

Guided Notes

Earth-Moon-Sun System

Celestial Observations
Constellations
Star Trail Photos
Path of the Sun
Celestial Spheres
Solar Time
Shadows

1. What are the objects we see in outer space?

- **Celestial objects: all objects observed in the sky during the day or night outside of Earth's atmosphere**
- **Examples: planets, moon, stars (constellations), comets**
- **Non-examples: airplanes, birds, clouds**

2. What are constellations?

- **Constellation: a group of stars visible in the night sky that appear to make a pattern**

3. Why do celestial objects appear to move through our sky?

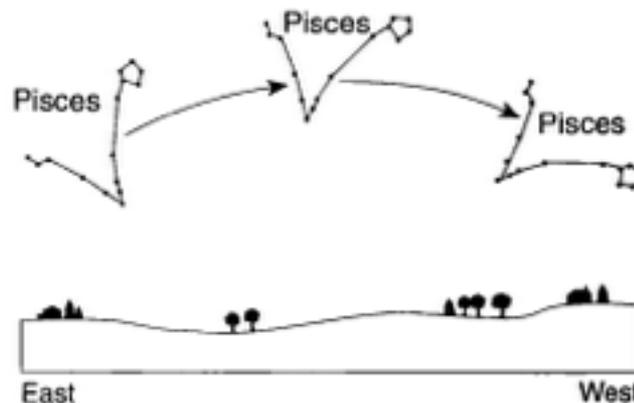
- **Apparent Motion: the appearance of an objects motion in the sky (caused by Earth's rotation)**
- **Celestial objects "appear" to move from east to west across sphere in a circular or arc-shaped path at a rate of 15° per hour (Earth's rate of rotation).**

3. Why do celestial objects appear to move through our sky?

- **Examples:**

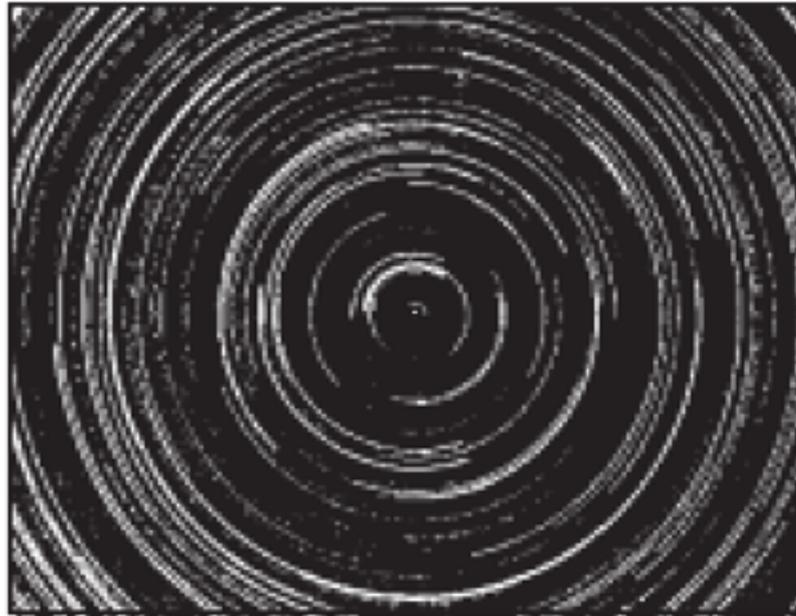
1) Daily rising & setting of the Sun

2) Movement of the Moon, planets, and stars across the night sky



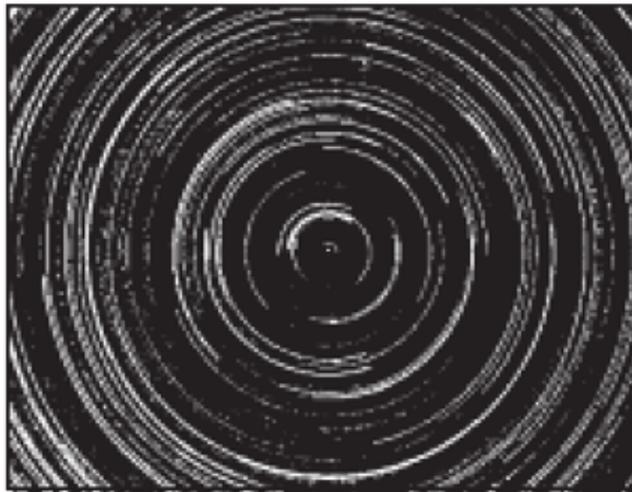
4. How can we analyze the daily movement of celestial objects?

- **Star trails photos: long exposure photographs of the night sky show stars appearing to move at a rate of 15° per hour (Earth's rate of rotation).**



4. How can we analyze the daily movement of celestial objects?

- Polaris is an exception. It does not appear to move because it is located directly above the North Pole.
- The other stars appear to rotate counterclockwise around Polaris.



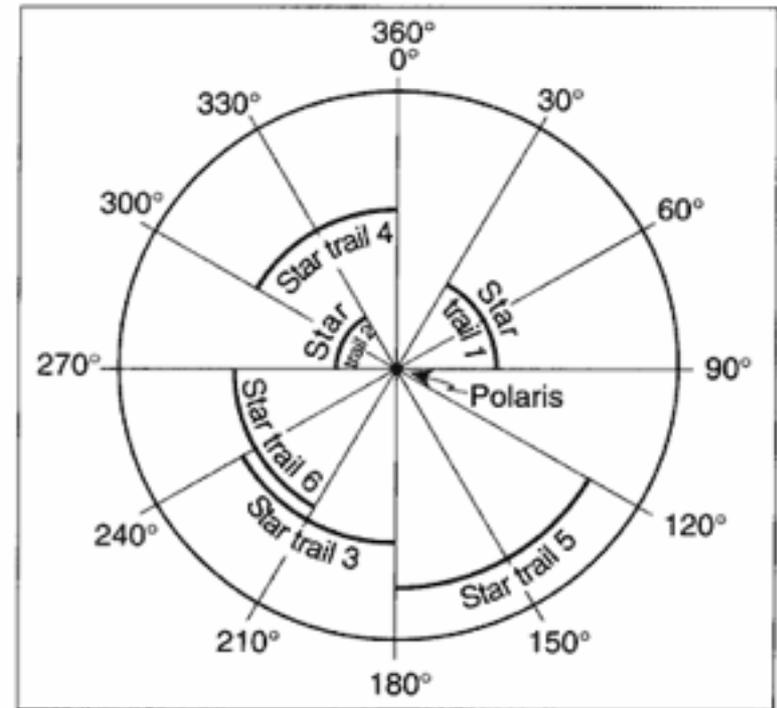
4. How can we analyze the daily movement of celestial objects?

- You can use the angular measurement of the star trail to determine the number of hours that have passed.

$$\# \text{ of Hours} = \frac{\text{Angular Measurement (degrees)}}{15 \text{ degrees per hour}}$$

4. How can we analyze the daily movement of celestial objects?

Example: A camera was placed outside at night and pointed directly at Polaris and several other stars. The lens was kept open and a time-exposure photograph was taken. The diagram to the right represents that photograph of Polaris and star trails, with an angular protractor to measure apparent motion. How many hours was the lens kept open to create the star trails in this photograph?

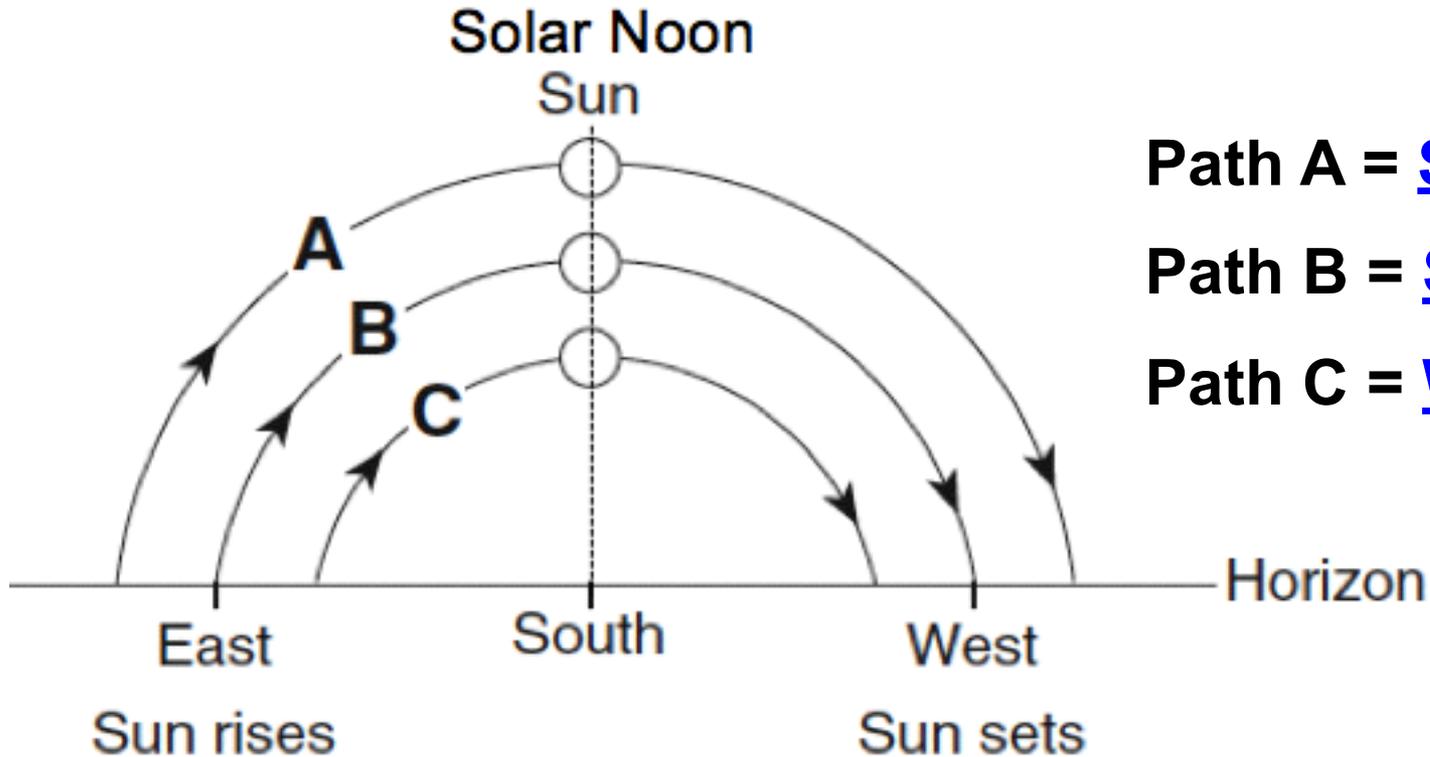


?

5. How does the Sun appear to move across our sky each day?

- **Apparent Path of the Sun: it only looks as if the Sun is moving across the sky. Really, the Earth is rotating**
- **The apparent path of the Sun changes throughout the course of the year.**
 - The apparent path of the Sun is **longer** in the summer than in the winter because the duration of insolation is **greater** in the summer than the winter.

