Sundial

Overview: Using the position of the Sun, you can tell what time it us by making one of these sundials. The Sun will cast a shadow onto a surface marked with the hours, and the time-telling *gnomon* edge will align with the proper time.

What to Learn: In general, sundials are susceptible to different kinds of errors. If the sundial isn't pointed north, it's not going to work. If the sundial's gnomon isn't perpendicular, it's going to give errors when you read the time. Latitude and longitude corrections may also need to be made. Some designs need to be aligned with the latitude they reside at (in effect, they need to be tipped toward the Sun at an angle). To correct for longitude, simply shift the sundial to read exactly noon when indicated on your clock. This is especially important for sundials that lie between longitudinal standardized time zones. If daylight savings time is in effect, then the sundial timeline must be shifted to accommodate for this. Most shifts are one hour.

Materials

<u>Simple Sundial</u>

- Index card
- Scissors
- Tape

<u>Intermediate Sundial</u>

- 2 yardsticks or metersticks
- Protractor
- Chalk
- Clock

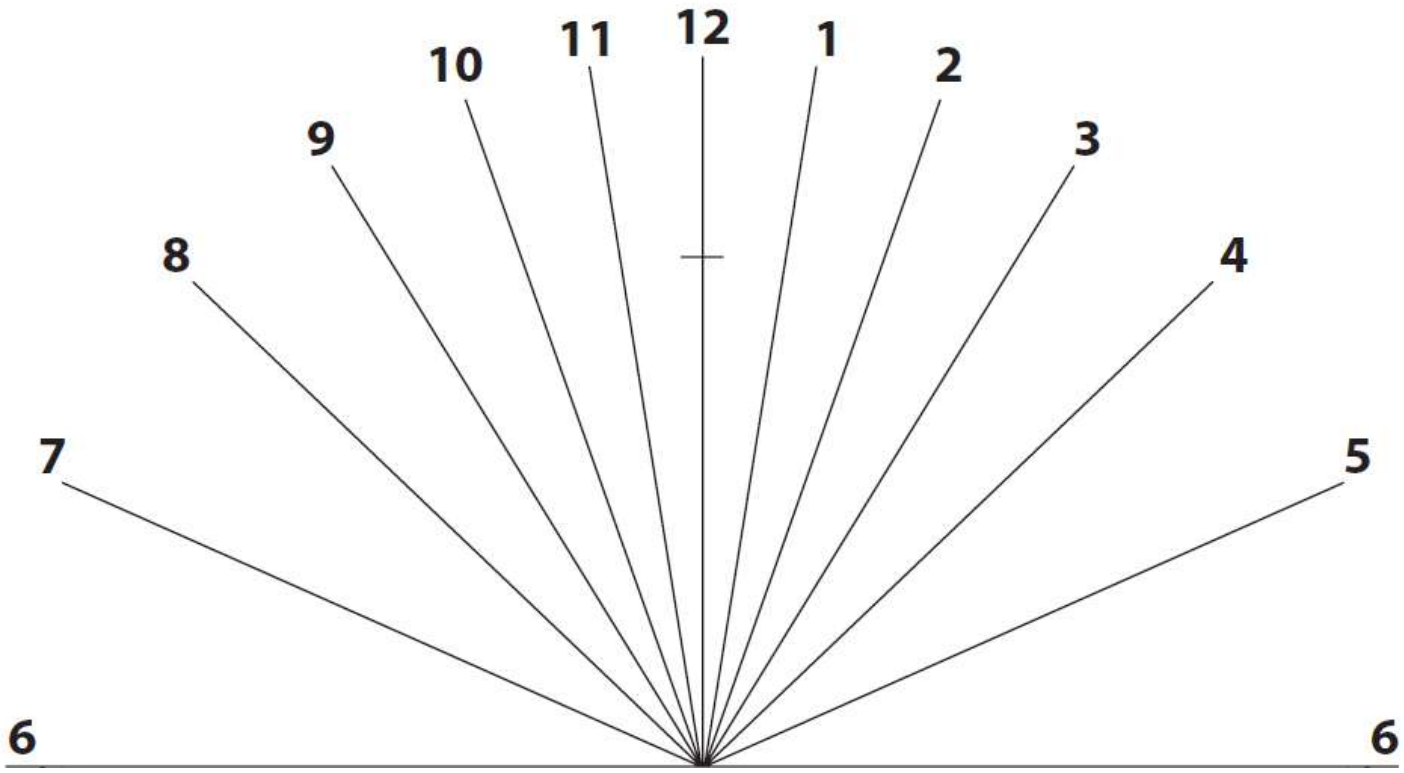
<u>Advanced Sundial</u>

- Old CD (this can also be the transparent CD at the top of DVD/CD spindles)
- Empty CD Case
- Skewer
- Sticky tape
- Cardboard or small piece of clay
- Protractor
- Scissors
- Tape
- Hot glue

Simple Sundial

1. This sundial takes only a couple minutes to make, and reads easily for beginner students.
2. Cut the template.
3. Cut your index card into two triangles by cutting from one corner to the opposite diagonal corner. Stack the two triangles and tape together. This is called your *gnomon*.
4. Tape the triangle to your 12-hour line, putting tape on both sides of the gnomon as you stick it to the paper.
5. Put the sundial in a sunny place where it won't be disturbed (like inside of a sunny window or on a table outdoors).
