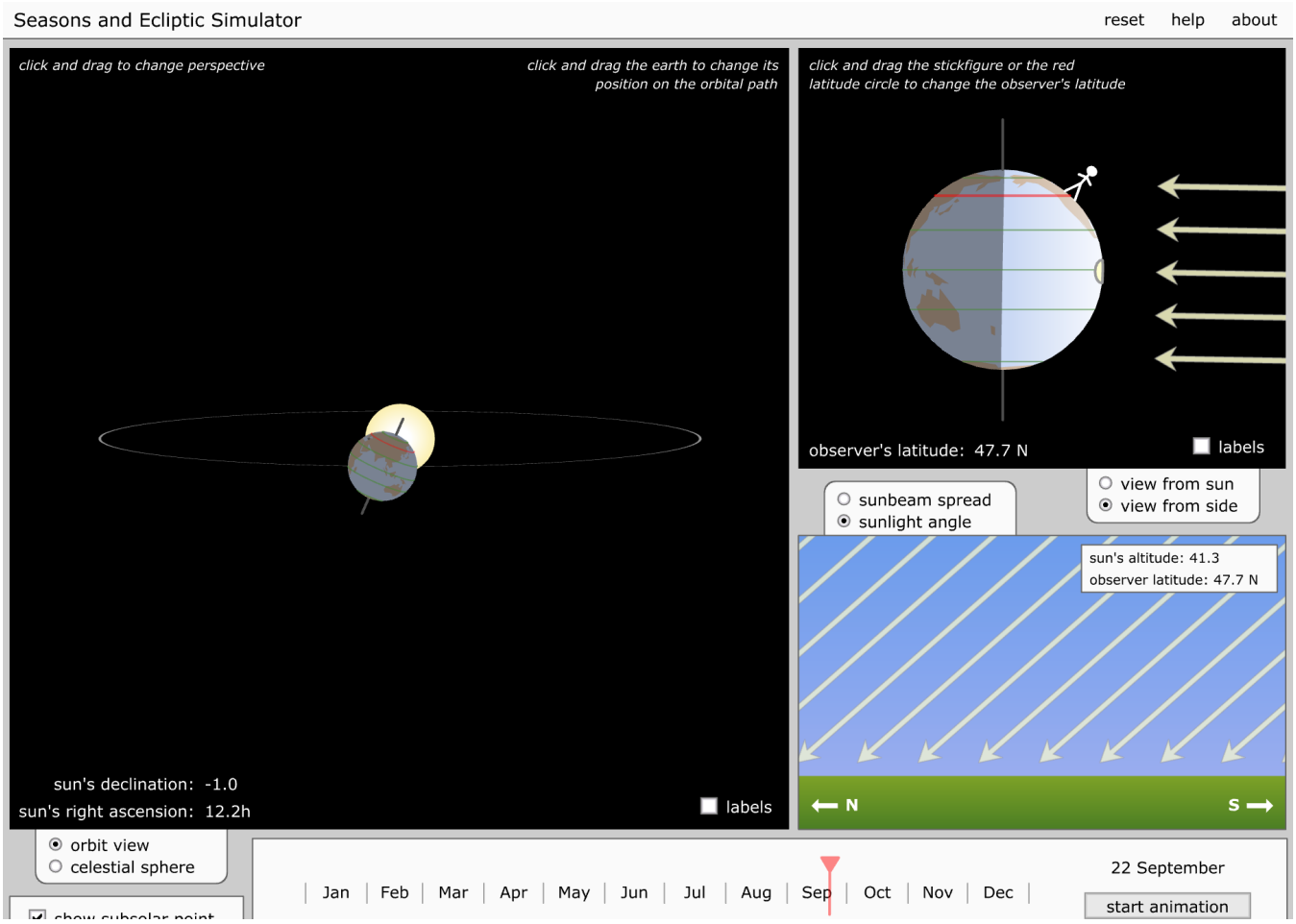
TASK 2: Let's calculate the altitude of the Sun above the horizon in Seattle at Autumnal Equinox in the Northern Hemisphere

