

From Marcia's Science Teaching Ideas

A Great Way to Introduce Astronomy to Middle Schoolers

by Marcia J. Krech



1. The Importance of One Activity to Teaching Astronomy



The Importance of One Activity to Teaching Astronomy

Looking back on my 30 year teaching career, this one lesson is most representative of my teaching philosophy: **Hands-on, active, meaningful, engaging learning.**

The bottom line is this: by measuring the azimuth and altitude of the sun for the entire school year, you have set up many wonderful learning objectives.

Here are a few of those OBJECTIVES:

- 1 Making scientific instruments
- 2 Learning to calibrate and properly use the instruments
- 3 Taking accurate measurements over time
- 4 Make qualitative observations using the five senses
- 5 Collaborating with teams to work on a long-term project
- 6 Recording and interpreting data

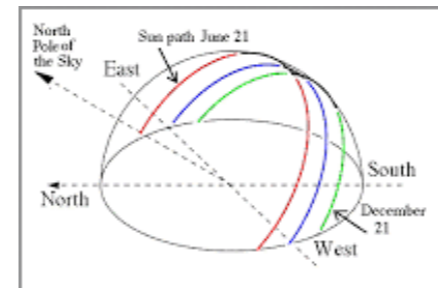
- 7 Relating units of time (i.e., day, month, year) to the regular and predictable motion of the planets and moons and their positions in the Solar system
- 8 Illustrating and explaining a year as the time it takes a planet to revolve around the Sun
- 9 Explaining seasonal phenomena (i.e., weather, length of day, temperature, intensity of sunlight) as a consequence of a planet's axial tilt as it rotates and a planet's orbital position as it revolves around the Sun
- 10 Predicting moon rise/set times, and eclipses when given the relative positions of the moon, planet, and Sun
- 11 Relating changes in the length and position of a shadow to the time of day and apparent position of the Sun in the sky, as determined by Earth's rotation
- 12 Describing the pattern that can be observed in the changes in number of hours of visible sunlight, and the time and location of sunrise and sunset, throughout the year
- 13 Recognizing, in the Northern Hemisphere, the Sun appears lower in the sky during the winter and higher in the sky during the summer
- 14 Recognizing, in winter, the Sun appears to rise in the Southeast and set in the Southwest, accounting for a relatively short day length, and, in summer, the Sun appears to rise in the Northeast and set in the Northwest, accounting for a relatively long day length
- 15 Recognizing the Sun is never directly overhead when observed from North America
- 16 Relating the axial tilt and orbital position of the Earth as it revolves around the Sun to the intensity of sunlight falling on different parts of the Earth during different seasons

Whew! And that isn't all! So amazing to cram so many important objectives into one activity.

2. Measuring the Sun's Movement

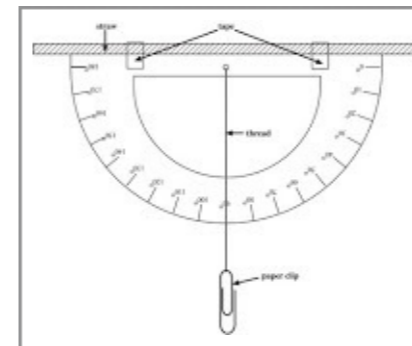
Measuring the Sun's Movement

For many years, my Earth Science classes measured the Sun's movement across the sky in three seasons and plotted and studied what that meant. It was one of the most meaningful and exciting things I've ever done.



Here's how you do this:

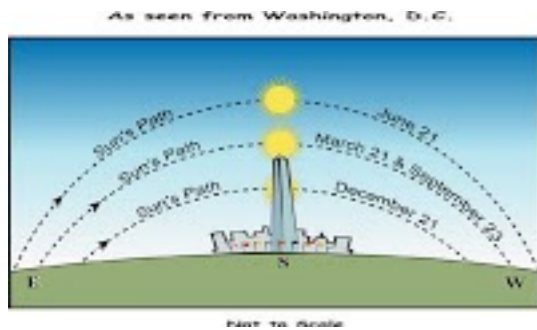
First, have your students build Sun Clinometers. (Directions in next section.)



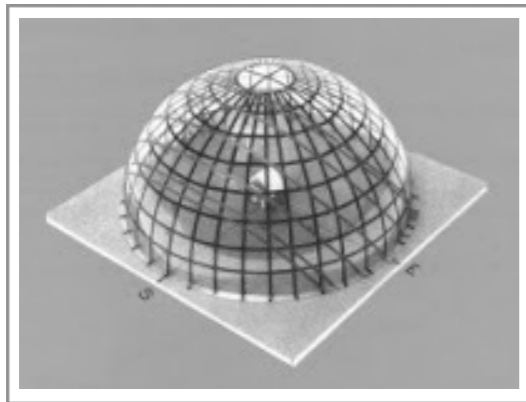
After they are built, have your students measure the altitude of many things inside and outside your school until they understand how to measure **Altitude** which measures height above the horizon in degrees.

You also have to teach **Azimuth** which uses a compass and indicates the direction from north in degrees.

Finally, by taking and plotting the measurements in the fall, winter, and spring, you can show the seasonal changes of the Sun in the sky. This touches things like length of day/night and where the sun is in the sky during each season.