6. Point the sundial so that the gnomon is pointing north. This is most easily done if you orient your sundial at exactly noon in your location. Line up the sundial with the Sun so that the shadow the gnomon makes lines up exactly with the 12.
7. Tape the sundial down so it won't move or get blown away.
8. The gnomon must be exactly perpendicular to the hour markers. Use a ruler or a book edge to help you line this up.

Simple Sundial Template



Exercises

1. What kinds of corrects need to be made for your sundial?
2. When wouldn't your sundial work?
3. How can you improve your sundial to be more accurate?

Intermediate Sundial

1. Find a sunny spot that has concrete and grassy area right next to each other. You're going to poke the yardstick into the grass and draw on the concrete with chalk, so be sure that the concrete goes in an approximately east-west direction.
2. First thing in the morning, stick one of the yardsticks into the dirt, right at the edge of the concrete.
3. At the top of the hour (like at 8 a.m. or 9 a.m.), go out to your yardstick to mark a position.
4. Lay the second yardstick down along the shadow that the upright yardstick makes on the ground. Use chalk to draw the shadow, and use the yardstick to make your line straight.
5. Label this line with the hour.
6. Set your timer and run back out at the top of the next hour.
7. Repeat steps 3-6 until you finish marking your sundial.
8. When you've completed your sundial, fill out the table.

Intermediate Data Table

Don't forget to label your units for columns 2 and 3!

Exact Time of Day	Shadow Length	Angle that the Sun Moved from Last Hour

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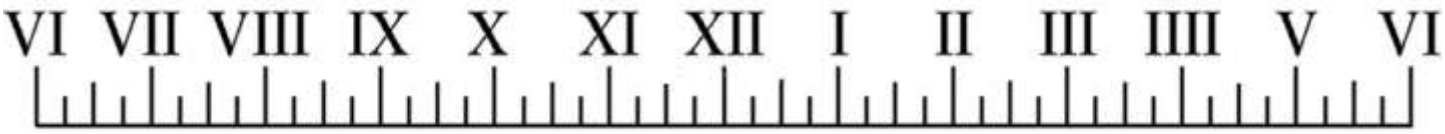
Advanced Sundial

This sundial will work for all longitudes, but has a limited range of latitudes. If you live in the far north or far south, you'll need to get creative about how to mount the CD so that the gnomon is pointed at the correct angle. For example, at the equator, the CD will lie flat (which is easy!), but near the north and south poles, the CD will be upside down.

