POLAR TREC

TEACHERS AND RESEARCHERS EXPLORING AND COLLABORATING

Seasonal Path of the Sun and Latitude

Overview

This lesson is a modification of what Dave Hess and I, Stan Skotnicki, use in our Earth Science classes at Cheektowaga Central High School. It is an extension of our lesson on Celestial Motions as we track the apparent path of the sun across the sky at different latitudes. Prior to this Lab activity they would have already created hemisphere models of 42 North (mid-latitudes) and at the Equator 0.

Working with Mike Loranty in Siberia during the summer of 2016 we experienced full sunlight for 24 hours and has been a topic of conversation in class, which inspired me to extend our Apparent Path of the Sun lab to include latitudes at the arctic circle.

Objectives

Explain how latitude affects the seasonal path of the Sun. During this lab activity, students will study the seasonal apparent path of the Sun above the Arctic Circle. Topics covered in this unit are coordinate location, insolation, celestial motions of Earth and the Sun, Seasons.

Lesson Preparation

Prior to this lesson, students would have learned about the general motions between the Sun and Earth in relation to each other. The Apparent Path that the sun takes across the sky. There are also two other hemisphere model labs that would have been done before this one, which are available on contact. The first model would have been created for 42 North and the other for the Equator at 0.

Procedure

Complete procedures for the activity are listed on the worksheets of the Lab.

Extension

Additional hemisphere model labs have been created for 42 North and the Equator at 0. They can also be modified for any latitude desired.

Resources

For data at any latitude at any interval: http://aa.usno.navy.mil/data/docs/AltAz.php

Can be modified for additional latitudes with data sets taken from http://aa.usno.navy.mil/data/docs/AltAz.php

Details

- Lesson
- Arctic
- Less than a week
- Download, Share, and Remix
- High school and Up

Materials

Clear plastic hemisphere model
External protractor for model
Dry erase markers – two different colors

Standards

New York State

Physical Setting/Earth Science Core Curriculum

STANDARD 6 Interconnectedness: Common Themes MODELS:

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

STANDARD 4

Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective

Major Understandings:
1.1a Most objects in the solar system are in regular and predictable motion. • These motions explain such phenomena as the day,

For an animation of the Apparent Path of the Sun at any Latitude:
http://astro.unl.edu/naap/motion3/animations/sunmotions.swf

Material Resources - Clear plastic hemisphere model:
https://www.wardsci.com/store/product/8889458/sun-tracking-hemisphere-kit

Assessment

This activity will be assessed as part of New York States minimum lab requirement for Regents credit.

Author / Credits

Created by Stan Skotnicki (sskotnicki@gmail.com) and Dave Hess from Cheektowaga Central Schools

the year, seasons, phases of the moon, eclipses, and tides
1.1c Earth's coordinate system of latitude and longitude, with the equator and prime meridian as reference lines, is based upon Earth's rotation and our observation of the Sun and stars.

National Science Education Standards

Content Standards, Grades 9-12
Content Standard A: Science As Inquiry
Content Standard D: Earth and Space Science

NAME;_____
PERIOD; ___ **DATE;**_____

LAB

SEASONAL PATH OF THE SUN AND LATITUDE
Hemisphere Model #3
at the Arctic Circle

OBJECTIVE

Explain how latitude affects the seasonal path of the Sun.

I) Path of the Sun and Latitude.

In the previous activity we observed that the Sun's path across the sky varies with the seasons. As its path changes, so too does the position of sunrise and sunset, the altitude of the noon sun, and the duration of sunlight (length of daylight). In New York State, the Winter Solstice (on December 21), marks the time when the noon sun is lowest in the sky and the period of daylight is the shortest. The Summer Solstice (on June 21), is the day when the noon sun is highest in the sky and the duration of daylight is the greatest. Although the noon sun is highest on this date, the sun will never be directly overhead (zenith position) in New York State. In only place where the sun is ever in the zenith position (90° altitude), is in the tropics. The tropics is anywhere between 23.5°N and 23.5°S latitude. The path of the sun during the equinoxes lies between the paths for the solstices. The equinoxes (equal nights) are the only time when the sun rises due east and set due west. It is also the date when the entire Earth experiences 12 hours of sunlight, regardless of your location.