5. How does the Sun appear to move across our sky each day?

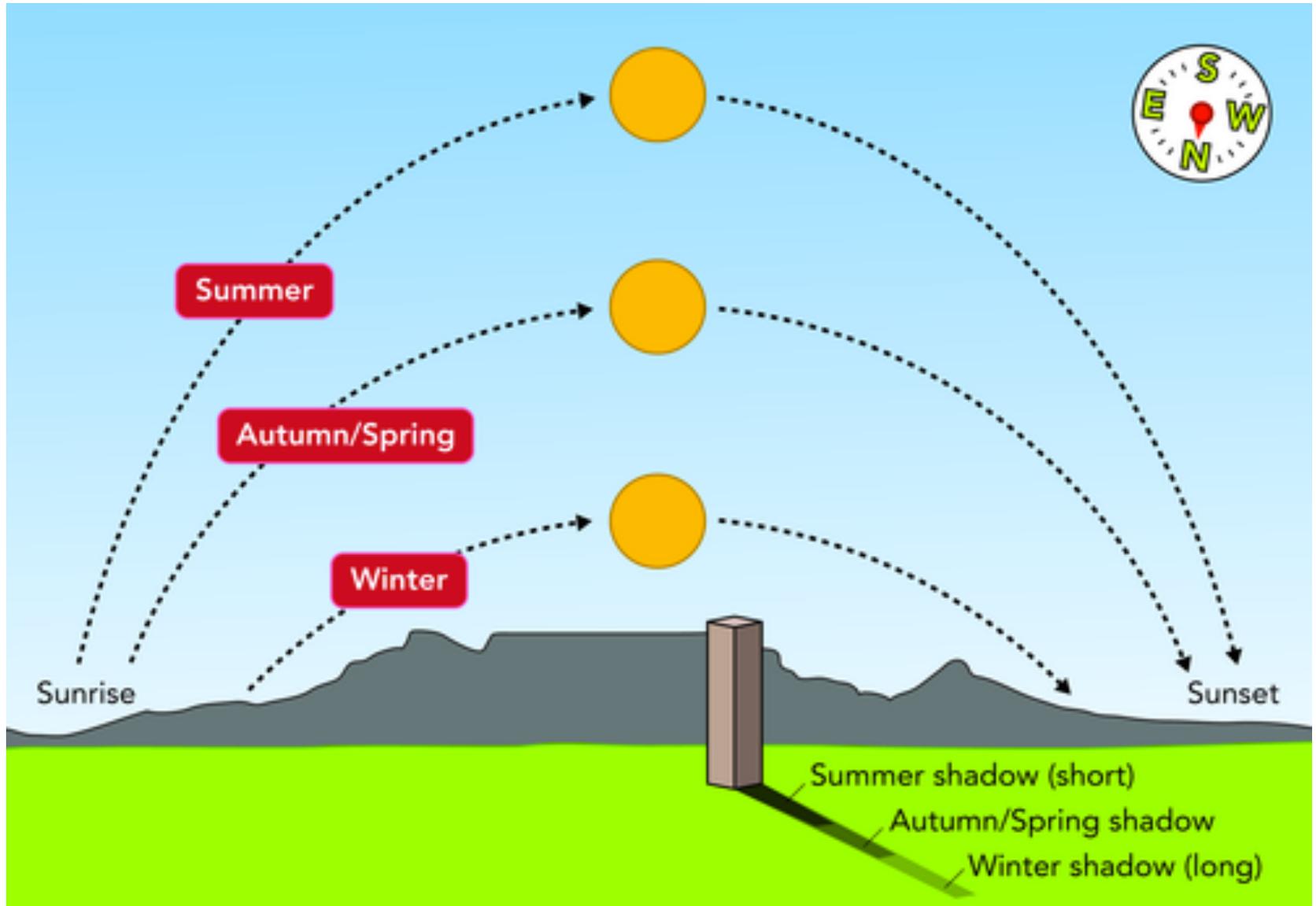


Path A = [Summer](#)

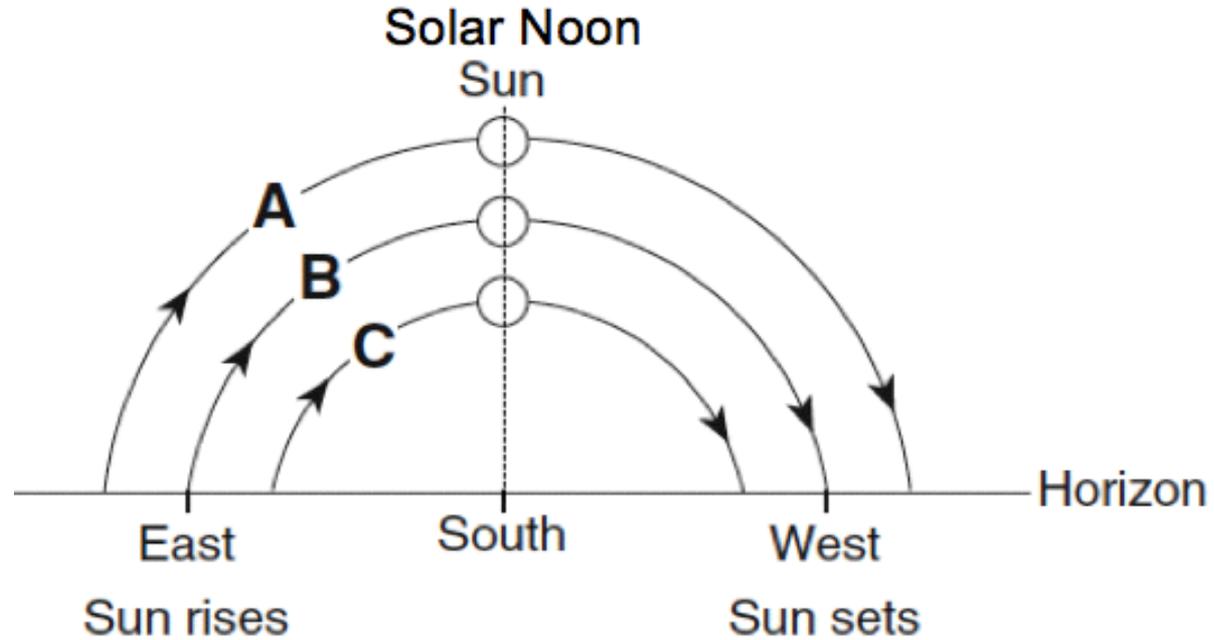
Path B = [Spring/Fall](#)

Path C = [Winter](#)

5. How does the Sun appear to move across our sky each day?

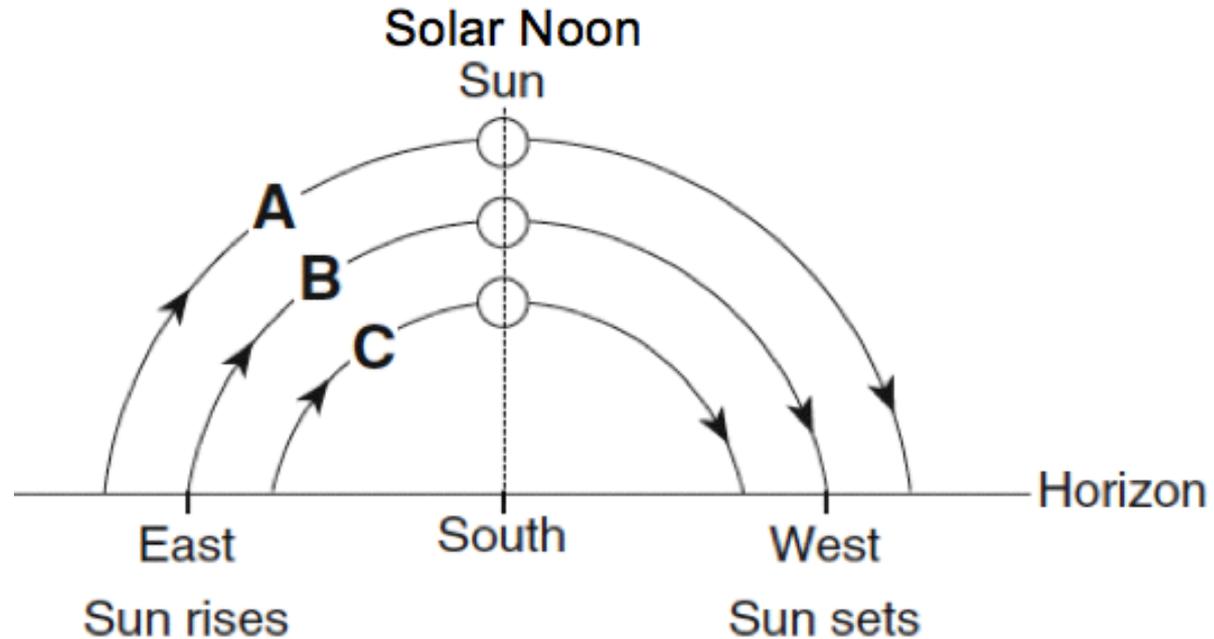


5. How does the Sun appear to move across our sky each day?



Horizon: where the land (or water) and the sky meet (0°)

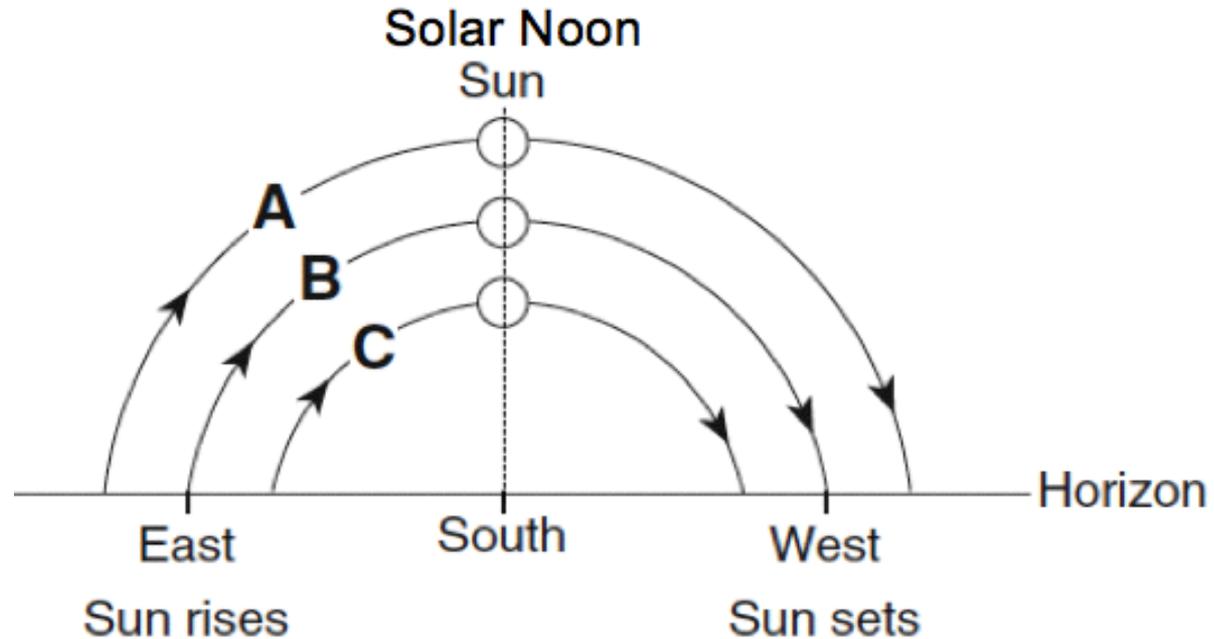
5. How does the Sun appear to move across our sky each day?



Sunrise: location where the Sun's path intersects the eastern horizon

- Location of sunrise changes throughout the year.
 - Summer: northeast
 - Spring/Fall: due east
 - Winter: southeast

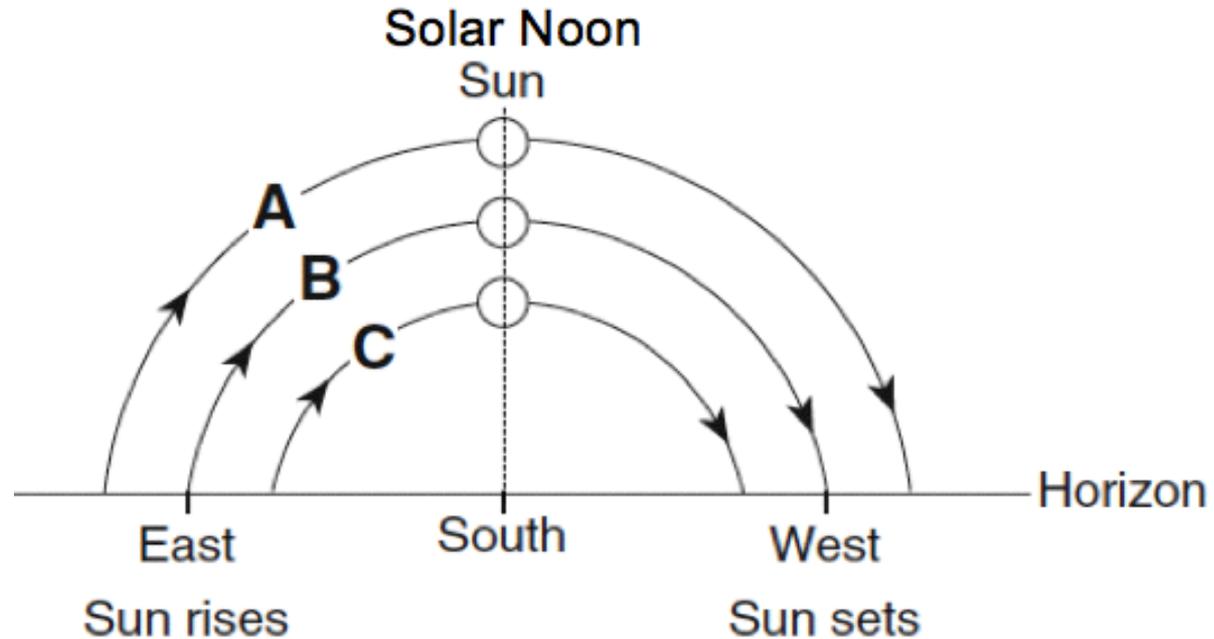
5. How does the Sun appear to move across our sky each day?



