

Teacher's Preparatory Guide

Noodling Around: Powers of Ten

Overview: This activity develops a K–12 student's skills in measurement by using a pool noodle to measure objects. The activity encourages students to consider features that are useful when developing or using a measurement tool. This activity focuses on measuring length, for this is the most common feature when presenting nanoscale structures or nanoscale science. Understanding size and scale is fundamental to learning about nanotechnology as size defines the nanoscale (1-100nm in one dimension). Size is often divided into scales – macro, micro, nano and atomic. Helping students understand these “worlds” is an important part of their science knowledge and will help them to understand the relatively small size of the nanoscale.

Purpose: This activity is designed to help students understand the size and scale of objects and the tools that are used to measure these objects.

Time Required: ~35 minutes; more time may be needed with younger students

Level Elementary, middle school, and high school; general science, life science, mathematics

Teacher Background: Students often have trouble understanding size and scale in science, due to the different measurement units taught (metric and English), the different types of units used for length and volume, and the lack of consistent practice through their educational career. These lessons are aimed at presenting size and scale to students from kindergarten to high school.

Common student misconceptions¹ include:

- mixing units such as centimeters and inches
- not realizing the connection between relative and absolute sizes of two objects
- the inability to use measurement tools accurately
- believing that objects that cannot be seen with the naked eye are approximately the same size

This lesson introduces scale by demonstrating scales as factors of ten. This facilitates the introduction and reinforcement of the metric scale and paves the way to the discussion of lengths that are smaller than what can be seen with the naked eye. The lesson also introduces the concept of using different tools to address different length scales. A commonly used ruler gives way to the microscope, which eventually gives way to the scanning electron microscope (SEM) and the atomic force microscope (AFM) when observing lengths that shrink to the nanoscale.

Source:

1. Stevens, S., Sutherland, L., Krajcik, J., *The Big Ideas of Nanoscale Science and Engineering*. NSTA Press, 2009.

Materials per student

- pool noodles cut into 1 meter lengths, 1 decimeter lengths, and 1 centimeter lengths
- non-numbered rulers, one per student (Grades 3–12 only, see *Advance Preparation*)

Materials per class

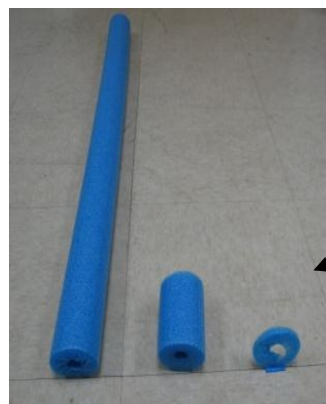
- pair of scissors
- meter stick
- miscellaneous objects (1 m, 1 dm, 1 cm)
- 3 equally-sized laundry baskets or boxes labeled “meter”, “decimeter”, and “centimeter”

Advance Preparation: Purchase pool noodles, which can be found seasonally in various grocery or all-purpose stores. Print out and cut to size rulers *without* numbers from this website: http://www.vendian.org/mncharity/dir3/paper_rulers/. Print enough so that each student can have a ruler.

1. **Use scissors to cut pool noodles to 1 meter, 1 decimeter, and 1 centimeter lengths.** Students will use these as measurement tools.



Examples of 1 meter, 1 decimeter, and 1 centimeter noodle lengths



A one centimeter noodle

2. **Prepare and place objects around the room that are approximately 1 meter, 1 decimeter, and 1 centimeter in length.** Here are some examples:
 - *Meter:* flag, chair, poster, width of door, window, or desk, whiteboard (height)
 - *Decimeter:* plastic or coffee cup, sponge, light switch, electrical outlet, sandwich, hinge
 - *Centimeter:* triple-beam balance pan (thickness), mouse pad (height), thickness of my ear, notepad (width), handle on filing cabinet (width), eraser (width)

Safety Information: Before distributing noodles, tell them no sword fighting, jedi impersonations, no hitting someone with a noodle, or throwing noodles.

Teaching Strategies: Students may have a tendency to talk about the noodle in terms of meters or feet; tell them that for this exercise we will pretend that this noodle is the only measurement system that exists—this *is* the ruler. When using the centi-noodle, point out to students that they are to measure using the thickness of the noodle not the diameter.

Homework: Separate student worksheets are available for grades K–2 and 3–12 with this lesson. Tell students that they will not take the noodles home, so for the homework, they need to look for something that is about the same size as what is already on the list. Encourage students to be creative when choosing units for their ruler. The units could be named after themselves, for example “1 Sarah”. Some students will use body parts or items around the house to define each unit length on their ruler. Remind students that they will use the rulers they make to measure *circumference* by wrapping the ruler around an object, such as a glass or a water bottle.

Kindergarten–Grade 2	Grades 3–12
<ol style="list-style-type: none"> Hand out a noodle (1 meter) to each student. Ask them to find an object of that length in the room, and take it back to their desk. Have students share what they found with the class. Have them confirm the measurement in front of the class before placing the object in the <i>1 noodle</i> basket. Collect noodles then repeat steps 1–2 for the deci-noodle and centi-noodle. Have students complete the noodle table on the worksheet and assign the at-home portion for homework. 	<ol style="list-style-type: none"> Hand out a noodle (1 meter) to each student. Ask them to find 2 objects of that length. Repeat step 1 for the deci-noodle and the centi-noodle. Have students share their answers to get at least 4 objects listed for each noodle unit, and complete the table. <i>Homework:</i> Distribute the non-numbered paper rulers. Have the students number the rulers with their own system, invent their own name for the units on the ruler. Emphasize neatness and thoroughness of work, for the rulers will be used for homework and future class work.

Cleanup: Collect all noodle measurement tools.

Assessment Verbal assessment can be done through class sharing and discussion of objects using the noodle as a measurement tool. Have the students share and discuss in class their thoughts of improving the noodle tool. This is a good way to assess their understanding of measurement tools in general.

Homework (30 min assessment): Grade rulers on design and ease of use. Since there are no numbers, reinforce and assess how students use tools to measure lengths. (Note: the rulers you handed out for homework were metric rulers without numbers.) The next day, have them measure (using the rulers they created) 5 images with different lengths. Students may choose several of the long lines to make one unit (for example, 5 of the unmarked centimeter lines were defined to equal 1 Sarah). If they do this, notice how they define and measure lengths that are less than 5 cm. When measuring a line shorter than their unit, (i.e. 3 cm) students may express it in decimals and not in fractions (such as 0.3 (3/10) Sarah, instead of 3/5 of a Sarah.) Review fractions with your class. Point out that, if the units are defined like this, it is more complex to measure using the smallest (millimeter) lines. Ask them: Did you run into any problems when using your measurement tool? What problems did you run into? How would you correct these problems? The rulers should be corrected before future use.

National Science Education Standards (Grades K–4, 5–8, 9–12)

Content Standard B: Physical Science

- Properties of objects and materials (Grades K–4)
- Properties and changes of properties in matter (Grades 5–8)
- Structure and properties of matter (Grades 9–12)

Content Standard E: Science and Technology

- Understandings about science and technology

Principles and Standards for School Mathematics

Measurement

- Understand measurable attributes of objects and the units, systems, and processes of measurement

- Apply appropriate techniques, tools, and formulas to determine measurements
- Numbers and Operation
- Understand numbers, ways of representing numbers, relationships among numbers, and number systems
 - Compute fluently and make reasonable estimates