Is the path of the Sun the same in New York as it is at the Arctic Circle, or at the equator? Does latitude (distance north or south from the equator) affect the path that the sun takes across the sky? Above the Arctic Circle, is there still 12 hours of daylight during the equinoxes? What will the duration of sunlight be like during the Solstices?

By comparing three locations; NY (mid-latitudes), the Arctic Circle (66.5°), and the equator (0°) a conclusion can be made for how latitude affects the duration of sunlight for each season.

PROCEDURE

Setting up the hemisphere model.

1) Turn to the last page of this lab. There should be a circle and the words "azimuth" on this page. Remove this page and tape it onto your piece of cardboard.

2) Label this piece of paper with your class period and all the members of your lab group.

3) Carefully place the hemisphere model on the circle. The hemisphere model should line up with the circle on the paper.

4) Use masking tape to fasten the hemisphere model to the cardboard. Place the tape at NE, SE, SW and NW.

Marking the path of the Sun at 66.5° The Arctic Circle)

1) Find Data Table 1 (Azimuth and Altitude at a latitude of 90° The North Pole)

Notice that there are only two available sets of data this time.

- One set for both March and September 21 (the sun follows the same path on these days) – the "Spring Equinox" and the "Autumn Equinox" (First Day of Spring and the Frist Day of Autumn).

- One set for June 21 – the first Day of Summer.

2) You will plot two lines on the hemisphere model – one for each set of data (each season).

3) Start with a green wet erase marker and plot the path of the sun for March/September 21.

- For March/September 21the first set of data occurs at 6:00am; AZIMUTH 88° and ALTITUDE 1°

- Azimuth values are listed along the circle.

- Find the location for 0° (North) azimuth on the circle, move clockwise until you find 88°.

- One member of the group lines up the external protractor with the azimuth value. This is done by holding the external protractor so that the 90° mark is at the top of the hemisphere model and the zero end points down towards the 88° reading for azimuth.

- The second group member is responsible for placing a dot at the correct altitude on the hemisphere model. To do this read the value for altitude from the data table (in this case it is 0°), find where this number is on the external protractor, and use the green wet erase marker to place a dot at this location.

4) After all the points have been plotted, connect the points with a smooth curve.

5) Use the green marker to label this line; "March/September – Equinox".

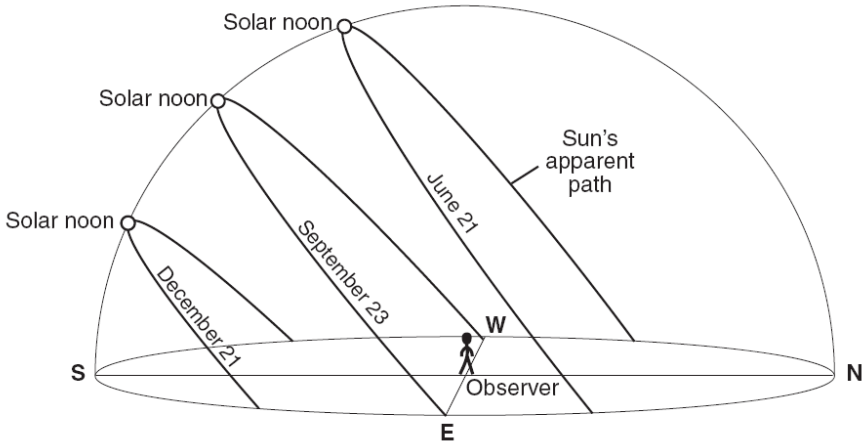
> **Noon occurs when the Sun reaches its highest point in the sky (highest altitude). Place a small drawing of the sun over the point that represents the position of the noon sun. Write the word "noon" above this image.**

6) Now do the same for June 21st data – use a red marker. Plot the points, label the line and identify the position of the noon sun.

