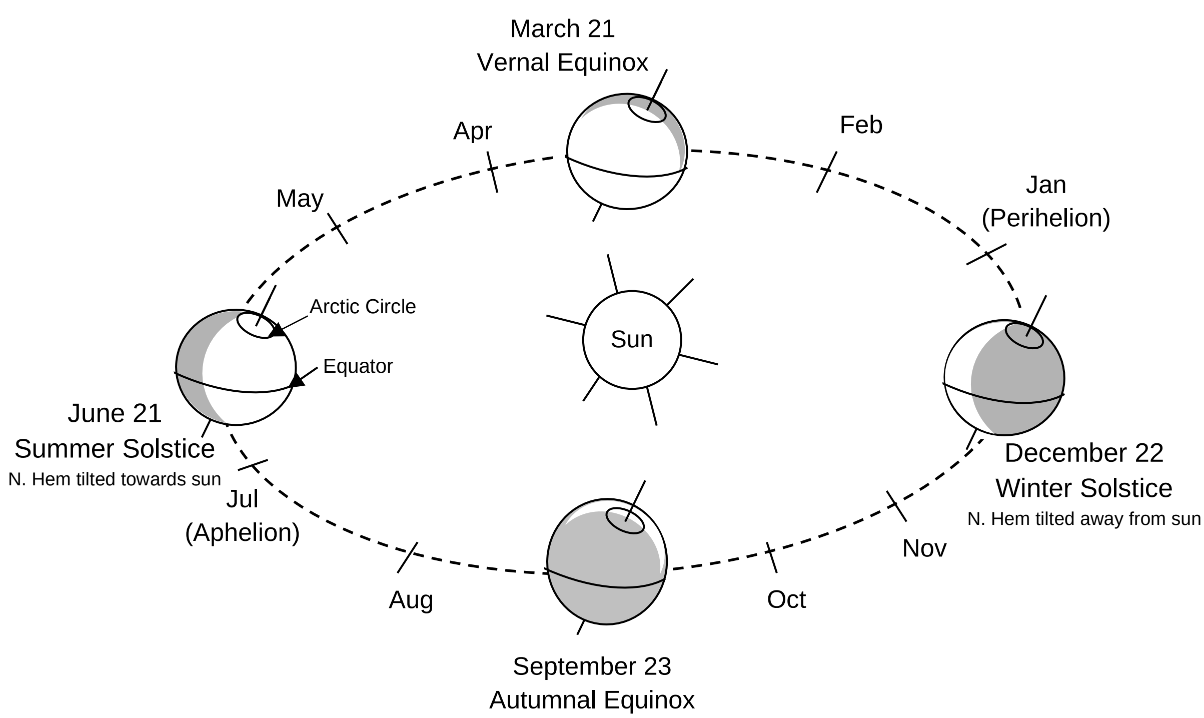
Lab 3a

Earth-Sun Relationships:

The purposes of this lab are to gain an understanding of the relationships between the Earth and the Sun. All weather and climate on our Earth begins with the sun. Solar radiation is the major source of energy that determines what the conditions will be on the Earth's surface, as well as in the atmosphere. This lab will also consider the variability of sunlight received annually at different latitudes.

There are two primary movements of the Earth: **rotation** and **revolution.** Rotation refers to the spinning of the Earth from west to east upon its axis once in approximately every 24 hours. Revolution refers to the movement of the Earth along an elliptical path around the Sun once every 365 ¼ days (approximately). As shown in Figure P3.1, the Earth's orbit is not an even circle, but rather an elliptical orbit with the Earth closest to the Sun in early January (91.5 million miles away), called the perihelion, and farthest away in early July (94.5 million miles away), called the aphelion.

