Name: ______________________ Laboratory Section: ______________________

Date: ______________________ Score/Grade: ______________________

Video
Exercise 6
Pre-Lab Video

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LAB EXERCISE

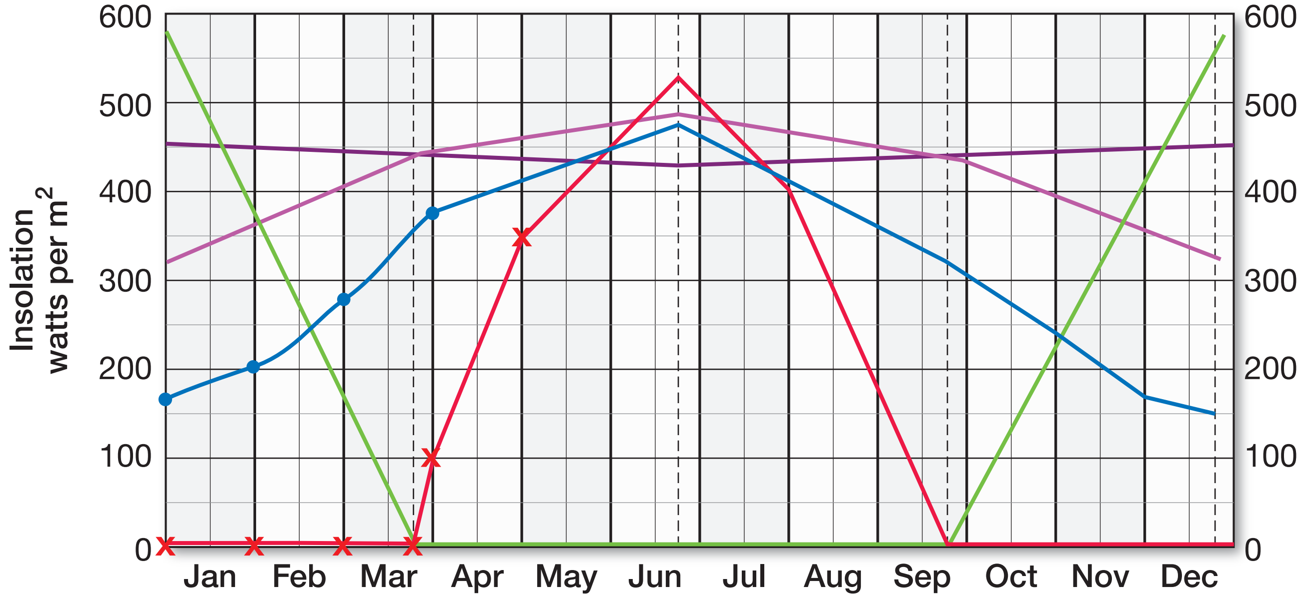
Insolation and Seasons

SECTION 1

Distribution of Insolation at the Top of the Atmosphere

1. Using the data in Figure 6.1 and the graph provided below, plot data for specific latitudes for the first of each month. The graph you create will enable you to note the changes throughout the year in the amount of insolation received at a given latitude. Compare the differences in annual insolation patterns at various latitudes. Plot all seven latitudes on one graph, using color pencils to distinguish each. (Be sure to include a legend.)

   - North Pole (started on the graph with a blue line and xs)
   - New York (started on the graph; with a red line and dots)
   - Tropic of Cancer
   - Equator
   - South Pole



After completing the graph of the energy receipt at these different latitudes, complete the following:

2. Compare and contrast the plotted insolation values at the equator and either of the poles. What factors explain these different patterns of energy receipt?

   Energy receipt (insolation) at the equator is consistently high throughout the year, whereas the receipt at the poles seasonally peaks higher and drops to zero. Earth's curvature presents an increasingly oblique surface to the Sun's rays at higher latitudes. This aspect of Earth's sphericity produces oblique rays and diffuse energy at higher latitudes. Seasonality factors account for the opposing peaks and valleys and pattern of energy receipt.

3. What factor results in the June (summer) solstice energy receipt at the North Pole exceeding that received on the same day at the equator?

   The North Pole receives radiation 24 hours per day at the June solstice. In contrast, the equator has only 12 hours of daylength. This is also one of the two times a year that the subsolar point is at its greatest distance, or declination, from the equator −23.5° north.