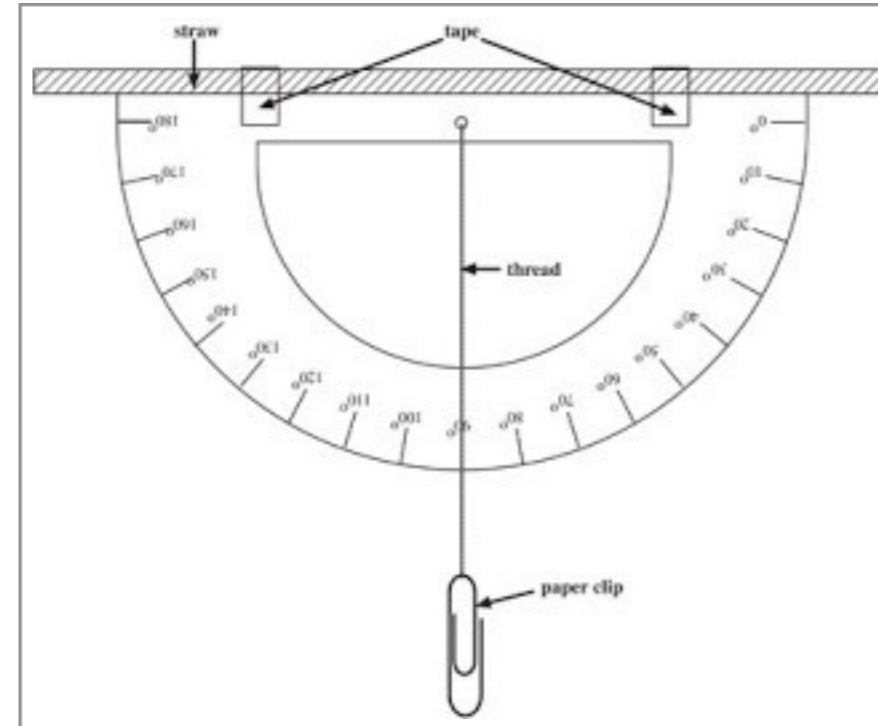
I had a set of clear plastic domes that we used to **plot the three seasons** with wax pencils. Even cooler!



This was one of the biggest ongoing projects I've ever done. It was worth all the work. It is **REAL SCIENCE** in its purest form: **OBSERVATION AND MEASUREMENT**. I loved it. I'm hoping you will, too!

3. Building the Sun Clinometer

Building the Sun Clinometer



I love having kids make scientific instruments!

Making scientific instruments requires a certain mindset from students. They have to be careful, precise, and **CARE** about what they are doing. Basically, if you are picky-picky in the grading, as well as cheerful and encouraging, you will be thrilled with the results!

Some students who are normally sloppy will rise to the occasion and make beautiful instruments. I personally believe that if you push kids to dig deep and find the **BEST** they've got inside

themselves, **THIS** is what gives them self-confidence in themselves! Not empty praise!

So, in the making of the Clinometer, you need to **set the stage correctly.**

By that, I mean:

- 1 Have all the materials collected.
- 2 Have a couple of Clinometers made by you and labeled with your name.
- 3 Have the Rubric run off.
- 4 Have the Clinometer Directions run off.

Here's how you introduce the day:

Show your Clinometer to the class. Talk with enthusiasm about how you will be going outside every sunny day for the next month to take sun measurements and once a week after that for the **REST OF THE YEAR.** Encourage them to make a really good one because it must be properly calibrated to get good measurements.

Tell them you will know for sure if someone's Clinometer isn't made correctly because their measurements will be different from the class average. Tell them you are going to be picky in the grading so that everyone has a good Clinometer to use.

Go over the Directions and the Rubric with them step by step. **Don't repeat yourself at all!** This is important. You want them to hear it once and then come up to look closely at your examples later if they missed something. **There is great value in not overdoing the set-up.** Quick and clean, I say. Then set them loose.

Put some fun music on the CD player. I loved playing a CD collection of science fiction movies and having them guess what movie it is.

When they are done, they line up by you with their Clinometer and the Rubric and you grade them on the spot. If they are less than perfect, give them a chance to go back and fix the errors and come back to get a new grade. **THIS IS VERY IMPORTANT.** By giving them a second-chance, they will **TRY HARDER!**

Tell them you will teach them how to use their Clinometers tomorrow and move on to the next thing if you have time or dismiss the class.

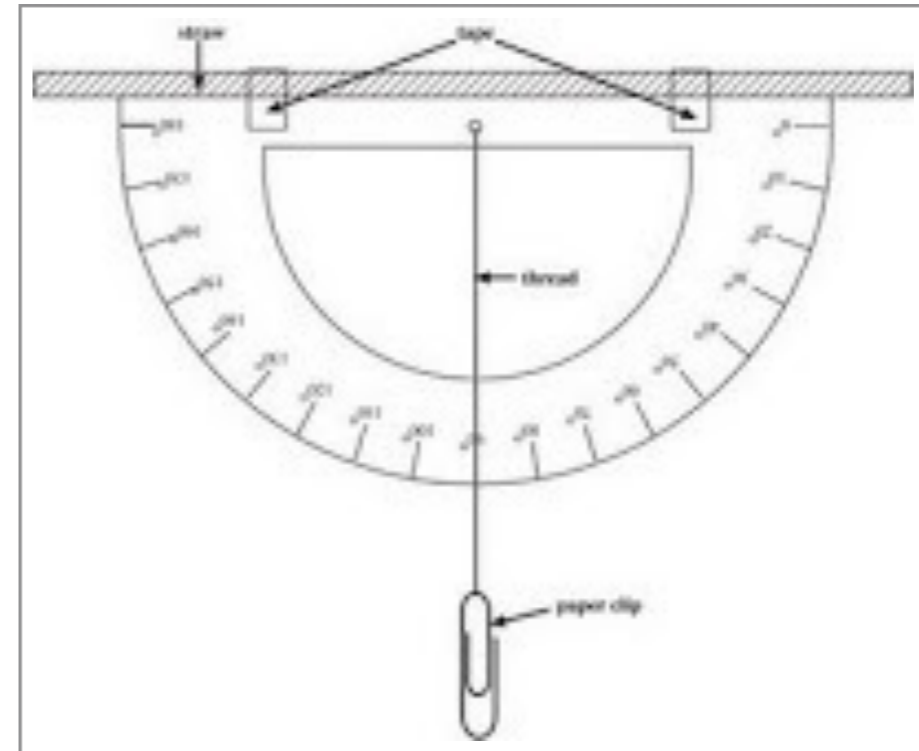
Be sure to collect the Clinometers in a bin labeled for their class.