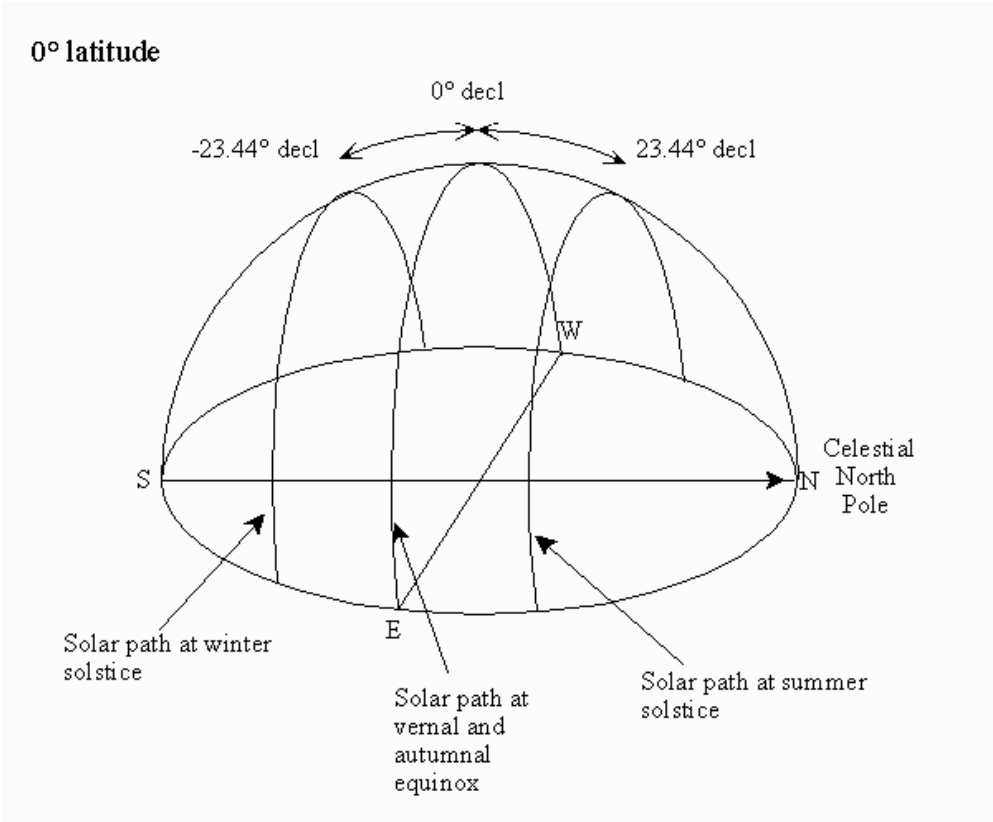
Data Table 2
Azimuth and Altitude at a latitude at the Arctic Circle 66.5°

Time of Day	A.M. or P.M.	December 21st		March/September 21st		June 21st	
		Altitude	Azimuth	Altitude	Azimuth	Altitude	Azimuth
12:00	A.M.	-	-	-	-	45	154
1:00	A.M.	-	-	-	-	47	174
2:00	A.M.	-	-	-	-	46	194
3:00	A.M.	-	-	-	-	44	213
4:00	A.M.	-	-	-	-	40	231
5:00	A.M.	-	-	-	-	35	247
6:00	A.M.	-	-	1	88	29	262
7:00	A.M.	-	-	6	102	23	276
8:00	A.M.	-	-	12	116	17	290
9:00	A.M.	-	-	17	131	12	302
10:00	A.M.	-	-	20	146	7	315
11:00	A.M.	-	-	23	162	4	329
12:00	P.M.	-	-	24	178	2	342
1:00	P.M.	-	-	23	194	1	356
2:00	P.M.	-	-	21	210	1	10
3:00	P.M.	-	-	17	225	2	23
4:00	P.M.	-	-	13	241	5	37
5:00	P.M.	-	-	7	256	9	50
6:00	P.M.	-	-	2	269	14	63
7:00	P.M.	-	-	-	-	20	76
8:00	P.M.	-	-	-	-	26	90
9:00	P.M.	-	-	-	-	32	104
10:00	P.M.	-	-	-	-	37	119
11:00	P.M.	-	-	-	-	42	136