4. What is happening at the poles on the March (vernal) equinox?

   At the vernal equinox: the Sun is just rising above the horizon at the North Pole and just setting below the horizon at the South Pole.

5. What kind of generalization can you make about the relationship between latitude and annual variation in insolation?

   Higher latitudes have greater annual variation in insolation. Consistency in annual insolation increases with nearness to the equator (lower latitude).

6. **Challenge question:** Why do you think the South Pole receives over 550 W/m^2 at the December solstice, whereas the North Pole receives over 500 W/m^2 during the June solstice?

   The South Pole receives slightly more energy at the December solstice than does the North Pole at the June solstice because Earth is closer to the Sun in December at perihelion in its orbit.

SECTION 2

Seasonal Variation in the Sun's Declination and Altitude

1. Use the analemma to find:

   a) The subsolar point on November 10 (marked) *[17° south latitude]*

   b) The subsolar point on May 11 ***17°N***

   c) The subsolar point today ***personal answer***

   d) The date(s) when the declination is 9°S ***October 19 and February 27***

   e) The date(s) when the declination is 21°N ***May 28 and July 17***

2. At what clock time does the Sun actually reach zenith on:

   October 13? *[11:47 A.M. The Sun is 13 minutes fast, so it will reach its zenith at 11:47 A.M.]*

   March 8? ***12:11 P.M.***

   May 20? ***May 20, 11:56 A.M.***

   Today? ***personal answer***

3. You are vacationing at Disney World near Orlando, Florida (28.5°N), on June 3. At what altitude will you observe the noon Sun? Include correct horizon. (Show work.) The problem has been started for you.

   ∠ = 90° − (arc distance between your latitude and subsolar point)

   ∠ = 90° − (28.5°N ↔ subsolar point)

   83.47° above the southern horizon

4. On that same day, friends of yours are sightseeing at Iguaçu Falls in Brazil (25.7°S). At what altitude will they observe the noon Sun?

   42.32° above the northern horizon

5. Calculate the altitude of the noon Sun if you are vacationing in Kuala Lumpur, Malaysia (3.2°N), on July 25.

   73.6° above the northern horizon

6. Suppose you were going to install photovoltaic solar panels to generate electricity from the Sun at your house, and you wanted the Sun to shine on them at a 90° angle on the equinoxes. At what angle would they need to be placed, based on the latitude of your home? Should they face north or south?

   Personal answer, but the angle of the panels equals the latitude of the panels.

Use the analemma in Figure 6.2 to answer the following questions:

7. **a)** If you are at 5°N latitude, on what dates will the noon Sun be directly overhead?

   September 10, April 6

   b) Approximately how many days will you view the noon Sun above your northern horizon? ***55***

   … above your southern horizon? ***310***

   c) If you are at 18°S latitude, on what dates will the noon Sun be directly overhead?

   November 14th, January 29th

   d) Approximately how many days will you view the noon Sun above your northern horizon? ***78***

   … above your southern horizon? ***287***

8. Calculate the latitude of a mariner who has measured the noon Sun altitude as 60° above the southern horizon on August 13.

   44°N (must be 30° away from subsolar point which is 14°N; sun is viewed above southern horizon)

9. What would the mariner's latitude be if the Sun had been measured above the northern horizon?

   16°S

10. Calculate the noon Sun angle for the following locations for the solstices and the equinoxes (March 20 or September 22, June 20, and December 21). Then, use the following graphs with your protractor to draw a side view of the noon Sun angle for each of the two solstices and one of the equinoxes. The graph for La Ronge, Saskatchewan is drawn for you and is shown with a protractor. If needed, refer to the analemma to determine the Sun's declination on these dates for each of the four locations.

a) Arctic Circle (66.5°N)

June solstice: ***47°*** December solstice: ***0°*** Equinoxes: ***23.5°***

b) La Ronge, Saskatchewan (55°N)—completed for you

June solstice: 58.5° December solstice: ***11.5*** Equinoxes: ***35.0***

c) Atlanta, Georgia (34°N)

June solstice: ***79.5°*** December solstice: ***32.5°*** Equinoxes: ***56°***

d) Equator (0.0°)

