

A Math 8 Unit in Scientific Notation Aligned to the New York State Common Core and
Learning Standards

by

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Dedication

This thesis is dedicated to my parents, who inspired me, encouraged me, and provided me with love and support through all my years.

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Abstract

In response to the implementation of new Common Core State Standards (CCSS), this curriculum project was designed to help teachers in the transition to the new standards. The curriculum project will be referred to as a unit plan throughout the paper. The unit plan on Scientific Notation, for the eighth grade mathematics curriculum, is aligned to the New York State Common Core and Learning Standards for Mathematics (NYSCCLSM). The unit plan addresses mathematical modeling, Mathematical Practice Standard 4. The unit plan may provide a way in which teachers can work towards the Common Core State Standards Initiative's goal to prepare students for college and career success (CCSSI, 2010).

Chapter 1: Introduction

The Common Core State Standards (CCSS) have been created through a collaboration of the National Governors Association Center for Best Practices and the Council of Chief State School Officers in order to strengthen the curriculum to address the ever-increasing gap in the performance and assessment of students in the United States in comparison with other nations, while standardizing a set of standards across the nation (Schmidt & Houang, 2012). Prior to the adoption of these standards, curriculum was aligned to state standards, which were built upon the long-standing National Council of Teachers of Mathematics (NCTM) standards that originated in 1989 (McLeod, 2003; CCSSI, 2010). Although modifications have been made to the NCTM standards since the first set of standards were created, there may not have been a large, drastic shift in the standards until now. Therefore, the states and territories that have adopted the national standards are currently experiencing a paradigm shift as the Common Core State Standards of Mathematics (CCSSM) and English Language Arts & Literacy are being implemented (CCSSI, 2012). Teachers may feel frustration, uncertainty and anxiety at this current time: Forty-five states, four territories, and the District of Columbia have adopted a new set of standards, the Common Core State Standards (CCSSI, 2012).

In response to the implementation of new learning standards, this unit plan has been created with teachers in mind. The unit plan was designed to help teachers in the transition to the new standards by including an eighth grade mathematics curriculum on Scientific Notation. The unit plan is aligned to the New York State Common Core and Learning Standards for Mathematics (NYSCCLSM). It is important to understand that although the unit plan is aligned to the NYSCCLSM the unit can be used in all states that have adopted the CCSSM. The unit plan can be used in states outside of New York because the NYSCCLSM address all CCSSM,

including an additional fifteen percent of New York State's standards to add to the rigor (NYSED, 2010, 2013b).

The CCSS Mathematical Practices

The CCSSM include eight mathematical practices teachers are required to teach throughout the year. The proponents of the CCSSM claim that the eight mathematical practices push towards coherence, rigor, and real-world application in the classroom, as defined below (CCSSI, 2010). NCTM addressed real-world problems in the standards, however there was not a mathematical modeling standard specifically designed to incorporate real world problems into the curriculum (NCTM, 2000). Therefore, this unit plan addresses mathematical modeling, the fourth Standard for Mathematical Practice of the CCSS, as this standard is completely new requirement of teachers to address in the curriculum. In addition, the unit plan also requires students to consistently and continuously justify their answers. This practice was addressed in the NCTM process standards: Problem Solving Standard for Grades 6 – 8 and the Reasoning and Proof Standard for Grades 6 – 8. Students were required to “make and investigate mathematical conjectures; develop and evaluate mathematical arguments,” as well as “communicate their mathematical thinking coherently and clearly to peers, teachers and others, [and] analyze and evaluate the mathematical thinking and strategies of others” (NCTM, 2000, n.p.). The third Standard for Mathematical Practice of the CCSSM relates to these two NCTM process standards, as it requires students to “construct viable arguments and critique the reasoning of others” (CCSSI, 2010). Therefore, throughout the unit, students will “justify their conclusions, communicate them to others, and respond to the arguments of others” (CCSSI, 2010). Lastly, the CCSSI claims that the CCSS will prepare all students for college and career success (CCSSI,

2010). This unit plan will implement strategies that may prepare students for college and career success, as they model real world examples and students are required to justify their answers and critique the reasoning of others throughout the unit. As a result, teachers and instructional specialists will have available to them a unit plan in an eighth grade mathematics classroom.

The ultimate goal of this unit plan is to develop an effective unit plan for teaching Scientific Notation to 8th grade mathematics students. The unit plan dives deep into the curriculum and provides educators with a resource when teaching Scientific Notation. As previously mentioned, the unit plan can be used in states across the United States as it aligns to the Common Core State Standards.

Key Terms and Definitions

CCSSM – Common Core State Standards of Mathematics are the standards adopted by numerous states in the United States, to which the unit plan is aligned.

Clusters– groups of related standards. Standards may sometimes be closely related, because mathematics is a connected subject (CCSSI, 2012). These appear inside domains.

Major clusters – areas of intensive focus, where students need fluent understanding and application of the core concepts (NYSED, 2013a, p. 3).

Supporting clusters – rethinking and linking; areas where some material is being covered but in a way that applies core understandings (NYSED, 2013a, p. 3).

Additional clusters – expose students to other subjects, though at a distinct level of depth and intensity (NYSED, 2013a, p. 3).

Coherence– the ability to connect content across grade levels and subject areas within a particular grade in order to build on prior knowledge (EngageNY, 2012b; Dick, 2012)

Domains – large groups of standards related to one another. Domains are coded with one or two letters. For example, Expressions and Equations is coded as EE. (CCSSI, 2012).

Deep Understanding – “students deeply understand and can operate easily within a math concept before moving on” (EngageNY, 2012b, p. 1).

Dual Intensity – students practice and understand, with a balance between the two (EngageNY, 2012b).

Fluency – the students’ ability to complete basic calculations with speed and fluency (EngageNY, 2012b).

Focus – key ideas, understandings, and skills are identified by the standards (EngageNY, 2012b).

NCTM– National Council of Teachers of Mathematics created the standards upon which the CCSSM were based upon, the *Principles and Standards for School Mathematics*.

NYS CCLSM– New York State Common Core and Learning Standards of Mathematics address all CCSSM, including an additional fifteen percent of New York State’s own standards to add to the rigor (NYSED, 2010, 2013b).

(Real - world) Application– the ability to apply the math concepts to a variety of situations, possibly without prompt (EngageNY, 2012b).

Rigor– pursue conceptual understanding, procedural skill and fluency, and applications with equal intensity in major topics (CCSSI, 2013).

Standards – define what students should be able to understand and be able to do (CCSSI, 2012).

These are a part of a cluster.

Chapter Two: Literature Review

Common Core State Standards and the New York State Common Core and Learning Standards of Mathematics

For years, the United States has fallen behind other countries across the globe in terms of assessment and performance of students. The Third International Mathematics and Science Study (TIMSS) provides reliable and timely data on the mathematics and science achievement of U.S. 4th- and 8th- grade students compared to that of students in other countries” (National Center for Education Statistics (NCES), n.d.). “The 1997 release of the original TIMSS data showed a downward trend of performance relative to other countries” (Schmidt & Houang, 2012). Based on the succeeding TIMSS data from 1999, 2003, 2007, and 2011, the United States has been ranked 19th, 15th, 9th, 9th, respectively, for 8th grade mathematics, in comparison to the other nations that completed the survey (NCES, n.d.). Additionally, the National Assessment of Educational Progress (NAEP) has indicated that approximately thirty percent of twelfth grade students are considered proficient in mathematics, suggesting that the curriculum is too weak (Schmidt & Houang, 2012). The National Governors Association Center for Best Practices and the Council of Chief State School Officers undertook a large project to create the Common Core State Standards (CCSS) (Common Core State Standards Initiative [CCSSI], 2010).

Standards Based Education

The CCSSI has led a new pathway for curriculum across the nation by providing states and territories within the United States of America a new set of national standards. The CCSS were built upon the preexisting state standards (CCSSI, 2010). Looking even further back, the state standards were based upon the model of the National Council of Teachers of Mathematics (NCTM) *Curriculum and Evaluation Standards for School Mathematics*, developed in 1989 as

the first set of standards in mathematics education, a new era of standards-based education (McLeod, 2003; Burris, 2010, p. 5). Prior to standards-based education, teachers chose what they taught their students based on their own personal opinions of what was necessary versus not necessary, and what was interesting to the teacher (Kendall, 2011). Problems with the standards, in many disciplines, may have included the fact that there were too many standards to address in the given amount of time of a school year. Additionally, there was too little curriculum at the time. Prior to standards-based education the textbook was the sole support for curriculum, as it was the curriculum (Kendall, 2011). With the NCTM standards, the standards were the forefront of education, while the curriculum was the backbone, supporting the standards. Thus, with the implementation of standards-based education, provided by the NCTM standards, schools may have felt as though they were at a stand still, as there was not much curriculum support available. States began creating their own standards and high stakes assessments aligned to those standards. New York State developed the New York State Learning Standards in 1995, built upon the NCTM standards. The NCTM standards “provided a useful foundation for continuing the improvement of mathematics education in the next millennium” (McLeod, 2003, p. 810). Many states chose to increase “the specificity of the Curriculum and Evaluation Standards by laying out expectations for each grade level,” including New York in 2005 (McLeod, 2003, p. 797; New York State Education Department [NYSED], 2010). As a result, instructional materials and curriculum supports were created based on specific standards from one state. These materials may have differed for those of another state, making it difficult to share resources. Table 1 provides a “comparison of education before standards-based education, during the standards movement, and under the common core,” adopted from Kendall (2011, p. 4). This table describes the changes, which have occurred over the past forty years in education. It is important to

understand from this table that under the CCSS, states are able to collaborate on instructional materials and curriculums aligned to the standards, as most states have adopted the standards. The goal of the CCSS was to create a national set of standards. Race To the Top (RTT), “a competitive grant program to encourage and reward States that are implementing significant reforms in the four education areas” (U.S. Department of Education, 2010, p. 3). RTT, created by the national government, was used as an incentive to adopt and fully implement the CCSS by 2014. In return for adoption and implementation of the standards, “States that are leading the way with ambitious yet achievable plans for implementing coherent, compelling, and comprehensive education reform” will receive rewards (U.S. Department of Education, 2013, n.p.). California, Texas, New York, and Florida were placed in Category 1, with awards between \$350 and \$700 million dollars in return for implementation of the CCSS. Thus, states may be able to collaborate more than ever on curriculum, student outcomes, and assessments (Kendall, 2011).

Prior to the CCSS, in between 1995 and 2000 specifically, “the proportion of institutions reporting an average of one year of remediation needed for students upon college entry increased from 28 percent to 35 percent, while the proportion of institutions indicating that students needed less than one year of remediation declined from 67 percent to 60 percent” (Kendall, 2011, p. 10). Therefore, the CCSS are claimed to increase preparation of students with the “knowledge and skills required for being college- and career- ready” (Kendall, 2011, p. 4; CCSSI, 2010). The National Governors Association Center for Best Practices (2010) claim the middle school standards are robust and provide a coherent and rich preparation for high school mathematics. The standards may provide teachers with guidance on what they need to prepare their students with in order for them to succeed in the subsequent grade level and ultimately to succeed in life beyond high school.

Table 1

A Comparison of Education before Standards-Based Education, During the Standards Movement, and Under the Common Core (Kendall, 2011, p. 4)

Criterion	Before Standards-Based Education	During the Standards Movement (NCTM)	Under the Common Core
<i>Appropriateness of expectations to instructional time available</i>	Time available = time needed	Varies by state; no explicit design criteria. Often, not enough instructional time to address all standards.	Standards are designed to require 85 percent of instructional time available.
<i>Curriculum support</i>	Curriculum is defined by the textbook.	Standards drive the curriculum, but curriculum development lags behind standards development.	Standards publication is quickly followed by curriculum development.
<i>Methods of describing student outcomes</i>	Seat time; Carnegie units (emphasis on inputs over outcomes)	State standards; criterion-based.	Cross-state standards; consortia of states.
<i>Source of expectations for students</i>	The expectations in textbooks or those described in Carnegie units; historical, traditional influences.	Varies by state; over time, moved from traditional course descriptions to college-and career-ready criteria.	The knowledge and skills required to be college-and career-ready; international benchmarks; state standards.
<i>Primary assessment purposes</i>	Infrequent comparison of students against a national sample; minimum competency tests in the 1970s.	Accountability; to clarify student performance by subgroup (NCLB).	Accountability; to inform and improve teaching and learning.
<i>Systemic nature of reform</i>	Not systemic; reform is enacted through programs at the school or district level.	Reform varies by state and within states. Some are tightly aligned; "local control" states are much less systemic.	Standards, curriculum, and assessment are shared among participating states and territories.

A variety of national councils and associations of mathematics, including NCTM, show support in the goals of the CCSSI to "describe a coherent, focused curriculum that has realistically high expectations and supports an equitable mathematics education for all students... as many aspects of the central elements of the CCSS echo the longstanding positions and principles of our organizations" (NCTM, 2010, p. 1). The New York State

Learning Standards and subsequent revisions of the standards were followed until New York State recently adopted the Common Core State Standards of Mathematics (CCSSM) in 2010. EngageNY (2012a) claims that the new standards can ensure all students will succeed after high school graduation, as students may be college and career ready.

The Paradigm Shift to the CCSS

New York State, along with forty-five other states, four territories, and the District of Columbia, are currently experiencing a paradigm shift as the Common Core State Standards of Mathematics (CCSSM) and English Language Arts & Literacy are being implemented (CCSSI, 2012). “It is no longer considered acceptable that students in different states are learning at different levels” (Kendall, 2011, p. 2). Although New York has adopted the CCSSM, the state has added up to fifteen percent of it’s own standards to add to the rigor. The CCSSM and the additional standards were combined, creating a document known as the New York State Common Core Learning Standards for Mathematics (NYSCCLSM) (NYSED, 2010, 2013b). The mission statement of the CCSSI (2012) states:

The Common Core State Standards provide a consistent, clear understanding of what students are expected to learn, so teachers and parents know what they need to do to help them. The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers. With American students fully prepared for the future, our communities will be best positioned to compete successfully in the global economy (p. 1).

In order to promote college and career readiness, the CCSSI (2012) claim that a focus on

mathematical modeling will help students make a connection between mathematics classroom instruction and the real world. The previous state standards may not have had a focus in mathematical modeling. Therefore, “the Common Core standards represent considerable change from what states currently call for in their standards and what they assess” (Porter, McMaken, Hwang & Yang, 2012, p. 114). The implementation of the CCSS may allow states to collaborate on materials for instruction including curricula, textbooks, professional development opportunities, assessments, and other instructional materials aligned with the documents of the CCSS (Achieve, 2010a).

The Structure of the CCSS

The CCSSM and NYSCCLSM contain two distinct documents, the Standards for Mathematical Practice and the Standards for Mathematical Content. Both of these have been adopted by the aforementioned states. The Standards for Mathematical content “define what students should understand and be able to do” (Burns, 2013, p.2). These are organized into domains, which include clusters, and furthermore include the standards (NYSED, 2011). These standards are grade specific. In contrast, The Standards for Mathematical Practice “include the same eight standards for all grades” (Burns, 2013, p. 1). The Standards for Mathematical Practice contain the following eight components (NYSED, 2011):

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.

5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

The Standards for Mathematical Practice and the Standards for Mathematical Content are encompassed in a few defining characteristics.

The CCSSM is defined by three characteristics: focus, rigor, and coherence, identified by six shifts in mathematics (Schmidt & Houang, 2012; EngageNY, 2012b). These shifts include: focus, coherence, fluency, deep understanding, application, and dual intensity (EngageNY, 2012b). In order for teachers to provide instruction that is focused, they should “focus deeply on only the concepts that are prioritized in the standards” (EngageNY, 2012b, p. 1). In other words, the goal is for teachers to shift away from the “mile-wide, inch-deep curriculum” (McGraw-Hill, 2011, p. 4). Achieve (2010a) claims that the CCSSM requires deep thinking and understanding for students at all grade levels, providing focus on the content to support deep understanding and promote rigor. The goal is for teachers to connect content across grade levels and subject areas to build on prior knowledge in an effort to provide a coherent curriculum (EngageNY, 2012b; Dick, 2012). It is essential that students have the ability to complete basic calculations with speed and accuracy in order to be fluent in mathematics. Additionally, EngageNY (2012b) claims that the CCSS require deep understanding and students may be able to apply the math concepts to a variety of situations, possibly without prompt, as described by Shift 5: Application. Lastly, EngageNY (2012b) claims that the dual intensity will require teachers to maintain a balance between students practice and understanding. Rigor encompasses many of these shifts, as the

CCSSM were made to lessen the gap between American student performance and assessment in comparison with other nations (Schmidt & Houang, 2012). The six shifts in Mathematics, as described by the CCSSM, may change the way educators provide instruction and work for the students.

EngageNY (2012a) provides a parent guide that may help parents and students in the shifts for mathematics. This guide may also be helpful for educators: The guide claims what the changes represent for the classroom. For example, deep understanding may require that students “show their work and explain how they arrived at an answer” (EngageNY, 2012a, p. 2). In order to achieve coherence, assignments may build upon one another and on previous knowledge. Students must obtain and maintain fluency in mathematics. In order for students to do so it is important for educators to provide ample time for memorization and practice of mathematical facts (EngageNY, 2012b). Lastly, EngageNY (2012a) claims that the CCSS will require students to apply math to the real world, through modeling. This may be done in the form of homework assignments based on the real world (EngageNY, 2012a). As noted previously, the CCSSM and NYSCCLSM may represent a change in the instruction of mathematics through the six shifts.