Click here for: BUILD A SUN CLINOMETER.

4. THE VIRTUAL COMPASS

Teaching Azimuth and
Using a Compass Rose

The VIRTUAL COMPASS - Teaching Azimuth and Using a Compass Rose



So, all your students have made a Clinometer. Now what do you do?

Well, first you have to teach altitude and azimuth, but because they have made their **Clinometers**, they are more likely to pay attention while you teach the basics.

I would recommend holding off teaching how to use the **Clinometers** for a bit. **Teach how to use a compass first.**

TEACHING AZIMUTH USING THE COMPASS

If you are lucky, you will have a class set of compasses, maybe even orienteering compasses. The most fun? Everyone has their own compass. Even small, cheap ones, just enough for everyone!

Have your students help push the room's tables or desks toward the center of the room. Have everyone stand in a ring around the outside of the room.

Run them through a series of review exercises. Start with lining the needle up with north, of course. Ask them to point to north. Then have them all point to the east, the west, the south, etc. Then try for the fancier ones, like southwest, southeast, etc. If they do well with this, throw in south-southwest and see if anyone knows these, or can work it out.

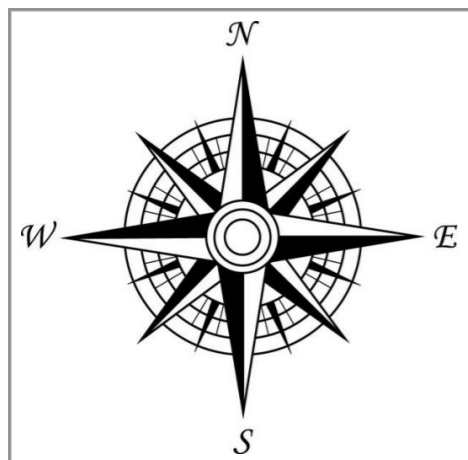
During this session, **have volunteers stick large printed labels of the various compass points on the classroom walls.** My classroom was not facing true north so the walls were all the southeast, northwest. North was in a corner. Made it easier to have them up for my students. Use sticky putty on the backs of the labels. Take them down at the end of each class so the next can put them up, too. You can leave them up after your last class leaves.

Now, here's the really fun part: **REALLY TEACH AZIMUTH!** Make sure your students are evenly spaced around the edge of the room and in a circle of sorts.

Run through a **tough, quick review** of what you just reviewed and add on:

- 1 Raise your hand if you are at north. (Should only be one hand up. If no one is perfectly north, have a student move into that position.)
- 2 What degrees is the North person? (If no one knows, ask them to guess. Don't tell them outright. Lead them by asking how many total degrees in a circle, and so on. They should see that North is both 0 and 360.)
- 3 Move on to South. Raise your hand if you are at South.
- 4 What degrees is the South person?
- 5 Repeat for East and West.
- 6 Move on to northeast, southeast, northwest, southwest.
- 7 Go over all again. **This time have everyone point** to the representative person. Always ask for degrees and compass point.

- 8 Try a couple of the south-southwest or north-northwest, etc., but don't do much if they are on overload.



- 9 **NOW** have everyone walk a quarter turn around the room. **Go over many of them again.**
- 10 Repeat again if they can handle it. Otherwise move on to the worksheet.

NOTE: We will do this type of **Virtual Compass** tomorrow, only use altitude in the sky instead. When you put them together, you really have something, my friends!

After you think your class understands the compass points and degrees, have them sit down and give them all [this worksheet](#) which reviews what you've just covered.

TEACHING AZIMUTH USING THE COMPASS ROSE

You can do something similar using **paper compass roses**. [Click here](#) for a good one. You can have your first class glue the entire page onto cardboard. Smooth carefully. (You now have a complete set for the rest of the year. Just be sure to number them and collect back each hour.)

[Click here](#) for a blank compass rose from Enchanted Learning.
[Click here](#) for a good review page.

With a **Compass Rose**, you need to masking-tape or chalk a **north-south line** on your floor or in the parking lot or on the concrete playground. Your students put their compass roses on the north-south line, all norths facing north and move themselves around the rose, always looking at the direction from across the rose.

