Workshop Handout: Sun, Sky, Seasons, Shadows

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Introduction

Before people used electric lights to light up streets and buildings, about a century ago, people paid greater attention to the sky, sun, moon and stars. Observing the sky helps us observe the natural world and understand the seasons. This workshop will introduce you to several activities to bring awareness to the sky, sun, seasons and shadows. These are great learning activities for outdoor classes and school gardens, in all seasons.

Garden-based Activities

1) Tracking the path of the sun with your body

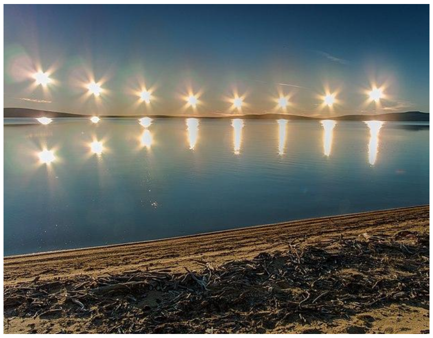
Background information:

Where does the sun rise and set? How can you tell whether a tall building will shade your garden? How can you experience and chart the "path of the sun in the sky" throughout the year using your body?

Most of us learned that the sun rises in the east and sets in the west. That is quite true, year-round if you live on the Equator! (The word 'equator' means 'what makes things equal'). On the Equator, there are equal hours of daylight and night throughout the year—12 hours of day and 12 hours of night, with sunrise in the east and sunset in the west.

In the rest of the world, there are two days a year when the sun rises in the east and sets in the west, with equal hours of day and night: the spring and autumn equinoxes, on approximately March 21 and September 21. Equinox' means 'equal night'. On the equinoxes, every place on Earth has 12 hours of daylight and 12 hours of darkness!

FRESH ROOTS



Moving away from the Equator towards the North or South Pole, the difference in daylight hours in summer and winter become more extreme. North of the Arctic Circle and south of the Antarctic Circle (at approximately 60° north/south latitude), the Solstices bring the midnight sun (at least one day when the sun never sets) and the long nights of winter (at least one day when the sun never rises above the horizon). The northern Summer Solstice is ~June 21 and Winter Solstice ~December 21, and the opposite in the southern hemisphere, because of the tilt of the Earth on its axis.

Between the Equator (0° latitude) and the Arctic/Antarctic zones (60° - 90° north/south latitude), there are gradual changes in the daylight hours, the places where the sun rises and sets and the appearance of the path of the sun in the sky.

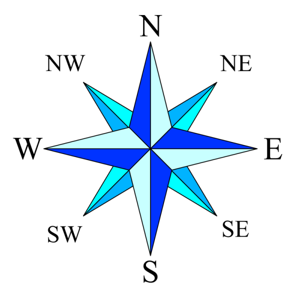
You can calculate the elevation of the sun at any location on Earth at the solstices using this formula and recalling 23.5° is the tilt of Earth on its axis:

Summer solstice noon sun elevation = 90° - (your latitude) + 23.5°
Winter solstice noon sun elevation = 90° - (your latitude) - 23.5°
Spring/ Autumn equinox noon sun elevation = 90° - (your latitude)

Example:

Vancouver is at 49° north latitude, a little more than halfway between the Equator (0°) and the North Pole (90° north latitude). At Vancouver's latitude, the Summer Solstice Longest Day sun rises in the northeast and sets in the northwest, and at noon when the sun is at its peak it is in the south at ~64° above the horizon.

90° - 49° + 23.5° = 64.5° (about 2/3 of the way up the sky, with 90° directly above us)



The Winter Solstice Shortest Day sun at Vancouver's latitude rises in the southeast, sets in the southwest, and is at its peak in the south sky at just ~18° above the horizon!

90° - 49° - 23.5° = 17.5° (less than 1/5 of the way up the sky)

On the Spring and Autumn Equinoxes at Vancouver's latitude, the sun rises in the east, sets in the west, and is at its peak in the south sky at ~41° above the horizon.

90° - 49° = 41° (almost halfway up the sky)

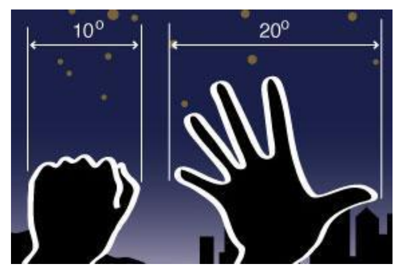
Note that in the Southern Hemisphere, Summer and Winter Solstice dates are reversed, and the sun reaches its peak in the northern sky! It might be interesting to pair up with a penpal class at a similar latitude in the Southern Hemisphere to compare student observations around Solstices and Equinoxes.