The New York State Common Core Learning Standards for Mathematics (NYSCCLSM) provide a structure on which educators, administrators, and specialists may lean upon to create curriculum for the mathematics classroom. The curriculum must be designed to meet the expectation that CCSSI has set forth: Educators must prepare students to be successful in college and in the workforce (CCSSI, 2010). The NYSCCLSM and the previous state standards (New York Learning Standards) have shifted grade levels standards in some instances, eliminated standards, and provided more in depth standards.

Most standards encourage mathematical modeling to help students make connections with the world around them. It is important that teachers know and understand the new changes to the NYSCCLSM in order to help all students succeed.

The Common Core State Standards are sorted by grade level, each building upon one another. Standards, clusters, and domains define the grade level standards. Domains are large groups of standards related to one another. For example, Expressions and Equations (EE) is the domain in which the eighth grade unit on Scientific Notation will be based. Within domains there are clusters. These are groups of related standards. The unit on Scientific Notation works within the cluster that states, students will “work with radicals and integer exponents” (National Governors Association Center for Best Practices, 2010, p. 54). Standards from different clusters and domains may be closely related, “because mathematics is a connected subject” (National Governors Association Center for Best Practices, 2010, p. 5). Lastly, there are standards set within clusters to define what students should understand and be able to do. Standards 3 and 4 of 8.EE will be represented in the unit on Scientific Notation. The Common Core State Standards do not define the methods of instruction, activities for learning the standards, nor the time frame for when, where in the year, and for how long each standard should be taught. EngageNY.org has provided a document created by the New York State Education Department (NYSED) to possibly guide teachers in planning for instruction of each topic. The document titled “Emphases in Common Core Standards for Mathematical Content Kindergarten – High School” details a break down of the mathematical content standards for each grade level, dividing them up across three categories: Major Clusters, Supporting Clusters, and Additional Clusters. Major clusters, supporting clusters, and additional clusters account for approximately 70%, 20%,

and 10% of the final assessment, respectively. Below, Table 2 is provided to guide teachers of eighth grade mathematics.

Table 2

Emphases in Common Core Standards for Mathematical Content by Cluster

(NYSED, 2013a, p. 12)

Grade 8		
Major Clusters	Supporting Clusters	Additional Clusters
<p>Expressions and Equations</p> <ul style="list-style-type: none"> - Work with radicals and integer exponents. - Understand the connections between proportional relationships, lines, and linear equations. - Analyze and solve linear equations and pairs of simultaneous linear equations. <p>Functions</p> <ul style="list-style-type: none"> - Define, evaluate, and compare functions. <p>Geometry</p> <ul style="list-style-type: none"> - Understand and apply the Pythagorean Theorem. - Understand congruence and similarity using physical models, transparencies, or geometry software. 	<p>The Number System</p> <ul style="list-style-type: none"> - Know that there are numbers that are not rational, and approximate them by rational numbers. <p>Functions</p> <ul style="list-style-type: none"> - Use functions to model relationships between quantities. <p>Statistics and Probability</p> <ul style="list-style-type: none"> - Investigate patterns of association in bivariate data. 	<p>Geometry</p> <ul style="list-style-type: none"> - Solve real-world and mathematical problems involving volume of cylinders, cones, and spheres.
<p>Depth Opportunities: EE 5, 7, 8; F 2; G 7</p>		

Additionally, at the bottom of each table a section, “depth opportunities,” defines the CCSS that are crucial to focus on for in-depth instruction at each grade level.

When looking at the differences between the old “New York State Learning Standards for Mathematics” (NYSLSM) (from 2005) and the new “New York State Common Core and Learning Standards for Mathematics” (NYSCCLSM) (from 2011), there are noticeable differences among the content standards for each grade level. It is noted that standards have been moved from one grade level to another, either forwards or backwards. Therefore, some standards from the NYSLSM have been added to or taken from any specific grade level. Bromley, Jovell, and Sobolewski have created multiple documents to show the re-alignment of the old standards and also compare the old NYSLSM to the new NYSCCLSM. These documents are created for multiple grade levels, including grade 7 and grade 8. Table 3 provides the Grade 8 – Core vs. NYS Standards document, detailing the New Topics (“NT”) versus the “Same” topics, recovered from nyscirs.org.

Scientific Notation and the CCSS

In regards to scientific notation, students in seventh grade mathematics were expected to achieve the following standards from the NYSLSM (NYSED, 2005a; Bromley, Jovell, and Sobolewski, August 2011a):

- 7.N.4 Develop the laws of exponents for multiplication and division
- 7.N.5 Write numbers in scientific notation
- 7.N.6 Translate numbers from scientific notation into standard form
- 7.N.7 Compare numbers written in scientific notation

7.N.14 Develop a conceptual understanding of negative and zero exponents with a base of ten and relate to fractions and decimals (e.g., $10^{-2} = 0.01 = 1/100$)

However, students in grade 8 had no standards related to scientific notation (NYSED, 2005b). Therefore, since scientific notation was not previously required for grade 8 students, it should be understood that a shift in standards from one grade level to another is represented in this unit plan.

Table 3

Grade 8 – Core vs. NYS Standards

(Bromley, Jovell, and Sobolewski, August 2011b)

Grade 8	Core	NYS
<i>Expressions and Equations</i> -----		<i>8.EE</i>
<i>Exponents</i>	Operate and evaluate integer and zero exponents	Same
	Estimate using powers of 10 for very small and large quantities	<u>New Topic</u>
	Scientific Notation	NT
	Operations with Scientific Notation	NT
	Know simple perfect squares and cubes	NT
	Solve equations using square roots or cube roots	NT

Once again, it should be noted that the topic of scientific notation was originally addressed in grade 7, and has since been moved to grade 8 as a result of the CCSS. According to

Bromley, Jovell, and Sobolewski (August, 2011b) there are twenty-nine new topics in 8th grade mathematics, while there were only thirteen topics that remained the same in eighth grade mathematics with the shift to the CCSS. Thus, many changes have been made to the state standards for each grade level, including, but not limited to, the state standards in New York. Curriculum is being developed and implemented across the nation, aligned to the CCSS. One example of this is being done currently by the Partnership for Assessment of Readiness for College and Careers (PARCC), an organization whom claims to be “committed to developing model content and frameworks for the mathematics and English language arts/literacy (ELA/literacy) to serve as a bridge between the Common Core State Standards and the PARCC assessments” (PARCC, 2013). New York State has chosen to administer the PARCC assessments in order to assess student learning, as PARCC Model Content Frameworks and assessments claim to be “firmly rooted in the Common Core Learning Standards and college/career readiness” (EngageNY, n.d.). Therefore, the unit plan that follows addresses information from the PARCC Model Content Frameworks, as it addresses and focuses on Scientific Notation, a major cluster, in the grade 8 CCSSM (see Table 2 above). The unit plan will provide lessons that incorporate two Standards for Mathematical Practice: Mathematical modeling and constructing viable arguments and critiquing arguments of others. This unit plan may help educators in the transition to the new standards, both NYSCCLSM and CCSSM and meet the needs of all learners to help them succeed in the unit.

Chapter Three: Unit Plan

The Math 8 unit plan detailed below addresses the topic of scientific notation. This topic was recently added to the grade 8 standards, as a result of the Common Core State Standards (CCSS). New York State, among other states, has adopted these standards and began implementing them in the 2012- 2013 school year. The New York State Common Core and Learning Standards for Mathematics (NYSCCLSM) are the same as the Common Core State Standards, with the addition of a few standards. However, the standards related to scientific notation are identical. Therefore, either set of standards will be applicable to this unit. Since this unit is intended mostly for those within New York State, the standards listed below are from the NYSCCLSM. Within the NYSCCLSM/CCSS there is a cluster titled “Expressions & Equations,” referred to as EE. The Math 8 Unit in Scientific Notation is aligned to the following standards from the EE cluster (New York State Education Department [NYSED], 2013b, p. 46):

8.EE.3 – Use numbers expressed in the form of a single digit times a whole-number power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. *For example, estimate the population of the United States is 3 times 10^8 and the population of the world as 7 times 10^9 , and determine that the world population is more than 20 times larger.*

8.EE.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.

The lesson plans presented below will use the Understanding by Design (UbD) lesson planning format, adopted from Grant Wiggins and Jay McTighe (Wiggins & McTighe, 2005). There are several stages that the lesson plan template works through, as a part of the UbD format. Stage one is clarifying desired results. It is important for educators to focus on the goals and what students will understand by the end of the lesson. This section also determines what the students will need to get to those goals based upon skills and vocabulary words. The next stage is “assessment evidence,” where teachers communicate what students will be doing and how they will be assessed, such as independent practice, group work, homework, checks for understanding, or ticket-out-the-doors. Finally, stage three is the learning plan. The learning plan details the acquisition activities, meaning-making activities, and transfer activities throughout the unit. The UbD lesson design template is used at the school in which the author is employed, thus, the reason for its use in this paper.

Below, in Table 4, the unit plan is displayed in a unit calendar, with a sequencing of topics within the unit of Scientific Notation, based upon eighty-minute blocks, meeting every other day. This unit plan will cover two weeks, including a day of review. The first day of the third week has been planned for the unit test. Immediately following the next page one will find lesson plans. Note pages (to be copied for students) are provided after each lesson. The original intent for the note pages was for them to be copied in the form of a unit packet, keeping all notes together. Students would fill out particular pages of the notes on the corresponding day of the lesson. However, to make the reading of the lessons and materials more clear, the materials for each lesson succeed the lesson plan for any given day of the unit.

Table 4*Unit Calendar*

Monday	Tuesday	Wednesday	Thursday	Friday
Writing Numbers in Scientific Notation		Comparing Numbers in Scientific Notation		Adding and Subtracting Numbers in Scientific Notation
	Multiplying and Dividing Numbers in Scientific Notation		Review	
Unit 2 Test				

In addition to the note pages, ticket-out-the-doors (TOTDs) and homework assignments are also located after each section of notes for the particular lesson. Lesson five describes a review day, in which a review packet is provided. Lesson six is the day of the unit test, in which all students will work independently to complete the unit test, as an assessment for the unit on scientific notation. The content in the notes, TOTDs, homework assignments, review packet, and unit test is a compilation from a variety of resources. Although the main source of content is original content from the author, additional resources include New York State Common Core Mathematics Curriculum Grade 8 Module 1 (2013), Math in Focus (Marshall Cavendish, 2013), and a McGraw-Hill worksheet (n.d). An answer key to all materials may be found in the Appendix.

Math 8 Unit Plan- Scientific Notation

Math 8 – Unit: Scientific Notation – Lesson 1

Lesson Topic: Writing Numbers in Scientific Notation

Grade Level: 8

Duration: 80 minutes

Teacher Name: _____

Stage 1 – Desired Results		
<p>External Standard(s):</p> <p>CCSS/NYSCCLSM 8.EE.3 – Use numbers expressed in the form of a single digit times a whole-number power of 10 to estimate very large or very small quantities</p>	<p>Essential Question: Why is scientific notation helpful to scientists and other people that work with very, very large or small numbers?</p>	
	<p>Understanding Goal:</p> <p><i>Students will understand that:</i></p> <ul style="list-style-type: none"> • Scientific Notation is a method created by scientists to represent very, very large and very, very small numbers. • Scientific Notation is written as $d \times 10^n$ (where $1 \leq d < 10$ and n is an integer) 	
	<p>Skills: <i>students will be able to...</i></p> <ol style="list-style-type: none"> 1. write numbers in scientific notation from standard notation 2. write numbers in standard notation from scientific notation 	<p>Content: <i>(facts, vocabulary, knowledge)</i></p> <ul style="list-style-type: none"> - scientific notation - standard notation - coefficient - base - exponent - power of 10 - integer - Scientific Notation: $d \times 10^n$ ($1 \leq d < 10$)
Stage 2 – Assessment Evidence		
<p>Performance Task(s):</p> <p>- Notes p. 1 - 4</p>	<p>Other Evidence (TOTD's, quizzes):</p> <ul style="list-style-type: none"> - Individual Practice - TOTD #1 - Homework #1 	
Stage 3 – Learning Plan: Learning Activities: TMA		
<p>Acquisition Activities:</p> <p>How many stars are there in the universe? Recall: powers of 10</p>	<p>Meaning- Making Activities:</p> <p>Determining if numbers of real life objects are written in scientific notation.</p>	<p>Transfer Activities:</p> <p>Converting between standard and scientific, as scientists do.</p>

Name _____

Class _____

Unit: Scientific Notation

☆☆ Day 1 – Writing Very Large and Small Numbers in Scientific Notation



How many stars are there in the universe?

Scientists estimate there to be _____ stars in the universe! (22 zeros!) Numbers like this are so large that scientists have invented a method called _____ to write these very, very large numbers (and very, very small numbers).



Recall

Powers of 10

$10^1 =$ _____

$10^2 =$ _____

$10^3 =$ _____

$10^{-1} =$ _____

$10^{-2} =$ _____

$10^{-3} =$ _____

When we multiply a decimal by a _____ power of ten, we move the decimal to the _____.

When we multiply a decimal by a _____ power of ten, we move the decimal to the _____.

Examples:

$1.58 \cdot 10^1 = 1.58 \cdot$ _____ $=$ _____

$1.58 \cdot 10^2 = 1.58 \cdot$ _____ $=$ _____

$1.58 \cdot 10^3 = 1.58 \cdot$ _____ $=$ _____

Examples:

$1.5 \cdot 10^{-1} = 1.5 \cdot$ _____ $=$ _____

$1.5 \cdot 10^{-2} = 1.5 \cdot$ _____ $=$ _____

$1.5 \cdot 10^{-3} = 1.5 \cdot$ _____ $=$ _____

Quick Check

• $1.8 \cdot 100 =$ _____

• $0.28 \cdot 10^3 =$ _____

• $1.3 \cdot 10^4 =$ _____

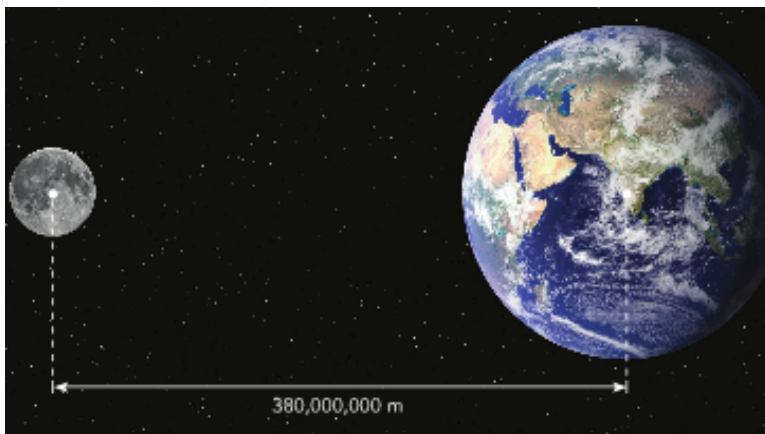
• $74.5 \cdot 10^{-3} =$ _____

• $3.8 \cdot 10^{-1} =$ _____

• $2.81 \cdot 10^{-2} =$ _____

Scientists, like Astronomers, work with very large and very small numbers.

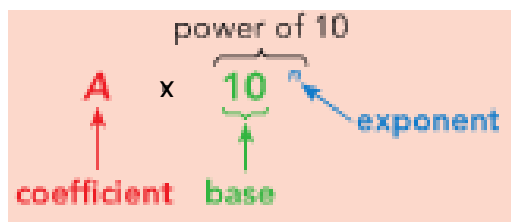
For example, the average distance from the Earth to the moon is approximately 380,000,000 meters. Sometimes it's hard to keep track of so many zeros in such a large number. This is why scientific notation is very helpful!



What other things can you think of that we might want to represent very large or very small numbers with?

Scientific Notation can be used to represent a positive, finite decimal s as the product $d \times 10^n$, where d is a finite decimal greater than or equal to 1, but less than 10 (i.e. $1 \leq d < 10$), and n is an integer.

Scientific Notation



For numbers greater than or equal to 10, use a _____ exponent.

Example 1

The finite decimal 584.392 is equal to every one of the following:

- | | | | |
|------------------------|--------------------------|--------------------------|--------------------------|
| 5.84392×10^2 | 584.392×10^0 | 58439.2×10^{-2} | 5843.92×10^{-1} |
| 0.584392×10^3 | 5843920×10^{-4} | 58.4392×10^1 | 0.00584392×10^5 |

However, there is only one that is written in scientific notation. Why is this the only one written in scientific notation?

Practice 1

Are the following numbers written in scientific notation? If not, state the reason.

- a) The Statue of Liberty is 3.05×10^2 feet tall.

- b) People spend approximately 4050.0×10^{-1} minutes on Facebook each month.

- c) A golf ball has a diameter of about 1.680×10^0 inches.

- d) It would take a person approximately $0.116 + 10^3$ hours to walk to Washington, DC from Rochester, NY.

Example 2

Write each number in scientific notation.

- a) 567.8
- b) 0.0246

Practice 2

- a) 9483.32
- b) 0.005623

Remember: For numbers greater than or equal to 10, move the decimal to the _____ and use a _____ exponent.

For positive numbers less than 1, move the decimal to the _____ use a _____ exponent.