Sunset: location where the Sun's path intersects the western horizon

- Location of sunset changes throughout the year.
 - Summer: northwest
 - Spring/Fall: due west
 - Winter: southwest

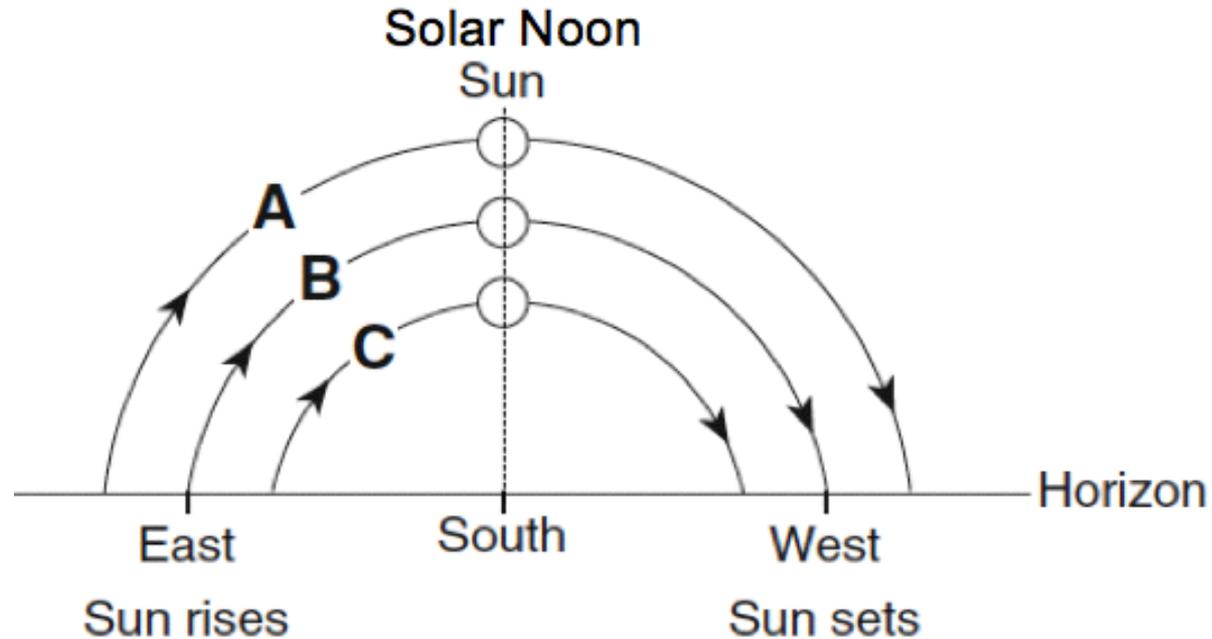
5. How does the Sun appear to move across our sky each day?



Altitude: the angle up from the horizon (90° maximum) to a celestial object

- The Sun's altitude changes throughout the year.
 - Summer: highest angle
 - Winter: lowest angle

5. How does the Sun appear to move across our sky each day?

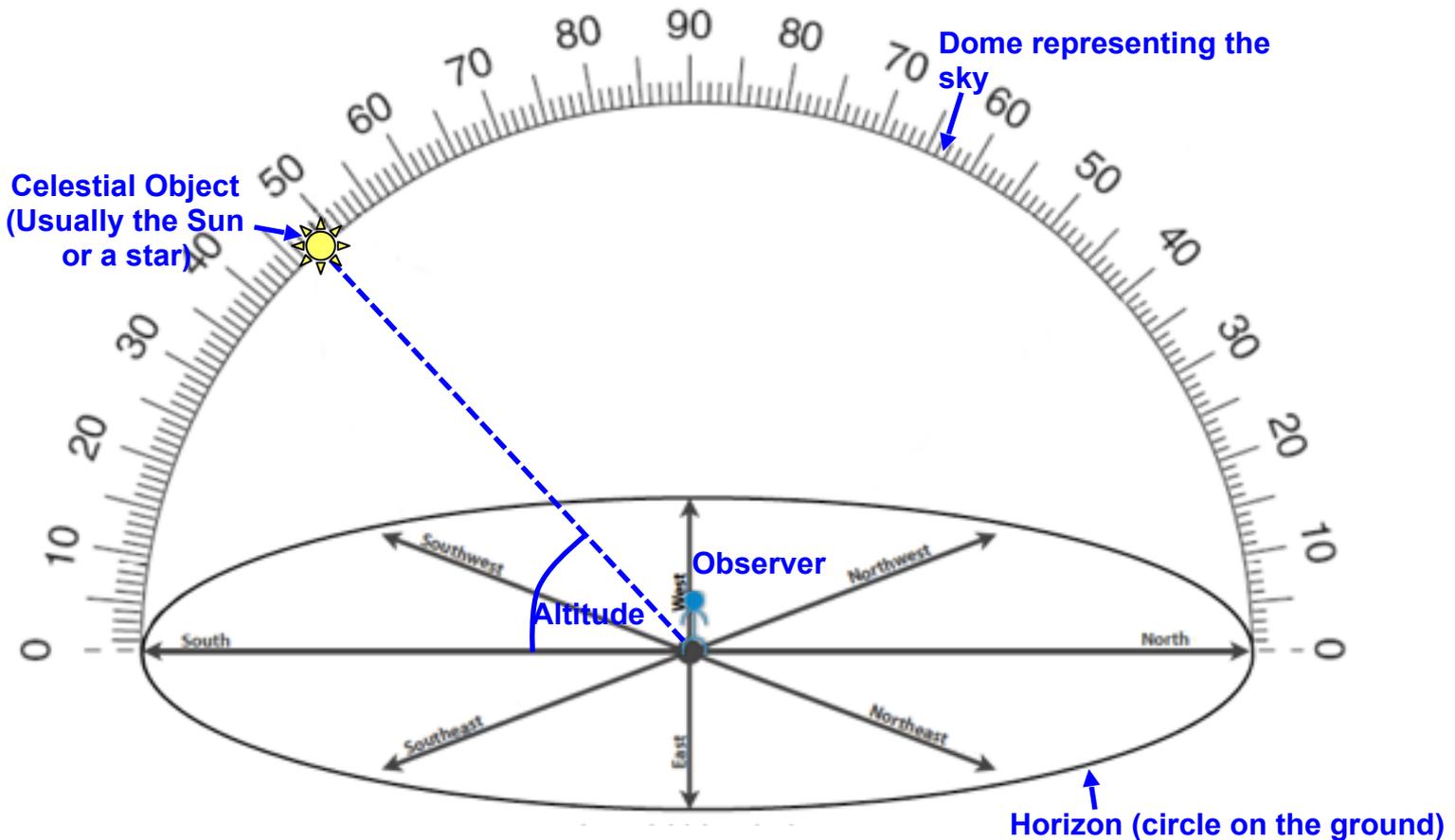


Solar noon: the time when the Sun reaches the highest angle in the sky on any day

- In the Northern Hemisphere, the noon Sun is always located **due south**.

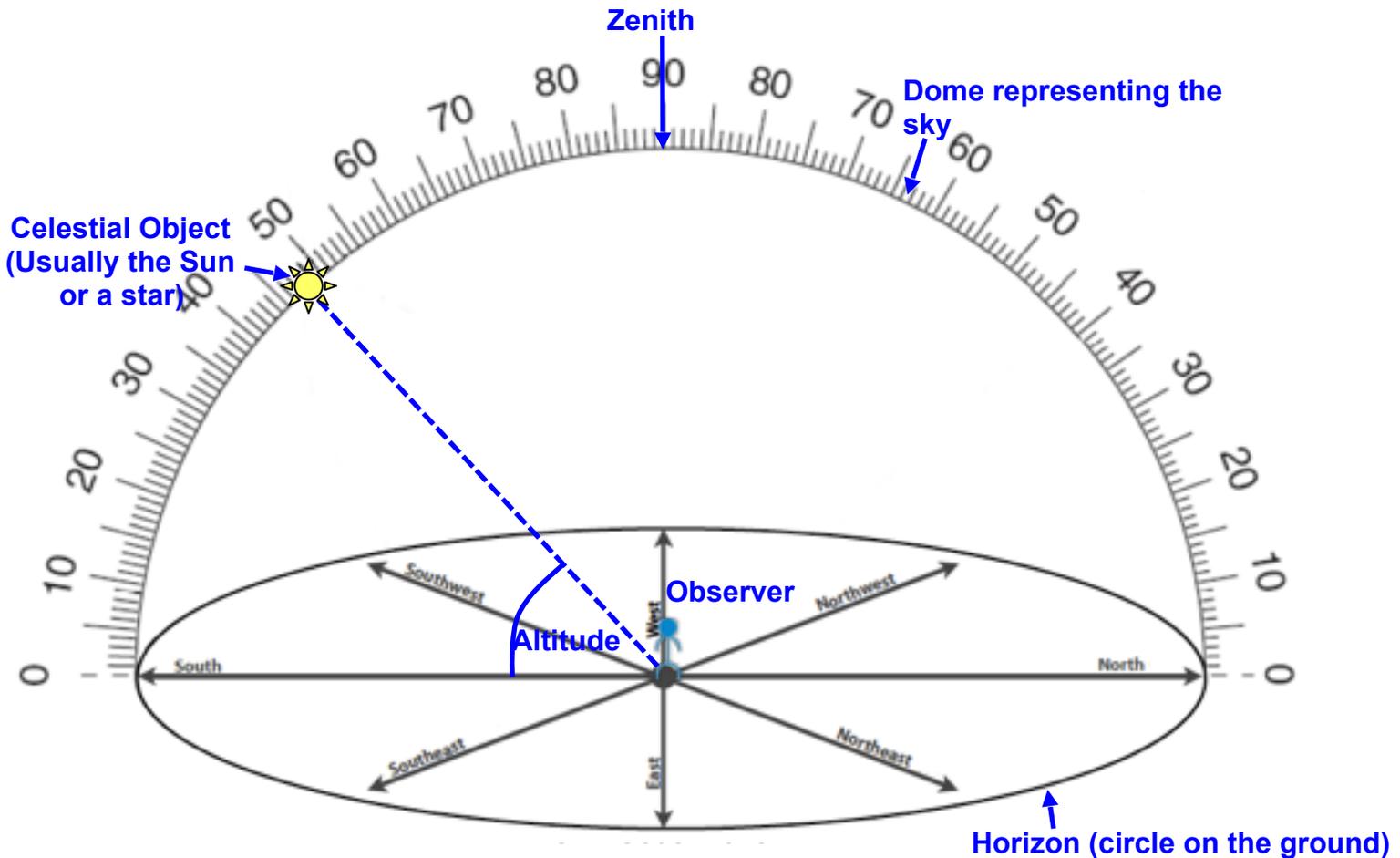
6. How can we represent the path of the Sun and other objects in our sky?

- **Celestial sphere:** a model (“dome”) of the sky surrounding Earth that celestial objects appear to move across.