Experiencing and tracking the path of the sun at the Solstices:

- In the Northern Hemisphere, get outdoors with a good view of the sky, facing south. (An easy way to find south is with a conventional or digital compass—or by marking east (sunrise) and west (sunset) on an equinox, and measuring halfway between them!)

- We can easily find southeast or southwest (halfway between south and east or west) for the Winter Solstice, and northeast and northwest (halfway between north and east or west) for the Summer Solstice.

- To measure the angle of elevation with our bodies, work with a partner to calibrate your own handspan (the width of an open hand held at arm's length) or your own fist height (the width of your fist held at arm's length). Pile up and count handspans or fists at arm's length to go from 0° (horizontal, straight in front of you) to 90° (directly above your head). 90° divided by the number of handspans or fists gives you the number of degrees of one of these. (For me, about 10 fists or 5 handspans makes 90°, so one fist = 90°/10 = 9°, and one handspan = 90°/5 = 18° -- each person's hand is slightly different.)



- Use your handspan or fist angle-of-elevation measurement to find the highest elevation of the sun in the Winter Solstice south sky. Then, starting in the southeast and sweeping through that high point to the southwest, you can trace the path of the sun on Dec. 21.

- You can do the same for the Summer Solstice, but this time starting in the northeast (way behind you) and ending up in the northwest (ditto), with the sun much higher in the noon sky!

- And the same for the Equinoxes, but this time with the sun rising exactly in the east and setting in the west, with the highest elevation exactly the average of the two Solstice elevations. (In Vancouver, this is (64.5° + 17.5°)/2 = 82°/ 2 = 41°)

By tracking the sun at its extreme points, you can estimate quite accurately whether your garden will be in sun or shade throughout the seasons!

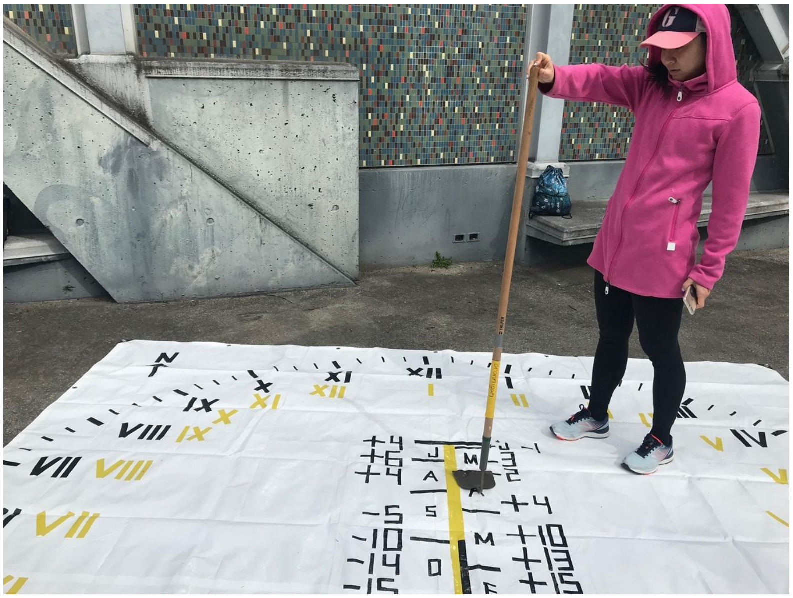
2) Six-month pinhole camera photos of the path of the sun

We made these beautiful images of the path of the sun in the UBC Orchard Garden with six-month exposure pinhole cameras, with the guidance of visiting mathematical artist Nick Sayers. You can do this in your own garden or schoolground too! It's fascinating to see images of the south sky over a familiar place with the daily path of the sun highlighted— something we can't see over time with just our eyes!

Instructions for making a pinhole camera can be viewed in Justin Quinnell's video titled "How to Make a 6-month duration Pinhole camera". For our cameras, we used coconut water cans instead.

Attach the pinhole camera firmly to a post or tree, facing the south sky, remove the piece of tape over the pinhole (the 'shutter'), and leave in place for up to six months before removing and scanning the image as per video instructions.

3) Making a portable analemmic sundial with a human gnomon



Start with an exploration and measurement of the lengths and directions of people's shadows on sunny days, from morning to noon to afternoon. As your students realize that our shadows grow longer and shorter, and move with the sun throughout the day, they will be ready to learn how people in every culture tell time and direction with shadows. It's an exciting project to learn about sundials and build a portable sundial for your school garden, where the gnomon (that casts a shadow) can be a person standing on the appropriate month marker. The sundial pictured here was made by UBC teacher candidates with coloured duct tape on a white tarp for Vancouver’s specific latitude. It needs to be oriented toward the north to function.

Instructions on how to make your own analemmic sundial can be found on the North American Sundial Society’s post titled “[Making an Analemmatic Sundial]”. The mathematics involved are at a senior secondary school level (using trig functions).