Example 3

We can also write numbers in standard form from scientific notation.

a) 8.46×10^5

b) 9.25×10^{-5}

Practice 3

Write each number in standard form.

a) 5.6×10^3

b) 4.62×10^{-2}

Tips for changing notation: Standard \Leftrightarrow Scientific

Standard \Rightarrow Scientific

$(d \times 10^n)$

- Move the decimal point in the given number so there is only _____ nonzero digit to the left. The resulting number is d ($1 \leq d < 10$).
- Count the number of places you moved the decimal point in step 1. If the decimal point was moved to the _____, n is **positive**; if it was moved to the _____, n is **negative**.
- Write $d \times 10^n$

Scientific \Rightarrow Standard

- If the exponent is **positive**, move the decimal point to the _____ as indicated by the exponent of 10; if the exponent is **negative**, move the decimal point to the _____ as indicated by the exponent of 10.

Name _____

TOTD #1

Class _____

Which are not written in scientific notation? Explain your reason.

a) $3.56 + 10^4$

b) 35.6×10^3

c) 3.56×5^4

d) 3.56×10^4

There were approximately 1700 players in the NFL in 2011. Write this number in scientific notation.

A carpenter ant is approximately 5.0×10^{-1} inches long. Write this number in standard notation.

Name _____

TOTD #1

Class _____

Which are not written in scientific notation? Explain your reason.

a) $3.56 + 10^4$

b) 35.6×10^3

c) 3.56×5^4

d) 3.56×10^4

There were approximately 1700 players in the NFL in 2011. Write this number in scientific notation.

A carpenter ant is approximately 5.0×10^{-1} inches long. Write this number in standard notation.

Name _____

Homework #1

Class _____

1. Are the following numbers written in scientific notation? If not, state the reason.

a) 65.04×10^1

d) 6.78×10^{45}

b) 4.583×10^5

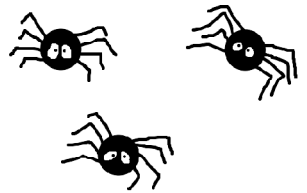
e) $1.59 + 10^3$

c) 0.439×10^{-8}

f) 5×10^{-23}

2. The approximate distance to the sun is 93,000,000 miles, and the wavelength of its ultraviolet light is 0.000035 centimeter. Write both numbers in scientific notation.

3. A jumbo jet weighs 7.75×10^5 pounds, whereas a house spider weighs 2.2×10^{-4} pound. Write both weights in standard notation.



Math 8 – Unit: Scientific Notation – Lesson 2

Lesson Topic: Comparing Numbers in Scientific Notation

Grade Level: 8

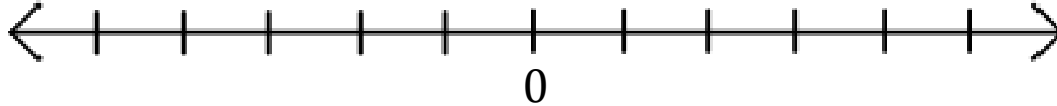
Duration: 80 minutes

Teacher Name: _____

Stage 1 – Desired Results		
External Standard(s):	Essential Question: How can we compare numbers that are written in scientific notation?	
CCSS/NYSCLSM 8.EE.3 – Use numbers expressed in the form of a single digit times a whole-number power of 10 to estimate very large or very small quantities	Understanding Goal: <i>Students will understand that:</i> <ul style="list-style-type: none"> • can be compared to one another to determine which is greater by looking at the exponents first. If the exponents are the same, we can compare the coefficients. 	
	Skills: <i>students will be able to...</i> <ul style="list-style-type: none"> - compare numbers written in scientific notation 	Content: <i>(facts, vocabulary, knowledge)</i> <ul style="list-style-type: none"> - scientific notation - standard notation - coefficient - base - exponent - powers of 10 - integer - < and > - number line (negatives and positives)
Stage 2 – Assessment Evidence		
Performance Task(s): - Notes p. 5 - 8	Other Evidence (TOTD's, quizzes): <ul style="list-style-type: none"> - Individual Practice - Classwork with partners - TOTD #2 - Homework #2 	
Stage 3 – Learning Plan: Learning Activities: TMA		
Acquisition Activities: Who has more Facebook fans? Which planet has the largest diameter? Recall: number line	Meaning- Making Activities: Comparing very large and very small numbers, expressed in scientific notation, to determine greater number; looking at Facebook fans of celebrities, air pressure gauges; diameter of planets	Transfer Activities: Writing numbers in standard/scientific notation and comparing them in scientific notation to see the greater number; Partner work, individual practice, group discussions

Day 2 – Comparing Numbers in Scientific Notation**Recall**

Complete the number line below.

**Example 1**

We can compare the _____ to determine which number is greater. If the powers are _____, we will compare the _____.

Identify the greater number in each pair of numbers. Justify your reasoning.

a) 3.4×10^5 and 7.2×10^2

b) 1.6×10^{-2} and 4.8×10^{-2}

Practice 1

Identify the greater number in each pair of numbers. Justify your reasoning.

1. 3.4×10^8 and 7.2×10^9

2. 5.6×10^{-9} and 2.8×10^{-9}

3. Challenge: 6.5×10^{-5} and 5.8×10^{-3}

Example 2



Taylor Swift, a singer/songwriter has approximately 47,800,000 fans on Facebook. Selena, an actress/singer, has approximately 47.1×10^6 fans on Facebook. Which celebrity has the greater number of fans?



Practice 2

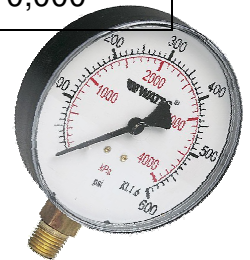
A technician reads and records the air pressure from several pressure gauges. The table shows each air pressure reading in pascals (Pa). A pascal is a unit used to measure the amount of force applied on a given area by air or other gases. Justify your reasoning for each question below.

Pressure Gauge	Air Pressure (Pa)
A	210,000
B	5.2×10^5
C	170,000

1. Which pressure gauge has the greatest reading?

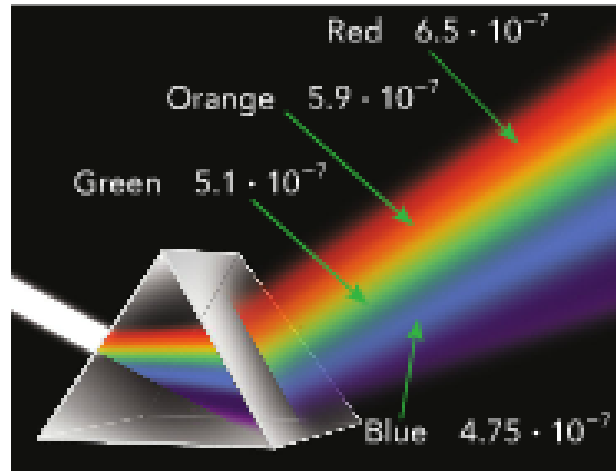
2. Which pressure gauge has the lowest reading?

3. The atmospheric pressure when these readings were made was 1.1×10^5 . Which gauge(s) showed a reading *greater than* the atmospheric pressure?



Classwork

1. When visible light passes through a prism, the light waves refract, or bend, and the colors that make up the light can be seen. Each color has a different wavelength, as shown in the diagram, which is refracted to a different degree.



- a) Shorter wavelengths refract more than longer wavelengths. Which color of light wave shows the most refraction? Which color of light wave shows the least refraction? Justify your answer.

- b) The frequency of a light wave is the number of waves that travel a given distance in a given amount of time. The shorter the wavelength, the greater the frequency. Order the wavelengths, in order of their frequencies, from least to greatest.

2. The approximate diameters of the planets in our solar system are listed in a table below in either Standard Notation or Scientific Notation.

a) Complete the table.

Planet	Diameter (km) in Standard Notation	Diameter (km) in Scientific Notation
Mercury		4.8×10^3
Venus	12,100	
Earth		1.28×10^4
Mars	6,792	
Jupiter		1.429×10^5
Saturn	120,500	
Uranus	51,100	
Neptune		4.953×10^4
Pluto		2.3×10^3

<http://nineplanets.org/data1.html>

b) Which three planets have the greatest diameter? Justify your reasoning based on the diameters in scientific notation.

c) Which planet has the least diameter? Justify your reasoning.

d) The moon has a diameter of 3.5×10^3 km. Which planet(s) have a diameter smaller than the moon?

Name _____

TOTD #2

Class _____

The population of California is approximately 38,040,000. The population of Texas is approximately 26.06×10^6 . The population of New York State is approximately 1.96×10^7 .

a) Write each population in scientific notation.



b) Which state has the greater population? Justify your reasoning.

Name _____

TOTD #2

Class _____

The population of California is approximately 38,040,000. The population of Texas is approximately 26.06×10^6 . The population of New York State is approximately 1.96×10^7 .

a) Write each population in scientific notation.



b) Which state has the greater population? Justify your reasoning.

Name _____
 Class _____

Homework #2

1. James came across the following fun facts about the human body while searching on the Internet. Complete the table by writing each figure in scientific notation.

Facts	Figures in Standard Notation	Figures in Scientific Notation
Number of cells in a human body	12,000,000,000,000	
Diameter of a red blood cell (m)	0.0000084	
Average number of times the human eye blinks	4,200,000	
Number of hairs on a human scalp	100,000	
Width of a human hair (cm)	0.00108	
Average number of times a human heart beats in its lifetime	3,000 million	

2. The table shows the speed of two mediums in the air.

Medium	Speed (m/s) in Standard Notation	Speed in Scientific Notation (m/s)
Sound	330	
Light		3.0×10^8

- a) Complete the table by writing the speed of each medium in scientific notation or in standard notation.
- b) Which is most likely to occur first, a person seeing a flash of lightning or a person hearing the sound of thunder? Justify your reasoning based on the speed in scientific notation.

Math 8 – Unit: Scientific Notation – Lesson 3

Lesson Topic: Adding/Subtracting Numbers in Scientific Notation

Grade Level: 8

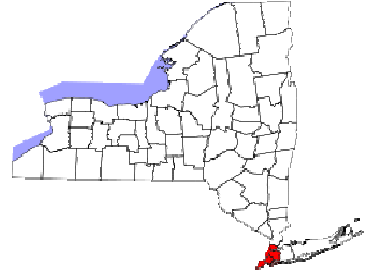
Duration: 80 minutes

Teacher Name: _____

Stage 1 – Desired Results		
External Standard(s): CCSS/NYSCCLSM 8.EE.3 – Use numbers expressed in the form of a single digit times a whole-number power of 10 to estimate very large or very small quantities, 8.EE.4 – Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used.	Essential Question: How do we add and subtract numbers in scientific notation?	
	Understanding Goal: <i>Students will understand that:</i> <ul style="list-style-type: none"> • to add and subtract numbers in scientific notation we write the numbers with the same magnitude (exponent, n), meaning we may need to change some of the numbers. 	
	Skills: <i>students will be able to...</i> <ul style="list-style-type: none"> - add and subtract numbers written in scientific notation 	Content: <i>(facts, vocabulary, knowledge)</i> <ul style="list-style-type: none"> - scientific notation - standard notation - magnitude - coefficient - base - exponent - powers of 10 - integer - < and > - difference - sum
Stage 2 – Assessment Evidence		
Performance Task(s): - Notes p. 9 - 12	Other Evidence (TOTD's, quizzes): <ul style="list-style-type: none"> - Individual Practice - Partner Practice - TOTD #3 - Homework #3 	
Stage 3 – Learning Plan: Learning Activities: TMA		
Acquisition Activities: How many people, in scientific notation, live in New York State? Are there more people in NYS than California?	Meaning- Making Activities: Adding and subtracting populations, measurements of objects, distances between planets.	Transfer Activities: Writing numbers in standard/scientific notation and adding/subtracting them in scientific notation to find sum or difference; Partner work, individual practice, group discussions

Day 3 –Adding and Subtracting Numbers in Scientific Notation**Example 1 - Subtracting**

The population of New York State is approximately 1.96×10^7 . The population of New York City alone is 8,245,000. How many people do not live in New York City?



To find the number of people that live in New York State but not in New York City, we must _____ the population of _____ from the population of _____

First, we need to change the population of New York City to scientific notation.

To find the difference, we subtract:

To find the difference (or sum) of numbers in scientific notation, it is best to make the order of magnitude (n) the same in all numbers.

So, each number must have the same base (10) and same order of magnitude (n). We can rewrite the population of New York State as an integer multiplied by 10^6 and then subtract.

Example 2 - Subtracting

The approximate thickness of an iPhone 4s is 9.398×10^{-1} centimeters. The approximate thickness of a standard deck of 52 cards is 1.515×10^0 . Which is thicker? Justify your answer.



What is the difference between the thickness of an iPhone 4s and a standard deck of 52 cards?

Practice 1

- a) According to scientists, the Earth's mass is 5.98×10^{24} kilograms. The mass of the Sun is 1.989×10^{30} . How much greater is the mass of the Sun than the mass of the Earth?
- b) A quarter is approximately 0.07 inches thick. A dollar bill is approximately 4.3×10^{-3} inches thick. Using scientific notation, determine which piece of money is thicker and by how much.

Partner Practice

a) $(1.2 \times 10^5) + (5.35 \times 10^6)$

e) $(8.41 \times 10^{-5}) - (7.9 \times 10^{-6})$

b) $(6.91 \times 10^{-2}) + (2.4 \times 10^{-3})$

f) $(1.33 \times 10^5) - (4.9 \times 10^4)$

c) $(9.70 \times 10^6) + (8.3 \times 10^7)$

g) $(1.5 \times 10^7) - (8.9 \times 10^5)$

d) $(3.67 \times 10^2) - (1.6 \times 10^1)$

h) $(2.45 \times 10^3) + (1.23 \times 10^1)$

Name _____

TOTD #3

Class _____

In 1900 there were approximately 76,100,000 people in the United States. In 1999 there were approximately 272,700,000 people in the United States.

(<http://www.demographia.com/db-uspop1900.htm>)

a) Using scientific notation, how much larger is the population in 1999 than in 1990?

b) The population in Canada in 1999 was 3.04×10^7 . What is the total population of the United States and Canada in 1999? (http://en.wikipedia.org/wiki/Population_of_Canada_by_year)

Name _____

TOTD #3

Class _____

In 1900 there were approximately 76,100,000 people in the United States. In 1999 there were approximately 272,700,000 people in the United States.

(<http://www.demographia.com/db-uspop1900.htm>)

1. Using scientific notation, how much larger is the population in 1999 than in 1990?

2. The population in Canada in 1999 was 3.04×10^7 . What is the total population of the United States and Canada in 1999? (http://en.wikipedia.org/wiki/Population_of_Canada_by_year)

Name _____

Homework #3

Class _____

1. The approximate thickness of a standard CD is 1.2×10^{-3} meter. A slim jewel case is about 5.3×10^{-3} meter thick.

- a. The CD is placed on top of the jewel case. What is the total thickness of the CD and the jewel case?



- b. How much thicker is the jewel case than the CD?

2. Rochester, NY has an average of 28.2 inches of snow fall in January, while Atlanta, GA has an average of 1.3 inches of snow fall in January.

<http://www.currentresults.com/Weather/US/average-snowfall-by-city-in-january.php>

- a. Rewrite the snowfall averages in scientific notation.

- b. How much more snow does Rochester, NY receive in January than Atlanta, GA, on average? Calculate this using scientific notation.

- c. Buffalo, NY has an average of 25.3 inches of snow fall in January. What is the total average snow fall of Buffalo and Rochester, NY in the month of January? Calculate this using scientific notation.

Math 8 – Unit: Scientific Notation – Lesson 4

Lesson Topic: Multiplying/Dividing Numbers in Scientific Notation

Grade Level: 8

Duration: 80 minutes

Teacher Name: _____

Stage 1 – Desired Results		
External Standard(s): CCSS/NYSCCLSM 8.EE.3 – Use numbers expressed in the form of a single digit times a whole-number power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. 8.EE.4 – Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used.	Essential Question: How do we multiply and divide numbers in scientific notation?	
	Understanding Goal: <i>Students will understand that:</i> <ul style="list-style-type: none"> • to multiply or divide numbers in scientific notation we can have different magnitudes (n) and use the rules for exponents: <ul style="list-style-type: none"> - multiplying numbers with powers: add exponents - dividing numbers with powers: subtract exponents 	
	Skills: <i>students will be able to...</i> <ul style="list-style-type: none"> - multiply and divide numbers written in scientific notation 	Content: <i>(facts, vocabulary, knowledge)</i> <ul style="list-style-type: none"> - scientific notation - standard notation - magnitude - coefficient - base - exponent - powers of 10 - integer - product - quotient
Stage 2 – Assessment Evidence		
Performance Task(s): - Notes p. 13 - 16	Other Evidence (TOTD's, quizzes): <ul style="list-style-type: none"> - Individual Practice - Partner Practice - TOTD #4 - Homework #4 	
Stage 3 – Learning Plan: Learning Activities: TMA		
Acquisition Activities: What is the formula for area of a rectangle? What is the area of a football field?	Meaning- Making Activities: Multiplying and dividing numbers to find area, how far light travels, how fast light travels, how many “likes” users on social network are responsible for, and NASA problems.	Transfer Activities: Writing numbers in standard/scientific notation and multiplying/dividing them in scientific notation to find product or quotient; Partner work, individual practice, group discussions

Day 4 –Multiplying and Dividing Numbers in Scientific Notation

Recall – Multiplying/Dividing with Exponents

When **multiplying** numbers with powers, we _____ the exponents.

When **dividing** numbers with powers, we _____ the exponents.