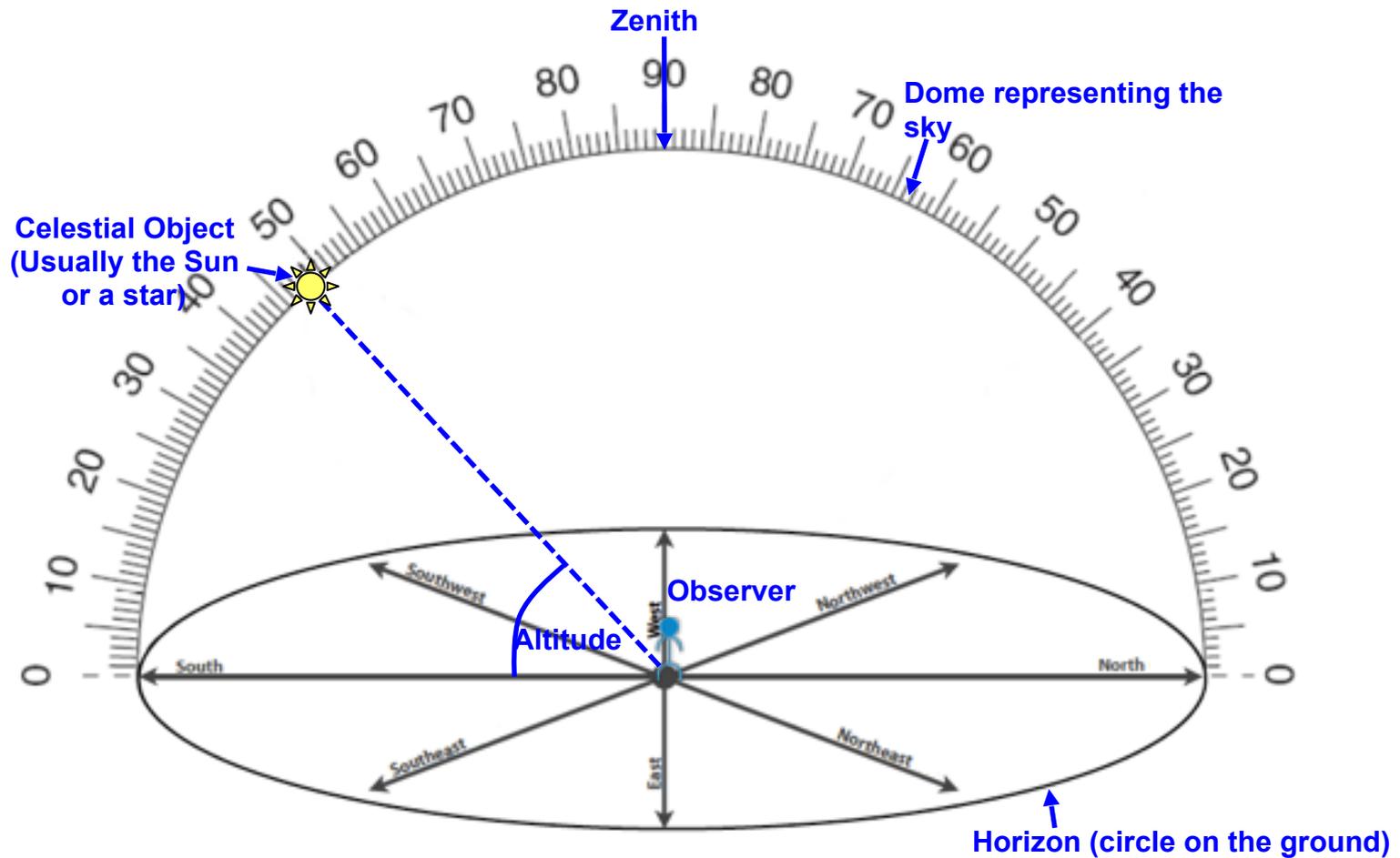


6. How can we represent the path of the Sun and other objects in our sky?

- **Zenith:** point directly overhead (90° above) of observer within celestial sphere



6. How can we represent the path of the Sun and other objects in our sky?



- **Note:** Compass directions are not in “normal” locations because you need to plot the path of the Sun at specific angles.

7. How can we use the path of the Sun to determine a date?

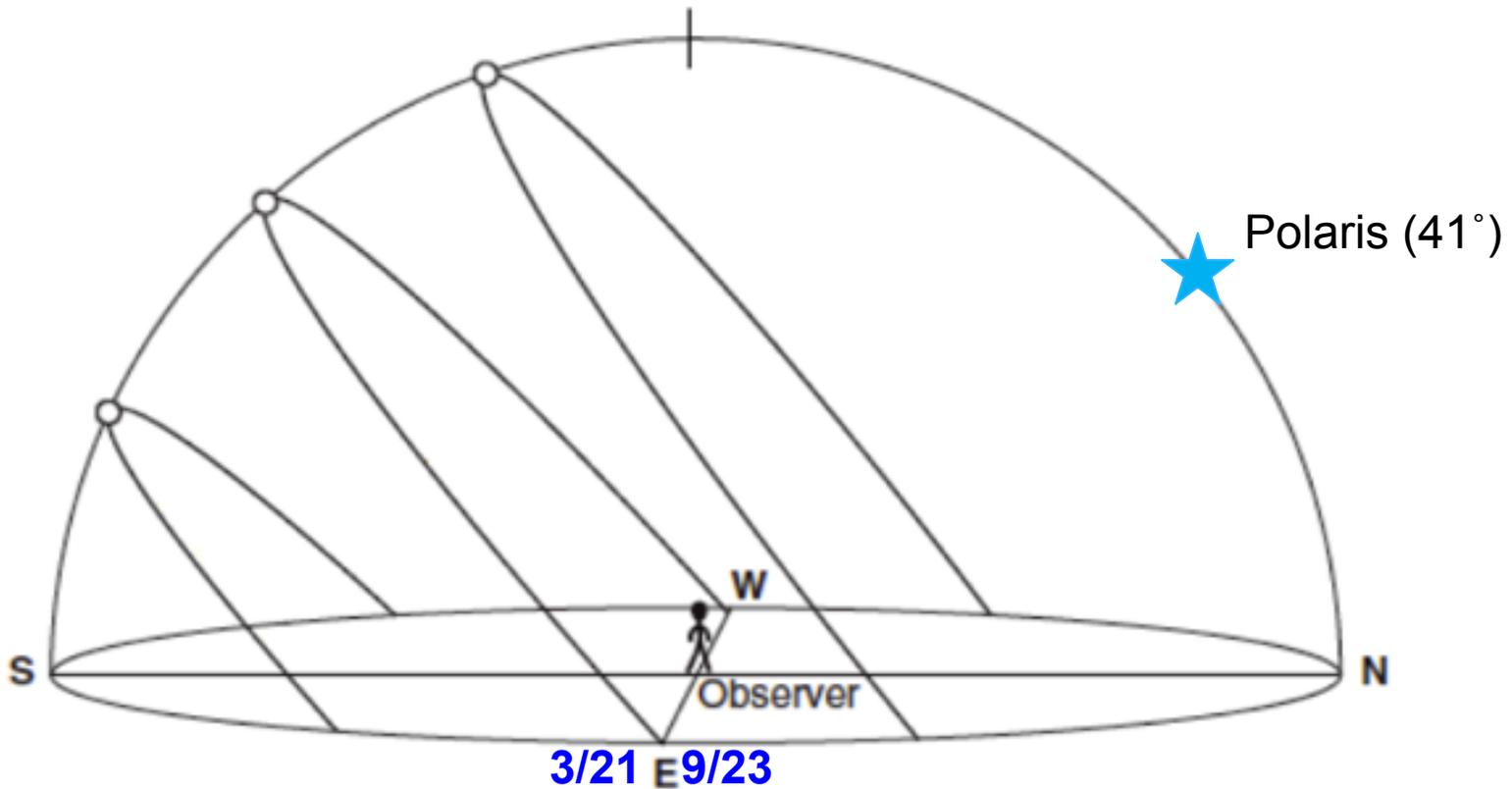
- To determine the date of any path of the Sun in any location, look at the location of sunrise and sunset.
 - June 21: Sun will rise and set closest to North
 - December 21: Sun will rise and set closest to South
 - March 21/September 23: Sun will rise due East and set due West
- Altitude of the Sun at solar noon will always change by 23.5° between the 1st day of one season and the 1st day of the next season.

8. How does the altitude of Polaris help us determine latitudes?

- The altitude of Polaris above the *Northern horizon* is equal to the latitude of an observer in the Northern Hemisphere.

9. How do you determine dates and latitudes using the path of the sun on a celestial sphere?

NYS Celestial Sphere (41°N)

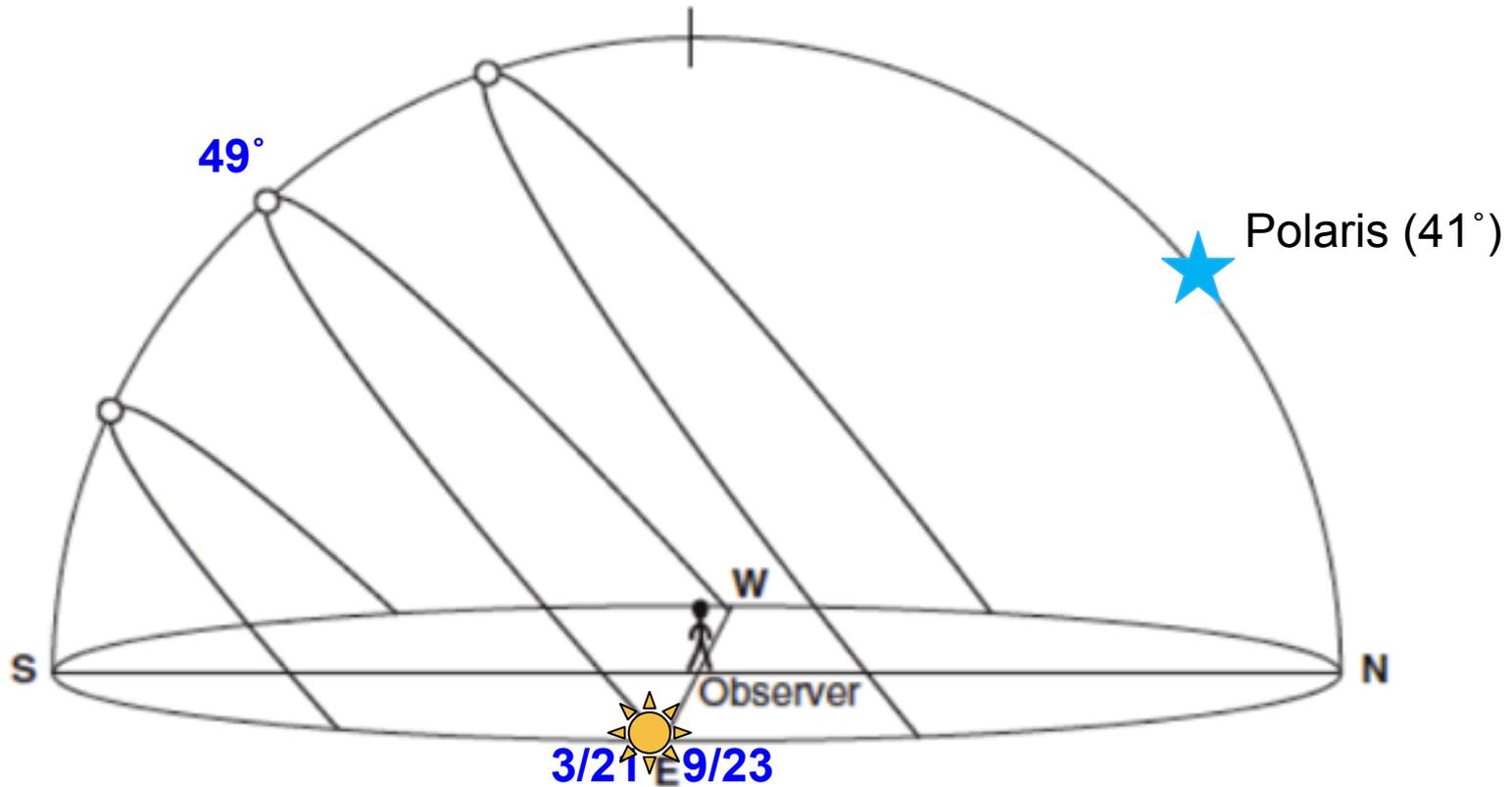


9. How do you determine dates and latitudes using the path of the sun on a celestial sphere?

| Date | December 21 | March 21/ September 23 | June 21 |
|-------------------------|-------------|----------------------------------|---------|
| Sunrise Direction | | Due east | |
| Sunset Direction | | Due west | |
| Direction of Noon Sun | | South | |
| Altitude of Noon Sun | | $90^\circ - 41^\circ = 49^\circ$ | |
| Latitude of Direct Rays | | 0° (Equator) | |

