Adapted to STEMAZing ECE Format by
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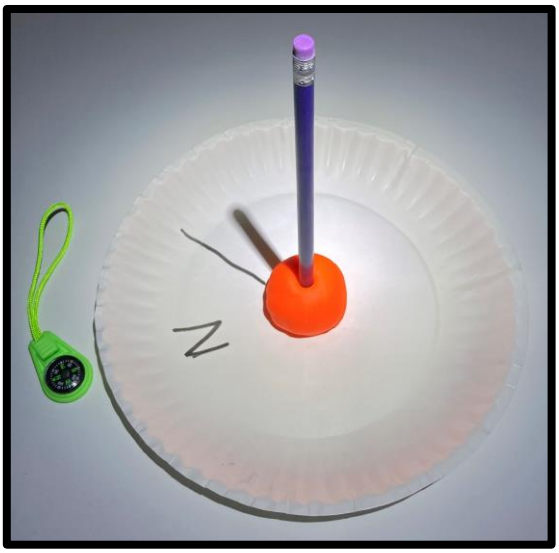
Sundials for Everyone!

Evidence of Earth's Rotation



NOTE: Children should always be given ample time to experiment, notice, and wonder before they are provided an explanation.

Always engage children with our two favorite questions:

What do you notice?
What do you wonder?

Resist the urge to answer any questions children have while exploring. Instead, respond back with questions to children and let them make sense of the world. Sample questions you might use: What do you think? Do you notice any patterns? What could we change? Can we test something else? What can we try next? If children ask a testable question, which they can answer by doing an experiment, talk through with them how they might design a test to help answer their question. As much as possible and within reason, let them test their questions by trying the experiments they propose.

Learning Objectives

Children will…

- learn what a sundial is and how it works.
- observe and record the pattern of shadows the sun creates on their sundial.

Key Question

How can we use simple materials to tell time?

Vocabulary (See **What the heck? Explanation of Science** at the end for definitions.)

Sun	Compass	Gnomon
Earth	Orbit	Sundial
Rotation	Dial	

Materials

Paper Plate	Play-Doh	Marker
Pencil	Compass	

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Notice and Wonder Developmentally Appropriate Practice

1. Form a big blob of Play-Doh in the middle of the paper plate.
2. Stick the pencil in the middle of Play-Doh standing up straight.
3. Write N for North on the edge of the paper plate.
4. Take plate outside, place in a sunny area and use compass to make sure the N on the plate is pointed North.
    - Ask children: What do you notice?
5. Record the first shadow by drawing a line from the center of the plate along the middle of the shadow created by the pencil all the way to the edge of the paper. Label it with the time.
6. Check on the plate every hour, draw the pencil's shadow on the plate, and record the time.
    - After the third observation, ask children: What do you notice?
7. Using a different colored marker, have children predict where they think the next shadow will be in an hour.
    - Ask children to explain why they made the prediction they did.
8. Repeat for as many hours as you can and continue to have children make predictions in one color and record the actual shadow in the same color they started with each hour.
    - Ask children: What do you notice? What do you wonder?

Children should notice…

- the pencil casts a shadow on the plate.
- after the third observation, they should notice a pattern – the angle between the shadows is about the same each hour.
- the shadows only show up on half of the plate.

Extensions for Additional Learning

As always, ask the children throughout the experiment what they notice and what they wonder. If their wonder questions are testable, as much as possible and within reason, let them test their questions by trying new experiments.

See below for examples of what they might wonder and experiments they might do to test their wonderings.

- I wonder if we can use something else besides a pencil?
- I wonder why the shadows do not cover the whole plate?
- I wonder what would happen if we make it bigger? Smaller?
- I wonder how other people make sundials?
- I wonder if I could make a sundial to wear on my wrist to tell time?
    - Let them try it!

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Differentiating Developmentally Appropriate Practice

For younger children, you can use them (their shadow) as the sundial! Mark where they should stand each hour on the sidewalk with chalk by outlining their shoes. Draw a line from their feet to the top edge of their shadow (their head). Mark north using a compass set at their feet. Or you can use a block of wood children stand on as shown in this video from NASA: http://bit.ly/HumanSundial

For younger children, you can also do this as a group with a broom handle or similar placed into a bucket of sand or rocks to make it stand straight up. This scales the whole project up and makes it a little easier to make observations.

Older children can use the system above with a broom handle, long dowel, or stick. They can record the length of the shadow as well as the direction each time by drawing the line to the end of shadow cast by the broom handle. They should notice an additional pattern about how the length of the shadow changes throughout the day.

