



### Grade Level

3rd - 8th Grades

### Lesson Length

40 Minutes

### STEM Careers

- Engineer
- Meteorologist
- Cartographer

### Life Skills

- Cooperation
- Communication
- Planning/Organizing
- Critical Thinking

#### Learn More

- Visit Raising Nebraska [raisingnebraska.unl.edu](http://raisingnebraska.unl.edu)
- Visit Hastings Museum [hastingsmuseum.org](http://hastingsmuseum.org)
- Learn about the Tower of Winds [britannica.com/topic/Tower-of-the-Winds-building-Athens-Greece](http://britannica.com/topic/Tower-of-the-Winds-building-Athens-Greece)

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# SUNDIALS

Science

*In this grab and go lesson students will discover how sundials are used.*

## LEARNING OBJECTIVES

By the end of the lesson, students should be able to:

- Share results of why they used their design of the gnomon
- Recognize steps of the engineering process
- Utilize the correct tools for measurements

## EDUCATIONAL STANDARDS SUPPORTED

- NE 5.1.1.d Make relevant observations and measurements
- NE 5.1.1.g Share information, procedures, and results with peers and/or adults
- NE 5.1.3.b Propose a solution to a simple problem
- NE 5.1.3.c Implement the proposed solution
- NE 5.1.3.d Evaluate the implementation
- NE 5.1.3.e Communicate the problem, design, and solution
- NGSS 3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- NE 8.1.1.d Select and use equipment appropriate to the investigation, demonstrate correct techniques
- NE 8.1.1.h Share information, procedures, results, and conclusions with appropriate audiences
- NE 8.1.3.b Design a solution or product
- NE 8.1.3.c Implement the proposed design
- NE 8.1.3.d Evaluate completed technological designs or products
- NGSS MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- NGSS MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

**We want to hear from you!**

Let us know what you thought of the lesson or send us a picture of youth participating in the lesson.

**#NE4HSTEM**

**#ECLIPSE2017**



## MATERIALS LIST

You may revise list to fit what you have in classroom supplies.

- Clothes Pin
- Coffee Stirrer
- Drinking Straw
- Highlighter
- Marker / Crayon
- Newspaper (rolled up)
- Pencil / Pen
- Water Bottle
- Wooden Craft Stick
- Paper Plates
- Paper
- Protractor
- Tape
- Glue

## PREPARATION

- Request students to bring a flashlight
- Collect items on the Materials List
- Print off following items:
  - Shadow with Purpose Worksheet
  - Engineering Design Process
- Check weather forecast for a sunny day
- Depending on Engineering Test Options:
  - If Option 1: Ensure time to observe every hour
  - If Option 2: Print off Sundial Base



## INTRODUCTION

### History of Inventing the Sundial:

- It is believed astronomer Theodosius of Bithynia invented the sundial that could be used anywhere on Earth.
- According to records, Romans were the first to use sundials (293 BCE).
- China also used sundials early on.

### How Sundials Work:

Typically, sundials have a flat plate and a gnomon (pronounced no-mon). Because sundials rely on latitude and longitude, sundials set to work in Canada will not work correctly in Mexico. Sundials will be off about 4 minutes per degree it is displaced from the original setting point.

### Vocabulary

**Sundial:** a device that tells the time of day based upon the position of a shadow casted by a gnomon

**Gnomon** (pronounced no-mon): is a thin rod that casts a shadow.

Typically, sundials have two sets of numbers. The inner numbers are for summer time and the outer layers are for winter time. This has to do with how the gnomon casts shadows in different seasons. This really only matters if you are making a sundial for year round. If it is just for an experiment, you can use one set of numbers and be fine.

*The sun is lower in the winter, which is why the shadows are different. The gnomon cast a longer shadow.*

### Significance of Sundials:

Sometimes sundials would be used to check the accuracy of the town's clock tower. They stopped doing this as traveling became easier thanks to trains. Each town had their own time since sundials depend so heavily on location. They started to standardize time zones as railroads were built to make it easier.

## OPENING QUESTIONS

- Before there were clocks, how did people tell time?
- How would you describe a shadow?

Today we are going to dive into sundials. Sundials are able to work because of the shadow that the sun casts on the gnomon (a thin rod or triangle that casts a shadow on the plate). Today we are going to discover what happens if we move the light source and engineer our own sundial.

## ACTIVITY 1: SHADOW WITH PURPOSE

We are going to start off by using flashlights in the classroom to learn more about shadows. The flashlight is going to serve as the sun and we are going to observe the shadow that is cast based on the angle of the flashlight & the type of gnomon. You may choose to test three of the materials as the gnomon. The materials are:

- Clothes Pin
- Coffee Stirrer
- Drinking Straw
- Highlighter
- Marker / Crayon
- Newspaper (rolled up)
- Pencil / Pen
- Water Bottle
- Wooden Craft Stick

In groups of two or three (recommend in pairs), choose three types of materials to test as a gnomon and record on the worksheet.