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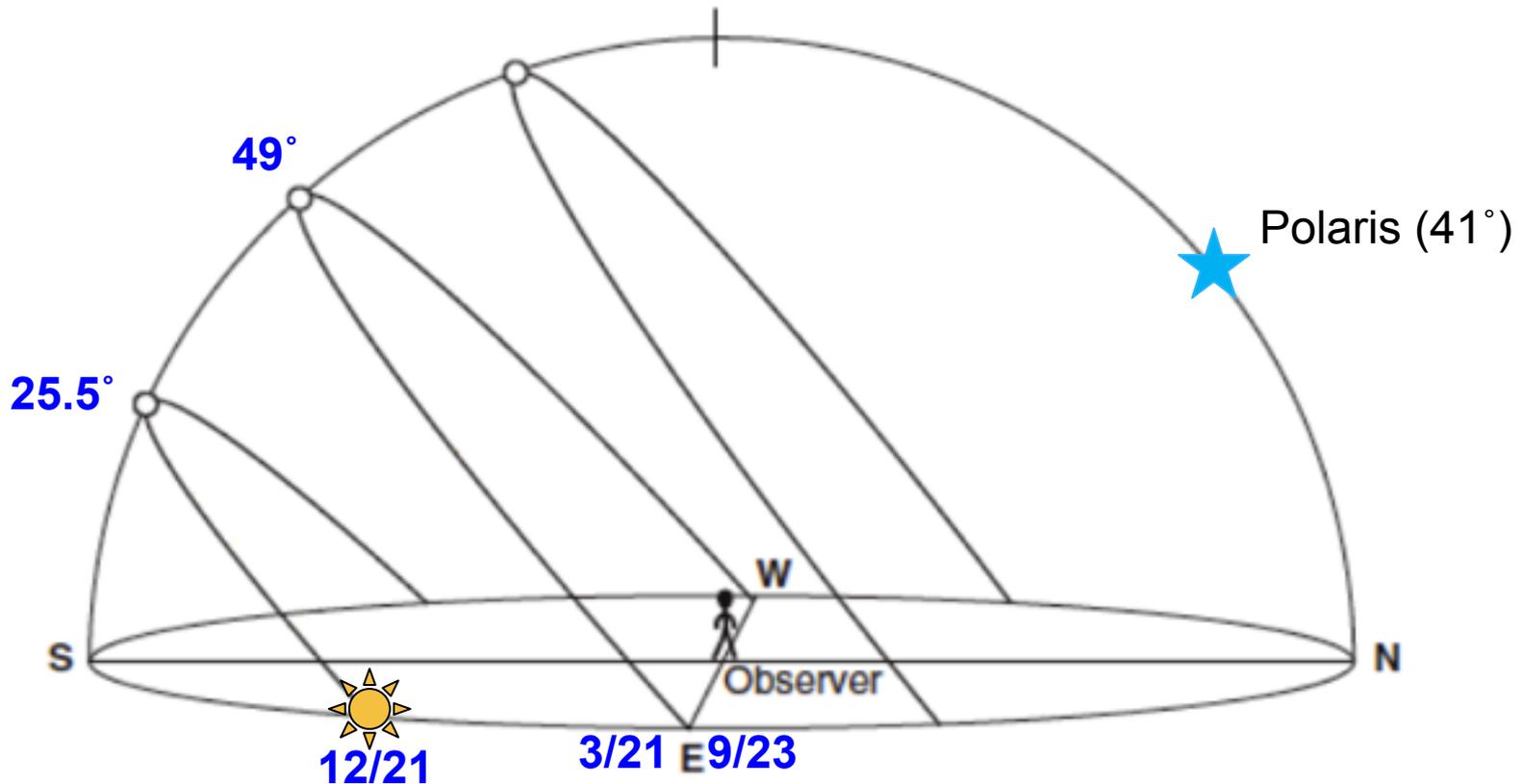


9. How do you determine dates and latitudes using the path of the sun on a celestial sphere?

| Date | December 21 | March 21/ September 23 | June 21 |
|-------------------------|--|----------------------------------|---------|
| Sunrise Direction | Southeast | Due east | |
| Sunset Direction | Southwest | Due west | |
| Direction of Noon Sun | South | South | |
| Altitude of Noon Sun | $49^\circ - 23.5^\circ = 25.5^\circ$ | $90^\circ - 41^\circ = 49^\circ$ | |
| Latitude of Direct Rays | 23.5°S (Tropic of Capricorn) | 0° (Equator) | |

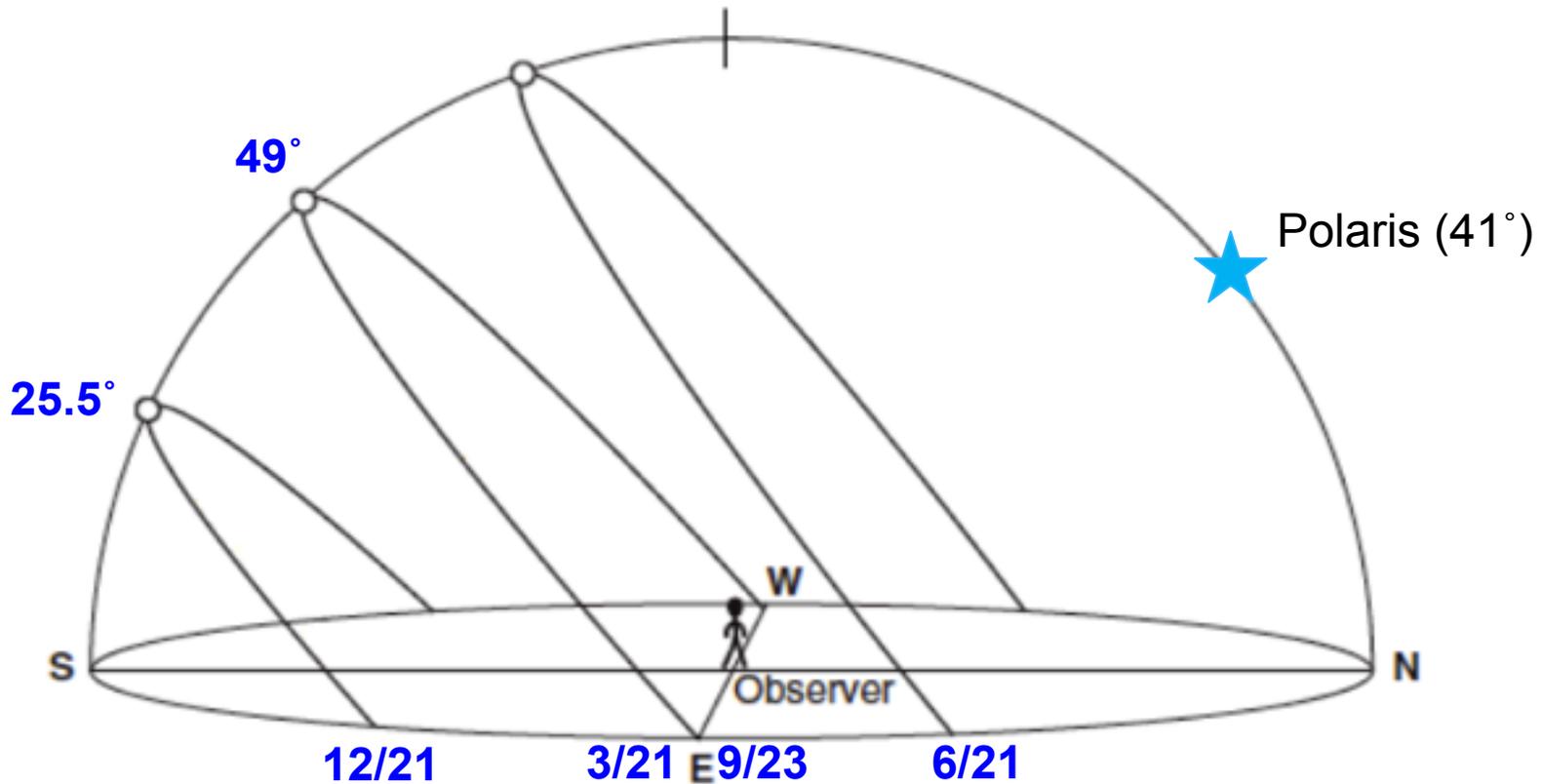
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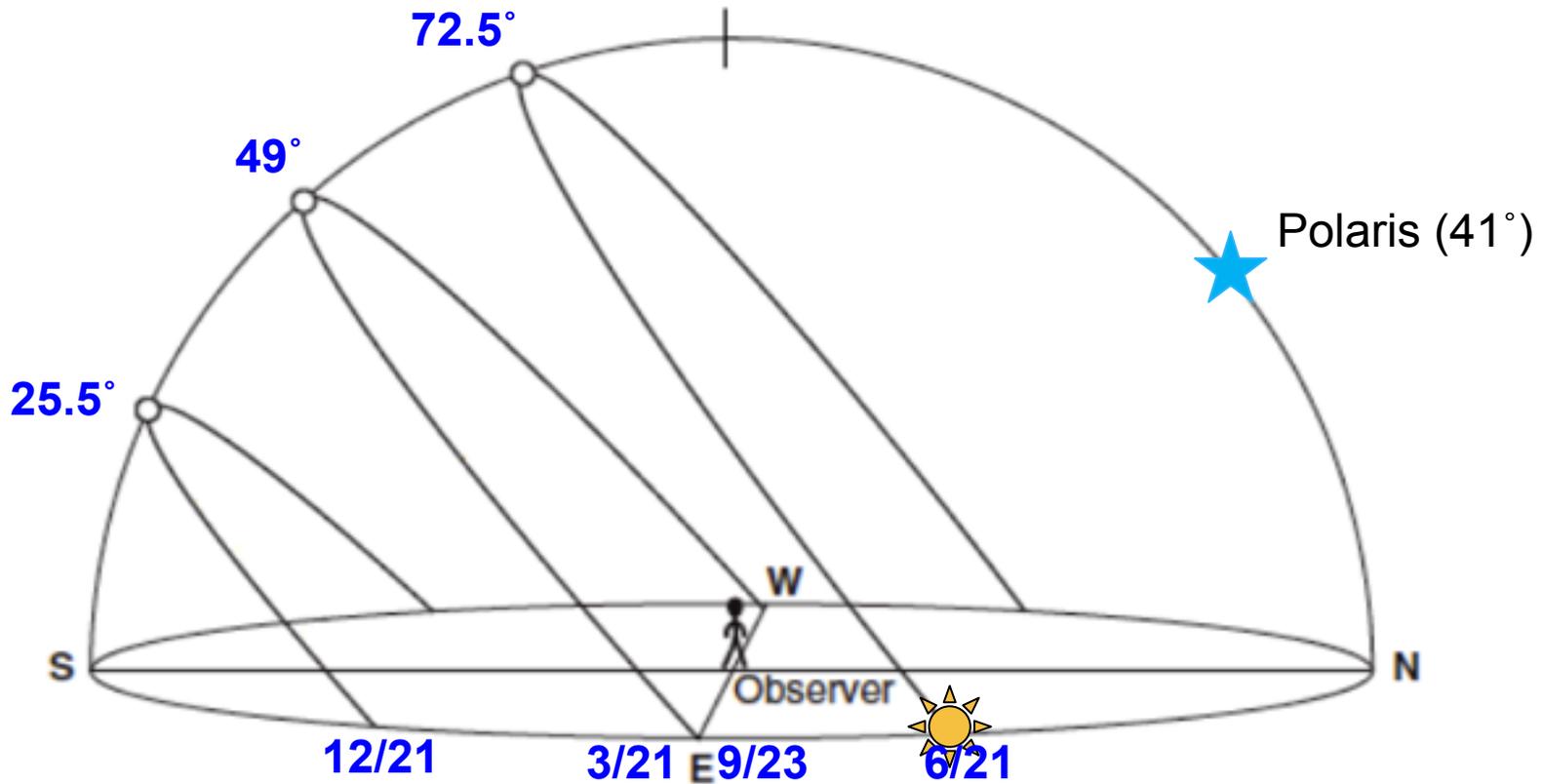