Compute the following:

a. $5^3 \cdot 5^6 =$ _____

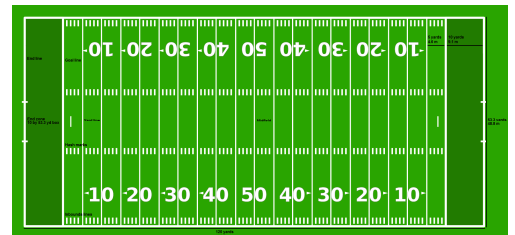
c. $5^6 \div 5^2 =$ _____

b. $10^{10} \cdot 10^5 =$ _____

d. $10^{10} \div 10^5 =$ _____

Example 1 – Multiplying

A football field is approximately 1.20×10^2 yards by 5.33×10^1 yards. What is the approximate area of the football field? Justify your answer.



Practice 1

Light travels at approximately 3.0×10^8 m/sec. How far does light travel in one week?

Example 2

The Earth is approximately 93,000,000 miles from the sun. How long does it take light from the sun to reach the earth? Use the speed of light to be 1.86×10^5 miles per second. Calculate the answer using scientific notation. Write your final answer in standard notation.

Practice 2

A company on Facepplace, a social network, receives approximately 839 million “likes” per year on posts, pictures, etc. If the company has approximately 7,560,000 fans, about how many “likes” is each user responsible for each year?



Partner Practice

1. The table shows some models of LCD televisions and their native pixel resolution

Model	Native Pixel Resolution
A	1,280 · 720
B	1,024 · 768
C	1,366 · 768
D	1,920 · 1,080



- a) Express the given resolution of each model in scientific notation to the nearest tenth. Use the most appropriate unit.

- b) All flat screen LCD televisions must have a resolution of at least one megapixel. Determine which models are not flat screen LCD televisions.

Problems from NASA!

http://www.nasa.gov/pdf/371727main_SMI_Problem9.pdf

1. The sun produces 3.9×10^{33} ergs per second of radiant energy. How much energy does it produce in one year (3.1×10^7 seconds)?
2. One gram of matter converted into energy yields 3.0×10^{20} ergs of energy. How many tons of matter in the sun is annihilated every second to produce its luminosity of 3.9×10^{33} ergs per second? (One metric ton = 10^6 grams)
3. The approximate volume of the visible universe (a sphere with a radius of about 14 billion light years) is 1.1×10^{31} cubic light-years. If a light-year equals 9.2×10^{17} centimeters, how many cubic centimeters does the visible universe occupy?
4. The NASA data archive at the Goddard Space Flight Center contains 25 terabytes of data from over 1000 science missions and investigations. (1 terabyte = 10^{15} bytes). How many CD-roms does this equal if the capacity of a CD-rom is about 6×10^8 bytes?

Name _____
Class _____

Homework #4

1. Light travels at a speed of 1.86×10^5 miles per second. If a light year is the distance that light travels in one year, how many miles are in a light year?

2. Assume that there are 20,000 runners in the New York City Marathon. Each runner runs a distance of 36 miles. If you add together the total number of miles for all runners, how many times around the globe would the marathon runners have gone? Let the circumference of the Earth be 2.5×10^4 miles. Calculate your answer using scientific notation.



3. Perform the following operations and express your answer in scientific notation.

a. $(4.3 \times 10^8) \times (2.0 \times 10^6)$

b. $\frac{(7.8 \times 10^3)}{(1.2 \times 10^4)}$

c. $\frac{(6.48 \times 10^5)}{(2.4 \times 10^4)(1.8 \times 10^{-2})}$

Math 8 – Unit: Scientific Notation – Lesson 5 – Review for Unit Test

Lesson Topic: Review for Unit Test on Scientific Notation

Grade Level: 8

Duration: 80 minutes

Teacher Name: _____

Stage 1 – Desired Results		
<p>External Standard(s):</p> <p>CCSS/NYSCCLSM 8.EE.3 – Use numbers expressed in the form of a single digit times a whole-number power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. 8.EE.4 – Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used.</p>	<p>Essential Question: How do we write, add, subtract, multiply, divide, and compare numbers in scientific notation?</p>	
	<p>Understanding Goal: <i>Students will understand that:</i></p> <ul style="list-style-type: none"> • Scientific Notation is written as $d \times 10^n$ (where $1 \leq d < 10$ and n is an integer) • can be compared to one another to determine which is greater by looking at the exponents first. If the exponents are the same, we can compare the coefficients. • to add and subtract numbers in scientific notation we write the numbers with the same magnitude (exponent, n), meaning we may need to change some of the numbers. • to multiply or divide numbers in scientific notation we can have different magnitudes (n) and use the rules for exponents: <ul style="list-style-type: none"> - multiplying numbers with powers: add exponents - dividing numbers with powers: subtract exponents 	
	<p>Skills: <i>students will be able to...</i></p> <ul style="list-style-type: none"> - write numbers, compare numbers, add/subtract, and multiply/divide numbers in scientific notation 	<p>Content: <i>(facts, vocabulary, knowledge)</i></p> <ul style="list-style-type: none"> - scientific notation ($d \times 10^n$) - sum, difference, product, quotient - $<$ and $>$
Stage 2 – Assessment Evidence		
<p>Performance Task(s):</p> <ul style="list-style-type: none"> - Unit Test Review Packet 	<p>Other Evidence (TOTD's, quizzes):</p> <ul style="list-style-type: none"> - Individual / Partner Practice 	
Stage 3 – Learning Plan: Learning Activities: TMA		
<p>Acquisition Activities:</p> <ul style="list-style-type: none"> - Begin unit review packet with real-life examples 	<p>Meaning- Making Activities:</p> <p>Review packet with real-life examples for the skills above.</p>	<p>Transfer Activities:</p> <p>Writing numbers in standard/scientific notation and adding/subtracting/multiplying/dividing them in scientific notation. Partner work, individual work, group discussions</p>

Name _____

Scientific Notation Review

Class _____

1. Use the table to answer questions a – c

The table shows the amounts of energy, in Calories, contained in various foods. Write each food's energy in either Standard Notation or Scientific Notation.

Food (per 100 g)	Energy (Cal) in Standard Notation	Energy (Cal) in Scientific Notation
Chicken Breast		1.71×10^5
Raw Potato		7.7×10^1
Cabbage	25,000	
Salmon	167,000	

a. Find the total energy in each food combination. Complete *all* calculations in Scientific Notation.

i. Chicken breast and cabbage. Write your answer in scientific notation.

ii. Cabbage and raw potato. Write your answer in standard notation.

iii. Chicken breast, raw potato, and cabbage. Write your answer in standard notation.

Food (per 100 g)	Energy (Cal) in Standard Notation	Energy (Cal) in Scientific Notation
Chicken Breast		1.71×10^5
Raw Potato		7.7×10^1
Cabbage	25,000	
Salmon	167,000	

b. How many more energy calories are in chicken breast than in salmon? Write your answer in standard notation.

c. How many more energy calories are in salmon than in cabbage? Write your answer in standard notation.

2. A flight from New York to Singapore includes a stopover at Hawaii. The distance between New York and Singapore is about 1.16×10^4 . The distance between New York and Hawaii is about 4.9×10^3 miles. How many miles are between Hawaii and Singapore? Write your answer in scientific notation.

3. Angora wool, obtained from rabbits, has fibers with a diameter of about 1×10^{-6} meter. Cashmere, obtained from goats, has fibers with a diameter of about 1.45×10^{-5} meter. Write your answer in the appropriate units, using scientific notation.

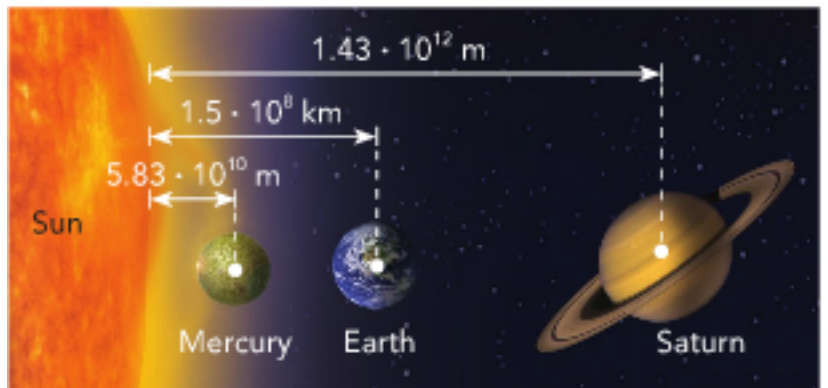
a. Find the sum of the diameters of the two types of fiber.

b. How much wider is the cashmere fiber than the angora fiber?

c. What is the radius of the angora fiber? What is the radius of the cashmere fiber?

4. The average distances of three planets from the Sun are shown in the diagram. Use this information for questions a – d. Express your answer in kilometers.

Note: $1 \times 10^1 \text{ m} = 1 \times 10^{-3} \text{ km}$



- a. What is the closest Mercury comes to the Earth when both are at an average distance from the Sun?
- b. What is the closest Saturn comes to Mercury when both are at an average distance from the Sun?
- c. What is the closest Saturn comes to Earth when both are at an average distance from the Sun?
- d. Is the distance you found in (c) greater or less than the average distance from Earth to the Sun? Explain.

5. There are approximately 0.05 liters of acetic acid in 1 liter of vinegar. How many liters of acetic acid are there in 2 gallons of vinegar? (Note: 1 gal \approx 3.8 liters)
6. The size of the Indian Ocean is 2.7×10^7 square miles. The Arctic Ocean is $\frac{1}{5}$ the size of the Indian Ocean. How big is the Arctic Ocean?
7. The Georgia Aquarium in Atlanta is about (2.63×10^3) feet long, (1.26×10^2) feet wide, and (3.0×10^1) feet deep at its largest point. Find its approximate volume.
8. A spherical particle was found to have a radius of 3.5×10^{-10} meters.
- Express the diameter in scientific notation using picometers.
Note: 1 meter = 10^{12} picometers
 - Use your answer from (a) to express the circumference in scientific notation using nanometers. Use 3.14 as an approximation for π . Note: 1 picometer = 0.001 nanometers.

Math 8 – Unit: Scientific Notation – Lesson 6 –Unit Test

Lesson Topic: Unit Test on Scientific Notation

Grade Level: 8

Duration: 90 minutes

Teacher Name: _____

Stage 1 – Desired Results

External Standard(s): CCSS/NYSCCLSM 8.EE.3 – Use numbers expressed in the form of a single digit times a whole-number power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. 8.EE.4 – Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used.	Essential Question: How do we write, add, subtract, multiply, divide, and compare numbers in scientific notation?	
	Understanding Goal: <i>Students will understand that:</i> <ul style="list-style-type: none"> • Scientific Notation is written as $d \times 10^n$ (where $1 \leq d < 10$ and n is an integer) • can be compared to one another to determine which is greater by looking at the exponents first. If the exponents are the same, we can compare the coefficients. • to add and subtract numbers in scientific notation we write the numbers with the same magnitude (exponent, n), meaning we may need to change some of the numbers. • to multiply or divide numbers in scientific notation we can have different magnitudes (n) and use the rules for exponents: <ul style="list-style-type: none"> - multiplying numbers with powers: add exponents - dividing numbers with powers: subtract exponents 	
	Skills: <i>students will be able to...</i> <ul style="list-style-type: none"> - write numbers, compare numbers, add/subtract, and multiply/divide numbers in scientific notation 	Content: <i>(facts, vocabulary, knowledge)</i> <ul style="list-style-type: none"> - scientific notation ($d \times 10^n$) - sum, difference, product, quotient - $<$ and $>$

Stage 2 – Assessment Evidence

Performance Task(s): - Unit Test	Other Evidence (TOTD's, quizzes): - Unit Test
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Stage 3 – Learning Plan: Learning Activities: TMA

Acquisition Activities: - Last minute questions for test	Meaning- Making Activities: Unit test	Transfer Activities: Writing numbers in standard/scientific notation and adding/subtracting/multiplying/dividing them in scientific notation. Individual work.
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Name _____
Class _____

Unit 2 Test
Scientific Notation

1. The approximate populations of the following countries in North America in 2011 are shown in the table.
- a. Write each population in scientific notation.

Country	Population in standard notation	Population in scientific notation
Mexico	110,000,000	
Haiti	9,700,000	
Costa Rica	4,600,000	
USA	310,000,000	

- b. Explain how to use scientific notation to find the total population of the countries.
- c. Find the total population of the countries, using scientific notation.

2. The body of a 150 lb. person contains 2.3×10^{-4} lb. of copper. How much copper is contained in the bodies of 1200 such people?
3. Potato Chippers and Chips Plus produce potato chips. They use the same basic ingredients: potatoes, oil, and salt. Last year, each factory used different amounts of these ingredients, as shown in the table. Write each answer in scientific notation.

Ingredients	Potato Chippers Amount Used (lb.)	Chips Plus Amount Used (lb.)
Potato	4.87×10^6	3,309,000
Oil	356,000	5.61×10^5
Salt	2.87×10^5	193,500

- a. Which factory used more potatoes last year? How many more potatoes did it use?
- b. Which factory used more oil last year? How much more oil did it use than the other factory?

4. The volume of the Venus is approximately 9.4×10^{11} km³. The volume of Mars is approximately 1.6×10^{11} .
- About how many times as great as the volume of Mars is the volume of Venus? Round to the nearest tenth.
 - The volume of Earth is approximately 0.69×10^{-1} times larger than the volume of Mars. What is the approximate volume of Earth?
 - What is the difference in volume, in cubic kilometers, between the volume of the Earth and the volume of Venus?

Chapter Four: Validity

The Cycle: Intended, Implemented, and Attained Curriculum

In education, one may consider three phases to the curriculum and learning cycle: intended, implemented, and attained. The *intended curriculum* is the content and materials aligned to the Common Core State Standards for Mathematics (CCSSM). Prior to the CCSSM, the intended curriculum was the material aligned to the National Council of Teachers of Mathematics (NCTM) standards. The CCSSM aligned curriculum is placed in the hands of teachers, as is all curriculum. At this point, teachers will teach the students the curriculum, referred to as the *implemented curriculum*. “Implementation focuses on what happens in practice. It is concerned with the nature and extent of actual change, as well as the factors and processes that influence how and what changes are achieved” (Fullan, 1992, p. 21). Following the implementation is the *attained curriculum*, what the students have learned. This helps us to determine whether any change has actually occurred in practice (Fullan, 1992). These phrases – intended curriculum, implemented curriculum, and attained curriculum – will be simply referred to as intended, implemented, and attained. By means of the cycle, there has often been a perceived gap between the intended and the attained, because of the educator stepping in to teach the material. In a perfect world, the intended and attained may be one in the same. Unfortunately, the degree to which educators implement the curriculum with fidelity may be unknown. Thus, educational entities may look back at the intended curriculum to see if the intended and attained are the same. The cycle then repeats itself. It is up to the teacher to buy-in to the curriculum in order for the attained and intended to be one in the same, providing validity to the curriculum (Singer, 2005).

In the previous chapter, a unit plan for eighth grade mathematics was provided. This curriculum has been aligned to the New York State Common Core and Learning Standards for Mathematics (NYSCCLSM). Although the curriculum was aligned to NYSCCLSM, one does not have to use this curriculum solely in New York State: The curriculum may be used across the nation, as the NYSCCLSM are identical to the CCSSM, with an additional fifteen percent more standards to add to the rigor (NYSED, 2010, 2013b). Forty-five states have adopted the CCSSM. Therefore, the curriculum proposed above may be used in any of the forty-five states that have adopted. The curriculum provided may be considered the intended curriculum, as the above materials are aligned to the NYSCCLSM and CCSSM. Teachers now have the opportunity to use this curriculum. Depending on whether or not an educator uses the above curriculum will determine if a student attains the intended information, as a result of the middle step in the cycle, the implementation.

Numerous sources have mentioned the need for teacher buy-in as a necessity in order to achieve various goals in educational settings (Singer, 2005; O'Hanlon, 2009; Steans, 2012; Turnbull, 2001; Fullan, 1992). Although teacher buy-in may have different meanings in different contexts, it is important for teachers to believe in what they are being asked to do. Whether teachers are asked to implement a new program (Turnbull, Singer), implement technology in the classroom (O'Hanlon), or implement new curriculum, teacher buy-in is required for a successful curriculum. Turnbull (2001) defined teacher buy-in for a study she conducted as the "teachers' perception of five related issues: (1) whether teachers believed they had a good model for their school; (2) whether the model helped them to become better teachers; (3) whether they were personally motivated to make the model work; (4) if they believed that they were able to make the model work in their

classroom; and (5) if they understood how the model was supposed to improve student learning” (p. 243). These five questions regarding the teachers’ perception may be applied to the intended, implemented, and attained curriculum. In this case, the “model” that Turnbull (2001) refers to is the intended curriculum. Fullan (1992, p. viii) states, “Educational change fails many more times than it succeeds. One of the main reasons is that implementation – or the process of achieving something new into practice – has been neglected.” Teacher “buy-in can make or break reform implementation,” says Steans (2012, p. 1). This is because when “teachers confront the hard realities of serious change, many want to back-out” (Singer, 2005, p.1). Therefore, it may be crucial for educators to have positive perceptions of the five characteristics that Turnbull defines as teacher buy-in.