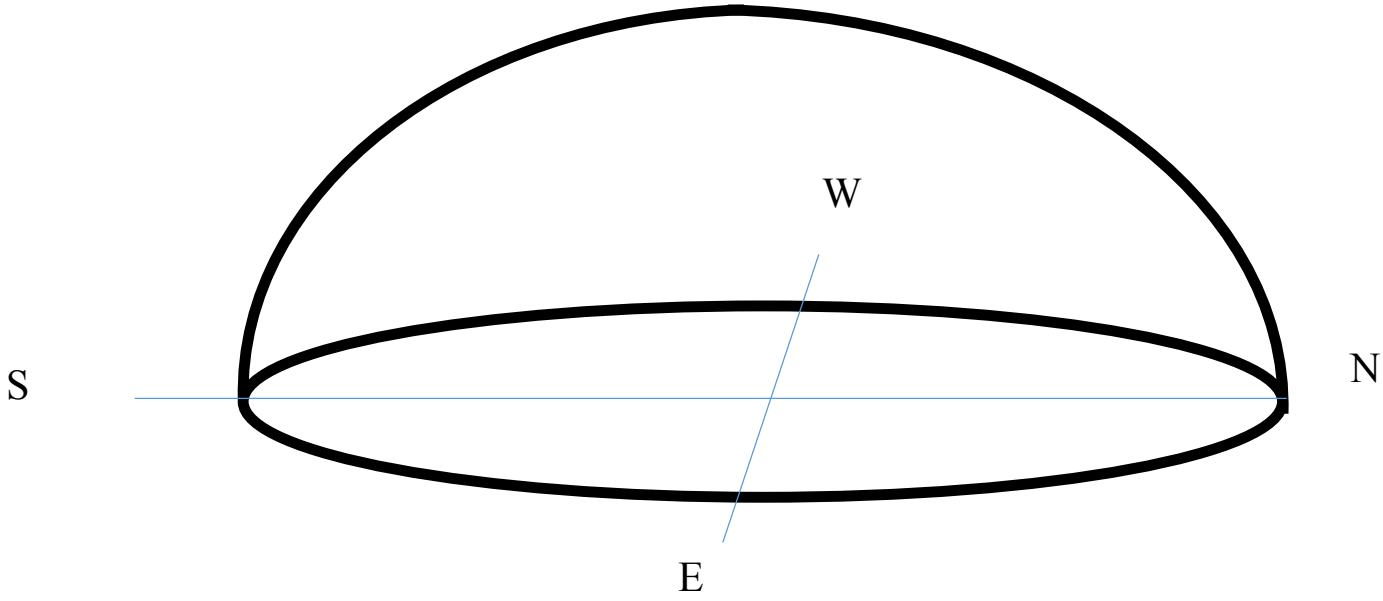
Apparent Path of the Sun in Jamestown, NY 42°N – Mid-Latitudes



Apparent Path of the Sun at the Equator 0°



Make Prediction on what the Path of the Sun might look like at the Arctic Circle 66.5°



<u>Use the hemisphere model and/or data table to complete the following tables.</u>

<u>1) Sun's Position</u> – state the compass direction for the position of the sun at sunrise, sunset and 12 noon.