9. How do you determine dates and latitudes using the path of the sun on a celestial sphere?

| Date | December 21 | March 21/ September 23 | June 21 |
|-------------------------|--|----------------------------------|---|
| Sunrise Direction | Southeast | Due east | Northeast |
| Sunset Direction | Southwest | Due west | Northwest |
| Direction of Noon Sun | South | South | South |
| Altitude of Noon Sun | $49^\circ - 23.5^\circ = 25.5^\circ$ | $90^\circ - 41^\circ = 49^\circ$ | $49^\circ + 23.5^\circ = 72.5^\circ$ |
| Latitude of Direct Rays | 23.5°S (Tropic of Capricorn) | 0° (Equator) | 23.5°N (Tropic of Cancer) |

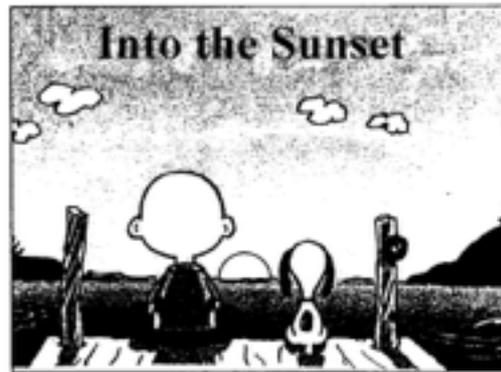
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NYS Celestial Sphere (41°N)



Practice #1 Apparent Path of the Sun

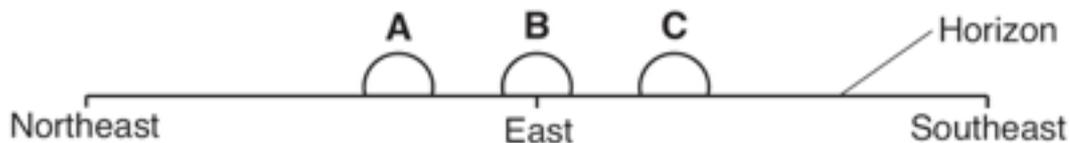
1) The cartoon characters below are watching the Sun set.



Toward which general direction are the characters looking?

- A) north B) south C) east D) west

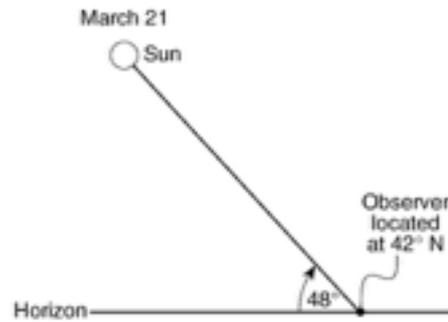
2) A student in New York State looked toward the eastern horizon to observe sunrise at three different times during the year. The student drew the following diagram that shows the positions of sunrise, A, B, and C, during this one-year period.



Which list correctly pairs the location of sunrise to the time of the year?

- | | | | |
|----|-----------------|----|-----------------|
| A) | A – June 21 | C) | A – March 21 |
| | B – March 21 | | B – June 21 |
| | C – December 21 | | C – December 21 |
| B) | A – December 21 | D) | A – June 21 |
| | B – March 21 | | B – December 21 |
| | C – June 21 | | C – March 21 |

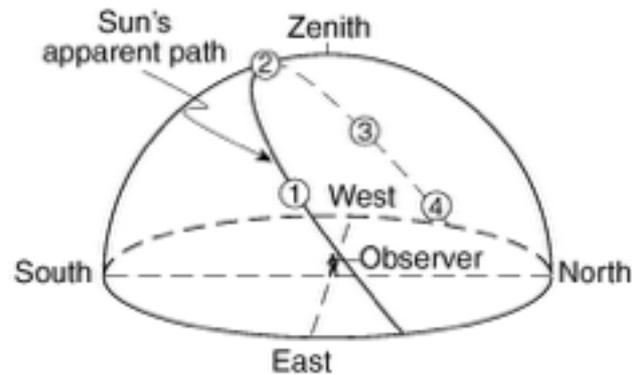
3) The diagram below shows the altitude of the Sun at solar noon on March 21, as seen by an observer at 42° N latitude.



Compared to the altitude of the Sun observed at solar noon on March 21, the altitude of the Sun observed at solar noon on June 21 will be

- A) 15° higher in the sky
- B) 23.5° higher in the sky
- C) 42° higher in the sky
- D) 48° higher in the sky

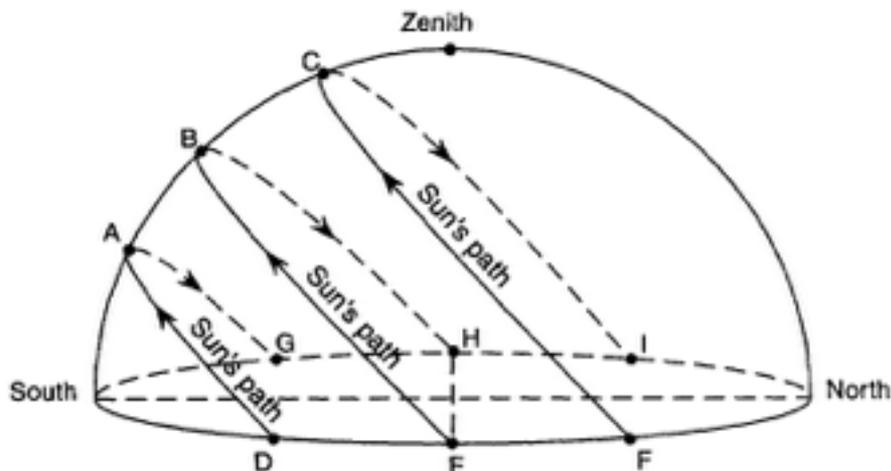
4) The diagram below shows numbered positions of the Sun at four different times along the Sun's apparent daily path, as seen by an observer in New Jersey. Numbers 1 through 4 represent apparent positions of the Sun.



During which day of the year is the Sun most likely to follow the apparent path shown?

- A) March 1
- B) July 1
- C) October 1
- D) December 1

5) The diagram below represents a plastic hemisphere upon which lines have been drawn to show the apparent paths of the Sun at a location in New York State on the first day of each season. Letters A through I represent points on the paths.



Which point represents the sunrise location on the first day of winter?

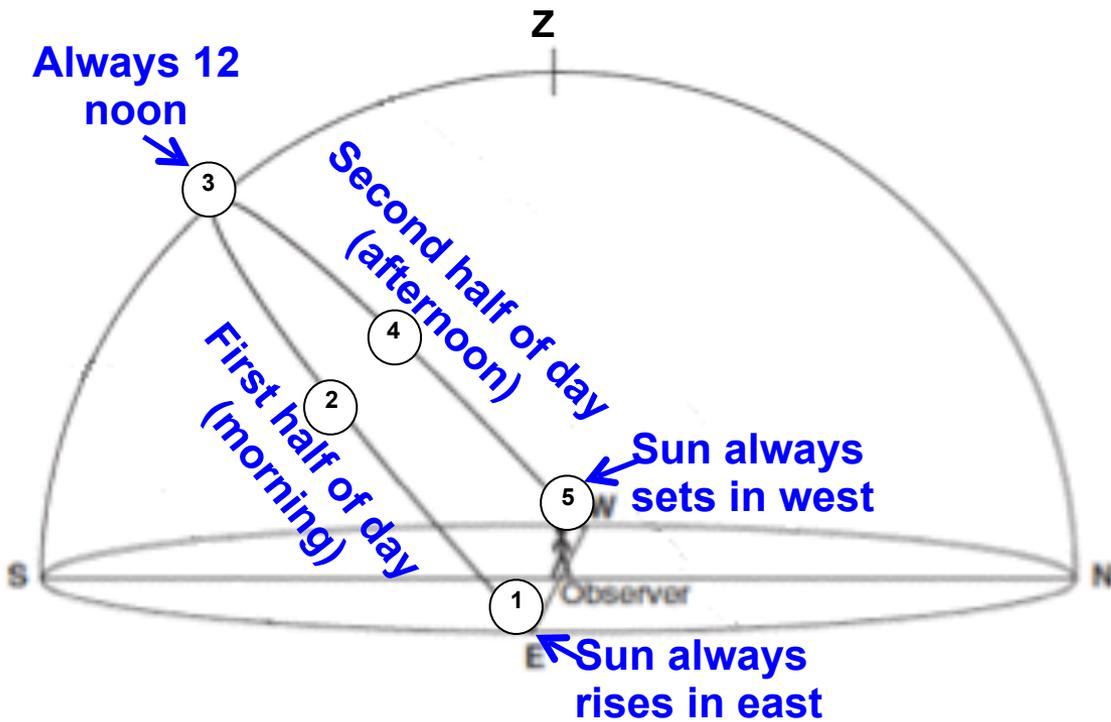
- A) G B) F C) E D) D

Continue Practice in Packet

11. How do we determine the time of day using the Sun?

- **Determining Time of Day Using the Sun:**
 - On 3/21 and 9/23, there are 12 hours of daylight all over Earth.
 - Noon is always the halfway point of the daylight period.

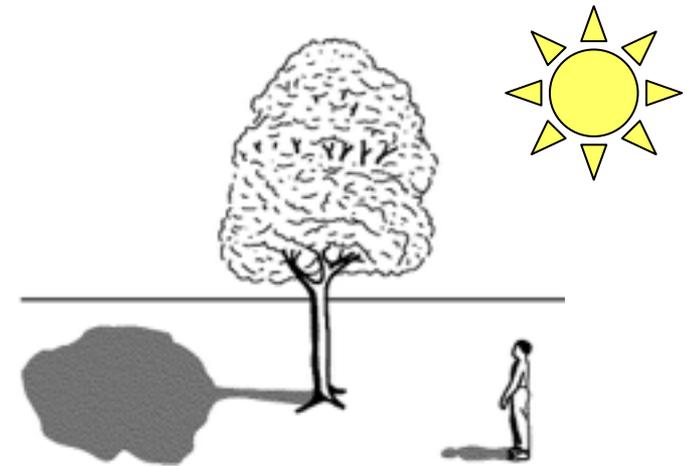
11. How do we determine the time of day using the Sun?



| Point # | Time Sun Reaches that Point |
|---------|-----------------------------|
| 1 | 6 am (Sunrise) |
| 2 | 9 am |
| 3 | 12 pm (Solar noon) |
| 4 | 3 pm |
| 5 | 6 pm (Sunset) |

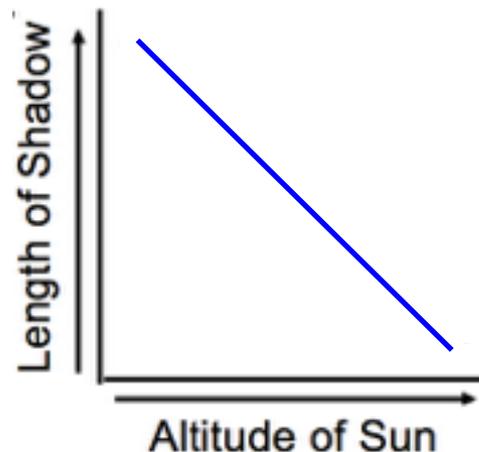
12. How does the changing position of the Sun affect shadows?

- **Shadow Direction:**
 - A shadow always points in the opposite direction from where the Sun is located.
 - The direction of an observer's shadow at solar noon in New York State is always due north because the Sun at solar noon is always located due south.