To achieve teacher buy in, Turnbull (2001) discovered through research that “teachers were most likely to ‘buy-in’ to their school reform program when they had adequate training, adequate resources, helpful support from the model developers, school-level support, administrator buy-in, and control over the reform implementation in their classrooms” (p. 248). Additionally, teacher participation may be a predictor of teacher buy-in. Although Turnbull (2001) did not find teacher participation in selection of a model to be a significant indicator of teacher buy-in, others (Eckert and Kohl, Singer, O’Hanlon) find that teacher participation is helpful in improving teacher buy in. Eckert and Kohl (2013, p.1) make a statement regarding the perfect world alluded to previously: “Imagine what could happen if practicing experts were involved in every step of reform – from initial design to planning to implementation to evaluation of results. [Teacher buy-in] most certainly would happen if we are smart about implementing the Common Core State Standards.” Additionally, it is important to have an “80% vote” before moving forward with

any new education reform to increase teacher buy-in (Singer, 2005, p.1). O’Hanlon states, “If teachers are being forced into using it, they will resist, especially if you don’t show them what value it will bring to their classroom” (2009, p. 34). O’Hanlon (2009) made this statement regarding implementing technology in the classroom and the importance of delivery. However, this may be true for any educational reform, including new curriculum and standards.

With that being said, the curriculum provided above may be used as a resource in implementing the CCSSM, as it is fully aligned to the intended standards. However, this curriculum provided may not be valid if teachers do not implement the curriculum with fidelity. However, should teachers use the curriculum provided as intended, the attained would be just as was intended: for students to be able to use and work with scientific notation. Students may be able to add, subtract, multiply, divide in scientific notation, as well as translate between scientific notation and standard notation. Students may also reach two of the Standards of Mathematical Practice, part of the CCSSM: Students under the instruction of the intended curriculum will be able to justify their reasoning and use mathematical modeling, through multiple examples and practice problems that model real world mathematical problems involving scientific notation. Each of these objectives may happen if teachers implement the intended curriculum as provided, with full fidelity.

Chapter Five: Conclusion

This unit plan has been created with teachers in mind, as they begin recreating, reworking, and readjusting curriculum in order to be aligned with the Common Core State Standards (CCSS). The unit plan may be used as a resource in the classroom to teach students to use scientific notation in order to compare numbers, add, subtract, multiply, and divide numbers. The unit plan is fully aligned with the New York State Common Core and Learning Standards for Mathematics (NYSCCLSM) but may be generalized to align with the Common Core State Standards of Mathematics (CCSSM), as the standards are identical, with a few additional standards in the NYSCCLSM (NYSED, 2011).

The CCSS were created in an effort to close the gap in the performance and assessment of students in the United States in comparison with other nations, while standardizing a set of standards across the United States of America (Schmidt & Houang, 2012). Forty-five states, four territories and the District of Columbia have adopted the CCSS (CCSSI, 2012). As a result, teachers may be experiencing a paradigm shift as the CCSSM and English Language Arts & Literacy are being implemented: The previous state standards were built on the foundation of the National Council of Teachers of Mathematics (NCTM) standards. Therefore, as previously mentioned, the unit plan provided in this document aligns to the NYSCCLSM and CCSS to provide teachers with a resource. In doing so, the curriculum provided touches upon the two documents included in the CCSSM: the Standards for Mathematical Practice and the Standards for Mathematical Content. The Standards for Mathematical Practice are the same for all grade levels of mathematics, providing consistency and coherence among the grade levels. The unit plan addresses two of the eight Standards for Mathematical Practices: (3) Construct viable arguments and

critique the reasoning of others and (4) Model with mathematics (CCSSI, 2010). The Standards for Mathematical Content detail what students “should understand and be able to do” (Burns, 2013, p.2). Thus, in contrast to the Standards for Mathematical Practice, the Standards for Mathematical Content are grade specific, organized through domains, clusters, and standards (NYSED, 2011). The CCSSI (2010) claims that the CCSSM work to provide coherence, focus, and rigor. The curriculum above addresses two distinct content standards related to scientific notation. Students will be able to:

8.EE.3 – Use numbers expressed in the form of a single digit times a whole-number power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other.

8.EE.4 – Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used.

(NYSED, 2011, p. 48).

Although the author of this curriculum plan claims that students will be able to achieve the standards mentioned above through the use of the unit plan, it depends on the teacher implementing the unit plan. If teachers do not implement the unit plan with fidelity, students may not succeed in reaching the standards mentioned. Thus, the cycle of intended, implemented, and attained curriculum is brought to the forefront of one’s mind. This is especially relevant with the intended curriculum being aligned to the new nationwide standards, the Common Core State Standards.

CCSSI claims that the CCSS will prepare all students for college and career success (CCSSI, 2010). In order to better meet this claim, the unit could be reworked for future use to include differentiated instruction. The term differentiation in education dates back to

Confucius. “He reflected its core meaning when he advised that people differ in their abilities. To teach them, he counseled, you have to start where they are” (Tomlinson, 2005, p. 8). Essentially, teachers may differentiate instruction to accommodate all students in a variety of ways to ensure all students reach their potential in the math classroom. This is a requirement of educators as a result of the No Child Left Behind Act (NCLB), which says teachers are mandated to provide students with effective teaching, powerful curriculum, and time and support to accomplish deep understanding of the material (Murray & Jorgensen, 2007). The NYSCCLSM indicates a shift in mathematics, requiring that students “deeply understand and can operate within a math concept before moving on” (EngageNY, 2012b). It is important that teachers know and understand the new changes to the NYSCCLSM in order to help all students succeed. The objective for educators in regards to differentiation is to “teach the same concept... to students at different developmental levels” (Small, 2009, p. viii).

In order to differentiate the unit plan provided, educators may consider the students’ learning profile, readiness and developmental levels, and student interests prior to differentiating instruction. Additionally, teachers should be flexible in their teaching style in order to meet the needs of the students, as a group and as individuals, in an ever-changing environment (D’Amico & Gallaway, 2008). Although differentiating every portion of the unit provide may be ideal, it may not be feasible or comfortable for a teacher to do so during the main portion of the lesson. However, it is absolutely adequate to differentiate follow-up activities, such as the ticket-out-the-door or homework assignments provided, for students to complete in order to practice the skills taught (Small & Lin, 2010).

Differentiated instruction is simply one approach to meeting the needs of all students, as educators are required by law to do so. Although differentiated instruction is one approach suggested, it is an important and valuable approach to consider to work towards improving the unit plan provided. Tomlinson (2001, p. vii- viii) sums this up wonderfully:

In life, kids choose from a variety of clothing to fit their differing sizes, styles, and preferences. We understand, without explanation, that this makes them more comfortable and gives expression to their developing personalities. In school, modifying or differentiating instruction for students of differing readiness and interests is also more comfortable, engaging, and inviting. One size fits all instruction will inevitably sag or pinch—exactly as single-size clothing would—students who differ in need, even if they are chronologically the same age.

Differentiated instruction works to encompass each and every student in the classroom by addressing their readiness, interests, and learning profile. Although it would be a lengthy task to differentiate the material above, it may provide increased understanding of the content for all students.

As a result of the new standards for mathematics, educators across the United States must find ways to educate all learners and prepare them for life after high school. The lessons provided may help teachers succeed in doing this. Additionally, teachers may differentiate the lessons as a way to possibly reach more students through the instruction of the unit provided. Regardless, the unit plan may help teachers in the transition to the new standards.

References

- Achieve, Inc. (2010a). Achieving the common core: Comparing the common core state standards in mathematics and NCTM's curriculum focal points [Webpage]. Retrieved from <http://www.achieve.org/files/CCSSandFocalPoints.pdf>
- Bromley, Jovell, Sobolewski (August 2011a). Grade 7 – NYS to common core re-alignment. [Webpage] Retrieved from <http://www.nyscirs.org/CCSS%20Toolkit/Math%20Toolkit/Crosswalks/Grade-7-Crosswalk%20Mrs.%20Fuller.pdf>
- Bromley, Jovell, Sobolewski (August 2011b). Grade 8 core vs. NYS standards. [Webpage] Retrieved from <http://teacherweb.com/NY/ChathamMiddleSchool/MrsFuller/Core--vs--NYS-Standards-Gd-8-Aug-2011.pdf>
- Burns, M. (2013). Go figure: Math and the common core. *Educational Leadership*. Alexandria, VA: ASCD.
- Burris, A. C. (2010). A brief history of mathematics education and the NCTM standards. [Webpage] Retrieved from <http://www.education.com/reference/article/history-mathematics-education-NCTM/?page=5>
- Cavendish, M. (2013). *Math in focus: Course 3 student book A*. Boston, MA: Houghton Mifflin Harcourt.
- CCSSI (2010). The standards. Common Core State Standards Initiative. Retrieved from <http://www.corestandards.org/the-standards>
- CCSSI (2012). In the states. Common Core State Standards Initiative. Retrieved from <http://www.corestandards.org/in-the-states>

CCSSI (2013). K – 8 publisher’s criteria for the common core state standards for mathematics. [Webpage]. Retrieved from

http://www.corestandards.org/assets/Math_Publishers_Criteria_K-8_Spring%202013_FINAL.pdf

Common Core (2013). New York State common core mathematics curriculum grade 8: Module 1. [Webpage] Retrieved from

<http://www.engageny.org/sites/default/files/resource/attachments/g8-m1-teacher-materials.pdf>

Dick, J. (2012). A guide to the shifts in the common core state standards in mathematics. Retrieved from

http://www.doe.k12.de.us/commoncore/math/admintoolkit/Math_Instructional_Shifts_Final.pdf

Eckert, J., & Kohl, K. (2013). Beyond buy-in. *Phi Delta Kappan*, 94(10), 80.

EngageNY (n.d.). Changes to New York state assessments. [Webpage]. Retrieved from <http://www.engageny.org/common-core-assessments>

EngageNY. (2012a). Parent’s backpack guide to common core state standards. [Webpage]. Retrieved from

http://www.engageny.org/sites/default/files/resource/attachments/parent_workshop_backpack_guide.pdf

EngageNY. (2012b). Pedagogical shifts demanded by the common core state standards. [Webpage]. Retrieved from

<http://www.engageny.org/sites/default/files/resource/attachments/common-core-shifts.pdf>

Kendall, J. (2011). *Understanding the common core*. Alexandria, VA: ASCD; Denver, CO: McREL.

Lemov, D. (2010). *Teach Like a Champion: 49 Techniques that Put Students on the Path to College (K-12)*. Wiley. com.

McGraw-Hill. (2011). Education brief: The common core state standards initiative. [Webpage]. Retrieved from

http://www.commoncoresolutions.com/PDF/education_brief.pdf

McGraw-Hill (n.d.). Math handbook transparency worksheets. [Webpage] Retrieved from <http://www1.nsd131.org/classpages/awilkens/Shared%20Documents/Scientific%20Notation%20Worksheets.pdf>

McLeod, D. B. (2003). From consensus to controversy: The story of the NCTM *standards*. In Stanic, G. M. & Kilpatrick, J. (Eds.), *A history of school mathematics* (pp. 753 – 818). Reston, VA: National Council of Teachers of Mathematics.

Murray, M., & Jorgensen, J. (2007). *The differentiated math classroom: A guide for teachers, K – 8*. Portsmouth, NH: Heinemann.

National Center for Education Statistics (n.d.). Trends in international mathematics and science study. [Webpage]. Retrieved from <https://nces.ed.gov/timss/>

National Council of Teachers of Mathematics (2000). Principles and standards for school mathematics. [Webpage]. Retrieved from <http://www.nctm.org/standards/content.aspx?id=26830>

National Governors Association Center for Best Practices; Council of Chief State School Officers. (2010). Common Core State Standards for Mathematics. [Webpage].

Retrieved from

http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf

New York State Education Department. (2013a). Emphases in common core standards for mathematical content kindergarten – high school: July 15, 2013. [Webpage].

Retrieved from <http://www.engageny.org/resource/math-content-emphases>

New York State Education Department (2005a). Grade 7 [standards]. [Webpage]. Retrieved from <http://www.p12.nysed.gov/ciai/mst/math/standards/revisedg7.html>

New York State Education Department (2005b). Grade 8 [standards]. [Webpage]. Retrieved from <http://www.p12.nysed.gov/ciai/mst/math/standards/revisedg8.htm>

New York State Education Department. (2010). History of New York State learning standards and core curriculum. [Webpage]. Retrieved from

<http://www.p12.nysed.gov/ciai/lscorehistory.html>

New York State Education Department. (2011). New York State P-12 common core learning standards for mathematics. [Webpage]. Retrieved from

http://www.p12.nysed.gov/ciai/common_core_standards/pdfdocs/nysp12cclsmat_h.pdf

New York State Education Department. (2013b). New York State learning standards and core curriculum. [Webpage]. Retrieved from

<http://www.p12.nysed.gov/ciai/cores.html>

O'Hanlon, C. (2009). Resistance is futile. *T H E Journal*, 36(3), 32 – 36.

Partnership for Assessment of Readiness for College and Careers (PARCC) (2013). PARCC model content frameworks. [Webpage]. Retrieved from

<http://www.parcconline.org/parcc-model-content-frameworks>

Schmidt, W. H. & Houang, R. T. (2012). Curricular coherence and the common core state standards for mathematics. *Educational Researcher*, 41(8), p. 294 – 308.

Singer, C. (2005). Getting buy-in. [Webpage]. Retrieved from

www.pbs.org/makingschoolswork/sbs/csp/buyin.html

Small, M. (2009). *Good questions: Great ways to differentiate mathematics instruction*. New York, NY: Teachers College Press

Small, M., & Lin, A. (2010). *More good questions: Great ways to differentiate secondary mathematics instruction*. New York, NY: Teachers College Press.

Steans, R., & Policy Innovators in Education, N. (2012). Engaging teachers in ed reform.

Policy Innovators in Education Network. Retrieved from

<http://files.eric.ed.gov/fulltext/ED540354.pdf>

Tomlinson, C. A. (2005b). Traveling the road to differentiation in staff development.

National Staff Development Council, 26 (4), 8 – 12.

Tomlinson, C.A. (2001) *How to differentiate instruction in mixed-ability classrooms*.

Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Turnbull, B. (2002). Teacher participation and buy-in: Implications for school reform initiatives. *Learning Environments Research* 5(3), 235 – 252.

United States Department of Education (2010). *Race to the top program guidance and frequently asked questions*. [Webpage] Retrieved from

<http://www2.ed.gov/programs/racetothetop/faq.pdf>

United States Department of Education (2013). *Race to the top fund: Purpose*. [Webpage]

Retrieved from <http://www2.ed.gov/programs/racetothetop/index.html>

Wiggins, G. P., & McTighe, J. A. (2005). *Understanding by design*. ASCD.

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Name _____

Class _____

KEY

Unit: Scientific Notation

Day 1 – Writing Very Large and Small Numbers in Scientific Notation

How many stars are there in the universe?

Scientists estimate there to be 60,000,000,000,000,000,000,000 stars in the universe! (22 zeros!)

Numbers like this are so large that scientists have invented a method called Scientific Notation to write these very, very large numbers (and very, very small numbers).



Recall

Powers of 10

$$10^1 = \underline{10}$$

$$10^2 = \underline{100}$$

$$10^3 = \underline{1000}$$

$$10^{-1} = \underline{\frac{1}{10}}$$

$$10^{-2} = \underline{\frac{1}{100}}$$

$$10^{-3} = \underline{\frac{1}{1000}}$$

When we multiply a decimal by a positive power of ten, we move the decimal to the right.

Examples:

$$1.58 \cdot 10^1 = 1.58 \cdot \underline{10} = \underline{15.8}$$

$$1.58 \cdot 10^2 = 1.58 \cdot \underline{100} = \underline{158.0}$$

$$1.58 \cdot 10^3 = 1.58 \cdot \underline{1000} = \underline{1,580.0}$$

When we multiply a decimal by a negative power of ten, we move the decimal to the left.

Examples:

$$1.5 \cdot 10^{-1} = 1.5 \cdot \underline{\frac{1}{10}} = \underline{.15}$$

$$1.5 \cdot 10^{-2} = 1.5 \cdot \underline{\frac{1}{100}} = \underline{0.015}$$

$$1.5 \cdot 10^{-3} = 1.5 \cdot \underline{\frac{1}{1000}} = \underline{0.0015}$$

Quick Check

a) $1.8 \cdot 100 = \underline{180}$

b) $0.28 \cdot 10^3 = \underline{280}$

c) $1.3 \cdot 10^4 = \underline{13000}$

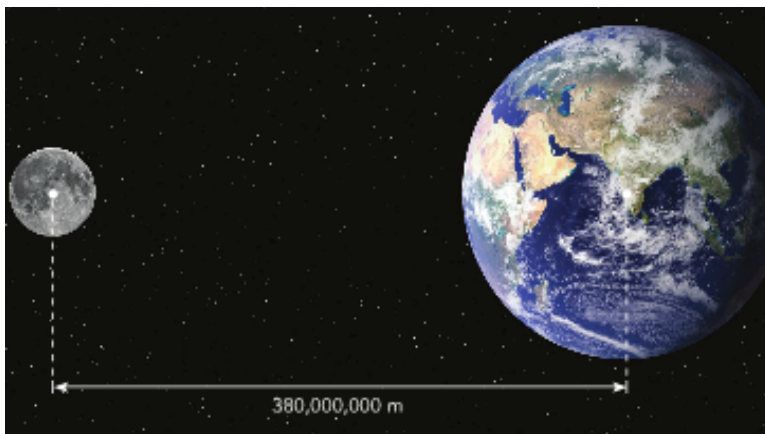
d) $74.5 \cdot 10^{-3} = \underline{0.0745}$

e) $3.8 \cdot 10^{-1} = \underline{0.38}$

f) $2.81 \cdot 10^{-2} = \underline{0.0281}$

Scientists, like Astronomers, work with very large and very small numbers.

