Uncertainty of Measurement

The students will learn the application of scientific notation, significant figures, accuracy and precision as they pertain to the collection of data (measurement).

### General Information

- **Subject(s):** Science, Mathematics
- **Grade Level(s):** 9, 10, 11, 12
- **Intended Audience:** Educators
- **Instructional Time:** 1 Hour(s) 40 Minute(s)
- **Resource supports reading in content area:** Yes
- **Suggested Technology:** Computer for Presenter, Basic Calculators, LCD Projector, Adobe Flash Player, Adobe Acrobat Reader, Microsoft Office, Java Plugin
- **Freely Available:** Yes
- **Instructional Component Type(s):** Lesson Plan, Worksheet, Presentation/Slideshow, Image/Photograph, Instructional Technique, Formative Assessment
- **Resource Collection:** CPALMS Lesson Plan Development Initiative

### Attachment

- measurement PREQUIZ (with answers).docx
- measurement NOTES.ppt
- measurement LAB (with sample data answers).doc

### Lesson Content

**Lesson Plan Template:** Learning Cycle (5E Model)

**Learning Objectives: What will students know and be able to do as a result of this lesson?**

- Students will recognize SI units of measurement.
- Students will be able to convert any data into scientific notation.
- Students will be able to derive area, volume, density, and speed from collected measurements of mass, length, and time.
- Students will be able to read and record a measurement to the correct degree of certainty.
- Students will be able to round off derived units to the correct number of significant figures to reflect the degree of certainty.
- Students will be able to define and compare accuracy and precision.
- Students will use percent error to describe the accuracy of experimental data.

**Prior Knowledge: What prior knowledge should students have for this lesson?**

- Students should have a firm grasp of quantitative observations.
- Students should have experience gathering and analyzing data, and drawing inferences based on that data.
- Students should be able to voice rationale supporting a uniform system of measurement.
- Students should be able to link math and science in terms of measurements.
- Students should understand the rationale for rounding.
This prior knowledge will be assessed through a preliminary quiz as well as through open discussion of the material.

Guiding Questions: What are the guiding questions for this lesson?
Ask students why volume is considered to be a derived unit. Ans. Volume is calculated as length x length x length. The SI unit of volume (m3) is derived from the SI base measurement of length, the meter.

Ask what the difference between numbers used in math and numbers used in science. Ans. Math uses numbers without units; science always uses numbers that include units because the numbers represent data or measurements.

When does $1 + 1 = 3$? Ans. In science, all numbers need units. Therefore, it is possible to have $1$ dog plus $1$ couple equals $3$ individuals.

What is the difference between $1$ cm and $1.0$ cm? Ans. $1$ cm can be $+1$ cm off from the “real” answer, meaning the range of acceptable values due to error could be $0$ to $2$ cm (poor precision). $1.0$ cm can be $+0.1$ off from the “real” answer, meaning the range of acceptable values due to error could be $0.9$ to $1.1$ cm (good precision).

Engage: What object, event, or questions will the teacher use to trigger the students’ curiosity and engage them in the concepts?
Using a photo of a star nebula (using internet), ask students what is involved when a star explodes. Lead them through discussion that the event involves both matter and energy. Tell them this interaction of matter and energy is what chemistry is all about. To further their interest, tell them that both energy and matter can be measured quantitatively. In theory, they could measure how much energy was released and how much matter was dispersed during the explosion.

Explore: What will the students do to explore the concepts and skills being developed through the lesson?
As for the hands-on portion of the lesson, the students will explore the lengths of various classroom objects using a paint stirrer. The fictitious measuring unit for length will be the “blah”, and its symbol will be designated as “bl”.

Explain: What will the students and teacher do so students have opportunities to clarify their ideas, reach a conclusion or generalization, and communicate what they know to others?
The students will take notes on the main points of measurement, its application and its limitation. Sample problems are built into the instruction (powerpoint) to ignite discussion.

Elaborate: What will the students do to apply their conceptual understanding and skills to solve a problem, make a decision, perform a task, or make sense of new knowledge?
The students shall reflect upon, as part of the conclusion of their activity, the limitations of their fictitious measuring tool.

Summative Assessment
The teacher should actively peruse the group session as the students record their answers. Many students will forget about the resolution of their instrument and either add or subtract significant digits from their measurements. In the end, each group will submit their recorded data and calculations.

Formative Assessment
A preliminary quiz will be administered before instruction. For each question, students will hold up a white board with their answer above their heads (while looking straight ahead). In this fashion, the teacher can appreciate the scope to which students know the necessary background information for the day’s activity, and students will NOT be able to see each other’s answers.