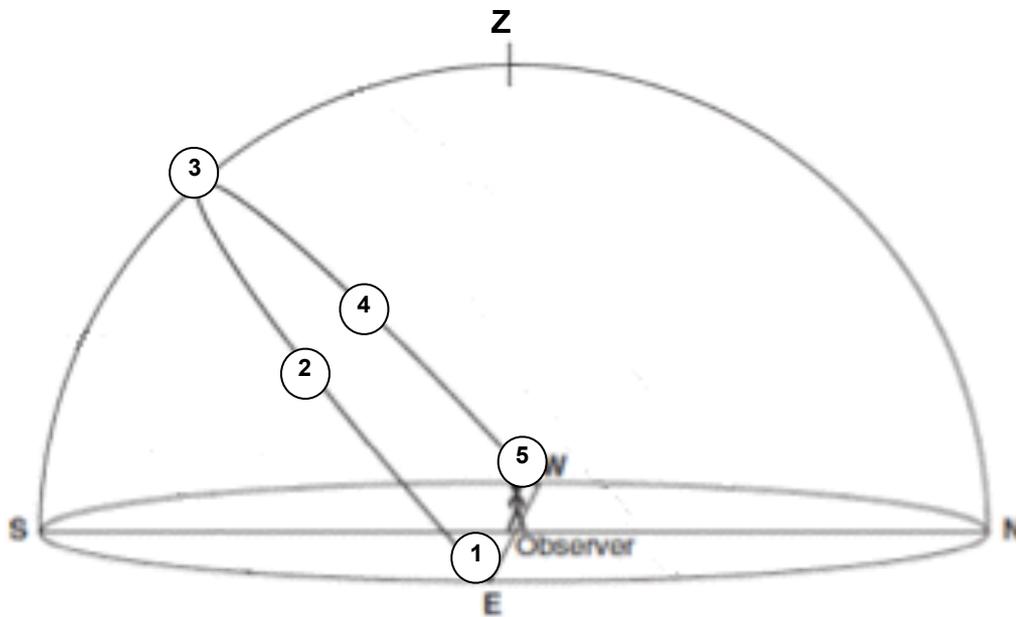
12. How does the changing position of the Sun affect shadows?

- **Shadow Length:**
 - Short shadow: high altitude of the Sun
 - Long shadow: low altitude of the Sun



13. How do shadows change throughout the day?

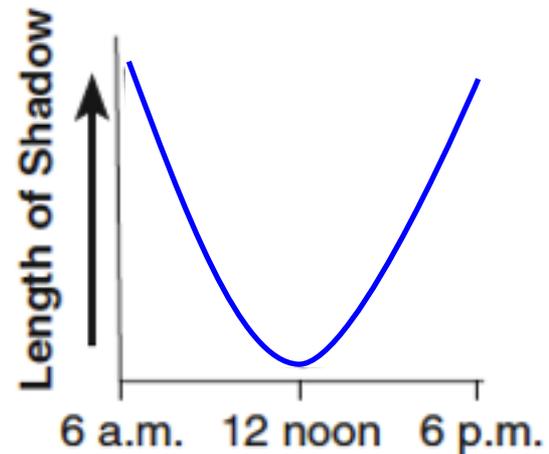
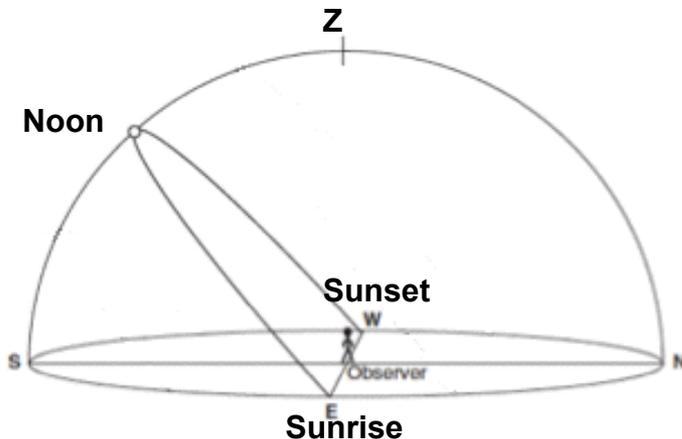
- **Direction of Shadow During Day:**



| Point # | Direction of Sun | Direction of Shadow |
|---------|------------------|---------------------|
| 1 | East | West |
| 2 | Southeast | Northwest |
| 3 | South | North |
| 4 | Southwest | Northeast |
| 5 | West | East |

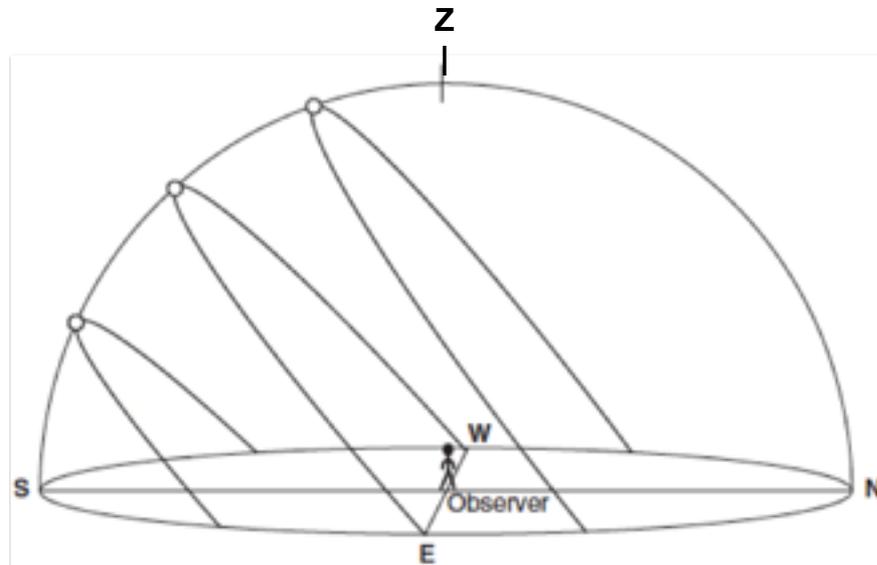
13. How do shadows change throughout the day?

- **Daily Shadow Length:**
 - Shortest daily shadow: solar noon (when the Sun reaches the highest altitude of the day).
 - Longest daily shadow: sunrise and sunset (when the Sun is at the lowest altitude of the day).



14. How does the length of a shadow change throughout the year?

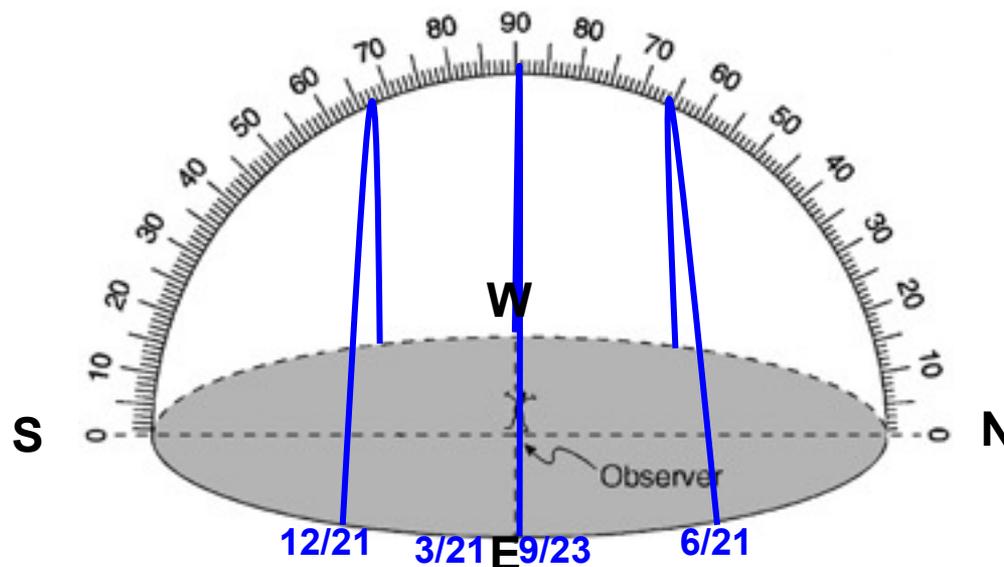
- Shortest yearly shadow: summer at solar noon (highest angle)
- Longest yearly shadow: winter at sunrise and sunset (lowest angle)



15. How is the path of the Sun different for locations around the world?

Location: Equator (0°)

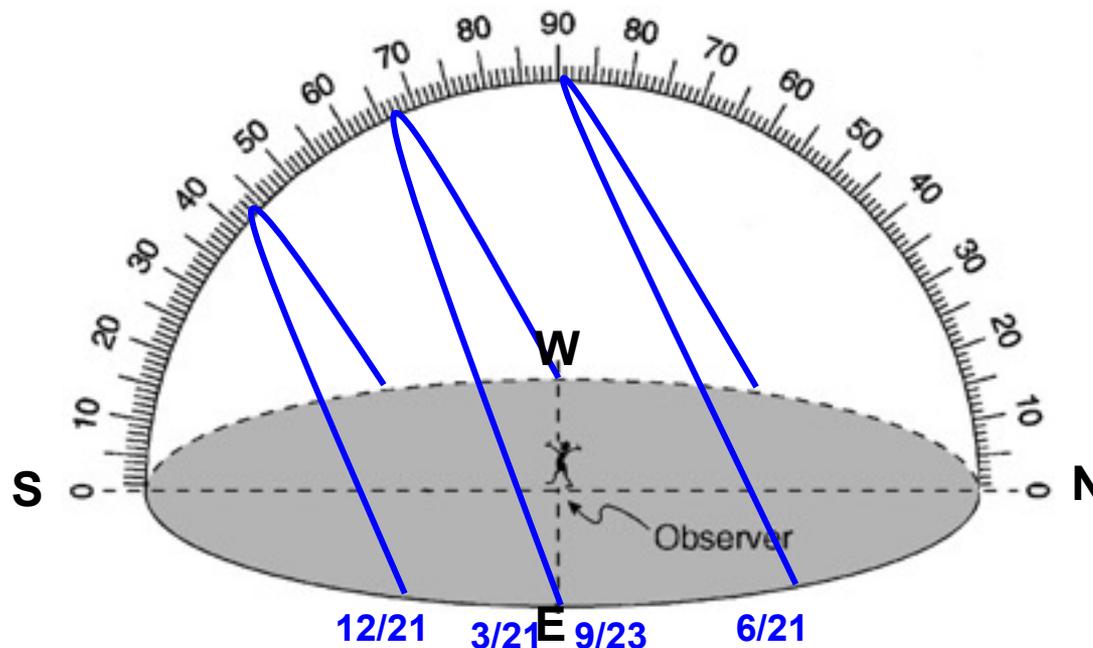
- The Sun reaches the zenith at solar noon at the equator on both equinoxes.
- The Sun does not follow the same path each day at the equator!



15. How is the path of the Sun different for locations around the world?

Location: Tropic of Cancer (23.5° N)

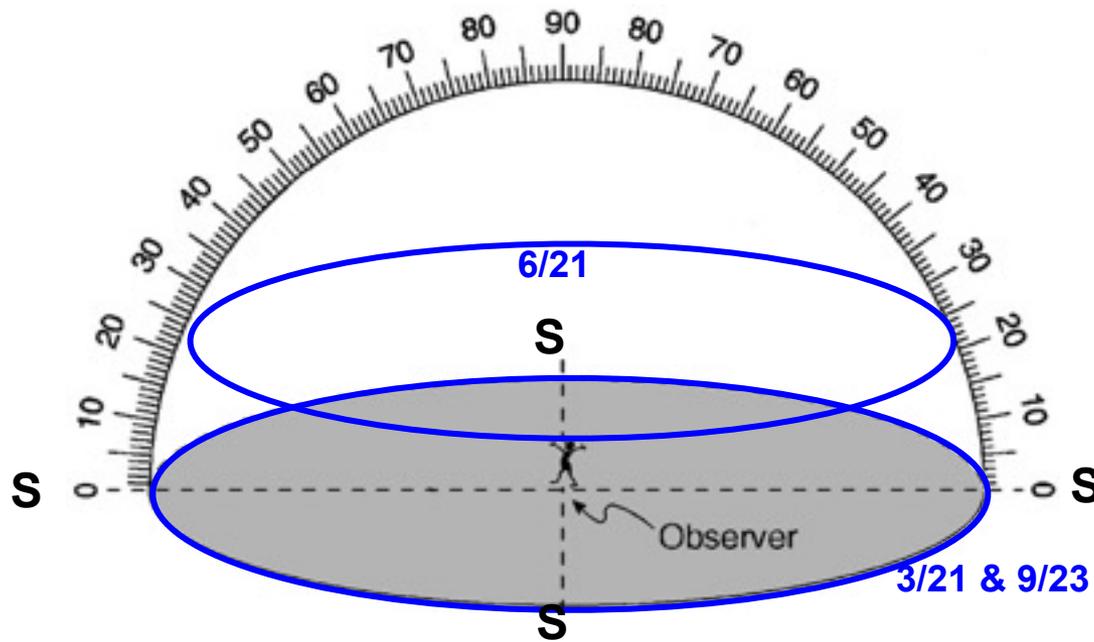
- The Sun reaches the zenith at solar noon at the Tropic of Cancer on June 21.