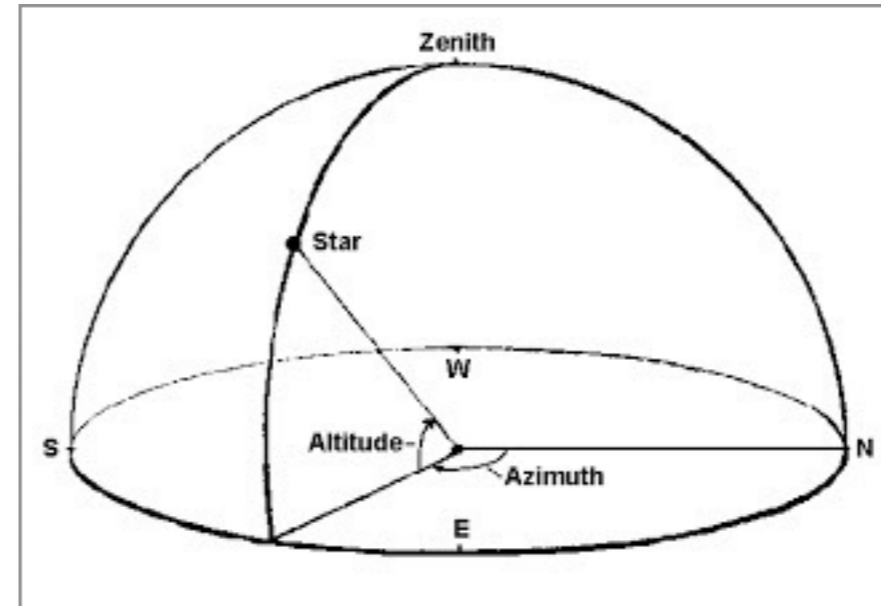
Works great if you don't have compasses!

Run your students through a review similar to the above. It will be slightly different but they should all be moving around their compasses. Standing on the point would be in the correct position. Look to the northwest, they would be standing southeast looking to the northwest.

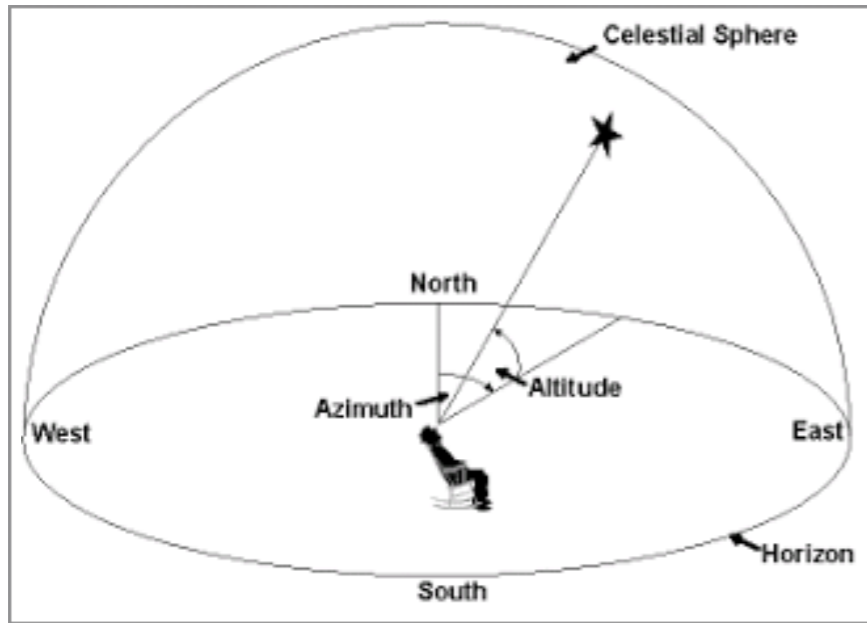
NOTE: You may need several **north-south lines** on the floor/pavement so they all have room to walk around their roses.

5. How to Teach Altitude

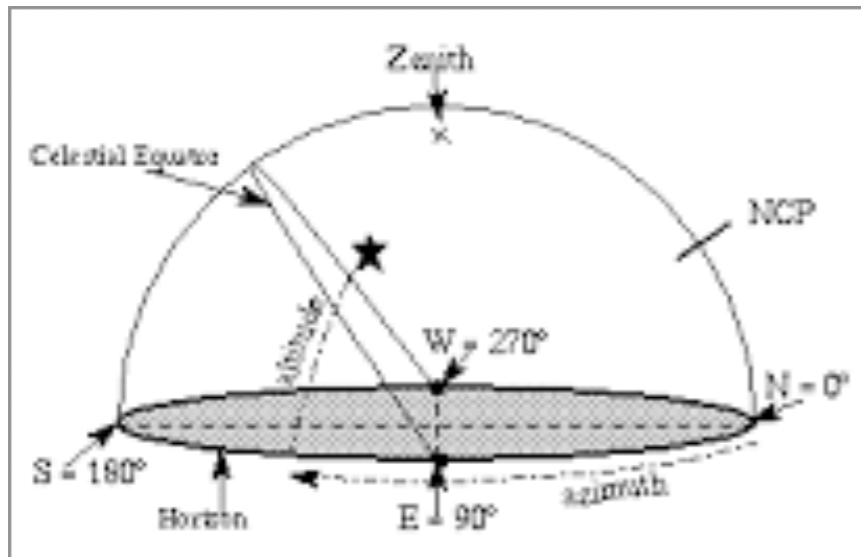
How to Teach Altitude



The point of teaching the "**Altitude in the Sky**" concept is getting kids thinking of the sky as an upside down bowl. **Altitude and Azimuth** are the Latitude and Longitude of the sky. The **altitude** of a star is how many degrees above the horizon it is. The **azimuth** of a star is how many degrees along the horizon it is and corresponds to a compass direction.