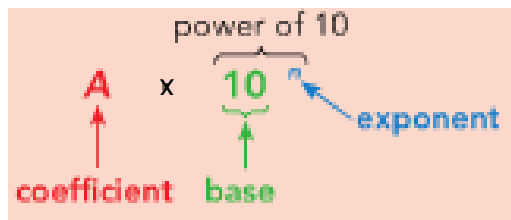
For example, the average distance from the Earth to the moon is approximately 380,000,000 meters. Sometimes it's hard to keep track of so many zeros in such a large number. This is why scientific notation is very helpful!



What other things can you think of that we might want to represent very large or very small numbers with?

Scientific Notation can be used to represent a positive, finite decimal s as the product $d \times 10^n$, where d is a finite decimal greater than or equal to 1, but less than 10 (i.e. $1 \leq d < 10$), and n is an integer.

Scientific Notation



For numbers greater than or equal to 10, use a positive exponent.
For positive numbers less

Example 1

The finite decimal 584.392 is equal to every one of the following:

- 5.84392×10^2 584.392×10^0 58439.2×10^{-2} 5843.92×10^{-1}
 0.584392×10^3 5843920×10^{-4} 58.4392×10^1 0.00584392×10^5

However, there is only one that is written in scientific notation. Why is this the only one written in scientific notation? The first one has d greater than or equal to 1 and less than 10.

Practice 1

Are the following numbers written in scientific notation? If not, state the reason.

- a) The Statue of Liberty is 3.05×10^2 feet tall.

Yes

- b) People spend approximately 4050.0×10^{-1} minutes on Facebook each month.

No, $d > 10$.

- c) A golf ball has a diameter of about 1.680×10^0 inches.

Yes

- d) It would take a person approximately $0.116 + 10^3$ hours to walk to Washington, DC from Rochester, NY.

No, $d < 1$ and we must have a product, not a sum.

Example 2

Write each number in scientific notation.

- a) 567.8

- b) 0.0246

5.678×10^2

2.46×10^{-2}

Practice 2

- a) 9483.32

- b) 0.005623

9.48332×10^3

5.623×10^{-3}

Remember: For numbers greater than or equal to 10, move the decimal to the left and use a positive exponent.

For positive numbers less than 1, move the decimal to the right us a negative exponent.

Example 3

We can also write numbers in standard form from scientific notation.

a) 8.46×10^5

b) 9.25×10^{-5}

846000.00.0000925**Practice 3**

Write each number in standard form.

a) 5.6×10^3

b) 4.62×10^{-2}

5600.00.0462

Tips for changing notation: Standard \Leftrightarrow Scientific

Standard \Rightarrow *Scientific*

($d \times 10^n$)

- g) Move the decimal point in the given number so there is only one nonzero digit to the left. The resulting number is d ($1 \leq d < 10$).
- h) Count the number of places you moved the decimal point in step 1. If the decimal point was moved to the left, n is **positive**; if it was moved to the right, n is **negative**.
- i) Write $d \times 10^n$

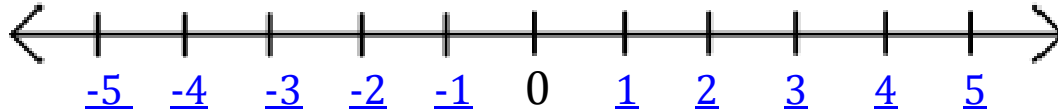
Scientific \Rightarrow *Standard*

4. If the exponent is **positive**, move the decimal point to the right as indicated by the exponent of 10; if the exponent is **negative**, move the decimal point to the left as indicated by the exponent of 10.

Day 2 – Comparing Numbers in Scientific Notation

Recall

Complete the number line below.



Example 1

We can compare the powers of 10 to determine which number is greater. If the powers are equal, we will compare the coefficients.

Identify the greater number in each pair of numbers. Justify your reasoning.

a) 3.4×10^5 and 7.2×10^2

b) 1.6×10^{-2} and 4.8×10^{-2}

(compare exponents)

$10^5 > 10^2$

$3.4 \times 10^5 > 7.2 \times 10^2$

So, 3.4×10^5 is greater.

(compare coefficients)

$4.8 > 1.6$

$4.8 \times 10^{-2} > 1.6 \times 10^{-2}$

So, 4.8×10^{-2} is greater.

Practice 1

Identify the greater number in each pair of numbers. Justify your reasoning.

1. 3.4×10^8 and 7.2×10^9

(compare exponents)

$10^9 > 10^8$

$7.2 \times 10^9 > 3.4 \times 10^8$

So, 7.2×10^9 is greater.

2. 5.6×10^{-9} and 2.8×10^{-9}

(compare coefficients)

$5.6 > 2.8$

$5.6 \times 10^{-9} > 2.8 \times 10^{-9}$

So, 5.6×10^{-9} is greater.

3. Challenge: 6.5×10^{-5} and 5.8×10^{-3}

(compare exponents)

$10^{-3} > 10^{-5}$

$5.8 \times 10^{-3} > 6.5 \times 10^{-5}$

So, 5.8×10^{-3} is greater.

Example 2

Taylor Swift, a singer/songwriter has approximately 47,800,000 fans on Facebook. Selena, an actress/singer, has approximately 47.1×10^6 fans on Facebook. Which celebrity has the greater number of fans?

1. Change both numbers into scientific notation (if not already).

Taylor: 4.78×10^7 fans

Selena: 4.71×10^7 fans

2. Compare the exponents. If the same, compare the coefficients.

Exponents are the same ($n = 7$) so we compare the coefficients.

$4.78 > 4.71$ $4.78 \times 10^7 > 4.71 \times 10^7$.

So, Taylor has more fans (4.78×10^7) on Facebook.

Practice 2

A technician reads and records the air pressure from several pressure gauges. The table shows each air pressure reading in pascals (Pa). A pascal is a unit used to measure the amount of force applied on a given area by air or other gases. Justify your reasoning for each question below.

- a) Which pressure gauge has the greatest reading?

$5.2 > 2.1 > 1.7$

$5.2 \times 10^5 > 2.1 \times 10^5 > 1.7 \times 10^5$

Gauge B has greatest reading

Pressure Gauge	Air Pressure (Pa)	
A	210,000	<u>2.1×10^5</u>
B	5.2×10^5	<u>5.2×10^5</u>
C	170,000	<u>1.7×10^5</u>

- b) Which pressure gauge has the lowest reading?

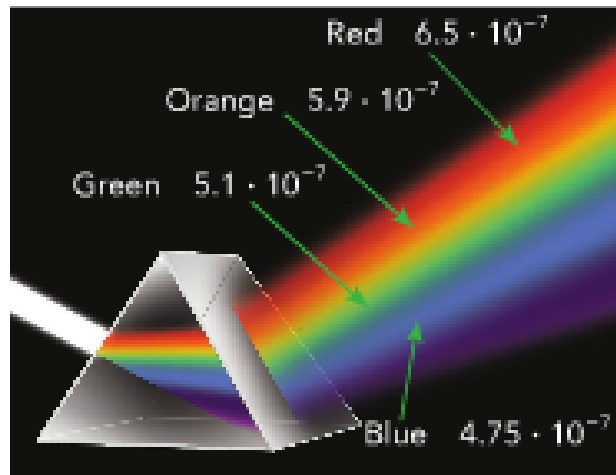
Based on work above, Gauge C has the lowest reading.

- c) The atmospheric pressure when these readings were made was 1.1×10^5 . Which gauge(s) showed a reading *greater than* the atmospheric pressure?

All gauges showed a reading greater than the atmospheric pressure. We can compare the coefficients because the exponents are the same. So, 5.2, 2.1, and 1.7 are all greater than 1.1.

Classwork

1. When visible light passes through a prism, the light waves refract, or bend, and the colors that make up the light can be seen. Each color has a different wavelength, as shown in the diagram, which is refracted to a different degree.



- a) Shorter wavelengths refract more than longer wavelengths. Which color of light wave shows the most refraction? Which color of light wave shows the least refraction? Justify your answer.

Blue shows the most refraction because the wavelength is the shortest. Red shows the most refraction because the wavelength is the longest.

- b) The frequency of a light wave is the number of waves that travel a given distance in a given amount of time. The shorter the wavelength, the greater the frequency. Order the wavelengths, in order of their frequencies, from least to greatest.

Red, Orange, Green, Blue

2. The approximate diameters of the planets in our solar system are listed in a table below in either Standard Notation or Scientific Notation.
- a) Complete the table.

Planet	Diameter (km) in Standard Notation	Diameter (km) in Scientific Notation
Mercury	<u>4,800</u>	4.8×10^3
Venus	12,100	<u>1.21×10^4</u>
Earth	<u>12,800</u>	1.28×10^4
Mars	6,792	<u>6.792×10^3</u>
Jupiter	<u>142,900</u>	1.429×10^5
Saturn	120,500	<u>1.205×10^5</u>
Uranus	51,100	<u>5.11×10^4</u>
Neptune	<u>49,530</u>	4.953×10^4
Pluto	<u>2,300</u>	2.3×10^3

<http://nineplanets.org/data1.html>

- b) Which three planets have the greatest diameter? Justify your reasoning based on the diameters in scientific notation.

Jupiter, Saturn and Uranus

- c) Which planet has the least diameter? Justify your reasoning.

Pluto, Mercury and Mars

- d) The moon has a diameter of 3.5×10^3 km. Which planet(s) have a diameter smaller than the moon?

Pluto

Day 3 – Adding and Subtracting Numbers in Scientific Notation

Example 1 - Subtracting

The population of New York State is approximately 1.96×10^7 . The population of New York City alone is 8,245,000. How many people do not live in New York City?

To find the number of people that live in New York State but not in New York City, we must subtract the population of New York City from the population of New York State.

First, we need to change the population of New York City to scientific notation.

New York City: 8.245×10^6

New York State: 1.96×10^7

To find the difference, we subtract:

$$\begin{aligned} & \underline{\text{New York State population} - \text{New York City population}} \\ & = \underline{1.96 \times 10^7 - 8.245 \times 10^6} \end{aligned}$$

To find the difference (or sum) of numbers in scientific notation, it is best to make the order of magnitude (n) the same in all numbers.

So, each number must have the same base (10) and same order of magnitude (n).

We can rewrite the population of New York State as an integer multiplied by 10^6 and then subtract.

New York State population – New York City population

1. Original Subtraction	<u>$= 1.96 \times 10^7 - 8.245 \times 10^6$</u>
2. Rewrite using Laws of Exponents	<u>$= (1.96 \times 10^1) \times 10^6 - 8.245 \times 10^6$</u>
3. Expand integer for NYS	<u>$= 19.6 \times 10^6 - 8.245 \times 10^6$</u>
4. Distributive Property	<u>$= (19.6 - 8.245) \times 10^6$</u>
5. Simplify & Rewrite in proper notation	<u>$= 11.355 \times 10^6 = 1.1355 \times 10^7$</u>
(6. Optional: Rewrite in Standard Form)	<u>$= 11,355,000$</u>

Example 2 - Subtracting

The approximate thickness of an iPhone 4s is 9.398×10^{-1} centimeters. The approximate thickness of a standard deck of 52 cards is 1.515×10^0 . Which is thicker? Justify your answer.

Deck of cards because $10^{-1} < 10^0$ and so $9.398 \times 10^{-1} < 1.515 \times 10^0$.

What is the difference between the thickness of an iPhone 4s and a standard deck of 52 cards?

Deck of Cards thickness – iPhone thickness

- | | |
|---|---|
| 1. Original Subtraction | <u>$= 1.515 \times 10^0 - 9.398 \times 10^{-1}$</u> |
| 2. Rewrite using Laws of Exponents | <u>$= (1.515 \times 10^1) \times 10^{-1} - 9.398 \times 10^{-1}$</u> |
| 3. Expand integer for NYS | <u>$= 15.15 \times 10^{-1} - 9.398 \times 10^{-1}$</u> |
| 4. Distributive Property | <u>$= (15.15 - 9.398) \times 10^{-1}$</u> |
| 5. Simplify | <u>$= 5.752 \times 10^{-1}$</u> |
| (6. Optional: Rewrite in Standard Form) | <u>$= 0.5752$</u> |

Practice 1

- a) According to scientists, the Earth's mass is 5.98×10^{24} kilograms. The mass of the Sun is 1.989×10^{30} . How much greater is the mass of the Sun than the mass of the Earth?

$$\begin{aligned}
 &\text{Mass of Sun} - \text{Mass of Earth} \\
 &= (1.989 \times 10^{30}) - (5.98 \times 10^{24}) \\
 &= (1989000 \times 10^{24}) - (5.98 \times 10^{24}) \\
 &= (1989000 - 5.98) \times 10^{24} = 1988994.02 \times 10^{24} \\
 &= \underline{1.98899402 \times 10^{30} \text{ kg greater}}
 \end{aligned}$$

- b) A quarter is approximately 0.07 inches thick. A dollar bill is approximately 4.3×10^{-3} inches thick. Using scientific notation, determine which piece of money is thicker and by how much.

$$\text{quarter: } 0.07 \text{ inches} = 7.0 \times 10^{-2} \text{ inches; dollar bill: } 4.3 \times 10^{-3}$$

A quarter is thicker.

Quarter thickness – dollar bill thickness

$$= (7.0 \times 10^{-2}) - (4.3 \times 10^{-3}) = 70 \times 10^{-3} - 4.3 \times 10^{-3} = 65.7 \times 10^{-3} = 6.57 \times 10^{-2} \text{ inches}$$

The quarter is thicker than the dollar bill by 0.0657 inches.

Example 3 – Adding

The approximate area of the Pacific Ocean is 6.4×10^7 square miles. The approximate area of the Arctic Ocean is about 5.4×10^6 square miles.

a) Find the approximate sum of the areas of the two oceans.

- Rewrite the area of the Pacific Ocean to have the same order of magnitude as the Arctic Ocean.

$$\begin{aligned}
 \text{Total} &= \text{Pacific Ocean} + \text{Arctic Ocean} \\
 &= 6.4 \times 10^7 + 5.4 \times 10^6 \\
 &= (6.4 \times 10^1) \times 10^6 + 5.4 \times 10^6 \\
 &= 64 \times 10^6 + 5.4 \times 10^6 \\
 &= (64 + 5.4) \times 10^6 \\
 &= 69.4 \times 10^6 \\
 &= 6.94 \times 10^7
 \end{aligned}$$

- Can we find the same answer by rewriting the area of the Arctic Ocean to have the same order of magnitude as the Pacific Ocean? Justify your reasoning.

Yes:

$$\begin{aligned}
 \text{Total} &= \text{Pacific Ocean} + \text{Arctic Ocean} \\
 &= 6.4 \times 10^7 + 5.4 \times 10^6 \\
 &= 6.4 \times 10^7 + (5.4 \times 10^{-1}) \times 10^7 \\
 &= 6.4 \times 10^7 + 0.54 \times 10^7 \\
 &= (6.4 + 0.54) \times 10^7 \\
 &= 6.94 \times 10^7
 \end{aligned}$$

b) About how much larger is the area of the Pacific Ocean than the Arctic Ocean?

$$\begin{aligned}
 \text{Total} &= \text{Pacific Ocean} - \text{Arctic Ocean} \\
 &= 6.4 \times 10^7 - 5.4 \times 10^6 \\
 &= (6.4 \times 10^1) \times 10^6 - 5.4 \times 10^6 \\
 &= 64 \times 10^6 - 5.4 \times 10^6 \\
 &= (64 - 5.4) \times 10^6 \\
 &= 58.6 \times 10^6 \\
 &= 5.86 \times 10^7
 \end{aligned}$$

Partner Practice

a) $(1.2 \times 10^5) + (5.35 \times 10^6)$

$$\underline{(1.2 \times 10^{-1}) \times 10^6 + 5.35 \times 10^6}$$

$$\underline{0.12 \times 10^6 + 5.35 \times 10^6}$$

$$\underline{(0.12 + 5.35) \times 10^6}$$

$$\underline{5.47 \times 10^6}$$

b) $(6.91 \times 10^{-2}) + (2.4 \times 10^{-3})$

$$\underline{(6.91 \times 10^1) \times 10^{-3} + 2.4 \times 10^{-3}}$$

$$\underline{69.1 \times 10^{-3} + 2.4 \times 10^{-3}}$$

$$\underline{(69.1 + 2.4) \times 10^{-3}}$$

$$\underline{71.5 \times 10^{-3}}$$

$$\underline{7.15 \times 10^{-2}}$$

c) $(9.70 \times 10^6) + (8.3 \times 10^7)$

$$\underline{(9.70 \times 10^{-1}) \times 10^7 + 8.3 \times 10^7}$$

$$\underline{0.97 \times 10^7 + 8.3 \times 10^7}$$

$$\underline{(0.97 + 8.3) \times 10^7}$$

$$\underline{9.27 \times 10^7}$$

d) $(3.67 \times 10^2) - (1.6 \times 10^1)$

$$\underline{(3.67 \times 10^1) \times 10^1 - 1.6 \times 10^1}$$

$$\underline{36.7 \times 10^1 - 1.6 \times 10^1}$$

$$\underline{(36.7 - 1.6) \times 10^1}$$

$$\underline{35.1 \times 10^1}$$

$$\underline{3.51 \times 10^2}$$

e) $(8.41 \times 10^{-5}) - (7.9 \times 10^{-6})$

$$\underline{(8.41 \times 10^1) \times 10^{-6} - 7.9 \times 10^{-6}}$$

$$\underline{84.1 \times 10^{-6} - 7.9 \times 10^{-6}}$$

$$\underline{(84.1 - 7.9) \times 10^{-6}}$$

$$\underline{92.0 \times 10^{-6}}$$

$$\underline{9.2 \times 10^{-5}}$$

f) $(1.33 \times 10^5) - (4.9 \times 10^4)$

$$\underline{(1.33 \times 10^1) \times 10^4 - 4.9 \times 10^4}$$

$$\underline{13.3 \times 10^4 - 4.9 \times 10^4}$$

$$\underline{(13.3 - 4.9) \times 10^4}$$

$$\underline{8.4 \times 10^4}$$

g) $(1.5 \times 10^7) - (8.9 \times 10^5)$

$$\underline{(1.5 \times 10^2) \times 10^5 - 8.9 \times 10^5}$$

$$\underline{150.0 \times 10^5 - 8.9 \times 10^5}$$

$$\underline{(150 - 8.9) \times 10^5}$$

$$\underline{141.1 \times 10^5}$$

$$\underline{1.411 \times 10^7}$$

h) $(2.45 \times 10^3) + (1.23 \times 10^1)$

$$\underline{(2.45 \times 10^2) \times 10^1 + 1.23 \times 10^1}$$

$$\underline{245 \times 10^1 + 1.23 \times 10^1}$$

$$\underline{(245 + 1.23) \times 10^1}$$

$$\underline{246.23 \times 10^1}$$

$$\underline{2.4623 \times 10^3}$$

Day 4 –Multiplying and Dividing Numbers in Scientific Notation

Recall – Multiplying/Dividing with Exponents

When **multiplying** numbers with powers, we add the exponents.

