ECT Lesson Plan: Scientific Notation

Lesson plan at a glance...

Core subject(s)	Mathematics
Subject area(s)	Pre-Algebra
Suggested age	12 to 15 years old
Prerequisites	*None*
Time	**Preparation:** 9 to 26 minutes **Instruction:** 85 minutes
Standards	**Core Subject:** CCSS Math **CS:** Australia, CSTA, UK

In this lesson plan…

- Lesson Overview
- Materials and Equipment
- Preparation Tasks
- The Lesson
- Learning Objectives and Standards
- Additional Information and Resources

Lesson Overview

In this lesson, students will **recognize patterns** that occur in working with positive and negative exponents, as well as those that occur when multiplying and dividing numbers written in scientific notation. Students will use these patterns to **design an algorithm** with which they can **generalize patterns** they've observed and apply their learning in problems drawn from a real-world context. Upon completion of this lesson, students will be able to translate numbers between scientific and expanded notation, as well as perform operations with numbers written in scientific notation.

Materials and Equipment

- For the teacher and student:
  - *Required:* Internet-connected computer
    - Chrome browser (https://www.google.com/chrome/browser/desktop) recommended
  - *Required:* Software Development Environment
    - Python 3.x or 2.x (https://www.python.org/) OR a web-based Integrated Development Environment (IDE) such as Trinket (https://trinket.io/)
- For the teacher:
  - *Recommended:* Presentation set-up
    - Projector and projection screen or other flat projection surface
- For the student:
  - *Required:* Journal
    - Google Docs (http://docs.google.com) or a wiki OR if not using a computer-based collaboration tool
      - Markers/Whiteboard or Paper and Pen/Pencil
  - *Required:* Sticky note or index card (if selecting 'Help Write the Test' for the Wrap-Up Activity)

Preparation Tasks

	Confirm that your computer is on and logged-in	1 to 3 minutes
	Confirm that your projector is turned on and is projecting properly	1 to 3 minutes
	Confirm required software is installed or install software as described below	1 to 3 minutes
	If students are using computers, confirm that all students' computers are turned on, logged-in, and connected to the Internet	1 to 10 minutes
	If software needs to be installed on your computer: • Go to https://www.python.org/downloads/ and Install Python 3.x OR Python 2.x	5 to 10 minutes

The Lesson

Warm-up Activity: Predicting the pattern	10 minutes
Activity 1: Developing an algorithm for scientific notation	15 minutes
Activity 2: Multiplying and dividing with scientific notation	20 minutes
Activity 3: Applying scientific notation	30 minutes
Wrap-up Activity: Reflection	10 minutes

Warm-up Activity: Predicting the pattern (10 minutes)

Activity Overview: In this activity, students will draw on their prior knowledge of multiplication to predict any patterns that occur in scientific notation.

Activity:

1. Journaling: Students respond to the following prompt in their journal or word processor:
   - **When two numbers are multiplied together, is the result larger, smaller, or something else? Give at least two examples that support your thinking**.
2. K-W-L: Students identify what they know or can do (the 'K') and what they want to know about the topic or the skills they want to learn (the 'W'). Students can either complete this activity in a journal, using a word processor, or on a graphic organizer.

Teaching Tip:

- If you start the lesson with the K-W-L activity, be sure to conclude the lesson by asking students to identify what they learned during the lesson (the 'L').

Activity 1: Developing an algorithm for scientific notation (15 minutes)

Activity Overview: In this activity, students will **recognize patterns** that emerge from multiplying a number by different powers of 10. Students will then apply their thinking to **design an algorithm** for solving future scientific notation problems.

Notes to the Teacher:
This activity assumes students are familiar with the structure of exponents. However, some review of vocabulary may be necessary before beginning the activity. The table below presents a way to show the relationship among the terms **exponent** and **base**.

Exponential Expression	Base	Exponent
$10^3 = 10 * 10 * 10$	10	3

If students are using the Python interpreter for this activity, they need to know that exponents are entered using a double multiplication symbol, '**'. For example, "10^3" would be entered "10**3".

This activity focuses on students recognizing patterns in scientific notation. The second activity in this lesson plan focuses on the application of scientific notation. One of the key patterns students should recognize is that positive exponents result in multiplication and negative exponents result in division.

Activity:
Have your students type the following problems into the Python interpreter or a calculator and record the results:

Scientific Notation	Expanded Notation	Result	How many places did the decimal point move?	Did the decimal move to the left or to the right?
(a) $1.5 * 10^4$	1.5 * 10000	15000	4	right
(b) $1.5 * 10^{-4}$	1.5 * 0.0001	0.00015	4	left
(c) $10.5 * 10^5$	___	___	___	___
(d) $10.5 * 10^{-5}$	___	___	___	___
(e) $3.0 * 10^3$	___	___	___	___
(f) $3.0 * 10^{-3}$	___	___	___	___

Q1: When multiplying, what direction does a positive exponent move the decimal point?

