UKanTeach Lesson Plan Format

Scientific Notation, Significant Figures, Accuracy and Precision

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Date lesson will be taught: 9/29 and 10/1

Grade level: High School, 10-12

Lesson Source:

1. Miller, Nancy M., National Teacher Training Institute, *Significant What?* Educational Broadcasting Corporation, 2006. http://www.thirteen.org/edonline/ntti/resources/lessons/significant/index.html
2. Astrophysics Science Project Integrating Research and Education (ASPIRE), *Scientific Notation*, University of Utah, 2003. http://aspire.cosmic-ray.org/javalabs/java12/SciNot/index.html
3. Shults, Sharla, Beacon Lesson Plan Library, *The Large and Small of It*, Bay District Schools. http://www.beaconlearningcenter.com/lessons/1669.htm

Concepts: Significant Figures, Scientific Notation, Accuracy and Precision

Objectives: At the conclusion of this two-day lesson students will be familiar with how to use scientific notation, the importance of significant figures and how to use them, the difference between precision and accuracy, and how to determine percent error.

Kansas Science and/or Mathematics Standards, Benchmarks, and Indicators:

Kansas Science Standard Grades 8-12

I. Standard 1 – Science as Inquiry: The student will develop the abilities necessary to do scientific inquiry and develop an understanding of scientific inquiry.
   A. Benchmark 1: The student will demonstrate the abilities necessary to do scientific inquiry.
      1. Indicator: The student actively engages in investigations, including developing questions, gathering and analyzing data, and designing and conducting research
      2. Indicator: The student actively engages in using technological tools and mathematics in their own scientific investigations.
         a. Using a variety of technologies, such as hand tools, measuring instruments, calculators, and computers as an integral component of scientific investigations.
         b. Using common mathematical functions to analyze and describe data.
         c. Recognizes that the accuracy and precision of the data, and therefore the quality of the investigation, depends on the instruments used.
         d. Using equipment properly and safely.

II. Standard 7 – History and Nature of Science: The student will develop understanding of science as a human endeavor, the nature of scientific knowledge, and historical perspectives.

A. Benchmark 2: The student will develop an understanding of the nature of scientific knowledge.

1. Indicator: Understands scientific knowledge begins with empirical observations, which are the data (also called facts or evidence) upon which further scientific knowledge is built.

a. Observations often include measurements, to varying degrees of accuracy and precision, so they can be described and analyzed with mathematics.

Materials list, advance preparation, and handouts: 15 Rulers, 30 Graduated Cylinders (2 sizes – 15 10 mL cylinders and 15 100 mL cylinders), Water, things to be measured (pennies, notecards, beakers, pencils etc., approximately 15 of each), notebook (students have their own), 15 scales, handouts (see attached)

Accommodations: Students will work in groups for the lab activities. This provides support for students who struggle with the lab or material.

Safety: Goggles

Five-E Plan

Day 1

Teacher Does	Probing Questions	Student responses
Engage: *Learning Experience(s)* *Time: __5_ minutes*	*Critical questions that will connect to prior knowledge and create a need to know.*	*Expected Student Responses/Misconceptions*
Ask students probing questions as a bell-ringer activity to introduce the concept of scientific notation. (5 minutes)	What are some things that usually come in big numbers? Can you think of any other ways to write these numbers?	Varied answers Can be written in words Some students may already have some knowledge of scientific notation

Teacher Does	Probing Questions	Student responses
Explore: *Learning Experience(s)* *Time: _10_ minutes*	*Critical questions that will guide students to a common set of experiences.*	*Expected Student Responses/Misconceptions*
Discuss as a class the	What are some large	Varied

engagement questions. Show examples of large numbers in science such as the number of stars in the milky way, atoms in 1 gram of hydrogen, etc., to get the kids interested in scientific notation. (10 minutes)	numbers that you came up with? What are some better ways to write these numbers that you came up with?	Word notation Shorthand word notation Some students may know scientific notation

Teacher Does	Probing Questions	Student responses
Engage: *Learning Experience(s)* *Time: __5_minutes*	*Critical questions that will connect to prior knowledge and create a need to know.*	*Expected Student Responses/Misconceptions*
Show different numbers such as number of students in the class, number of feet in a mile, pi, temperature in the room, measured height or weight of a person, etc. Handout or PowerPoint with pictures of measurements. This is to introduce the idea of exact and approximate numbers and their relationship to the idea of significant digits. (5 minutes)	Which of these numbers are exact? How many of the digits do you know for certain? If you measured something with a ruler and it was between 5.1 and 5.2 cm, what would you write?	Students will likely know that the number of students is exact but may be unsure of the others. Some students will likely think that all the digits can be known for certain. Students will likely answer 5.15.

Teacher Does	Probing Questions	Student responses
Explore: *Learning Experience(s)* *Time: _25_minutes*	*Critical questions that will guide students to a common set of experiences.*	*Expected Student Responses/Misconceptions*
Discuss engagement questions as a class. Lab activity where students are in groups. Each member of a group will measure different items with a ruler. (25 minutes) This activity is to have	Why are some numbers exact and some approximate? How big were the items? How many significant digits can you write in your answers?	Students may mistakenly think that numbers are exact when they are whole numbers and approximate when they include decimals. Students may think all decimals are significant, or may estimate the measurements beyond the scale of the ruler (for example if the ruler has

students work with significant figures.		marks for each 1/10 of a cm, and they measure something as 3.422cm).