When **dividing** numbers with powers, we subtract the exponents.

Compute the following:

$$a. 5^3 \cdot 5^6 = \underline{5^9}$$

$$c. 5^6 \div 5^2 = \underline{5^4}$$

$$b. 10^{10} \cdot 10^5 = \underline{10^{15}}$$

$$d. 10^{10} \div 10^5 = \underline{10^5}$$

Example 1 – Multiplying

A football field is approximately 1.20×10^2 yards by 5.33×10^1 yards. What is the approximate area of the football field? Justify your answer.

Area = length x width

1. Length x width $= \underline{(1.20 \times 10^2) \times (5.33 \times 10^1)}$
2. Rewrite using Associative and Commutative Property $= \underline{(1.20 \times 5.33)(10^2 \times 10^1)}$
3. Multiply inside first set of () $= \underline{6.396 \times (10^2 \times 10^1)}$
4. Use first law of exponents $= \underline{6.396 \times 10^3}$

Practice 1

Light travels at approximately 3.0×10^8 m/sec. How far does light travel in one week?

1. Find number of seconds in 1 wk. $\underline{60 \cdot 60 \cdot 24 \cdot 7 = 604,800 \text{ seconds}}$
2. Rewrite using Scientific Notation $\underline{6.048 \times 10^5 \text{ seconds}}$
3. Multiply sec/week by m/sec) $\underline{(3.0 \times 10^8) \cdot (6.048 \times 10^5)}$
4. Rewrite using Associative and Commutative Property $= \underline{(3.0 \times 6.048)(10^8 \times 10^5)}$
5. Multiply inside first set of () $= \underline{18.144 \times (10^8 \times 10^5)}$
6. Use first law of exponents $= \underline{18.144 \times 10^{13}}$
7. Rewrite in proper sci. notation $= \underline{1.8144 \times 10^{14} \text{ meters in one week}}$

Example 2

The Earth is approximately 93,000,000 miles from the sun. How long does it take light from the sun to reach the earth? Use the speed of light to be 1.86×10^5 miles per second. Calculate the answer using scientific notation. Write your final answer in standard notation.

Distance from Earth to sun = 9.3×10^7 miles

(distance = rate \cdot time \rightarrow time = distance/rate)

Time (seconds) = distance / rate

$$\begin{aligned}
 1. \text{ Substitute the numbers} &= \frac{(9.3 \times 10^7)}{(1.86 \times 10^5)} \\
 2. \text{ Divide the coefficients and divide the} &= \frac{9.3}{1.86} \times \frac{10^7}{10^5} \\
 \text{powers of 10 (using quotient of powers)} & \\
 3. \text{ Simplify and write in standard form} &= \underline{5.0 \times 10^2} \\
 &= \underline{500 \text{ seconds}}
 \end{aligned}$$

Practice 2

A company on Facepace, a social network, receives approximately 839 million “likes” per year on posts, pictures, etc. If the company has approximately 7,560,000 fans, about how many “likes” is each user responsible for each year?

Write the numbers in scientific notation:

Total likes: 839 million = 8.39×10^8 Total fans: 7,560,000 = 7.56×10^6

Number of “likes” per person = total number of likes / total number of fans

$$\begin{aligned}
 &= \frac{(8.39 \times 10^8)}{(7.56 \times 10^6)} \\
 &= \frac{8.39}{7.56} \times \frac{10^8}{10^6} \\
 &= \underline{1.10978836 \times 10^2} \\
 &\approx \underline{1.11 \times 10^2 = 110 \text{ likes per person (fan)}}
 \end{aligned}$$

Partner Practice

1. The table shows some models of LCD televisions and their native pixel resolution

Model	Native Pixel Resolution
A	1,280 · 720
B	1,024 · 768
C	1,366 · 768
D	1,920 · 1,080

- a. Express the given resolution of each model in scientific notation to the nearest tenth. Use the most appropriate unit.

Model A: 1280 · 720

$$= (1.28 \times 10^3)(7.2 \times 10^2)$$

$$= (1.28 \times 7.2)(10^3 \cdot 10^2)$$

$$= 9.216 \times 10^5 \text{ p}$$

$$= 0.9216 \times 10^6 \text{ Mp}$$

$$\approx 0.9 \text{ Mp}$$

Model B: 1024 · 768

$$= (1.024 \times 10^3)(7.68 \times 10^2)$$

$$= (1.024 \times 7.68)(10^3 \cdot 10^2)$$

$$= 7.86432 \times 10^5 \text{ p}$$

$$= 0.786432 \times 10^6 \text{ Mp}$$

$$\approx 0.8 \text{ Mp}$$

Model C: 1366 · 768

$$= (1.366 \times 10^3)(7.68 \times 10^2)$$

$$= (1.366 \times 7.68)(10^3 \cdot 10^2)$$

$$= 10.49088 \times 10^5 \text{ p}$$

$$= 1.049088 \times 10^6 \text{ Mp}$$

$$\approx 1.0 \text{ Mp}$$

Model D: 1920 · 1080

$$= (1.920 \times 10^3)(1.080 \times 10^3)$$

$$= (1.920 \times 1.080)(10^3 \cdot 10^3)$$

$$= 2.0736 \times 10^6 \text{ Mp}$$

$$\approx 2.0 \text{ Mp}$$

- b. All flat screen LCD televisions must have a resolution of at least one megapixel. Determine which models are not a flat screen LCD television.

0.9216 < 1 and 0.786432 < 1. Therefore, Models A and B are not flat screen LCD TVs.

Problems from NASA!

http://www.nasa.gov/pdf/371727main_SMLI_Problem9.pdf

1. The sun produces 3.9×10^{33} ergs per second of radiant energy. How much energy does it produce in one year (3.1×10^7 seconds)?

$$(3.9 \times 10^{33})(3.1 \times 10^7) = 1.2 \times 10^{41} \text{ ergs}$$

2. One gram of matter converted into energy yields 3.0×10^{20} ergs of energy. How many tons of matter in the sun is annihilated every second to produce its luminosity of 3.9×10^{33} ergs per second? (One metric ton = 10^6 grams)

$$\frac{(3.9 \times 10^{33})}{(3.0 \times 10^{20})} = 1.3 \times 10^{13} \text{ grams per second}$$

$$= \frac{(1.3 \times 10^{13})}{(10^6)} = 1.3 \times 10^5 \text{ metric tons of mass}$$

3. The approximate volume of the visible universe (a sphere with a radius of about 14 billion light years) is 1.1×10^{31} cubic light-years. If a light-year equals 9.2×10^{17} centimeters, how many cubic centimeters does the visible universe occupy?

$$1 \text{ cubic light year} = (9.2 \times 10^{17})^3 = (9.2)^3 \cdot (10^{17})^3 = 788.688 \times 10^{51} \approx 7.9 \times 10^{53} \text{ cubic centimeters}$$

$$\text{so the universe contains } (7.9 \times 10^{53})(1.1 \times 10^{31}) \\ = 8.69 \times 10^{84} \text{ cubic centimeters}$$

4. The NASA data archive at the Goddard Space Flight Center contains 25 terabytes of data from over 1000 science missions and investigations. (1 terabyte = 10^{15} bytes). How many CD-roms does this equal if the capacity of a CD-rom is about 6×10^8 bytes?

$$\frac{(2.5 \times 10^{16})}{(6.0 \times 10^8)} = 4.2 \times 10^7 \text{ CD-roms}$$

Name _____

TOTD #1

Class _____

Which are not written in scientific notation? Explain your reason.

- a) $3.56 + 10^4$ No, cannot have + b) 35.6×10^3 No, need $d < 10$.
c) 3.56×5^4 No, cannot have base of 5 d) 3.56×10^4 Yes

There were approximately 1700 players in the NFL in 2011. Write this number in scientific notation.

1.7×10^3

A carpenter ant is approximately 5.0×10^{-1} inches long. Write this number in standard notation.

0.5 inches

Name _____

TOTD #1

Class _____

Which are not written in scientific notation? Explain your reason.

- a) $3.56 + 10^4$ b) 35.6×10^3
c) 3.56×5^4 d) 3.56×10^4

There were approximately 1700 players in the NFL in 2011. Write this number in scientific notation.

A carpenter ant is approximately 5.0×10^{-1} inches long. Write this number in standard notation.

Name _____

Homework #1

Class _____

1. Are the following numbers written in scientific notation? If not, state the reason.

a) 65.04×10^1 no, d > 10

d) 6.78×10^{45} yes

b) 4.583×10^5 yes

e) $1.59 + 10^3$ no, must be product

c) 0.439×10^{-8} no, d < 1

f) 5×10^{-23} yes

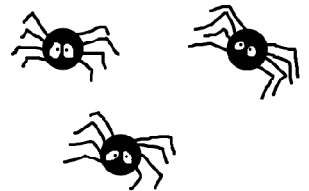
2. The approximate distance to the sun is 93,000,000 miles, and the wavelength of its ultraviolet light is 0.000035 centimeter. Write both numbers in scientific notation.

9.3×10^7 miles; 3.5×10^5 cm

3. A jumbo jet weighs 7.75×10^5 pounds, whereas a house spider weighs 2.2×10^{-4} pound. Write both weights in standard notation.

Jumbo Jet: 775,000 pounds

House Spider: 0.00022 pounds



Name _____

TOTD #2

Class _____

The population of California is approximately 38,040,000. The population of Texas is approximately 26.06×10^6 . The population of New York State is approximately 1.96×10^7 .

1. Write each population in scientific notation.



California: 3.804×10^7

Texas: 2.606×10^7

New York: 1.96×10^7



2. Which state has the greater population? Justify your reasoning.

Since the exponents are the same, we can compare the coefficients. $3.8 > 2.6 > 1.96$. So, California has the larger population because 3.804×10^7 is greater than the other two populations.

Name _____

TOTD #2

Class _____

The population of California is approximately 38,040,000. The population of Texas is approximately 26.06×10^6 . The population of New York State is approximately 1.96×10^7 .

1. Write each population in scientific notation.



2. Which state has the greater population? Justify your reasoning.

Name _____
 Class _____

Homework #2

1. James came across the following fun facts about the human body while searching on the Internet. Complete the table by writing each figure in scientific notation.

Facts	Figures in Standard Notation	Figures in Scientific Notation
Number of cells in a human body	12,000,000,000,000	<u>1.2×10^{13}</u>
Diameter of a red blood cell (m)	0.0000084	<u>8.4×10^{-6}</u>
Average number of times the human eye blinks	4,200,000	<u>4.2×10^6</u>
Number of hairs on a human scalp	100,000	<u>1.0×10^5</u>
Width of a human hair (cm)	0.00108	<u>1.08×10^{-3}</u>
Average number of times a human heart beats in its lifetime	3,000 million	(3000000000) <u>3.0×10^9</u>

2. The table shows the speed of two mediums in the air.

Medium	Speed (m/s) in Standard Notation	Speed in Scientific Notation (m/s)
Sound	330	<u>3.3×10^2</u>
Light	<u>300,000,000</u>	3.0×10^8

- a) Complete the table by writing the speed of each medium in scientific notation or in standard notation.
- b) Which is most likely to occur first, a person seeing a flash of lightning or a person hearing the sound of thunder? Justify your reasoning based on the speed in scientific notation.

Lightning because the speed is much greater than the speed of sound.

$10^8 > 10^2$ and therefore, $3.0 \times 10^8 > 3.3 \times 10^2$. Thus, lightning has a faster speed than sound in the air.

Name _____

TOTD #3

Class _____

In 1900 there were approximately 76,100,000 people in the United States. In 1999 there were approximately 272,700,000 people in the United States.

(<http://www.demographia.com/db-uspop1900.htm>)

- a) Using scientific notation, how much larger is the population in 1999 than in 1990?

$$\text{1900: } 7.61 \times 10^7; \text{ 1999: } 2.727 \times 10^8$$

$$\text{1999 Population} - \text{1990 Population}$$

$$= 2.727 \times 10^8 - 7.61 \times 10^7$$

$$= (2.727 \times 10^1) \times 10^7 - 7.61 \times 10^7$$

$$= 27.27 \times 10^7 - 7.61 \times 10^7 = 19.66 \times 10^7$$

$$= 1.966 \times 10^8$$

- b) The population in Canada in 1999 was 3.04×10^7 . What is the total population of the United States and Canada in 1999? (http://en.wikipedia.org/wiki/Population_of_Canada_by_year)

$$\text{US Population} + \text{Canada Population}$$

$$= 2.727 \times 10^8 + 3.04 \times 10^7$$

$$= (2.727 \times 10^1) \times 10^7 + 3.04 \times 10^7$$

$$= 27.27 \times 10^7 + 3.04 \times 10^7 = 30.31 \times 10^7$$

$$= 3.031 \times 10^8$$

Name _____

TOTD #3

Class _____

In 1900 there were approximately 76,100,000 people in the United States. In 1999 there were approximately 272,700,000 people in the United States.

(<http://www.demographia.com/db-uspop1900.htm>)

- a) Using scientific notation, how much larger is the population in 1999 than in 1990?

- b) The population in Canada in 1999 was 3.04×10^7 . What is the total population of the United States and Canada in 1999? (http://en.wikipedia.org/wiki/Population_of_Canada_by_year)

Name _____

Homework #3

Class _____

1. The approximate thickness of a standard CD is 1.2×10^{-3} meter. A slim jewel case is about 5.3×10^{-3} meter thick.

- a. The CD is placed on top of the jewel case. What is the total thickness of the CD and the jewel case?

$$\begin{aligned} & \underline{1.2 \times 10^{-3} + 5.3 \times 10^{-3}} \\ & = \underline{(1.2 + 5.3) \times 10^{-3}} \\ & = \underline{6.4 \times 10^{-3}} \end{aligned}$$



- b. How much thicker is the jewel case than the CD?

$$\begin{aligned} & \underline{5.3 \times 10^{-3} - 1.2 \times 10^{-3}} \\ & = \underline{(5.3 - 1.2) \times 10^{-3}} \\ & = \underline{4.1 \times 10^{-3}} \end{aligned}$$

2. Rochester, NY has an average of 28.2 inches of snow fall in January, while Atlanta, GA has an average of 1.3 inches of snow fall in January.

<http://www.currentresults.com/Weather/US/average-snowfall-by-city-in-january.php>

- a. Rewrite the snowfall averages in scientific notation.

Rochester: 2.82×10^1 , Atlanta: 1.3×10^0

- b. How much more snow does Rochester, NY receive in January than Atlanta, GA, on average? Calculate this using scientific notation.

$$\begin{aligned} & \underline{2.82 \times 10^1 - 1.3 \times 10^0 = (2.82 \times 10^1) \times 10^0 - 1.3 \times 10^0} \\ & = \underline{28.2 \times 10^0 - 1.3 \times 10^0 = 26.9 \times 10^0} \\ & = \underline{2.69 \times 10^1} \end{aligned}$$

- c. Buffalo, NY has an average of 25.3 inches of snow fall in January. What is the total average snow fall of Buffalo and Rochester, NY in the month of January? Calculate this using scientific notation.

Buffalo: 2.53×10^1

$$\begin{aligned} & \underline{2.53 \times 10^1 + 2.82 \times 10^1} \\ & = \underline{5.35 \times 10^1} \end{aligned}$$

Name _____

TOTD #4

Class _____

1. The speed of light is 3×10^8 meters per second. The sun is approximately 230,000,000,000 meters from Mars. How many seconds does it take for sunlight to reach Mars? Complete the calculation using scientific notation. Write your answer in standard notation.

$$\underline{230,000,000,000 \text{ meters} = 2.3 \times 10^{11}}$$

$$= \frac{(2.3 \times 10^{11})}{(3.0 \times 10^8)} = \frac{2.3}{3.0} \times \frac{10^{11}}{10^8} = \underline{0.76 \times 10^3 = 7.6 \times 10^2 \text{ seconds}}$$

$$= \underline{\text{approximately 760 seconds for sunlight to reach Mars.}}$$

2. If the sun is approximately 1.5×10^{11} meters from Earth, what is the approximate distance from Earth to Mars?

$$\underline{\text{Distance from Earth to Mars} = (\text{Distance from Mars to Sun}) - (\text{Distance from Earth to Sun})}$$

$$= \underline{2.3 \times 10^{11} - 1.5 \times 10^{11}}$$

$$= \underline{(2.3 - 1.5) \times 10^{11}}$$

$$= \underline{0.8 \times 10^{11}}$$

$$= \underline{8 \times 10^{10} \text{ meters from Mars to Earth}}$$

Name _____

Homework #4

Class _____

1. Light travels at a speed of 1.86×10^5 miles per second. If a light year is the distance that light travels in one year, how many miles are in a light year?