1. To do this we first need ***Seattle's lattitude which is calculated above to be +47.12***
2. We then need the ***lattitude of the sub-solar point*** on Earth on Sep 21st. In other words, this is the lattitude 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 ***lattitude 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 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 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 Altitiude = 1.84%
```

C. Calculate Sun's Altitude in Cali, CO on the Autumnal Equinox

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

Cali Lattitude: 3.45° 7' N Cali Longitude: 76.5° 59'W

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

```
Cali Lattitude = 3.57 degrees
```

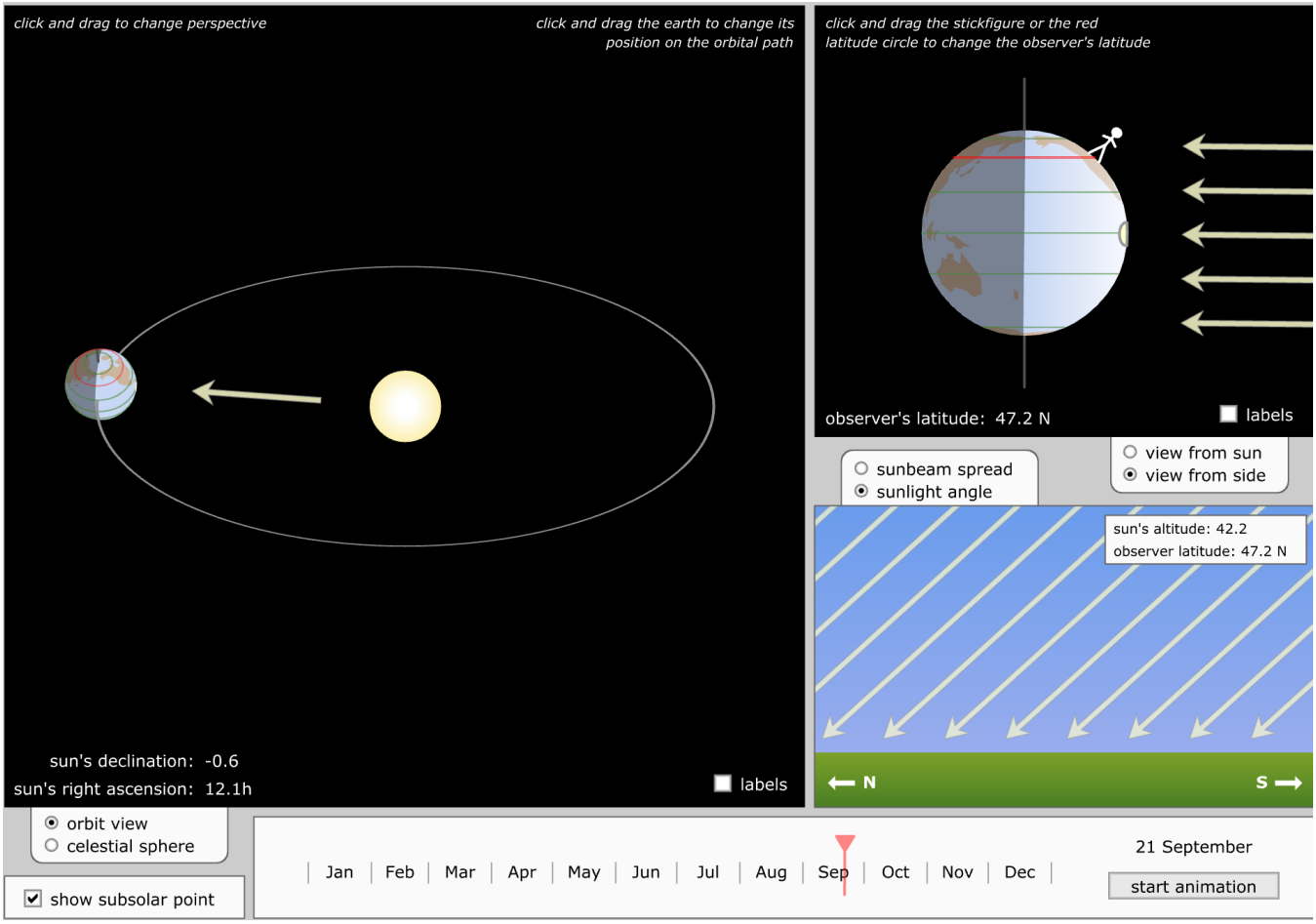
```
Cali Longitude = −122.03 degrees
```

TASK 2: Let's calculate the altitude of the Sun above the horizon in Cali at Autumnal Equinox

1. To do this we first need ***Seattle's lattitude which is calculated above to be +47.12***
2. We then need the ***lattitude of the sub-solar point*** on Earth on Sep 21st. In other words, this is the lattitude at which the Sun is directly overhead.
3. At (Autumnal Equinox) in NH, ***Sun is directly overhead any city on the Equator. At other dates, we can refer to the Analemma chart above.***
4. The ***lattitude 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 lattitudes***
6. Finally the ***Sun Altitude*** or Sun Elevation above the horizon on Sep 21st is calculated to be ***90 - angular distance***