	SUNRISE POSITION	SUNSET POSITION	12 NOON POSITION
WINTER SOLSTICE DECEMBER 21			
SPRING EQUINOX MARCH 21			
SUMMER SOLSTICE JUNE 21			
AUTUMN EQUINOX SEPTEMBER 21			

<u>2) Duration of Daylight</u> – state the time at which the sun rises, and sets for each of the given days. Use these numbers to determine the duration of sunlight on each day.

Hint; The first set of azimuth/altitude data represents sunrise.
The last set of azimuth/altitude data represents sunset.

	TIME OF SUNRISE	TIME OF SUNSET	DURATION OF SUNLIGHT
WINTER SOLSTICE DECEMBER 21			
SPRING EQUINOX MARCH 21			
SUMMER SOLSTICE JUNE 21			
AUTUMN EQUINOX SEPTEMBER 21			

VOCABULARY

Neatly write the definition for the following words.

duration – _____

_____

zenith – _____

_____

tropics – _____

_____

equinox – _____

_____

latitude – _____

_____

arctic circle – _____

_____

CONCLUSIONS

1) State the date for the Winter Solstice. _____

2) State the date for the Spring Equinox. _____

3) State the date for the Summer Solstice. _____

4) State the date for the Autumn Equinox. _____

5) What is the name for the position in the sky that is directly overhead? _____

6) During which season is the duration of sunlight the longest in NY state? _____

7) During which season is the duration of sunlight the shortest in NY state? _____

8) During which season is the noon sun at its highest point in NY state? _____

9) During which season is the noon sun at its lowest point in NY state? _____

10) During which seasons is the duration of sunlight 12 hours everywhere on the planet?

_____ _____

11) On which date does the North Pole receive 24 hours of sunlight? _____

12) On which date does the North Pole receive 0 hours of sunlight? _____

Position of Sunrise and Sunset at the Equator

13) Examine the three paths of the Sun. On average, for a location at the equator, in which compass direction does the sun rise?

_____

14) On average, in which compass direction does the sun set at the equator?

_____

15) "Due East" means exactly in the east (azimuth 90°). State the date, or dates, when sun will rise "due east" and set "due west" at the equator.

_____

16) For a person located at the equator, where would they have to look to see the noon sun during the Equinoxes?

17) Describe the shape of the Sun's path.

18) Describe the direction in which the Sun moves across the sky.

19) As the seasons change, explain what happens to the duration of sunlight at the equator?

Position of Sunrise and Sunset at the North Pole

20) As the seasons change, explain what happens to the duration of sunlight at the North Pole?

21) How does the Path of the Sun at the North Pole differ from the Equator and Jamestown, NY?

22) For a person located at the North Pole, would they ever see the Noon Sun at their Zenith point?

23) Describe the shape of the Sun's path.

24) Describe the direction in which the Sun moves across the sky.

25) To complete the table, fill in the duration of sunlight during each season, for the North Pole, Jamestown NY and the Equator. For New York state, fill in the equinoxes first then remember the rule of threes.

	NORTH POLE (90°N)	JAMESTOWN NY (42°N)	EQUATOR (0°)
WINTER SOLSTICE DECEMBER 21			
SPRING EQUINOX MARCH 21			
SUMMER SOLSTICE JUNE 21			
AUTUMN EQUINOX SEPTEMBER 21			

26) As latitude increases what happens to the duration of sunlight on the Winter Solstice?

_____

27) Explain the relationship between latitude and duration of sunlight on the Summer Solstice.

_____

_____

28) Describe how latitude affects the duration of sunlight on the Equinoxes.