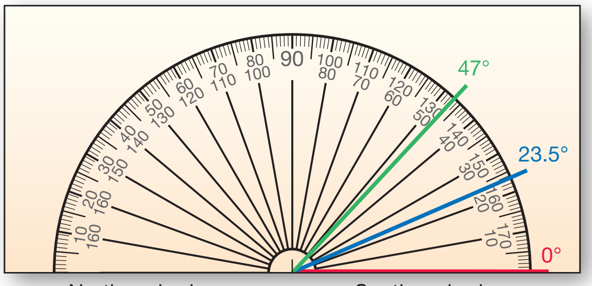
June solstice: ***66.5°*** December solstice: ***66.5°*** Equinoxes: ***90°***

e) Tropic of Capricorn (23.5°S)

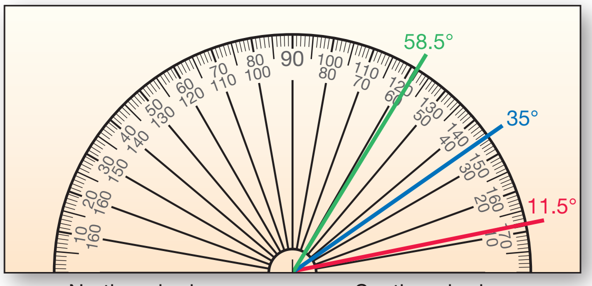
June solstice: ***43°*** December solstice: ***90°*** Equinoxes: ***66.5°***

f) Dunedin, New Zealand (46°S).

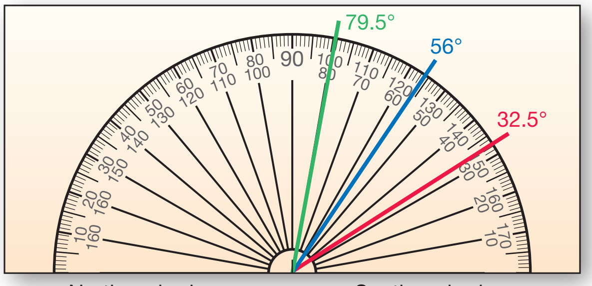
June solstice: ***20.5°*** December solstice: ***67.5°*** Equinoxes: ***44°***



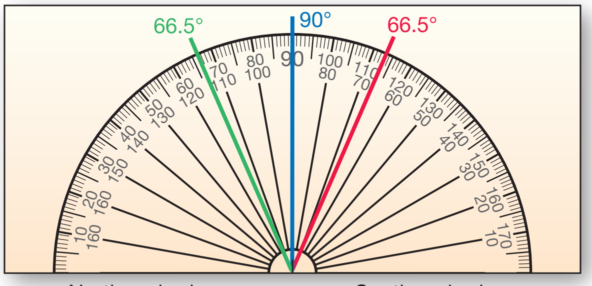
Northern horizon Southern horizon
(a) Arctic Circle (66.5°N)



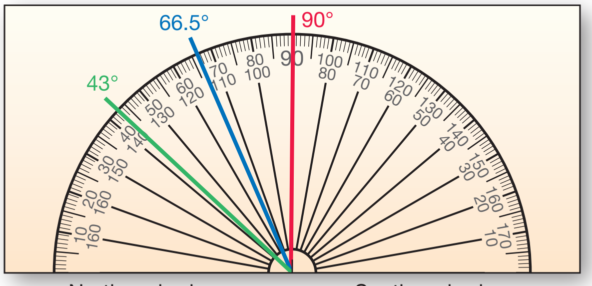
Northern horizon Southern horizon
(b) La Ronge, Saskatchewan (55°N)



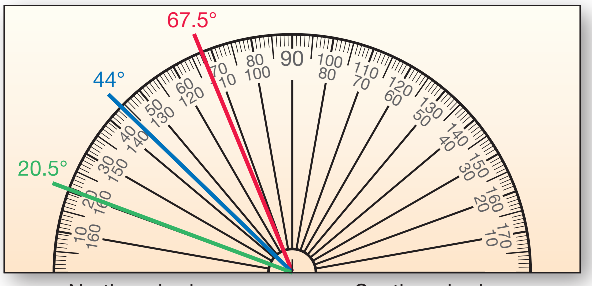
Northern horizon Southern horizon
(c) Atlanta, Georgia (34°N)



Northern horizon Southern horizon
(d) Equator (0.0°)



Northern horizon Southern horizon
(e) Tropic of Cancer (23.5°S)



Northern horizon Southern horizon
(f) Dunedin, New Zealand (46°S)