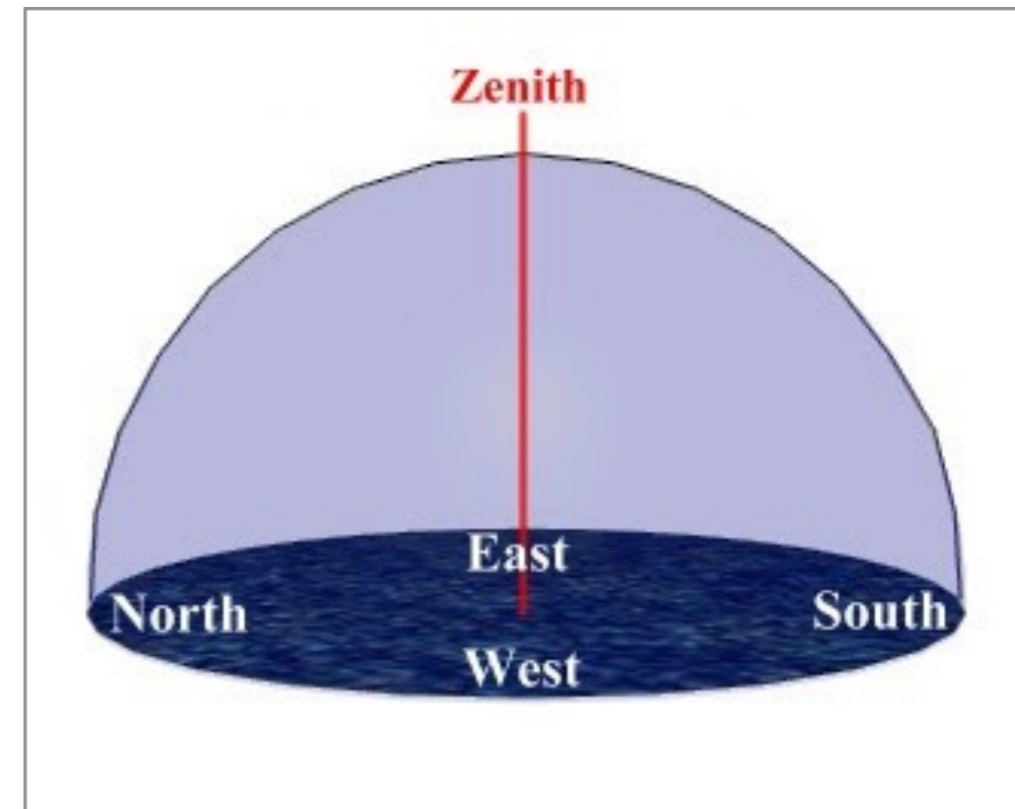


There's more to it than that, but I don't think middle schoolers need to worry about the **Celestial Equator** and such.



HOW TO TEACH ALTITUDE

Get your students back in the big circle around your room. Make sure different students are at the cardinal points on the compass (N, S, E, W). Of course, if you wanted to, it wouldn't hurt to **review azimuth for a couple of minutes**.

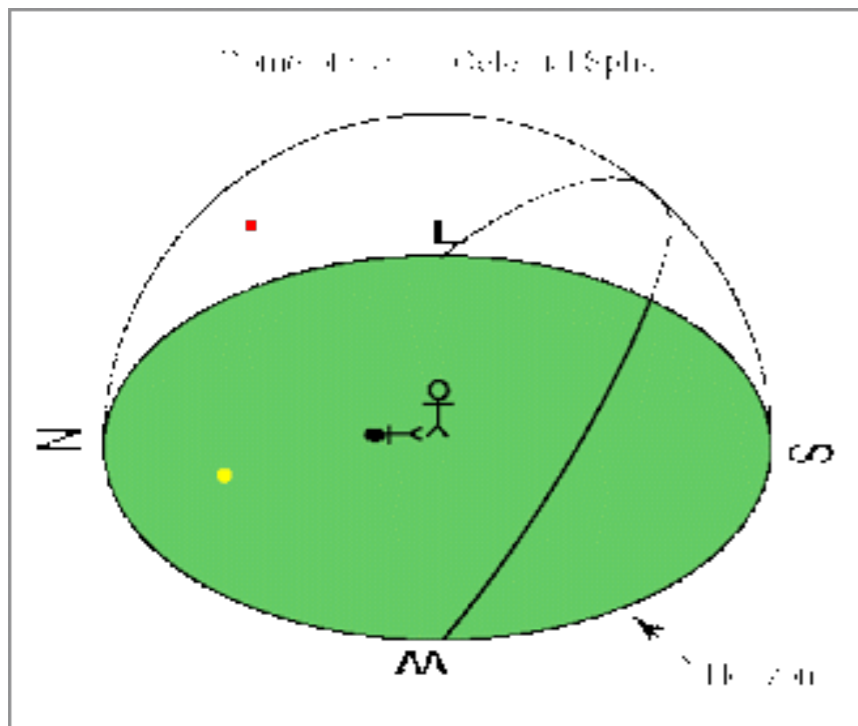


Now, go stand in the center of the room. First introduce the **ZENITH** of the sky.

1. Does anyone know what the very top of the sky is called? No matter where you are, it's always directly above your head. **NOT** where the brad is on the Star Wheel, (if you've made Star Wheels) but the very center of the oval that is the night sky. It's right above your head. That's right! **ZENITH!** (or tell them if no one knows.)

2. What's the place below your foot called? Where you are standing? That's called **NADIR.**

3. Then talk about the **HORIZON.** How there always is one, and how this is where the moon and stars come up from hiding in the Southern Hemisphere as the Earth turns on its axis each night.



Now, teach **altitude:**

1. Once you have **ZENITH** and **HORIZON** established, hold one of your arms over your head pointing at the ZENITH. Stretch your other arm straight out toward the **HORIZON.** Wiggle your upraised hand.