Feedback to Students
The students in groups of two or three will observe each other’s measurements. In turn, they will agree or disagree with each measurement from the standpoint of significant figures. In other words, the number can vary so as long as the measurement contains the correct number of digits. Units must accompany all answers. Students will repeat the measurement if there is disagreement. Once consensus is reached, the group may continue to the next step in the data collection process. Each student will take turns calculating a derived unit. The student doing the work will speak aloud as to their process. The observer-student shall listen until the problem is complete. The observer-student will either agree or disagree. If disagreement occurs, the problem will be reworked with the input of the group. If agreement exists, the next student will work out the next derived unit in the same fashion as before.

Accommodations & Recommendations

Accommodations:
Students will be given accommodations according to their Individualized Education Program (IEP) or 504 Plan. Auditory and visually impaired students will be placed in the front of the class with direct line of sight to the teacher. Students with emotional impairments will be given the opportunity to work independently or on an alternative assignment which would still cover and explain the pertaining material. ESOL students will be paired with a peer to check their work; they will also be given extended time to complete assignments and/or tasks. In addition, any student will be given a visual representation of the notes/instructions/lesson plan if requested.

Extensions:
The same lesson could be repeated for mass (using a common object such as a pencil). For example, one pencil would be equivalent to one mass unit. A simple center-fulcrum scale could be utilized to record how many pencil mass units another object would weigh. The same lesson could be repeated for time. A simple task of writing a word (for example: jiff) would be equivalent to one time unit. In this manner, various tasks could be measured in “jiffs” based on how many times the word, “jiff”, is written for a given performance task.

A possible extension of this lesson would be to include the conversion of the fictitious units into SI units using the factor label method. For example, how many pencil mass units equal a kilogram? Another extension could utilize unit prefixes in converting fictitious units of one magnitude to fictitious units of another magnitude. Example: convert pencil mass units to millipencil mass units.

Suggested Technology: Computer for Presenter, Basic Calculators, LCD Projector, Adobe Flash Player, Adobe Acrobat Reader, Microsoft Office, Java Plugin

Special Materials Needed:
Materials for student use:
**Aligned Standards**

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<tr>
<th>Name</th>
<th>Description</th>
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<tr>
<td>SC.912.N.1.1</td>
<td>Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following:</td>
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<td>1. <strong>Pose questions about the natural world,</strong> (Articulate the purpose of the investigation and identify the relevant scientific concepts).</td>
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<td>2. <strong>Conduct systematic observations,</strong> (Write procedures that are clear and replicable. Identify observables and examine relationships between test (independent) variable and outcome (dependent) variable. Employ appropriate methods for accurate and consistent observations; conduct and record measurements at appropriate levels of precision. Follow safety guidelines).</td>
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<td>3. <strong>Examine books and other sources of information to see what is already known,</strong></td>
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<td>4. <strong>Review what is known in light of empirical evidence,</strong> (Examine whether available empirical evidence can be interpreted in terms of existing knowledge and models, and if not, modify or develop new models).</td>
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<td>5. <strong>Plan investigations,</strong> (Design and evaluate a scientific investigation).</td>
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<td>6. <strong>Use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs),</strong> (Collect data or evidence in an organized way. Properly use instruments, equipment, and materials (e.g., scales, probeware, meter sticks, microscopes, computers) including set-up, calibration, technique, maintenance, and storage).</td>
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<td>7. <strong>Pose answers, explanations, or descriptions of events,</strong></td>
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<td>8. <strong>Generate explanations that explicate or describe natural phenomena (inferences),</strong></td>
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<td>9. <strong>Use appropriate evidence and reasoning to justify these explanations to others,</strong></td>
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<td>10. <strong>Communicate results of scientific investigations, and</strong></td>
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<td>11. <strong>Evaluate the merits of the explanations produced by others.</strong></td>
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| MAFS.912.N-Q.1.3          | Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. ★                                                                                                          |

**Further Recommendations:**

It takes about 1 hour to accurately mark the paint stirrers in ten equal divisions (best done the day before lesson).

**Additional Information/Instructions**

**By Author/Submitter**

This lesson can be revisited when addressing SCIENCE STANDARD 8, which includes measurable properties of matter.

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**Source and Access Information**

**Contributed by:** Bryan Wilk

**Name of Author/Source:** Bryan Wilk

**District/Organization of Contributor(s):** Seminole

**Is this Resource freely Available?** Yes

**Access Privileges:** Public

**License:** CPALMS License - no distribution - non commercial

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- Scales (digital or triple beam) up to 0.00 g resolution
- Notebook
- writing utensil
- stirring stick (fictitious length measuring device)
- index card various other classroom items to be measured

Materials for teacher use:

- Paint stirring sticks can be gotten from any hardware or paint store (usually for free). You will need a class set of 24 total: 12 unmarked (as is) and 12 marked with ten divisions/tick marks (teacher will need to do this ahead of time with a marker)