CLASSROOM ACTIVITY

Sundials

General information

★ Grade level: Elementary – cycle three

★ Students per group: Individual activity

★ When: Before the Planetarium visits your school

★ Duration: One to two 50-minute periods

★ Where: A sunny outdoor location

★ Type of activity: Observation, visualization, discovery

★ Subjects covered: Science and technology — Visual arts

★ Essential knowledge: Describe the influence of the Sun's apparent position on the length of shadows — Describe the rotational motion of the Earth — Associate the cycle of day and night with the rotation of the Earth — Use and manufacture simple observational and measuring instruments appropriately — Use terminology related to an understanding of the Earth and space

★ Subject-specific competencies: Propose explanations or solutions to scientific or technological problems — Seek answers or solutions to scientific or technological problems — Make the most of scientific and technological tools, objects and procedures — Make the most of scientific and technological knowledge — Communicate in the languages of science and technology

★ Cross-curricular competencies: Use information — Solve problems — Exercise critical judgment — Use creative thinking — Communicate appropriately

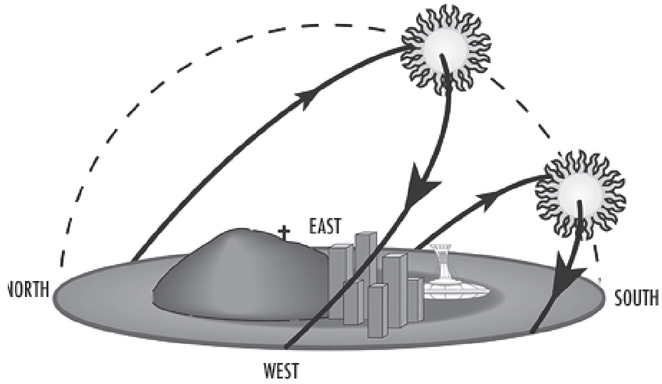
Goals

Students learn to:

- make a pocket sundial
- make observations on the passage of time using a sundial
- explain the relationship between the Sun's apparent movement across the sky, the rotation of the Earth, and our notion of time

Students make a small paper sundial that uses the shadow of a string (the style) to tell time based on the Sun's position in the sky. The sundial systematically develops students' observation skills and their notion of time measured in relation to the Sun's apparent movement across the sky.

They observe the movement of the shadow They then understand the relationship that exists between the Sun's apparent movement and our sense of time.



Basic concepts

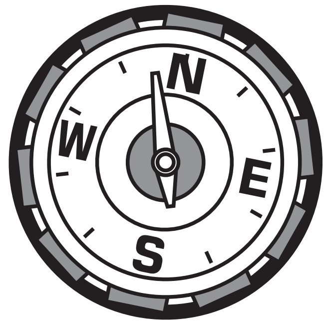
Our notions of time and day are based on the Sun's apparent movement across the sky. But this movement is in reality due to the Earth's rotation on its axis.

By rotating on its axis in 24 hours, the Earth carries us through the dark side of our planet and then the side facing the Sun. The apparent daytime movement of the Sun, the Moon and the stars from east to west across the sky is therefore an illusion resulting from our own movement. The sky doesn't revolve around the Earth: Instead, the Earth rotates and takes us along for the ride.
So when we say the Sun rises, it's actually the entire eastern horizon that descends to reveal the Sun. When the Sun sets, it's actually the western horizon that rises to meet the Sun.

The Sun's apparent movement and its position in the sky can help us determine the time of day. With a sundial, the Sun can become a clock: This activity teaches students to make a simple sundial; they must then learn to position the sundial correctly and tell time using it. By observing the Sun's shadow with the sundial, students can better understand the relationship between the Sun's apparent movement and our notion of time.

Warning: ***Light from the Sun is so intense it can burn the retina of our eyes.***
Never look directly at the Sun with the naked eye, or with binoculars or a telescope.

Steps in the activity



Supplies

You should have in class:
• a compass

Each student needs:
• a copy of the sundial to cut out (see Appendix 2)
• a piece of cardboard slightly bigger than the sundial (file folder, index card, etc.)
• a piece of string 20 cm long
• glue, scissors and tape
• chalk or a crayon

You must supply (optional):
• A piece of strong cardboard (9 x 9 cm) and a can of spray paint

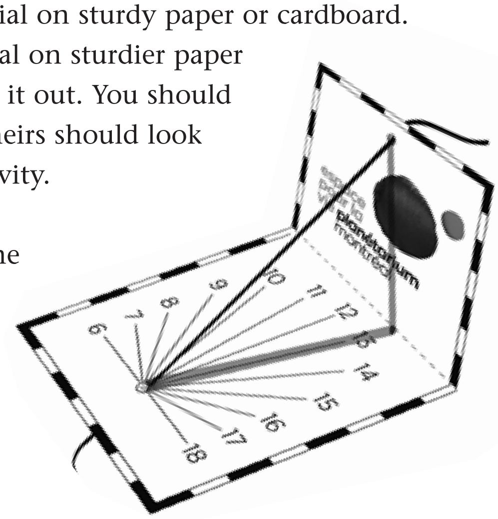
Assignment

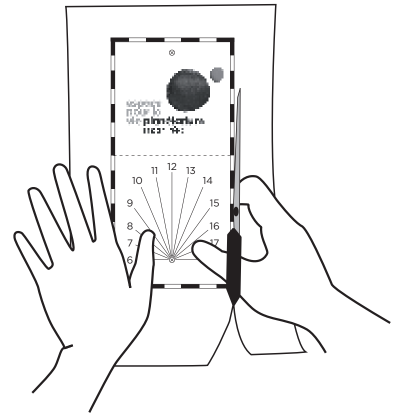
Note to teacher: The steps for the assignment are summarized in Appendix 1.