2. What is it pointing toward? You got it! **ZENITH.**

3. Wiggle your other hand. What is this one pointing toward? That's right. **HORIZON.**

4. Now, how many degrees have I formed with my two arms? Yes! 90 degrees!

5. So what degrees would you say the **HORIZON** is? Yup. Zero degrees.

6. And the degrees for the **ZENITH**? You got it! 90 degrees!

7. Have all the students imitate you. One arm up toward the **ZENITH** and one arm out toward the **HORIZON.**

8. And where are you standing? Does anyone remember that? Right! **NADIR!**

9. (Wiggle your 90 degree hand.) And what is this pointing toward? Right. **ZENITH.**

10. (Wiggle your 0 degree hand.) And this? Right.

HORIZON.

11. (Just say this next sentence, don't demonstrate!) Raise your **HORIZON** hand to 45 degrees. (Wait till most of them have it.) Half way up, right?

12. Try for 30 and 60 degrees. (Demonstrate the concept of one-third up from the HORIZON is 30 degrees and two-thirds up from the HORIZON is 60 degrees.)

HERE'S THE FUN PART:

1. Ask the students to point to 85 degrees. Point to 15 degrees.(Do several more.)

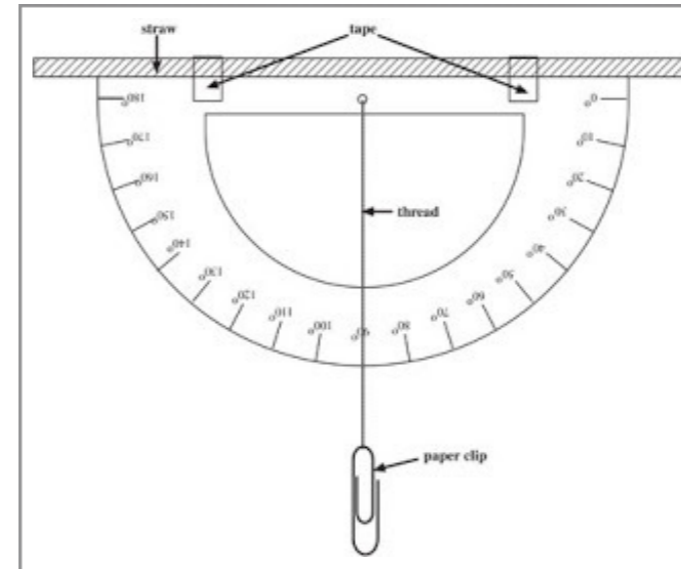
2. What about 45 degrees altitude at an azimuth of 0 degrees? (You are previewing "coming attractions" here.)

3. Can you all point to 30 degrees at azimuthal 90 degrees?
(I suggest you say nobody point yet, five seconds to think about it, count down, then 5-4-3-2-1-0 Point!) This gives the slower ones time to think. Stops them from pointing where the smarter ones point.

4. Repeat several combinations of altitude and azimuth, then go on with whatever you have planned next.

6. Using the Clinometer

Using the Clinometer



The Clinometer is such a fun instrument to teach kids to use!

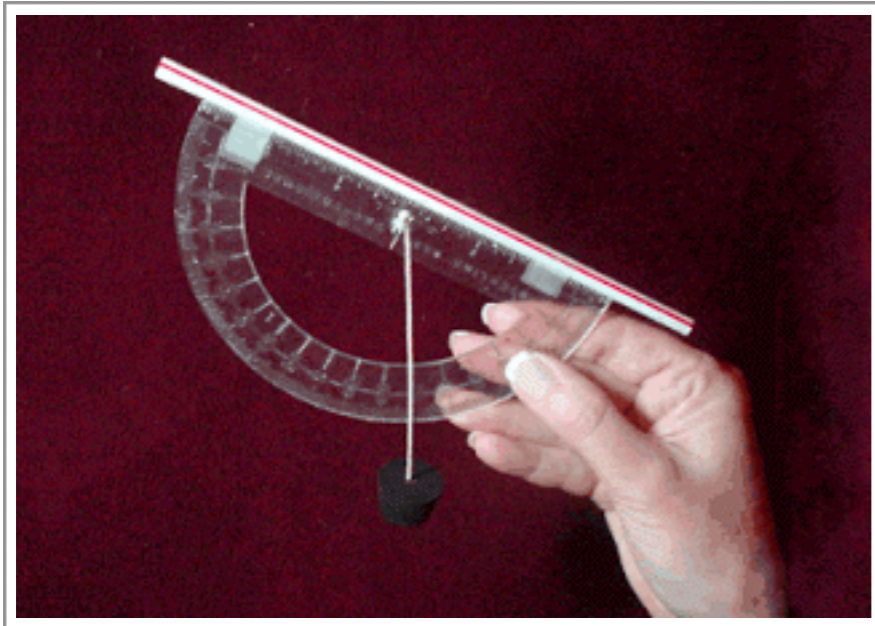
Here is the process in a nutshell:

For the Sun:

- 1 Hold the clinometer near the ground.
- 2 Point the soda straw at the sun. **NEVER LOOK THROUGH THE STRAW!**
- 3 When you see the bright spot of the Sun surrounded by the shadow of the soda straw (the sunlight is passing through the straw), on the ground or the palm of your hand.
- 4 Read the angle where the thread (attached to the paper clip) crosses the angle indicated on the protractor.

For the moon, stars, and planets:

- 1 Look through the straw at the object.
- 2 Read the angle where the thread (attached to the paper clip) crosses the angle indicated on the protractor.



Before you use the Clinometer outside, be sure to stress that every instrument **MUST** be calibrated first.

Ask them how they can be sure their Clinometer is calibrated. **This is pretty simple.** If they hold the Clinometer so the string swings to the 90 degrees, then there should be a right angle between the string and the straw. They can all use the corner of a piece of paper to check. Have partners check each other. Unless they did something drastically wrong, all of them will be calibrated!