Q2: When multiplying, what direction does a negative exponent move the decimal point?

Q3: What arithmetic operation does the negative exponent represent?

Q4: Describe any patterns you see between the exponent and the number of places the decimal point moves.

Assessment:
A1: A positive exponent moves the decimal point to the right.

A2: A negative exponent moves the decimal point to the left.

A3: Division

A4: The number of spaces the decimal point moves is equal to the exponent.

Activity 2: Multiplying and dividing with scientific notation (20 minutes)

Activity Overview: In this activity, students will **recognize** even more **patterns** that emerge in exponents from multiplying and dividing numbers written in scientific notation. Students will then continue to apply their thinking to design an algorithm for solving future scientific notation problems.

Activity:
Have your students open their Python editor and type **Ctrl-N** (PC) or **Command-N** (Mac) to create a new file.

Share the following code segment with your students and have them copy it into their Python editor. Instruct the students to press **F5** or from the menu **Run → Run Module** to compile and execute the code.

```
coeff_1 = input('Enter the coefficient of the first number: ')
exp_1 = input('Enter the exponent of the first number: ')
```

```
coeff_2 = input('Enter the coefficient of the second number: ')
exp_2 = input('Enter the exponent of the second number: ')

number_1 = float(coeff_1) * (10**int(exp_1))
number_2 = float(coeff_2) * (10**int(exp_2))

print 'First Number: ', '%.3E' % number_1
print 'Second Number: ', '%.3E' % number_2
print 'Product: ', '%.3E' % (number_1 * number_2)
print 'Quotient: ', '%.3E' % (number_1 / number_2)
```

Have your students use their Python code to evaluate the following arithmetic expressions and record the results:

Arithmetic Expression	Coefficient Expression	Exponent Expression	Combined Expression	Result, in Scientific Notation
(a) $(6.0 * 10^4) * (3.0 * 10^2)$	6.0 * 3.0	$10^4 * 10^2$	$18.0 * 10^6$	$1.8 * 10^7$
(b) $(6.0 * 10^4) / (3.0 * 10^2)$	6.0 / 3.0	$10^4 / 10^2$	$2.0 * 10^2$	$2.0 * 10^2$
(c) $(9.0 * 10^{10}) * (4.5 * 10^6)$	____	____	____	____
(d) $(9.0 * 10^{10}) / (4.5 * 10^6)$	____	____	____	____
(e) $(2.5 * 10^8) * (2.5 * 10^{-5})$	____	____	____	____
(f) $(2.5 * 10^8) / (2.5 * 10^{-5})$	____	____	____	____

Q1: When multiplying two numbers written in scientific notation, what mathematical operation occurs with the exponents?

Q2: When dividing two numbers written in scientific notation, what mathematical operation occurs with the exponents?

Q3: In expression (a) in the above table, explain why the exponent in the final result is more than the sum of the exponents in the original expression.

Assessment:
A1: When multiplying two numbers in scientific notation, the exponents of powers of 10 are added together.

A2: When dividing two numbers in scientific notation, the exponents of powers of 10 are subtracted.

A3: The product of the coefficients was greater than 10 and another power of 10 could be factored into the final result.

Activity 3: Applying scientific notation (30 minutes)

Activity Overview: In this activity, students will generalize the patterns they have observed and apply the algorithm they have developed in activities 1 and 2 to solve real-world mathematical problems.

Notes to the Teacher:
Though the arithmetic in these application problems is multiplication and division, the process of setting up each problem may require some scaffolding from the teacher. The answers to these problems are not as critical as the process students use to apply their learning.

The Python code from Activity 2 can be re-used in this activity.

Activity:
Have your students complete the table by setting up and solving each application problem.

Application Problem	Arithmetic Expression	Exponent Arithmetic	Result, in Scientific Notation
(a) The mass of a carbon atom is 1.994×10^{-23} g. Diamond is made up entirely of carbon atoms. If the mass of a diamond is 8.5 g, how many carbon atoms are in the diamond?	$(8.5 * 10^{0}$ g$) / (1.994 * 10^{-23}$ g$)$	0 - (-23) = 23	$4.263 * 10^{23}$ atoms
(b) The diameter of a human red blood cell is about $7.0 * 10^{-6}$ m. If there are about $2.5 * 10^{13}$ red blood cells in the human body, how tall would all the red blood cells in a body be if stacked end-to-end?	___	___	___
(c) Light travels at a speed of about $3.0 * 10^{8}$ m/s. The Sun is about 1.5 $* 10^{11}$ m away from Earth. How long does it take light to reach Earth from the Sun?	___	___	___
(d) Using the speed of light from (c), how many meters are in a "light-year" if 1 light-year is the distance light travels in one year?	___	___	___

Q1: What is the greatest benefit to writing numbers in scientific notation?