Teacher Does	Probing Questions	Student responses
Explain: *Learning Experience(s)* *Time: _35_ minutes*	*Critical questions that will help students clarify their understanding and introduce information related to the lesson concepts/skills.*	*Expected Student Responses/Misconceptions*
Brief lecture / examples of how to use scientific notation and significant figures. Worksheet activity where students convert numbers from scientific notation to word notation, integer notation and the reverse and also identify the number of significant digits. (35 minutes)	Ask students in small groups if they are having trouble, have them show us how they would work a problem. Ask about their thought process for a worksheet problem.	They may have trouble with zeros past the decimal point or in between numbers. They may also have trouble with zeros before the numbers (after a decimal) and after the other numbers.

Teacher Does	Probing Questions	Student responses
Evaluate: Include summative evaluation below. *Time: _--_ minutes*	*Critical questions that ask students to demonstrate their understanding of the concepts and process skills. These questions must directly relate to the lesson's performance objectives.*	*Expected Student Outcomes*
The worksheet activity will be used as formative assessment to gauge student understanding of the first day of the lesson. This will allow us to see individual student understanding.	Questions include converting powers of 10 to standard notation, converting numbers from standard notation to scientific notation to word notation and the reverse, and identifying the number of significant digits	The questions all relate to material that was covered in the lesson from Day 1. If the students understand the material from the lesson they should answer the questions correctly. Incorrectly answered questions will alert us to any part of the lesson that needs additional coverage.

Day 2

Teacher Does	Probing Questions	Student responses
Engage: *Learning Experience(s)* *Time: __5_ minutes*	*Critical questions that will connect to prior knowledge and create a need to know.*	*Expected Student Responses/Misconceptions*
Show students examples of measurements or targets with bulls-eyes with different accuracy and precision (5 minutes)	Which is more accurate? Which is more precise? Is there a difference?	Students might not know that there is a difference between accuracy and precision.

Teacher Does	Probing Questions	Student responses
Explore: *Learning Experience(s)* *Time: _30_ minutes*	*Critical questions that will guide students to a common set of experiences.*	*Expected Student Responses/Misconceptions*
Discuss engagement questions as a class. Lab experiment measuring water using different sized graduated cylinders. *Note – explain to students how to properly fill up their beakers. (30 minutes)	What is the difference between accuracy and precision? Which is more important in scientific measurements? Was the 10 mL or 100 mL graduated cylinder more accurate? Which was more precise?	Students may not think there is a difference. Students may think that accuracy is more important than precision. Some may know that both are important. Students should be able to tell that the 10mL cylinder is more accurate.

Teacher Does	Probing Questions	Student responses
Explain: *Learning Experience(s)* *Time: _15_ minutes*	*Critical questions that will help students clarify their understanding and introduce information related to the lesson concepts/skills.*	*Expected Student Responses/Misconceptions*
Have students from each lab group give us their data and plot it on the board. Discuss the data. (15 minutes)	Which cylinder was more accurate? Was one more precise than the other?	Students should be able to answer that the smaller cylinder was more accurate and precise. Students may not know that

	Did the accuracy and precision of the scale affect the data?	the scale had any impact.

Teacher Does	Probing Questions	Student responses
Extend / Elaborate: Learning Experience(s) *Time: _35_ minutes (total)*	*Critical questions that will help students extend or apply their newly acquired concepts/skills in new situations.*	*Expected Student Responses/Misconceptions*
Do examples with the class for how to calculate percent error. Have students look at their data and class data from the significant figure measuring activity and calculate their percent error. (15 minutes) This is an extension on the topic of accuracy and precision already introduced.	What was the percent error of your measurements? How accurate were the measurements. Did the accuracy of the measurements improve when you looked at the class data as a whole compared to your group data?	Students may forget what should be the numerator and denominator when calculating percent error.
Put up examples of how you add, multiply, and divide numbers with significant digits with standard notation and scientific notation. Give the students a worksheet and help them in small groups. Let them try to figure out the process / rules. (20 minutes) This is an extension of the topic of significant digits and scientific notation which was introduced and discussed in day 1 of the lesson.	How would you use these when calculating average measurements?	Students might confuse whether they should apply the rules of addition or multiplication with significant figures. Students may have trouble adding / multiplying with exponents.

Teacher Does	Probing Questions	Student responses
Evaluate: Include summative evaluation below. *Time: _15_ minutes*	*Critical questions that ask students to demonstrate their understanding of the concepts and process skills. These questions must directly relate to the lesson's performance objectives.*	*Expected Student Outcomes*
During the last 15 minutes of class call on students to summarize what they learned. Additionally, the worksheet students were given in the elaborate section using scientific notation and significant digits in calculations will be used to assess student understanding. This will allow us to see individual student understanding.	What are the rules for significant figures? How do you convert to scientific notation? When is scientific notation useful? What are some numbers that you would represent with scientific notation? What does accuracy mean? What is precision? How do you calculate percent error?	Students would be expected to know the answers to these questions. The worksheet questions all relate to material that was covered in the lesson. If the students understand the material from the lesson they should answer the questions correctly. Incorrectly answered questions will alert us to any part of the lesson that we might not want to use in the future.