15. How is the path of the Sun different for locations around the world?

Location: North Pole (90°N)

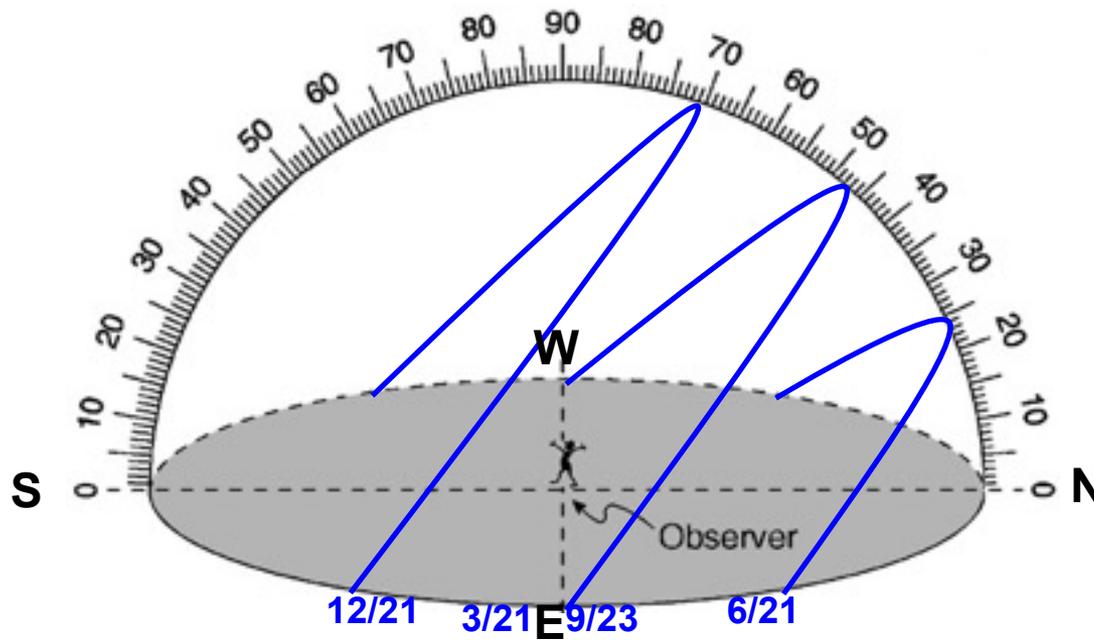
- At the North Pole, any direction you will move will be South.
- On June 21, there is 24 hours of daylight at the North Pole. Sun's path is a ring parallel to the horizon.
- On the Equinoxes, the Sun remains on the horizon.



15. How is the path of the Sun different for locations around the world?

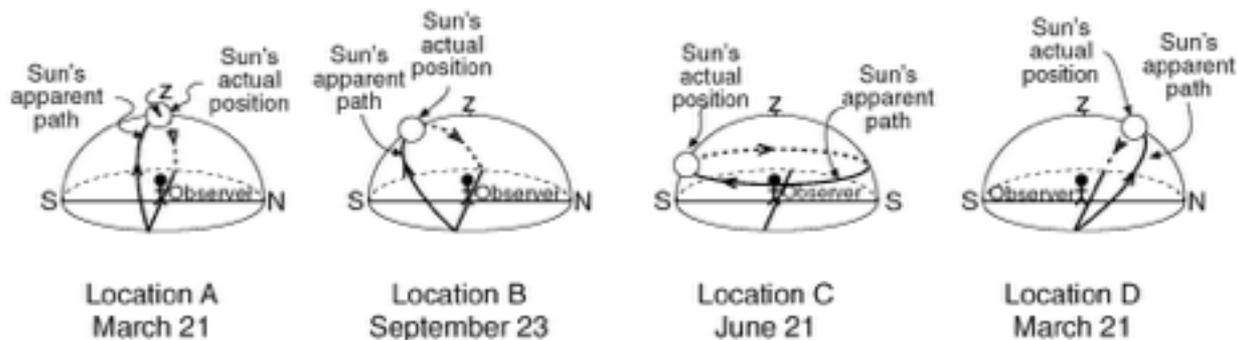
Location: [Southern Hemisphere \(42°S\)](#)

- The Sun will rise into the [northern](#) sky in the Southern Hemisphere.
- Seasons are opposite in the Southern Hemisphere (12/21 is [summer](#), 6/21 is [winter](#)).



Practice #2

1) The diagram below shows a model of the apparent path and position of the Sun in relation to an observer at four different locations, A, B, C, and D, on Earth's surface on the dates indicated. The zenith (z) and the actual position of the Sun in the model at the time of the observation are shown. [The zenith is the point directly over the observer.]

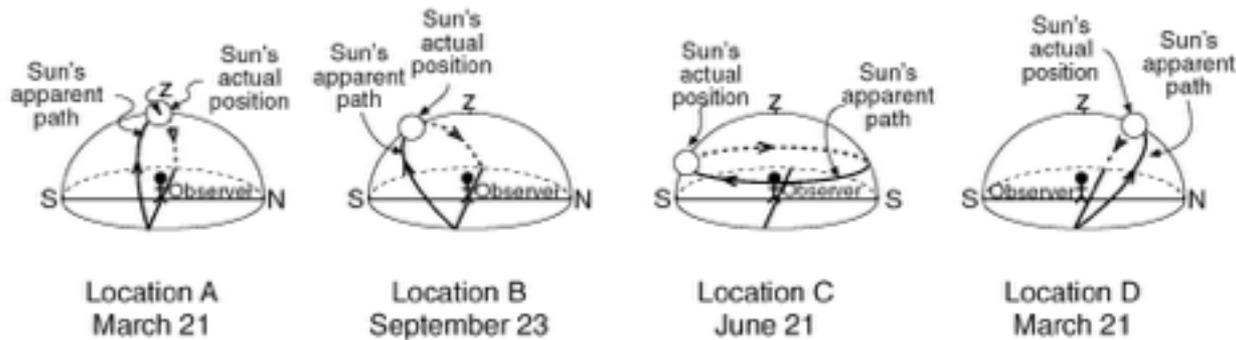


Name the likely latitude for each location shown above. State one piece of evidence that led you to your answer.

Location A: _____

Checkpoint: Celestial Spheres from Around the World

1) The diagram below shows a model of the apparent path and position of the Sun in relation to an observer at four different locations, A, B, C, and D, on Earth's surface on the dates indicated. The zenith (z) and the actual position of the Sun in the model at the time of the observation are shown. [The zenith is the point directly over the observer.]

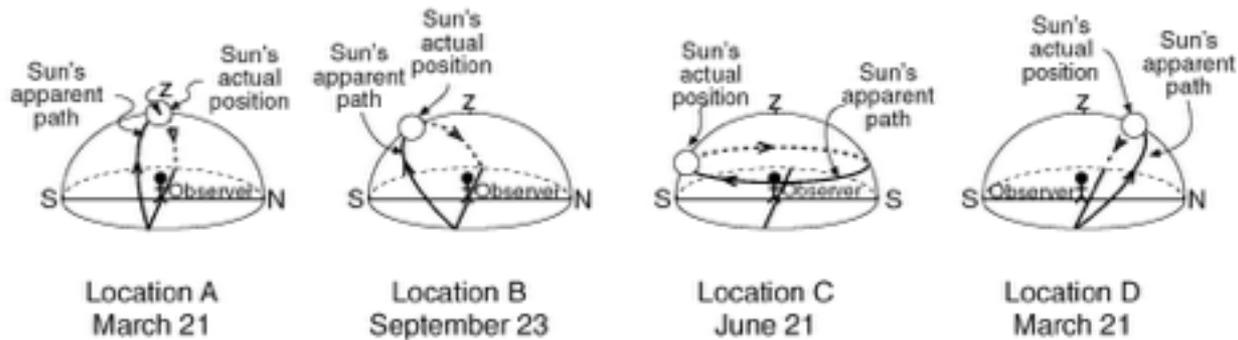


Name the likely latitude for each location shown above. State one piece of evidence that led you to your answer.

Location B: _____

Checkpoint: Celestial Spheres from Around the World

1) The diagram below shows a model of the apparent path and position of the Sun in relation to an observer at four different locations, A, B, C, and D, on Earth's surface on the dates indicated. The zenith (z) and the actual position of the Sun in the model at the time of the observation are shown. [The zenith is the point directly over the observer.]

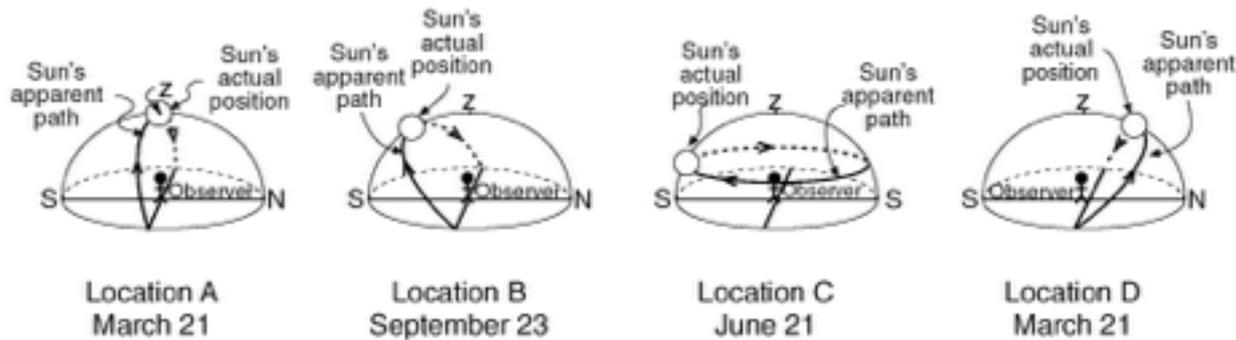


Name the likely latitude for each location shown above. State one piece of evidence that led you to your answer.

Location C: _____

Checkpoint: Celestial Spheres from Around the World

1) The diagram below shows a model of the apparent path and position of the Sun in relation to an observer at four different locations, A, B, C, and D, on Earth's surface on the dates indicated. The zenith (z) and the actual position of the Sun in the model at the time of the observation are shown. [The zenith is the point directly over the observer.]

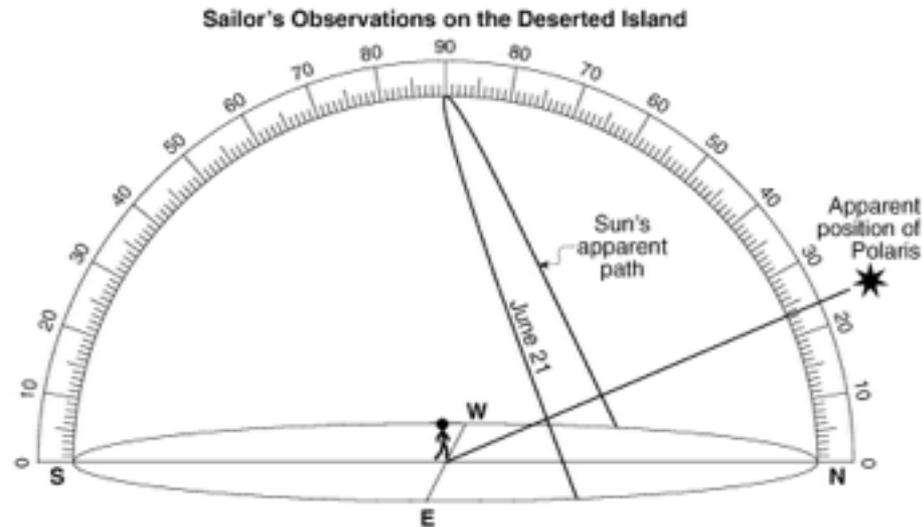


Name the likely latitude for each location shown above. State one piece of evidence that led you to your answer.

Location D: _____

Checkpoint: Celestial Spheres from Around the World

2) The diagram below shows observations made by a sailor who left his ship and landed on a small deserted island on June 21. The diagram represents the apparent path of the Sun and the position of Polaris, as observed by the sailor on this island.



Based on the sailor's observations, what is the latitude of this island? Include the units and the compass direction in your answer. Explain how you were able to determine this latitude.