```
Sun Altitude in Cali at Autumnal Equinox (Sep 21nd) = 86.93 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 Altitiude = 2.80%
```

D. Calculate Sun's Altitude in Stockholm, SE on Dec 22nd which is the Winter Solstice in Northern Hemisphere

TASK 1: Storing Lattitude and Longitude of Stockholm below in decimal degrees for computing

Stockholm Lattitude: 59° 20' N Stockholm Longitude: -18° 3' W

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

```
Stockholm Lattitude = 59.33 degrees

Stockholm Longitude = -18.05 degrees
```

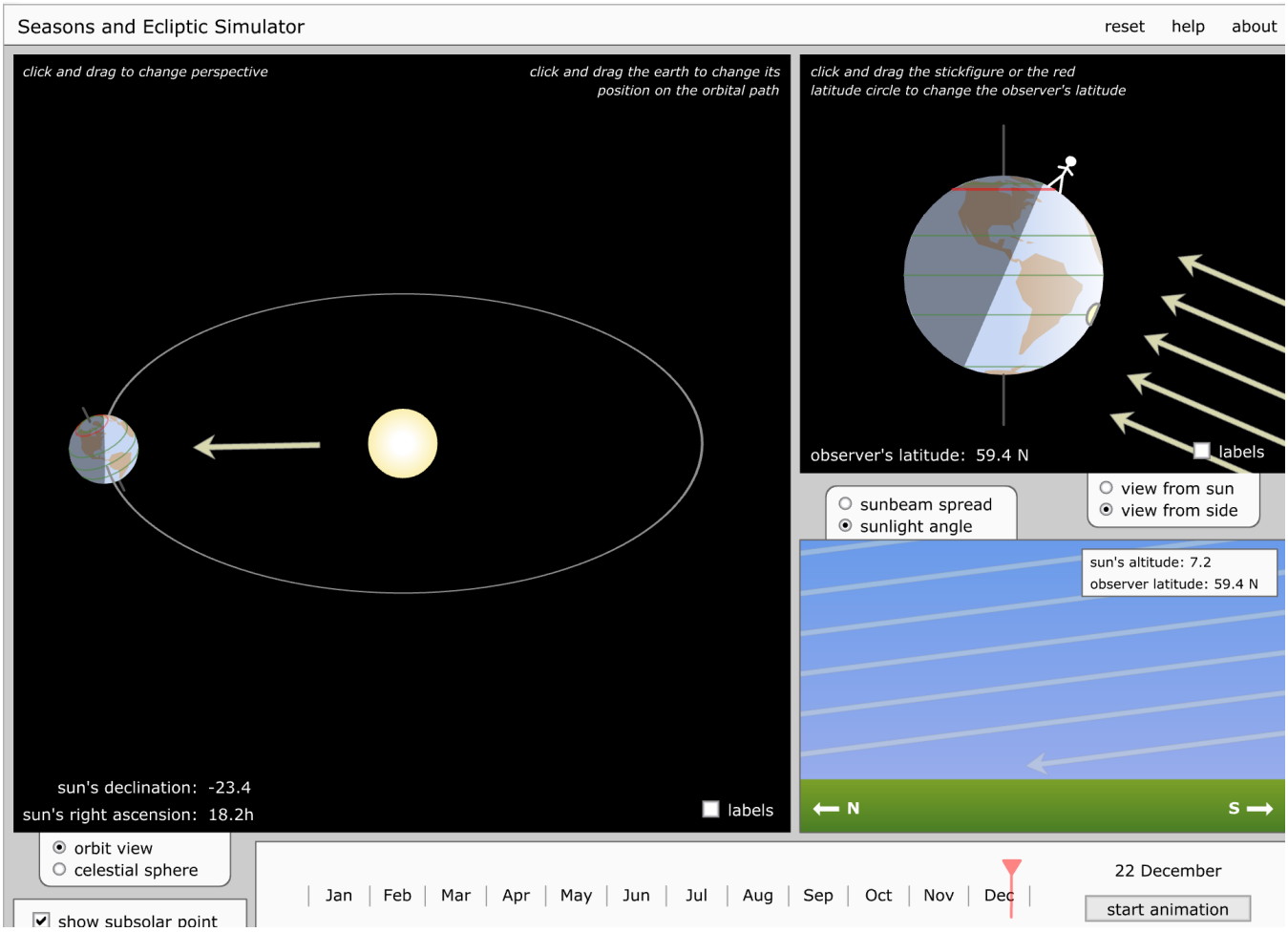
TASK 2: Let's calculate the altitude of the Sun above the horizon in Stockholm at Winter Solstice in the Northern Hemisphere

1. To do this we first need ***Stockholm's lattitude which is calculated above to be +59.33***
2. We then need the ***lattitude of the sub-solar point*** on Earth on Dec 22nd. In other words, this is the lattitude at which the Sun is directly overhead.

3. At Winter Solstice, Sun is directly overhead any city on the Tropic of Caprocorn. At other dates, we can refer to the Analemma chart above.
4. The ***lattitude 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 Stockholm at Winter Solstice (Dec 22nd) = 7.17 deg
```

TASK 3: Screenshot of Seasons Simulator




```
Percent Error in calculating Sun Altitiude = 0.46%
```