Part one: Making a sundial in class

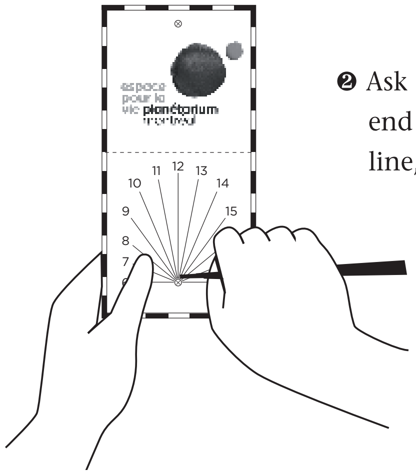
What to prepare in advance:
Prepare a copy of the sundial for each student to cut out. The sundial to photocopy is found in Appendix 2. If possible, photocopy the sundial on sturdy paper or cardboard. If you use regular paper, ask students to glue their sundial on sturdier paper (like old file folders or large index cards) before they cut it out. You should make the first sundial yourself to show students what theirs should look like when completed. You'll also need it later in the activity.

Before beginning the activity, use the compass to find the approximate direction of the magnetic south in the area where students will use their sundials. But don't share this information with them unless they specifically ask for it.

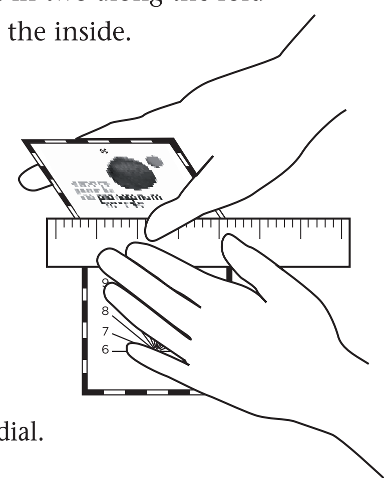




❶ Hand out copies of the sundial. Ask students to glue their sundial to sturdy cardboard (if necessary) and then to cut along the dotted line. Make sure they don't cut the sundial in two along the fold line.



❷ Ask students to make small holes at the points marked (⊗) at each end of the sundial. They should then fold it in two along the fold line, making sure that the hour lines are on the inside.

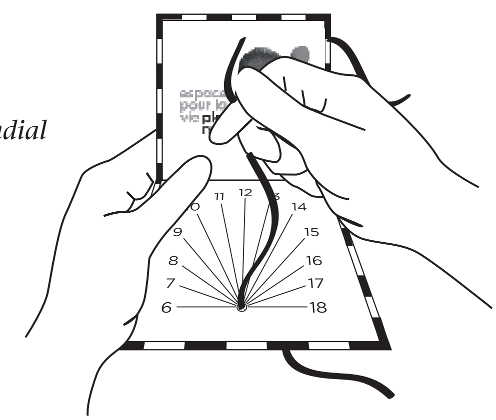


❸ Ask students to take a piece of string about 20 cm long and stick one end through one of the holes and to tape this end to the back of the sundial.

❹ Have them stick the other end of the string through the opposite slit. The string should be taut when the two sections of the sundial are straight and form a 90° angle. Ask students to tape the other end of the string to the back of the sundial.

❺ Ask students what they should do to tell time using their sundial. Ask if they think the sundial must be in a specific position to give the right time.

Note to teacher: Students should discover on their own that the sundial must always face south. This is a great problem-solving exercise. Set aside enough time for them to find the correct position for the sundial.



Part two: Telling time with a sundial

❶ Before you go outside to use the sundials, check the time on a watch or clock. If you're in daylight time, subtract one hour to obtain standard time.
Note to teacher: Students should discover on their own that the sundial must always face south. This is a great problem-solving exercise. Set aside enough time for them to find the correct position for the sundial.

❷ Once students know the exact standard time, take them outside in a sunny area with a flat surface. Choose an area that will stay sunny all day. The string on the sundial must be very taut. Ask students to position their sundial so that the shadow of the string gives the exact time. Ask them if there's more than one way to position the sundial to get the exact time.

❸ Ask students to use a crayon or chalk to draw the outline of their sundials so that they remember their position. Have them write their initials in the outline so that they can find the location of their sundial when they continue their observations later.

If snow or ice prevents you from outlining the sundials, get a piece of thick cardboard the same size as the sundial base (9 x 9 cm) and a can of spray paint. Once students find the position they think is correct, place the thick cardboard where the sundial is set down and outline it using spray paint.