Older children can make the sundial found here: https://skyandtelescope.org/observing/how-to-make-a-sundial/ and can then be given an engineering design challenge to design their own sundial, which is better than this initial design. You can decide on what qualifies as being "better" – made of more robust materials, more accurate, able to work year round, etc.

#STEMAZingPictureBook Recommendation:

Sun! One in a Billion by Stacy McAnulty

Connections to the activity:

Show model of Earth orbiting the Sun.

Make sun shadow art.

References

https://www.giftofcuriosity.com/recording-the-earths-rotation-with-shadows/

SAFETY CONCERNS

Warn children not to look directly at the Sun.

AZ Early Learning Standards

Science Standard - Strand 1: Inquiry & Application - Concept 1: Exploration, Observation & Hypotheses
The child observes, explore, and interacts with materials, others, and the environment.

Science Standard - Strand 1: Inquiry & Application - Concept 2: Investigation
The child researches their own predictions and the ideas of others through active exploration and experimentation.

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What the heck? Explanation of the Science (Vocabulary in bold.)

Earth is the planet we live on – the world. It is the third planet from the Sun. There are eight planets in our solar system. Mercury is closest to the Sun, followed by Venus, and then Earth. There are five planets with orbits further from the Sun. Those are (in order) Mars, Jupiter, Saturn, Uranus, and Neptune.

NOTE: Pluto was demoted from planet to dwarf planet in 2006 by the International Astronomical Union. A decision that is still controversial for some astronomers and lots of the general public who learned about nine planets when they were in school. A **planet** is now defined as a celestial body which (a) is in orbit around the Sun, (b) is nearly round in shape due to its mass, and (c) has cleared other objects from around its orbit.

The **Sun** is the star at the center of our solar system. It is the closest star to Earth. The Sun is a yellow dwarf star. It gives off energy in the form of light, which includes infrared, visible light, ultraviolet light, and radio waves.

As the Earth is **orbiting** around the Sun (a complete revolution takes a year – 365¼ days), it rotates on its axis once every 23.9 hours (absolutely find to round this to 24 hours for younger students). One **rotation** on Earth's axis is a day.

What the heck? Explanation of the Science of Sundials

A **sundial** is the earliest timekeeping device dating back as far as 3500 BC. It displays the time of day based on the position of the shadow of an object exposed to the Sun. As the Earth rotates, and the day passes, the shadow of the object moves and shows the passage of time. For the sundial constructed in this activity, the plate is the **dial** – the horizontal surface on which the hour locations are marked. The pencil is the **gnomon** – the part of the sundial that casts the shadow on the surface of the sundial. The first sundials were very similar to the design used in this activity. Overtime, improvements were made to sundials to make them more accurate. Interestingly, sundials were still used to reset mechanical clocks until the 19th century.

Children should have noticed the marks they made each hour only showed up on half of the plate. Once the Sun sets, there is no light to keep the shadow going around the plate. If you marked the entire length of the shadow cast by the gnomon, then children should have noticed the shadow was longest at sunrise and sunset and shortest at noon.

The **compass** used to align the sundial with north has a magnetized needle. The needle's magnetic field is affected by Earth's magnetic field and lines up along a north-south line.

Reference: https://www.britannica.com/technology/sundial

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Bonus Demonstration – modeling a sundial as the Earth rotates

Materials

Globe

Screw (or nail or straight pin)

Tape

Flashlight

Directions

Push the screw through a piece of tape from the sticky side forward.

Tape the screw to the surface of the globe. In this case, we taped it close to our actual location.

In a dark room, turn on a flashlight and set it across the room to represent light coming from the Sun.

Being sure to hold the globe with the axis tilted (if not already in a stand that tilts it for you), slowly rotate the Earth clockwise (as you look down upon it) and watch what happens to the shadow of the screw as it moves from the night side of the globe to the experiencing sunrise, noon, and then sunset.

Ask children what they notice and wonder. Ask them how it is similar to their sundials and how it is different.

You can demonstrate how the sundial would be the same and different in the northern hemisphere compared to the southern hemisphere.

Let children explore with strange Earth tilts and rotations as they see fit!

A note on scale: If the globe you are using has a 12 inch diameter, a 1 inch screw on its surface, as shown in the image, would scale to about 660 miles tall! The atmosphere is an average of 7.5 miles high – about 1/100th of an inch on this model globe. The International Space Station orbits at a height of 254 miles above Earth's surface. This would be about 6/16 of an inch off the surface of the 12 inch model globe!