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

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

Sydney Lattitude: 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

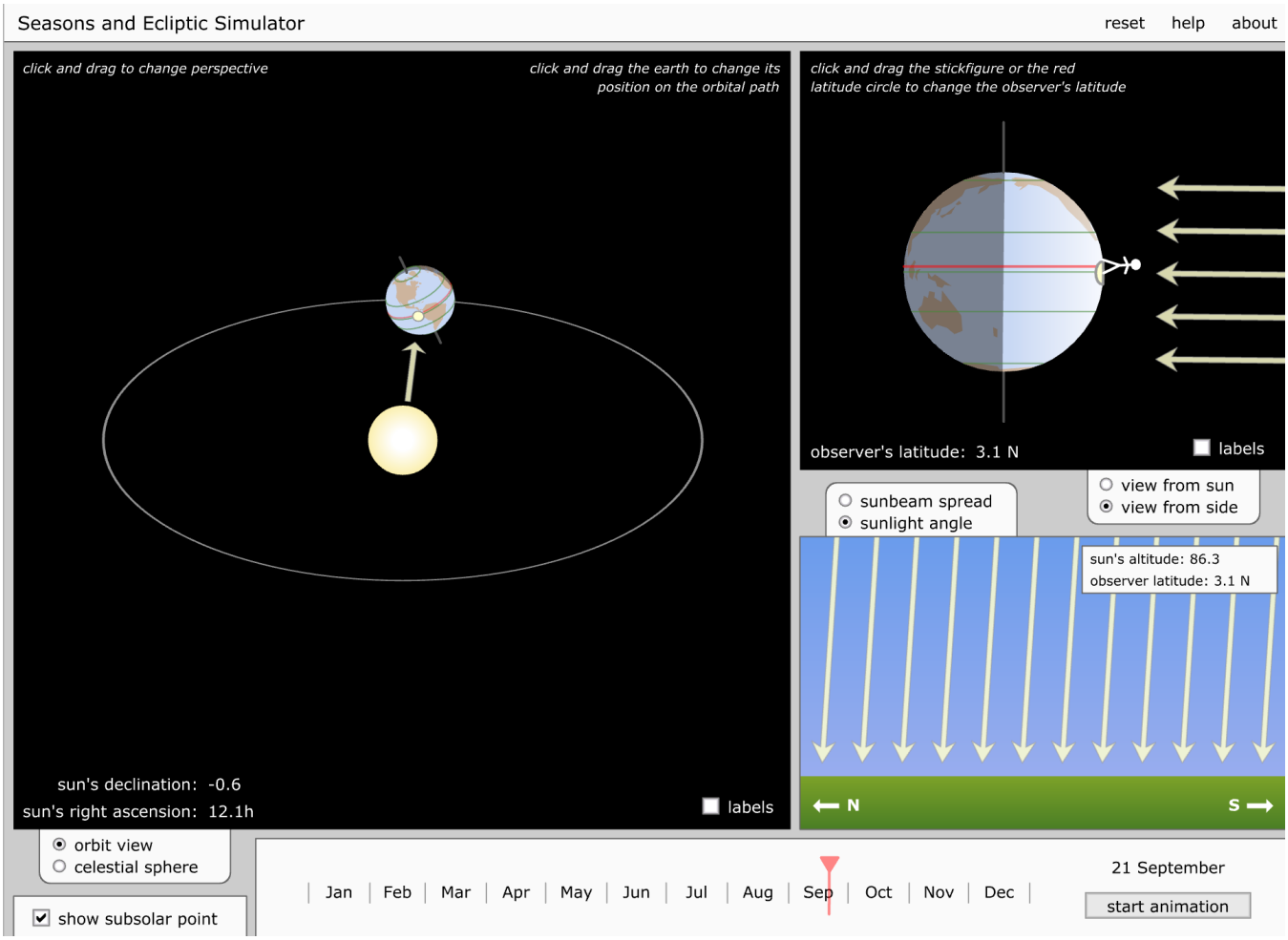
```
Sydney Lattitude = −33.87 degrees

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 lattitude which is calculated above to be -33.87***
2. We then need the ***lattitude of the sub-solar point*** on Earth on Dec 21st. In other words, this is the lattitude 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 ***lattitude 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 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 Altitiude = 0.73%
```

F. Calculate Sun's Altitude in Alice Springs, AU on the Vernal Equinox(March 21)

TASK 1: Let's store the Lattitude and Longitude of Alice Springs below in decimal degrees for computing

Alice springs(AS) Lattitude: 23° 42' N* Alice springs(AS) Longitude: -133° 52' W*

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

```
Alice Springs Lattitude = 23.70 degrees
```

```
Alice Springs Longitude = -133.87 degrees
```