Now help your students become "conversant" in the use of their Clinometers by measuring the altitude of objects in the room. First show them how to use the Clinometer by sighting objects through the straw and catching the plumb bob string with their finger and then lowering the Clinometer, carefully holding the string and reading the altitude.

This is NOT, of course, how they will use the Clinometer while observing the Sun! If you do choose to go outside to do some observations for the Using the Clinometer Activity, be sure to stress they are NOT to EVER look directly at the Sun! Permanent eye damage is very possible!



Retinal Damage caused by looking at the Sun

They will be anxious after a couple of minutes to get on their own. Have them choose partners (or assign) and hand out the **Using the Clinometer Activity**. Each student gets their own page even though they will be working in pairs.

My classroom was right across the hall from the school's auditorium. Perfect because of the height of the ceiling! I put masking tape X's about 4 inches across at about 10 - 15 places in the auditorium. I labeled each with a number and wrote what to measure, using a Sharpie.

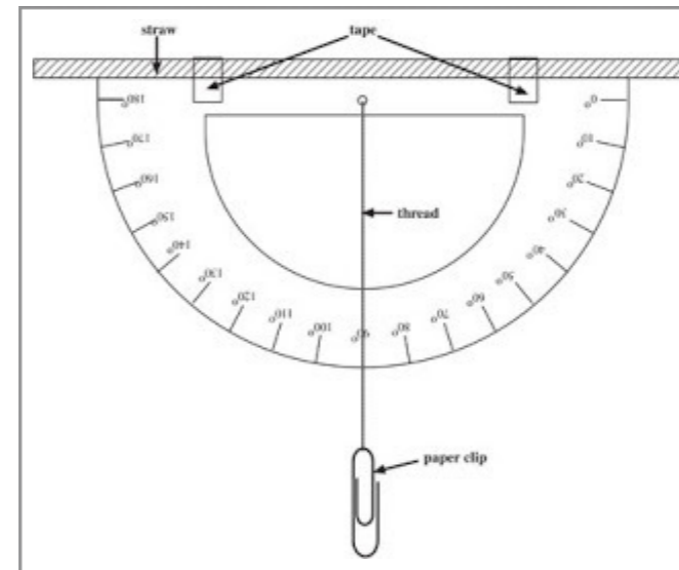
I took each class into the auditorium to take measurements with their Clinometers. (This works great because you can take all the measurements yourself, and by looking at their papers, actually know who is really off and needs your help.)

You can do the same with your students. Pick a large space, such as an auditorium, gymnasium, or outside, even. Take your students there after some talk about proper behavior.

They all find an X and get busy. Each one takes a sighting with the partner taking the reading. Then they switch. They need to be sure they use their own Clinometer as you want them to be familiar with their own instrument.

They stay where they are and when all seem done, you can blow a whistle, ring a bell, or holler, "Time to move!" and they move in a ring around the space to the next number. Be sure to remind them to record on the corresponding number on the Activity Sheet. This can also be done outside, especially if you have tall buildings and trees close by.

Click here for a fun [Improve your Clinometer Activity](#).



NOTE: Some possibilities for Improving: Adding more tick marks for degrees, Adding a handle, Adding a heavier weight such as a large washer, Attaching the Clinometer to the middle of the Compass Rose. Fun to do in spare time in class, when done with an assignment, for **BONUS** points.

7. The Clinometer Activity

A School-Year-Long Project

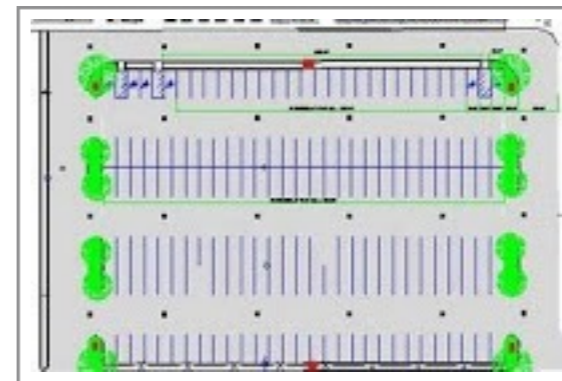
The Clinometer Activity - a School-Year-Long Project

So, your students have made their Clinometers. They know how to use them. You've taught altitude and azimuth.

What next? You're ready to start **your school-year-long observation activity!**

Here's a good first day introduction:

1 Beforehand, you should have drawn or taped long north-south lines in your parking lot/playground. This makes using the compass rose easier and is a good way to keep your students semi-under control! They tend to stay near the lines. If you are very lucky, your parking lot has natural **North-South lines** and you can convince the teachers to leave one area free all year. I didn't have that luck so drew my own with heavy tape.



2 Before you take your students outside, it's a good idea to cover the rules and consequences. I always told my students that the first time was a test. First, they must be very quiet in the hall on the way outside. As soon as they are outside, they must walk directly to the north-south line and get set up and take their measurements. No delays! Take and record both measurements. Line up at a certain spot when you are done. You have a total of 5 (or whatever) minutes to take the measurements and be lined up to go back inside.

Consequences were: they didn't go outside the next day, but sat out in the hall by a neighboring teacher and waited for us to return. Worked pretty well for me. I certainly had my share of "hall sitters" over the years! They want to go outside, so they clean up their act quickly!

REPEAT A CAUTION TO NOT LOOK DIRECTLY AT THE SUN!

3 If you have to lock your door--I always did--then you are at the end of the line. You could tell them before you left that by the time you get outside, they should **ALL** be at work taking their measurements.