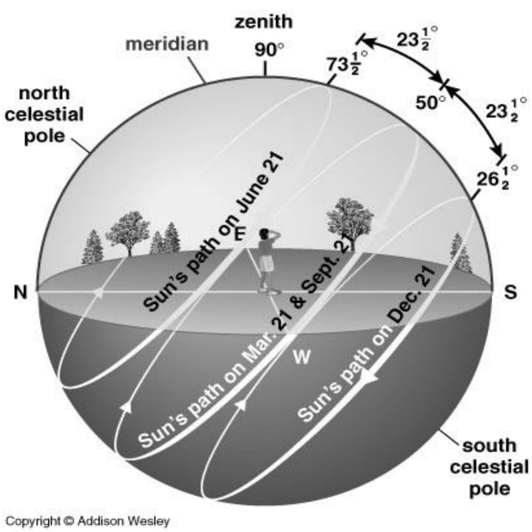
Figure P3.1 Earth's Elliptical Orbit



These movements (rotation and revolution) combined with the tilt of the Earth's axis relative to the orbital plane contribute to the daily and seasonal fluctuations in the amount of solar radiation for different locations. Figure P3.1 illustrates the annual motion of the Earth as it revolves around the sun and lists the seasons based on the northern hemisphere perspective. Only four positions of the Earth in its annual elliptical orbit are shown: December 22, the **winter solstice**; March 21, the **vernal** or **spring equinox**; June 21, the **summer solstice**; September 23, the **autumnal equinox**. The plane of the ecliptic is the imaginary plane composed of all points in the Earth's orbit, which also pass through the sun. The Earth's axis is inclined at an angle of **23 ½ °** to the vertical drawn to a plane of the ecliptic.

Note that in Figure P3.1 the Earth's axis always remains parallel to itself throughout the annual orbit, i.e. it is always tilted in the same direction. This parallelism of the axis produces the seasons. There is greater heating of the surface when the sun is directly overhead, i.e. the sun's rays are perpendicular to the surface. The latitude at which the sun is directly overhead changes continuously in an annual cycle as the Earth moves in its orbit around the sun. The sun appears to move from northern latitudes to the equator to southern latitudes and back to the equator and northern latitudes. This apparent motion of the sun (although it is the Earth that moves) may be observed in northern latitudes as the sun in our winter is low in the sky even at noon while the noon sun in our summer sky is high (Figure P3.2).

Figure P3.2 Northern Sun Path



As seen from the point of view of an observer at a northern mid-latitude, Figure 2.2 traces the path of the sun across the sky during the year.

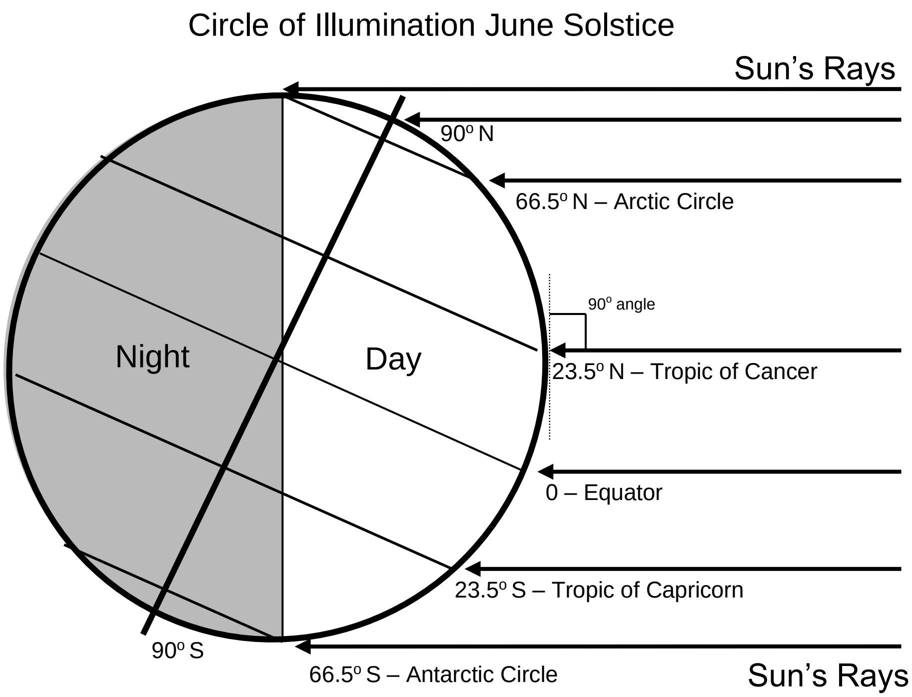
From this diagram it becomes clear that in northern latitudes in winter the days are shorter and the sun arcs south and low across the sky. Conversely, in summer the days are longer and the sun arcs high but still south. At the equinoxes the sun rises due east and sets due west (in the summer it rises and sets closer to the northeast and northwest and in winter it rises and sets closer to the southeast and southwest).