Q2: What, if any, is a disadvantage to writing numbers in scientific notation?

Assessment:
The answers to the problems in the table are provided here, for reference:

Application Problem	Arithmetic Expression	Exponent Arithmetic	Result, in Scientific Notation
(a) Carbon atoms in diamond sample	$(8.5 * 10^{0}$ g$) / (1.994 * 10^{-23}$ g$)$	0 - (-23) = 23	$4.263 * 10^{23}$ atoms
(b) Height of red blood cells	$(7.0 * 10^{-6}$ m$) * (2.5 * 10^{13})$	(-6) + 13 = 7	$1.75 * 10^{8}$ m

(c) Length of time for light to reach Earth from the Sun	$(1.5 * 10^{11}$ m) / $(3.0 * 10^{8}$ m/s)	11 - 8 = 3	$5.0 * 10^{2}$ s (about 8 min. 20 s)
(d) Meters in a light-year	$(3.0 * 10^{8}$ m/s) * $(3.1536 * 10^{7}$ s)	8 + 7 = 15	$9.46 * 10^{15}$ m

A1: Scientific notation provides a structure that allows us to efficiently write large or small numbers.

A2: It can be difficult to visualize the size and magnitude of a number written in scientific notation.

Teaching Tips:
- Create opportunities for self-direction by allowing students to conduct online research to create their own application problem with the expectation that they will write, solve, and share at least one problem.

Wrap-up Activity: Reflection (10 minutes)

Activity Highlights: In this activity, students will reflect on how their understanding of scientific notation has changed over the course of the lesson. Students found patterns and began to develop and apply an algorithm to solve arithmetic expressions involving scientific notation.

Activity:
1. K-W-L: Students identify something new that they learned or something that was clarified for them (the 'L') by the end of the lesson
    a. NOTE: Use this Wrap-up Activity if you used K-W-L during the Warm-up Activity
2. Help Write the Test: Students conclude the lesson by writing possible test questions for this lesson. Do this by having the students write the question on one side of a card or sticky-note and then an acceptable, detailed answer on the other side.

Learning Objectives and Standards

Learning Objectives	Standards
LO1: Students will be able to write and interpret numbers written in scientific notation.	*Core Subject* CCSS MATH.CONTENT.8.EE.A.3 Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. *Computer Science* CSTA L2.CT.15: Provide examples of interdisciplinary applications of computational thinking.
LO2: Students will be able to perform operations with numbers expressed in scientific notation by performing operations with these numbers' coefficients and	*Core Subject* CCSS MATH.CONTENT.8.EE.A.4 Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology.

exponents.	*Computer Science* CSTA L2.CT.15
LO3: Students will be able to apply an algorithm to multiply and divide numbers written in scientific notation.	*Core Subject* CCSS MATH.PRACTICE.MP7 Look for and make use of structure. *Computer Science* AUSTRALIA 6.4 (Creating digital solutions by: defining): Define problems in terms of data and functional requirements, and identify features similar to previously solved problems. CSTA L2.CT.1: Use the basic steps in algorithmic problem-solving to design solutions (e.g., problem statement and exploration, examination of sample instances, design, implementing a solution, testing and evaluation) UK 3.2: Understand several key algorithms that reflect computational thinking [for example, ones for sorting and searching]; use logical reasoning to compare the utility of alternative algorithms for the same problem.

Additional Information and Resources

Lesson Vocabulary

Term	Definition	For Additional Information
Exponent (or power)	An exponent represents the number of times the base is multiplied by itself	http://en.wikipedia.org/wiki/Exponentiation
Base	A number that is multiplied by itself when raised to a power	http://en.wikipedia.org/wiki/Exponentiation
Coefficient	A number multiplied by a power of 10 in scientific notation	http://en.wikipedia.org/wiki/Coefficient

Computational Thinking Concepts

Concept	Definition
Algorithm Design	Creating an ordered series of instructions for solving similar problems
Pattern Recognition	Observing patterns and regularities in data
Pattern Generalization	Creating models of observed patterns to test predicted outcomes

Administrative Details

Contact info For more info about Exploring Computational Thinking (ECT), visit the ECT website (g.co/exploringCT)

Credits Developed by the Exploring Computational Thinking team at Google and reviewed by K-12 educators from around the world.

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