4 Walk around with a clipboard with a list of names. I usually had them groups by teams, if I was using teams. There are a certain amount of Behavior Points that go with Weekly Points that are unrelated to the grade for this

activity. Another good management trick! Record points for good participation, etc. You may have to help a few of the groups. They may need reminders as to proper use of the rose or clinometer.

5 Once all are lined up to return, remind them about being quiet in the hall and head back in.

6 Once they are all back in and seated, tell them that from now on, they get to come in and record their readings on the chalkboard, whiteboard, etc. Perhaps each group has a different person record each day.

7 **HERE'S THE FUN PART.** You have gone to **this site** earlier and actually know what their measurements should be! Once you have all of the numbers up on a chart, have a volunteer take the average of each. Tell them how close the average is to the "real" azimuth and altitude. You may have "crafty" ones who check on the "real" numbers at home on the computer, which is why you walk around a lot outside to observe if they are all taking measurements.

8 Have someone record the class average on the class data table. Each team records their own measurements on their LabSheet. There are places for each class you teach during the day so you end up with a good bunch of hours of measurements by the end of the week.

9 At the end of the week, they will make a graph of one day's data. Have them project the lines to the horizon at each end, for sunrise and sunset using dashed lines.

Some of the concepts learned early on:

- 1 The curved line they graph on Friday shows the sunrise, sunset, and sun in sky for one day.
- 2 The sunrise is almost **NEVER** at east, nor sunset at west. This is a **BIG** surprise to them!
- 3 Once you get a few of the graphs, have them compare two of their graphs at least one month apart. They will see the arc rising or falling at the highest point, depending if it's moving toward summer or winter.
- 4 The length of the line corresponds to the length of daylight.

Very powerful stuff!

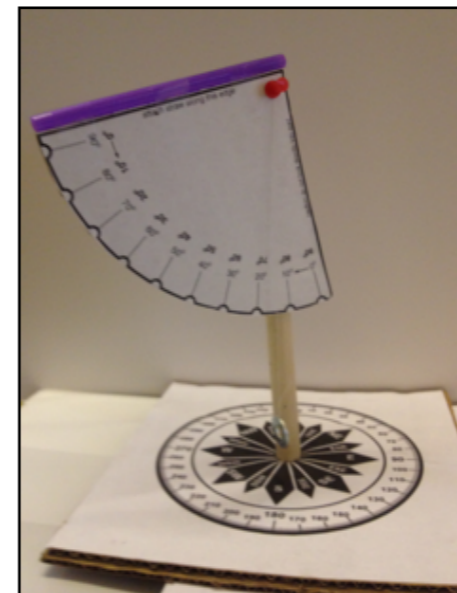
Here are the materials for this activity:

[Click here](#) for Weekly LabSheet for this year-long activity.

[Click here](#) for a good Azimuth & Altitude Worksheet.

[Click here](#) for a good Azimuth & Altitude Quiz.

IMPORTANT NOTE: You eventually want your students to get tired of using two instruments. You want them to figure out how to combine the rose and the clinometer! Don't tell them this the first week! Keep your ears open and point out comments that relate to this without too much hinting to the solution. But after a couple of weeks, you're going to want to take a day and have them design and construct a new instrument, combining the two into one. Much easier to use! Also nice way to avoid them looking at the sun, because the little sun spot shines down on the compass rose.



An example of a Theodolite:

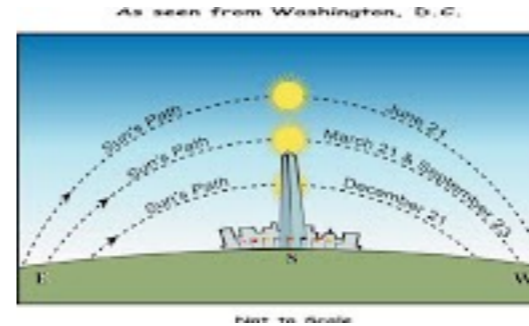
This is basically a short dowel rod screwed on at the bottom of a large Compass Rose glued onto cardboard with a pushpin at the top on the side pushed through the Astrolabe so it can rotate or hinge to measure altitude.

If you want your students to make one, you can just put it out and see if they can make a similar one, or provide the materials and have a fun day seeing what they come up with! Challenge them to make a "better" one!

8. The End-of-Year Data Analysis

The End-of-Year Data Analysis

It's nearing the end of the school year. **How do you wrap it all up?**



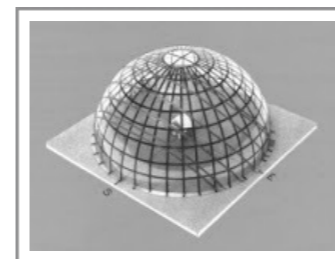
To be honest with you, the end of the year was usually crammed with so much **STUFF** I had trouble finding much class time. So I tried to have a one period for the students to graph and summarize what they've been learning all year.

Click here to download the **Graphing Sun Data Activity**.

By the end of the school year, your students should all be pretty good at graphing, so I would suggest just letting them go with the graphing of the data.

I actually looked up real data because I wanted my students to be using accurate data to get the “right” conclusions, so to speak, and then added one column for them to add any of their data they wanted to record and plot.

Make this a nice day! Put on music and wander around the room chatting with your students! They're about to move on. Enjoy them! I challenge you not to hide behind your desk!



And if you are lucky enough to find some clear plastic domes, set up a couple for finished-early students to play with! They can add the three arcs to the dome! Even approximate sketches are okay!

Thank you!

**I hope this mini-book helps you become
a better teacher of Astronomy!**

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