Figure P3.3 provides a more detailed view of the June 21 orbital position of the Earth. Note two important observations:

i) How the inclination of the Earth's axis influences the angle at which the sun's rays strike the surface.

ii) How the inclination of the Earth's axis and the angle at which the sun's rays strike the surface determine the relative amount of day and night.

Figure P3.3 June 21 Orbital Position



The Tropic of Cancer (23 ½ ° N) and the Tropic of Capricorn (23 ½ ° S) represent the maximum distance north and south of the equator that the sun's rays may be perpendicular to the surface of the Earth. The sun is directly overhead (the vertical noon sun) at the Tropic of Cancer on June 21 (Northern Hemisphere summer solstice). The sun is directly overhead at the Tropic of Capricorn on December 22 (northern hemisphere winter solstice). The sun is directly overhead at the Equator on March 21 (Vernal Equinox) and September 23 (Autumnal Equinox). The Arctic Circle (66 ½ ° N) and Antarctic Circle (66 ½ ° S), mark the limit of the possibility of 24 hours of darkness or light.

Internet Resources for Earth-Sun Relationships

1. US Naval Observatory: Sun and Moon information
http://aa.usno.navy.mil/data/
http://aa.usno.navy.mil/data/docs/RS_OneDay.html

2. Sandburg Center for Sky Awareness daylight calculator
http://www.wsanford.com/~wsanford/daylight/calculator.html

3. Earth-sun relationship
http://www.physicalgeography.net/fundamentals/6h.html

4. NOAA: Sunrise/Sunset Calculator
http://www.srrb.noaa.gov/highlights/sunrise/sunrise.html

5. Royal Observatory, Greenwich
http://www.rog.nmm.ac.uk/

Exercise 3a Lab Activity Name: ______________________________

Earth-Sun Relationships Lab Section: ______________________________

Please show your work. If necessary, please use additional paper to show work.

✐ 1a) Consider building a house in Massachusetts. In order to gain maximum sunlight in your living room, which direction should the window face? ______________________

Why?

b. If you were building a house in Santiago Chile and wanted maximum sunlight in the living room, what direction should your window face? ______________________

Why?

✐ 2) When (what date) is the Sun directly overhead of:

a. The Tropic of Capricorn ______________________________

b. The Tropic of Cancer ______________________________

c. The Equator ______________________________

d. The Arctic Circle ______________________________

✐3) Give the latitude and the significance of (what is important concerning):

a. The Tropic of Capricorn:

b. The Tropic of Cancer:

c. The Arctic Circle:

d. The Antarctic Circle

The Arctic & Antarctic Circles

The Arctic Circle (66 ½ ° N) and Antarctic Circle (66 ½ ° S), mark the limit of the possibility of 24 hours of darkness or light. For other latitudes we can roughly establish the length of day by first determining the proportion of the parallel that is in the light zone. The same proportion of 24 hours would be daylight.

✐ 4) Notice the relative length of daylight in the northern and southern hemispheres on June 21 in Figure P3.3. On June 21 what might the daylight situation be at:

a. The Arctic Circle: ________________

b. The Equator: ________________

c. Antarctic Circle: __________________

✐ 5) Six months later on December 22 what might the daylight situation be at:

a. The Arctic Circle: ________________

b. The Equator: ________________

c. Antarctic Circle: __________________

✐ 6) Usually we think of the seasons of the year as they occur in the Northern Hemisphere. Determine when the following seasonal positions occur in the **Southern Hemisphere**. List the dates.

a. Vernal Equinox _________________________

b. Autumnal Equinox _________________________

c. Winter Solstice _________________________

d. Summer Solstice _________________________