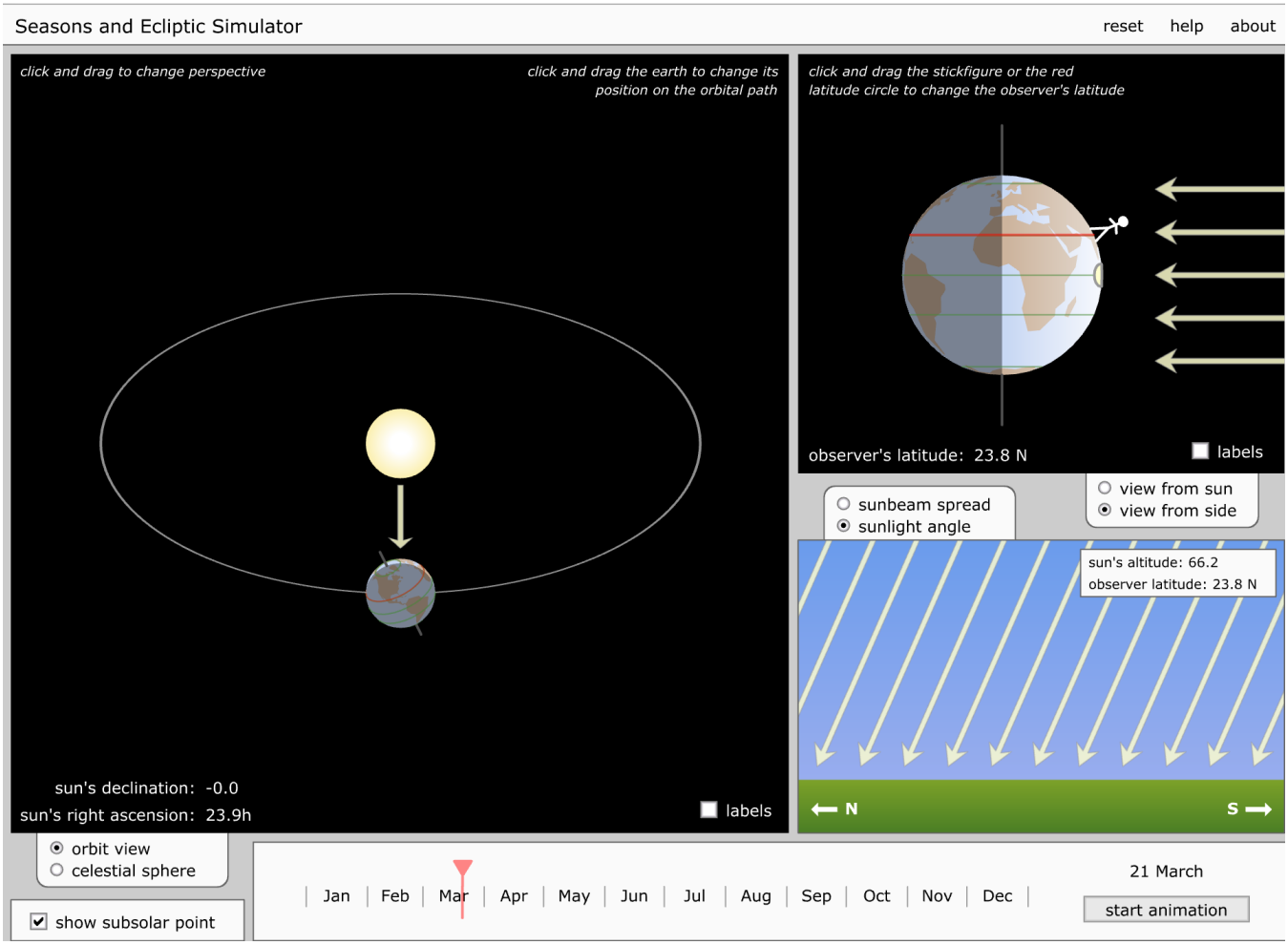
TASK 2: Let's calculate the altitude of the Sun above the horizon in Philadephia at Winter Solstice in the Northern Hemisphere

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

2. We then need the ***lattitude of the sub-solar point*** on Earth on Dec 22nd. In other words, this is the lattitude at which the Sun is directly overhead.
3. At Winter Solstice in NH, Sun is directly overhead any city on the Tropic of Caprocorn. At other dates, we can refer to the Analemma chart above.
4. The ***lattitude 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 Alice Springs at Vernal Equinox(March 21) = 66.30 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 Altitiude = 0.15%
```