Heat Transfer

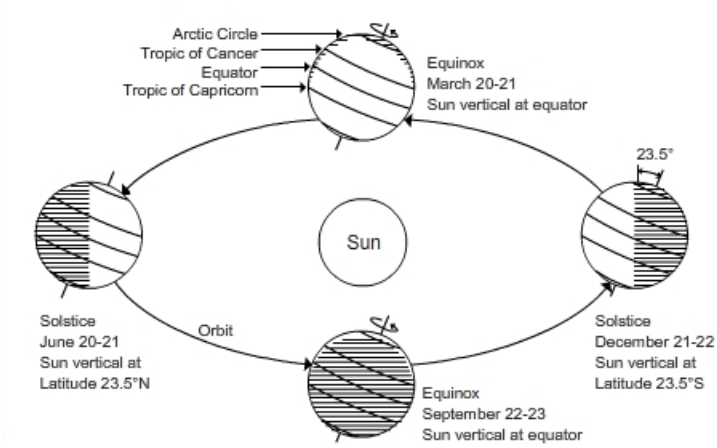
Energy from the Sun

Introduction

The sun rises in the east and sets in the west, but its exact path changes over the course of the year, which causes the seasons. In order to use the sun's energy in a building, we need to know where it is in the sky at different times of the year.

There are two ways to think about the sun's path in the sky. One way is to study the tilted Earth traveling around the sun viewed from outer space and figure out where the sun would appear in the sky at your latitude at different times of the day and year. If you have time, give this a try with your class.

Walk around a light source, real or imagined, with a globe that's tilted at the right angle. Turn the globe at different positions (times of the year). Try to picture the length of the day and the angle of the sun.



The other way is to stand on the Earth and plot the path of the sun from your point of view on the ground. This is easier to apply to a building, although, of course, the two ways give the same results.

We will use the earth-centered approach in this workbook.

For this project students must be able to picture the sun's path to design passive solar features in their houses. The focus of this chapter is not the complex geometry of a tilted earth moving around the sun, but simply the path of the sun from the point of view of someone on the earth. Where does it rise and set at different times of the year? How high in the sky is it at noon? How long are the day and night?

Learning goals

Explain the sun's daily and seasonal path in the sky, in the northern hemisphere at varying latitudes.

Apply this knowledge to explain how much sunlight energy can be collected using windows, roofs, and other collectors depending on their orientation.

To download Energy2D software, go to http://energy.concord.org/energy2d/

To run the models in this chapter, go to http://energy.concord.org/htb

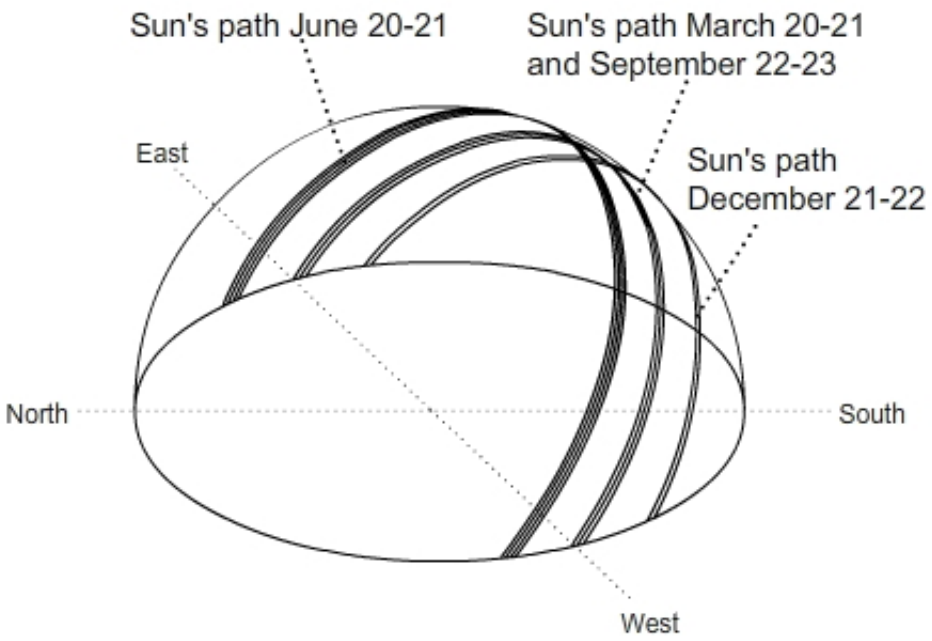
Note the video tutorial.

Note: This is one section of the "Science of Heat Transfer" chapter of the Engineering Energy Efficiency Project. See: http://concord.org/engineering

Point out that the winter arc above the horizon is both **lower in the sky** and **shorter in length (hence time)** than the summer arc. These two key facts explain the seasons.

Here is a diagram of the sun's path in the sky at different times of the year. It is roughly correct for a northern latitude of 40°. Note the three lines showing the sun's path. One is the summer solstice, one is the spring and fall equinoxes, and one is the winter solstice.

One is the summer solstice (June 21), one is the spring and fall equinoxes (March 20 and September 23), and one is the winter solstice (December 21). The exact dates change a little bit from year to year.



Where is the sun?

Learn the basic facts about the sun's path at your latitude. Use the above diagram, your background knowledge, and class discussion to fill out the following table. Here are some hints.

a) At the equinox at noon, the angle of the sun above the horizon is (90° minus the latitude). For example, at the equator this is 90°; at the pole this is 0°.

b) At the two solstices, the angular height of the sun at noon either increases or decreases by 23.5°– the tilt of the earth's axis – compared to the equinox.

c) For the length of the day, do some Internet research. Many sites give the times of sunrise and sunset. (For 40°N, daylight is about 3 extra hours in summer and 3 fewer hours in winter.)

Chapter 2: Sun's path throughout the year					
Your latitude: 40°N (Boston, Massachusetts)					
Event	Date	Length of day	Height of sun at noon	Sun rises in what direction?	Sun sets in what direction?
Winter solstice	December 21-22	9 hours	26 ½° (50° - 23 ½°)	23 1/2 ° **south** of East	23 1/2 ° **south** of West
Spring equinox	March 20-21	12 hours	50° (90° - latitude)	East	West
Summer solstice	June 20-21	15 hours	73 ½° (50° + 23 ½°)	23 1/2 ° **north** of East	23 1/2 ° **north** of West
Fall equinox	September 22-23	12 hours	50° (90° - latitude)	East	West

Fill out this chart together in class or assign it as homework, and then discuss the meaning of the numbers. Do the Sun's Path Calisthenics with the class (next page). This is the easiest way to show everyone exactly what the sun does all year.

Before you continue, the teacher will lead a discussion on the Sun's Path Calisthenics so that this diagram makes more sense.

Have everyone stand up and do this exercise.