After completion of worksheet, review these questions.

1. Was there an obvious type of material that is best for a gnomon?
2. How did the flashlight simulate the sun?

As the seasons change, the sun changes in the sky. During the winter the sun is more in the southern part of the sky, while during summer the sun is more in the northern. Was there a difference in your length of shadow based on the angle of the flashlight? This is true for real sundials.

### Fun Fact

Earth has 24 time zones.

### Extension

Tower of the Winds is an octagonal clock tower in Athens that was used as a sundial.

### Time

20 min

### Tip

You can adjust the provided materials to what is available in your classroom.

## ACTIVITY 2: ENGINEER A SUNDIAL

You are now going to be engineers. Let's think about the engineering design process.

1. ASK – This is the question or the challenge placed before you.
2. BRAINSTORM – Come up with as many ideas as possible that could solve the ASK. This is the start of the design.
3. COMPARE – Discuss the best options that arrived from the brainstorm.
4. CHOOSE – Select the best option.
5. CREATE – Build the design & test!
6. COMMUNICATE – Share with others what you learned.



### Resources

A full picture of the Engineering Design Process is available to print at end of lesson.

Let's take the engineering design process and apply it to the sundials. Today, I am going to give you the ASK. Usually an engineer looks at a situation and a problem and comes up with their own ASK, but today I am providing the ASK.

Your ASK: To make a sundial that tells time.

The materials you have available are:

- Clothes Pin
- Coffee Stirrer
- Drinking Straw
- Highlighter
- Marker / Crayon
- Newspaper (rolled up)
- Pencil / Pen
- Water Bottle
- Wooden Craft Stick
- Paper Plates
- Paper
- Protractor
- Tape
- Glue

### Materials

Make sure the gnomon pieces are the same from the Shadow with a Purpose.

I want you to think about what you just discovered through the testing of the different gnomons and your previous knowledge about sundials. You will now have time to work in your pair/group to BRAINSTORM, COMPARE, and CHOOSE your design. Before you can proceed, you must have the design drawn out that includes the type of materials used. Please give a thumbs up once you have your design drawn.

Now that everyone is ready to go, CREATE. You have 15 minutes to build before going outside to test.

Testing Options (Same Day or Next Day):

Option 1: If schedule allows, have students test their sundial by going outside every hour, on the hour to mark their lines to create the hour lines.

OR

Option 2: Create the Sundial base at <http://analemmatic.sf.net/cgi-bin/papercraft.pl> by entering in your location, time zone and more. Glue or tape sundial base to the engineered base. Once outside set to geographic or true north, which is different than magnetic north. For more information on setting visit <http://www.instructables.com/id/15-minute-paper-craft-sundial/> under "Aligning the Dial".

COMMUNICATE your results to the class. Did you design and build a working sundial?

**Design Time** 5 min

**Create Time** 5 min

**Test Time**  
Depends on Option Chosen

**Fun Fact**  
Sundials use geographic or true north compared to a compass that uses magnetic north.



## REFLECT

- What did you do today?
- Did you like testing the different materials?
- Did groups use similar materials to make the gnomon?
- What was your favorite part?



## APPLY

- Have you done something similar to what you did today?
- Could you see yourself in an engineering career?
- Could you see yourself in a science career, test and record observations?

# SHADOW WITH A PURPOSE

Sundials

NAME

DATE

Directions: Discover which gnomon is the best to make a sundial. Test three types of gnomon materials by recording the angle of the flashlight and length of the shadow. Test each type of gnomon at least three times.

## 1 | Type of Gnomon

| Test | Angle of Flashlight | Length of Shadow (inches) | Overall Observation |
|------|---------------------|---------------------------|---------------------|
| 1    |                     |                           |                     |
| 2    |                     |                           |                     |
| 3    |                     |                           |                     |
|      |                     |                           |                     |

## 2 | Type of Gnomon

| Test | Angle of Flashlight | Length of Shadow (inches) | Overall Observation |
|------|---------------------|---------------------------|---------------------|
| 1    |                     |                           |                     |
| 2    |                     |                           |                     |
| 3    |                     |                           |                     |
|      |                     |                           |                     |



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### 3 | Type of Gnomon

| Test | Angle of Flashlight | Length of Shadow (inches) | Overall Observation |
|------|---------------------|---------------------------|---------------------|
| 1    |                     |                           |                     |
| 2    |                     |                           |                     |
| 3    |                     |                           |                     |
|      |                     |                           |                     |

Based on our observations and tests,  
the best type of gnomon was:

Please explain why:



A spiral-bound notebook with lined pages and a red margin line. The notebook is open to a blank page, ready for writing.

# THE ENGINEERING DESIGN PROCESS

Sundials



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