1. Cut out the timeline.
2. Put a line of double-sided sticky tape along the back of the timeline. Extend the tape about ¼" (on the bottom edge) so it's hanging off a paper a little.
3. Flip the timeline over and roll the CD along this bottom edge, sticking the timeline to the edge of the CD. The timeline should be facing inward toward the center of the CD, perpendicular to the CD surface.
4. Now it's time to plug up the center hole. You can cut out circles from a CD and attach with tape, or use a small piece of clay.
5. Push the skewer through the exact middle of the CD.
6. Open up the CD case.
7. Position the noon marker at the bottom and stick it using a piece of double-sided sticky tape or hot glue.
8. The other side of the CD is glued to the CD case at the same angle as your latitude. For example, if I live at 43° north, I would use my protractor on the ground along the base of the CD case and lift the CD until the gnomon reads at 43°. Put a dab of hot glue to attach the CD to the lid of the case.
9. Go outside and point the gnomon north (you may want to use a compass for this if it's not noon.)
10. The dial will have a shadow that falls on the timeline. You can read the time right off the timeline.
11. *For advanced students:* Timeline correction: Do you remember how the Sun was fast or slow in the Stargazer's Wall Chart from the lesson entitled: *What's in the Sky*? That wavy line is called the Equation of Time, and you'll need it to correct your sundial if you want to be completely accurate. This is a great demonstration for a Science Fair project, especially when you add a model of the Sun and Earth to help you explain what's going on.



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Reading

Sundials have been used for centuries to keep track of the Sun. There are different types of sundials. Some use a line of light to indicate what time it is, while others use a shadow.

Here are a couple of different models that, although they look a lot different from each other, actually all work to give the same results! Your sundial will work all days of the year when the Sun is out.

You'll notice that north is the direction that your shadow's length is the shortest. However, if you don't know where east and west are, all you can do is know where north is. The equinox is a special time of year because the Sun rises in the exact east and sets in the exact west, making these two points exactly perpendicular with the north for your

location (which they usually aren't). At sunset, you can view your shadow (quickly before it disappears) and draw it with chalk on the ground, making a line that runs east-west. 90^{o} CCW from the line is north.

In general, sundials are susceptible to different kinds of errors. If the sundial isn't pointed north, it's not going to work. If the sundial's gnomon isn't perpendicular, it's going to give errors when you read the time. Latitude and longitude corrections may also need to be made. Some designs need to be aligned with the latitude they reside at (in effect, they need to be tipped toward the Sun at an angle). To correct for longitude, simply shift the sundial to read exactly noon when indicated on your clock. This is especially important for sundials that lie between longitudinal standardized time zones. The Equation of Time from the advanced lesson entitled: *What's in the Sky?* can be used to correct for the Sun running slow or fast. Remember, this effect is due to both the Earth's orbit not being a perfect circle and the fact that the tilt axis is not perpendicular to the orbit path. If daylight savings time is in effect, then the sundial timeline must be shifted to accommodate for this. Most shifts are one hour.

Answers to Exercises: Sundial

1. What kinds of corrections need to be made for your sundial?(In general, sundials are susceptible to different kinds of errors. If the sundial isn't pointed north, it's not going to work. If the sundial's gnomon isn't perpendicular, it's going to give errors when you read the time. Latitude and longitude corrections may also need to be made. Some designs need to be aligned with the latitude they reside at (in effect, they need to be tipped toward the Sun at an angle). To correct for longitude, simply shift the sundial to read exactly noon when indicated on your clock. This is especially important for sundials that lie between longitudinal standardized time zones. If daylight savings time is in effect, then the sundial timeline must be shifted to accommodate for this. Most shifts are one hour.)

2. When wouldn't your sundial work? (At night, or when it's cloudy.)

3. How can you improve your sundial to be more accurate? (Read over suggestions for each sundial near the experiment.)