❹ Return to class and ask students what they must do with their sundial to tell time later in the day. Must they reorient their sundial? Will they need to move their sundial? Will their sundial work facing more than one direction?

❺ One or two hours later, take students outside again. Ask them to set their sundial down where it was before and to do whatever is needed to get the right time. You can repeat this exercise at different times of the day.

❻ Discuss the correct position for the sundials. Do all positions give the right results? (Answer: Only one position works. The sundial must always face south.) When the sundials are positioned correctly, in what direction does the shadow of the string move? (Answer: Clockwise.) Where will the shadow be one hour from now?

❼ Once students grasp how to position their sundial correctly, they must remember the points below to ensure that the experiment works every time.

- They must always place the sundial on a flat surface away from shadows created by buildings and trees.
- They must position the sundial in the right direction (facing south).
- The first time they use their sundial, they must align the shadow of the string according to the time shown on a watch or clock. (If daylight time is in effect, they must subtract one hour from the time shown on a watch or clock.)
- They must draw an outline of their sundial so they can position it properly later and get a correct reading every time.

Going further

You can do this exercise at different times of the year to check if the changing seasons affect the use of a sundial.

Answers to objections raised by students

- We could just as well explain the movements of the shadow over our sundial by assuming that the Sun is rotating around the Earth. How do we know that in fact the Earth is rotating on its axis?

  In 1851, French physicist Léon Foucault suspended a 25-kilogram pendulum with a 60-meter-long wire from the dome of the Panthéon in Paris. After a few hours, he noted that the direction in which the pendulum was swinging had changed without any outside force acting on it. The only explanation possible was that the Earth was rotating under the pendulum, causing an apparent change in its direction. This was the first direct physical proof that the Earth was in fact rotating on its axis.

  Today, space probes and satellites orbiting the Earth confirm, each day, that the Sun isn't revolving around the Earth, but rather that the Earth is rotating once every 24 hours.

- If the Earth is rotating, why don't we feel the movement like in a moving car?

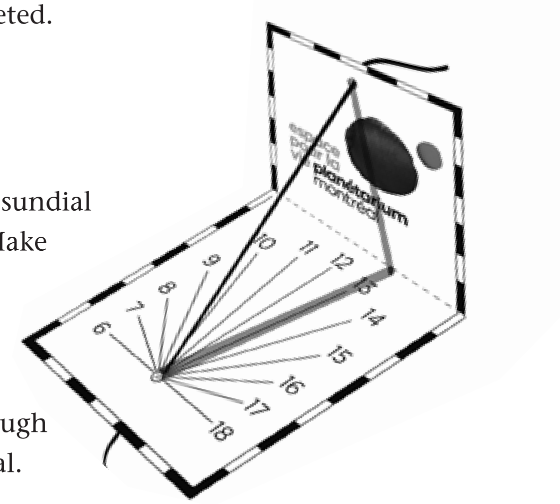
  Often we know that a car is moving because we feel it speed up or slow down, because the windows are open and we hear the wind blowing, or because uneven pavement causes all kinds of vibrations inside the car. But if we're in a closed vehicle driving in a straight line at a constant speed on smooth, even pavement, we can't easily tell if we're moving or not. All objects inside the car — the luggage we brought along, the book we're reading, the apple we're eating, the air around us — move at the same speed as we do.

  The same concept applies to the Earth. Its rotation is constant. There's no vibration (except for earthquakes, which are another matter altogether). And everything around us — trees, houses, people, and even the air we breathe — is carried along by the Earth's rotation at the same speed as we are. That's why we don't feel the Earth rotate.

Summary of the sundial activity

What to prepare in advance

Prepare copies of the sundial to cut out (one per student). Make an initial sundial yourself to show students what theirs should look like completed.



Steps in the activity

Part 1: Making the sundial

❶ Hand out copies of the sundial. Ask students to glue their sundial to a piece of cardboard and to cut along the dotted line. Make sure they don't cut the sundial in two along the fold line.

❷ Ask students to make small holes (⊗) at on each end of their sundial. They then fold it in two along the fold line (printed side inside). Next, they stick a piece of string through the slits and tape down the ends on the back of the sundial.

❸ Ask students to think about how their sundial should be positioned to give the right time.

Part 2: Telling time with a sundial

❶ Find an area that will stay sunny all day. Take students there.

❷ Let students experiment with their sundials. Don't reveal yet how the sundials should be positioned.

❸ Once students discover the correct position, ask them to outline their sundials on the ground and to write their initials beside their outline. If the ground is covered in snow or ice, use spray paint.

❹ Return to class and ask students what they must do with their sundial to tell time later in the day.

❺ One or two hours later, head back outside and repeat the experiment. Can students obtain the right time? If so, in what direction has the shadow of the string moved? Where will the shadow be one hour from now?

❻ Discuss the correct position for the sundials (facing south, on a flat surface, far from shadows).

Adapted from Sundial, Solar System Exploration Kit
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Appendix 2

The following is an illustration of the sundial to be photocopied.