_____

_____

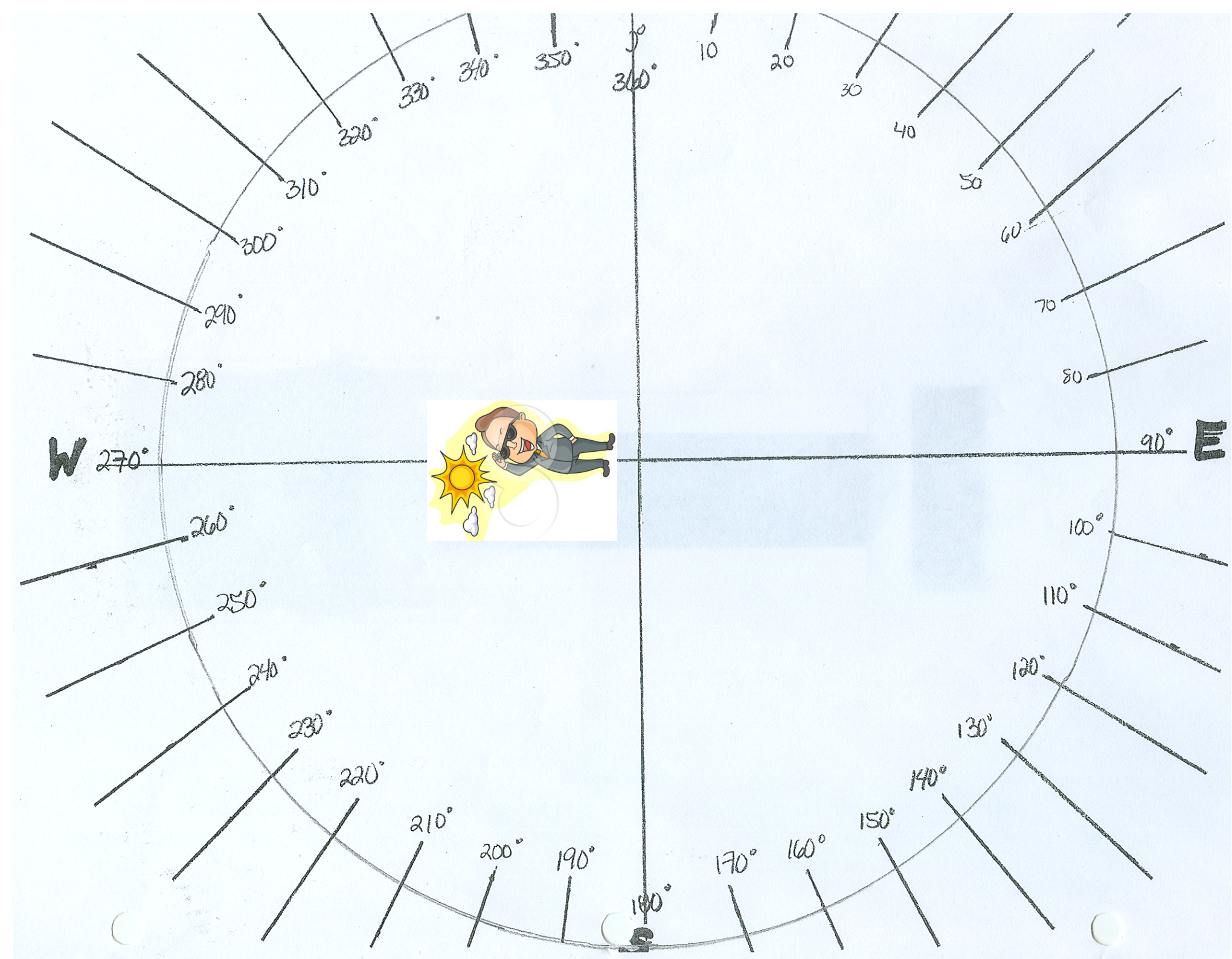
29) At which of these locations is the Noon sun usually highest in the sky? _____

30) At which of these locations is the Noon Sun usually low in the sky? _____

31) Explain how the altitude of the noon sun affects the temperature of a region.

_____

_____


0°
10
20
30
40
50
60
70
80
90° E
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
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