STEM gems

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# SIMPLE SUNDIALS

Summer is a great opportunity to engage young people with the outdoors. This inexpensive experience uses a simple sundial to demonstrate how the Sun moves across the sky and connects young people to the spinning of the Earth. It is a great activity kick off exploration of time, history, astronomy and the weather.

## big IDEAS

### WHAT DOES THE SUN HAVE TO DO WITH TELLING TIME?

For thousands of years, humans have used the sun's light and heat to regulate their activities. Early humans rose and retired with the sun. The sun's path across the sky from east to west measured the progression of each day. Watching the Sun move across the sky you can see how easy it was for people living in ancient times to believe that the Sun actually moved around Earth. Ancient Egyptians believed that the Sun, which they called Ra, rose in the east, flew across the sky each day, set in the west, and then traveled beneath the Earth to start all over again the next morning. About 3,500 years ago, the Egyptians divided each day and night into twelve parts, for a total of twenty-four parts, or hours, in each day. They observed that each day, the sun appeared to move through an entire 360-degree arc in 24 hours. They also discovered that as the sun appeared to move, so did the shadows it cast. When the ancient Egyptians placed a stick straight into the sand, its shadow would rotate at a fairly steady rate of 15 degrees per hour. This observation gave rise to the first sundials.

### WHY DOES THE SUN APPEAR TO MOVE ACROSS THE SKY?

Earth is spinning through space as it orbits around the Sun. As the Earth turns, different parts of it point towards the Sun. The Earth turning makes the Sun seem to rise in the east, slowly move across the sky, and then set in the west.

### WHAT IS A SUNDIAL AND HOW DOES IT WORK?

A sundial is an instrument that shows the time of day by the position of the shadow cast by a pointer on a dial. The oldest known sundial is an Egyptian device built around 1500 B.C. The gnomon (pronounced NO-men), or pointer, on the device cast a shadow onto a surface that was divided up into spaces representing the ten hours of daylight. As the position of the Sun changed in the sky, the shadow cast by the gnomon moved across the dial (surface) to indicate the time of day.

## SCIENCE talk

**COMPASS**
An instrument with a magnetic needle that points north.

**GNOMON**
The post or stick of a sundial that is placed so its shadow will be cast on the dial to show the time of day.

**SHADOW**
A shaded area cast on a surface by an object that is between the surface and the light source.

**SUNDIAL**
An instrument that shows the time of day by the position of the shadow cast by a pointer (gnomon) on a marked dial.

**ZENITH**
The point in the sky that is directly overhead; the highest point.

## engage

- **Have you ever been playing and outside and wondered what time it is? Is it time for lunch? Is it time to go home? How do you know?**
- **What are some ways you can tell time without a watch or a cell phone?**
- **How do you think people knew what time it was before they had these devices and clocks?**
- **How can you use the sun to know the general time of day?**

## what YOU WILL NEED

- **A straight 3 ft. x ½" diameter wooden dowel** *(or similar)*
- **A handful of light-colored rocks**
- **Bright length of ribbon**
- **A compass** *(optional)*

## & before YOU BEGIN

Find a three-foot square location that gets sun throughout the day.

## EXPLORE & EXPERIMENT

1. **Take your group outside** to a grassy location.
2. **Ask the kids to point to the Sun.** Ask if it seems like the sun is always in the same point in the sky. Ask them to describe what they've noticed about where the sun is at different times of day. Explain that the sun appears to move from one side of the sky to the other, but it's not the sun, but us. The Earth spins in front of the Sun making one complete turn every day or twenty-four hours.
3. **Have the young people stand where they can see you and pretend that they are the sun.** Slowly spin like the earth. They will see you go from one side of their vison to the other. Ask them what's spinning, the Sun or the Earth. Remind everyone that just like in this example the Sun spins, not the Earth.
4. **Ask the group to point to the part of the sky where the sun rises and then where it sets.** If they are unsure tell them to watch for the sunset at night. Explain to your group how ancient people used the sun and sundials to help tell the time *(information included in Big Ideas above).*

5. **Find a square of grass brightly lit by the sun** and gently push the wooden dowel into the ground, so it stands up straight on its own. Tie a bright ribbon to the top of the stick so everyone knows that it is there and will not walk into it.

6. **Have a volunteer look at the grass and find the long thin shadow made by the stick.** Ask the volunteer to place a rock on the shadow a couple of feet away from the dowel.

7. **Have the group leave the stick and rock and come back an hour later.** Invite kids to observe and share what the notice. Like the hour hand of a clock, the shadow will move around the stick. The shadow will rotate at a fairly steady rate of 15 degrees per hour.

8. **Encourage the group to use a clock and rocks to mark out the hours of the day.** The place where the shadow falls from the stick falls at 9:00 represents 9:00. If working with younger children have them use the rocks to mark key points in the daily schedule such as lunch. Have the group think of other key times and encourage them to mark those as well.

9. While waiting for the shadow to move around the stick **invite the group decorate rocks to go around the sundial.**

10. **Visit to the sundial throughout the day and have the kids observe and share what happens.** They will see that the shadow moves in a predictable way as the Sun moves across the sky.

11. **Explain that the sundial will keep time for a couple of weeks** and then after a while it will start to lose time. Ask kids why they think that is. Share that:

    - ☐ It is because the Earth is tilted and as it moves around the Sun will get lower or higher in the sky and change the angle of the shadow.

    - ☐ Real sundials solve this problem by tilting the stick at an angle that matches the tilt of the Earth at the location they are designed to be used in. In Los Angles the angle is 35 degrees while further North in New York it is 45 degrees.

## make THE CONNECTION

**SHARE WITH THE GROUP THAT ABOUT THE SAME TIME THE SUNDIAL WAS INVENTED, OTHER ANCIENT CIVILIZATIONS WERE INVENTING DIFFERENT METHODS FOR KEEPING TIME.** For example, some people began using hourglasses with sand in them. Others used water clocks, which consisted of water dripping from one jar into another jar with lines drawn or etched on it. Invite the kids to research ancient clocks. Provide craft materials and challenge them to design and build a sand or water timer that lasts for two minutes.

## EXTEND & EVALUATE

Ask the kids what they think some of the common problems are with using sundials as timekeepers? **Share the following as appropriate:**

Sundials do not work at night or when it is very cloudy. Even on a properly constructed sundial, several things reduce the sundial's accuracy as a timekeeping tool. For example, during Daylight Saving Time (throughout the summer months in most of the United States), sundial time is one hour behind actual clock time. A more subtle sundial error has to do with the existence of time zones. Until the middle of the 19th century, each community in the United States kept its own time by using sundials to set mechanical clocks. As a result, communities a few miles to the east or west of each other had slightly different local times. Communities separated by one hundred miles or more had local times that differed by ten or more minutes. As more rapid means of travel and communication developed, such as railroads and telegraphs, these slight differences in local times began to pose challenges. A system of uniform time zones was created and all communities within a given time zone set their mechanical clocks to the same time. As a result, sundials in the western part of a time zone show a time that is earlier than the standard time, while sundials in the eastern part of a time zone show a time that is later than the standard time. Another small error with sundials arises because the Sun itself can "run fast" or "run slow." Because Earth does not orbit the Sun in a perfectly circular orbit, at some times of the year the Sun takes slightly less than 24 hours to complete a full circle, and at other times it takes slightly longer than 24 hours. The cumulative error of this effect, known as the equation of time, can be 15 minutes or more.