- | | |
|---|---|
| 1. Find number of seconds in 1 yr. | <u>$60 \cdot 60 \cdot 24 \cdot 365 = 31,536,000$ seconds</u> |
| 2. Rewrite using Scientific Notation | <u>3.1536×10^7 seconds</u> |
| 3. Multiply sec/yr by mi/sec | <u>$(3.1536 \times 10^7) \cdot (1.86 \times 10^5)$</u> |
| 4. Rewrite using Associative and Commutative Property | <u>$= (3.1536 \times 1.86)(10^7 \times 10^5)$</u> |
| 5. Multiply inside first set of () | <u>$= 5.865696 \times (10^7 \times 10^5)$</u> |
| 6. Use first law of exponents | <u>$= 5.865696 \times 10^{12}$ meters in one year</u>
<u>$(= 5,865,696,000,000$ miles in one year)</u> |

2. Assume that there are 20,000 runners in the New York City Marathon. Each runner runs a distance of 36 miles. If you add together the total number of miles for all runners, how many times around the globe would the marathon runners have gone? Let the circumference of the Earth be 2.5×10^4 miles. Calculate your answer using scientific notation.

Total miles run = $20,000 \times 36 = 720,000$ miles = 7.2×10^5

Divide total miles by circumference

$$= \frac{(7.2 \times 10^5)}{(2.5 \times 10^4)} = \frac{7.2}{2.5} \times \frac{10^5}{10^4} = 2.88 \times 10^1$$

= 28.8 times around the globe



3. Perform the following operations and express your answer in scientific notation

a. $(4.3 \times 10^8) \times (2.0 \times 10^6)$

= 8.6×10^{14}

b. $\frac{(7.8 \times 10^3)}{(1.2 \times 10^4)}$

= 6.5×10^{-1}

c. $\frac{(6.48 \times 10^5)}{(2.4 \times 10^4)(1.8 \times 10^{-2})} = \frac{(6.48 \times 10^5)}{(4.32 \times 10^2)} = 1.5 \times 10^3$

Name _____

Scientific Notation Review

Class _____

1. Use the table to answer questions a – c

The table shows the amounts of energy, in Calories, contained in various foods. Write each food's energy in either Standard Notation or Scientific Notation.

Food (per 100 g)	Energy (Cal) in Standard Notation	Energy (Cal) in Scientific Notation
Chicken Breast	171,000	1.71×10^5
Raw Potato	77	7.7×10^1
Cabbage	25,000	2.5×10^4
Salmon	167,000	1.67×10^5

a. Find the total energy in each food combination. Complete *all* calculations in Scientific Notation.

i. Chicken breast and cabbage. Write your answer in scientific notation.

$$\begin{aligned} (1.71 \times 10^5) + (2.5 \times 10^4) &= (1.71 \times 10^1) \times 10^4 + (2.5 \times 10^4) \\ &= 17.1 \times 10^4 + 2.5 \times 10^4 = 19.5 \times 10^4 = \underline{1.95 \times 10^5} \end{aligned}$$

ii. Cabbage and raw potato. Write your answer in standard notation.

$$\begin{aligned} (1.71 \times 10^5) + (7.7 \times 10^1) &= (1.71 \times 10^4) \times 10^1 + (7.7 \times 10^1) \\ &= 17100 \times 10^1 + 7.7 \times 10^1 = 17107.7 \times 10^1 = 1.71077 \times 10^5 \\ &= \underline{171,077} \end{aligned}$$

iii. Chicken breast, raw potato, and cabbage. Write your answer in standard notation.

$$\begin{aligned} (1.71 \times 10^5) + (7.7 \times 10^1) + (2.5 \times 10^4) \\ &= (1.71 \times 10^4) \times 10^1 + (7.7 \times 10^1) + (2.5 \times 10^3) \times 10^1 \\ &= 17100 \times 10^1 + 7.7 \times 10^1 + 2500 \times 10^1 \\ &= (17100 + 7.7 + 2500) \times 10^1 = 19607.7 \times 10^1 \\ &= \underline{1.96077 \times 10^5} \end{aligned}$$

Food (per 100 g)	Energy (Cal) in Standard Notation	Energy (Cal) in Scientific Notation
Chicken Breast	171,000	1.71×10^5
Raw Potato	77	7.7×10^1
Cabbage	25,000	2.5×10^4
Salmon	167,000	1.67×10^5

- b. How many more energy calories are in chicken breast than in salmon? Write your answer in standard notation.

$$\begin{aligned}
 &\text{Chicken breast} - \text{Salmon} \\
 &= (1.71 \times 10^5) - (1.67 \times 10^5) \\
 &= (1.71 - 1.67) \times 10^5 \\
 &= 0.04 \times 10^5 \\
 &= 4.0 \times 10^3 \\
 &= 4,000 \text{ more calories in chicken breast than in salmon.}
 \end{aligned}$$

- c. How many more energy calories are in salmon than in cabbage? Write your answer in standard notation.

$$\begin{aligned}
 &\text{Salmon} - \text{Cabbage} \\
 &= (1.67 \times 10^5) - (2.5 \times 10^4) \\
 &= (1.67 \times 10^1) \times 10^4 - 2.5 \times 10^4 \\
 &= 16.7 \times 10^4 - 2.5 \times 10^4 \\
 &= (16.7 - 2.5) \times 10^4 \\
 &= 14.2 \times 10^4 \\
 &= 1.42 \times 10^5 \\
 &= 142,000 \text{ more calories in salmon than cabbage.}
 \end{aligned}$$

2. A flight from New York to Singapore includes a stopover at Hawaii. The distance between New York and Singapore is about 1.16×10^4 . The distance between New York and Hawaii is about 4.9×10^3 miles. How many miles are between Hawaii and Singapore? Write your answer in scientific notation.

$$\underline{6.7 \times 10^3 \text{ miles}}$$

3. Angora wool, obtained from rabbits, has fibers with a diameter of about 1×10^{-6} meter. Cashmere, obtained from goats, has fibers with a diameter of about 1.45×10^{-5} meter. Write your answer in the appropriate units, using scientific notation.

- a. Find the sum of the diameters of the two types of fiber.

$$\begin{aligned}
 \text{Sum} &= \text{diameter of angora} + \text{diameter of cashmere} \\
 &= 1 \times 10^{-6} + 1.45 \times 10^{-5} \\
 &= 1.0 \times 10^{-5} + 14.5 \times 10^{-6} \\
 &= 15.5 \times 10^{-6} \\
 &= 1.55 \times 10^{-5} \text{ meters}
 \end{aligned}$$

- b. How much wider is the cashmere fiber than the angora fiber?

$$\begin{aligned}
 \text{Difference} &= \text{diameter of cashmere} - \text{diameter of angora} \\
 &= 1.45 \times 10^{-5} - 1 \times 10^{-6} \\
 &= 14.5 \times 10^{-6} - 1 \times 10^{-6} \\
 &= (14.5 - 1) \times 10^{-6} \\
 &= 13.5 \times 10^{-6} \\
 &= 1.35 \times 10^{-5} \text{ meters}
 \end{aligned}$$

- c. What is the radius of the angora fiber? What is the radius of the cashmere fiber?

$$\text{diameter} = \text{radius} \times 2$$

$$\rightarrow \text{radius} = \text{diameter} / 2$$

$$\text{Angora: } 1 \times 10^{-6} / 2$$

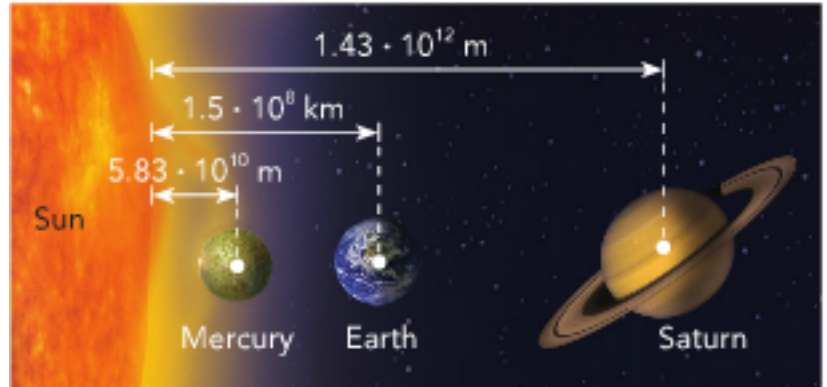
$$= \frac{(1.0 \times 10^{-6})}{(2.0 \times 10^0)} = \frac{1.0}{2.0} \times \frac{10^{-6}}{10^0} = 0.5 \times 10^{-6} = 5.0 \times 10^{-7}$$

$$\text{Cashmere: } 1.45 \times 10^{-5}$$

$$= \frac{(1.45 \times 10^{-5})}{(2.0 \times 10^0)} = \frac{1.45}{2.0} \times \frac{10^{-5}}{10^0} = 0.725 \times 10^{-5} = 7.25 \times 10^{-6}$$

4. The average distance of three planets from the Sun are shown in the diagram. Use this information for questions a – d. Express your answer in kilometers.

Note: $1 \times 10^1 \text{ m} = 1 \times 10^{-3} \text{ km}$



- a. What is the closest Mercury comes to the Earth when both are at an average distance from the Sun?

Distance from Mercury to Sun

$$5.83 \times 10^{10} \text{ m} = 5.83 \times 10^7 \text{ km}$$

Distance between Earth and Mercury

$$= (1.5 \times 10^8) - (5.83 \times 10^7) = 15.0 \times 10^7 - 5.83 \times 10^7$$

$$= (15 - 5.83) \times 10^7 = 9.17 \times 10^7 \text{ km}$$

The closest Mercury comes to Earth is $9.17 \times 10^7 \text{ km}$.

- b. What is the closest Saturn comes to Mercury when both are at an average distance from the Sun?

Distance from Saturn to Sun

$$1.43 \times 10^{12} \text{ m} = 1.43 \times 10^9 \text{ km}$$

Distance between Saturn and Mercury

$$= (1.43 \times 10^9) - (5.83 \times 10^7) = 143 \times 10^7 - 5.83 \times 10^7$$

$$= (143 - 5.83) \times 10^7 = 137.17 \times 10^7 = 1.3717 \times 10^9 \text{ km}$$

The closest Mercury comes to Saturn is $1.3717 \times 10^9 \text{ km}$

- c. What is the closest Saturn comes to Earth when both are at an average distance from the Sun?

Distance between Saturn and Earth

$$= (1.43 \times 10^9) - (1.5 \times 10^8) = (14.3 \times 10^8) - (1.5 \times 10^8)$$

$$= 12.8 \times 10^8 = 1.28 \times 10^9 \text{ km}$$

Saturn is $1.28 \times 10^9 \text{ km}$ from Earth.

- d. Is the distance you found in (c) greater or less than the average distance from Earth to the Sun? Explain.

$$1.5 \times 10^8 \text{ and } 1.28 \times 10^9 \rightarrow 1.5 \times 10^8 \text{ and } 12.8 \times 10^8$$

The distance in (c) is greater than the average distance from Earth to the Sun because $1.5 \times 10^8 < 12.8 \times 10^8$

5. There are approximately 0.05 liters of acetic acid in 1 liter of vinegar. How many liters of acetic acid are there in 2 gallons of vinegar? (Note: 1 gal \approx 3.8 liters)

$$2 \text{ gallons of vinegar} = 2(3.8\text{L}) = 7.6 \text{ liters}$$

$$\text{Total liters of acetic acid in 2 gallons of vinegar} = (\text{acetic acid in 1 L})(7.6 \text{ L})$$

$$= 5.0 \times 10^{-2} (7.6 \times 10^0)$$

$$= (5.0 \times 7.6) \times (10^{-2} \times 10^0)$$

$$= 38 \times 10^{-2}$$

$$= 3.8 \times 10^{-1}$$

$$= 0.38 \text{ liters of acetic acid in 2 gallons of vinegar}$$

6. The size of the Indian Ocean is 2.7×10^7 square miles. The Artic Ocean is $1/5$ the size of the Indian Ocean. How big is the Artic Ocean?

$$(2.7 \times 10^7)(0.2) = (2.7 \times 10^7)(2.0 \times 10^{-1}) = (2.7 \times 2.0) \times (10^7 \times 10^{-1})$$

$$= 5.4 \times 10^6 \text{ square miles}$$

7. The Georgia Aquarium in Atlanta is about (2.63×10^3) feet long, (1.26×10^2) feet wide, and (3.0×10^1) feet deep at its largest point. Find its approximate volume.

$$V = l \cdot w \cdot h$$

$$= (2.63 \times 10^3) \cdot (1.26 \times 10^2) \cdot (3.0 \times 10^1)$$

$$= (2.63 \cdot 1.26 \cdot 3.0) \times (10^3 \cdot 10^2 \cdot 10^1)$$

$$= 9.9414 \times 10^6$$

The approximate volume is 9.9414×10^6 cubic feet.

8. A spherical particle was found to have a radius of 3.5×10^{-10} meters.

- a. Express the diameter in scientific notation using picometers.

Note: 1 meter = 10^{12} picometers

$$d = 2r$$

$$d = (3.5 \times 10^{-10}) \cdot 2 = (3.5 \times 2) \times 10^{-10} = 7.0 \times 10^{-10} = 700 \times 10^{-2} \times 10^{-10}$$

$$= 700 \times 10^{-12} = 700 \text{ pm}$$

- b. Use your answer from (a) to express the circumference in scientific notation using nanometers. Use 3.14 as an approximation for π . Note: 1 picometer = 0.001 nanometers.

$$C = 2\pi r = 2(3.14)(3.5 \times 10^{-10})$$

$$= 21.98 \times 10^{-10} = 2.198 \times 10^{-9} = 2.198 \text{ nm}$$

Name _____

Unit 2 Test

Class _____

Scientific Notation

1. The approximate populations of the following countries in North America in 2011 are shown in the table.

a. Write each population in scientific notation.

Country	Population in standard notation	Population in scientific notation	
Mexico	110,000,000	1.1×10^8	$110. \times 10^6$
Haiti	9,700,000	9.7×10^6	9.7×10^6
Costa Rica	4,600,000	4.6×10^6	4.6×10^6
USA	310,000,000	3.1×10^8	310.0×10^6

b. Explain how to use scientific notation to find the total population of the countries.

c. Find the total population of the countries, using scientific notation.

$$\underline{\text{Total Population} = \text{Mexico} + \text{Haiti} + \text{Costa Rica} + \text{United States}}$$

$$\underline{= 110,000,000 + 9,700,000 + 4,600,000 + 310,000,000}$$

$$\underline{= 1.1 \times 10^8 + 9.7 \times 10^6 + 4.6 \times 10^6 + 3.1 \times 10^8}$$

$$\underline{= 110.0 \times 10^6 + 9.7 \times 10^6 + 4.6 \times 10^6 + 310.0 \times 10^6}$$

$$\underline{= (110.0 + 9.7 + 4.6 + 310.0) \times 10^6}$$

$$\underline{= 434.3 \times 10^6}$$

$$\underline{= 4.343 \times 10^8}$$

2. The body of a 150 lb. person contains 2.3×10^{-4} lb. of copper. How much copper is contained in the bodies of 1200 such people?

$$\begin{aligned}
 &= (2.3 \times 10^{-4}) \times (1.2 \times 10^3) \\
 &= (2.3 \times 1.2) \times (10^{-4} \times 10^3) \\
 &= 2.76 \times 10^{-1} \text{ lb. of copper in 1200 – 150lb. people}
 \end{aligned}$$

3. Potato Chippers and Chips Plus produce potato chips. They use the same basic ingredients: potatoes, oil, and salt. Last year, each factory used different amounts of these ingredients, as shown in the table. Write each answer in scientific notation.

Ingredients	Potato Chippers Amount Used (lb.)	Chips Plus Amount Used (lb.)
Potato	4.87×10^6	3,309,000 <u>3.309×10^6</u>
Oil	356,000 <u>3.56×10^5</u>	5.61×10^5
Salt	2.87×10^5	193,500 <u>1.935×10^5</u>

- a. Which factory used more potatoes last year? How many more potatoes did it use?

Potato Chippers used more potatoes.

$$\begin{aligned}
 &\underline{4.87 \times 10^6 - 3.039 \times 10^6} \\
 &= \underline{1.831 \times 10^6 \text{ lb. of chips}}
 \end{aligned}$$

- b. Which factory used more oil last year? How much more oil did it use than the other factory?

Chips Plus used more oil last year.

$$\begin{aligned}
 &\underline{5.61 \times 10^5 - 3.56 \times 10^5} \\
 &= \underline{2.05 \times 10^5 \text{ lb. of oil}}
 \end{aligned}$$

4. The volume of the Venus is approximately $9.4 \times 10^{11} \text{ km}^3$. The volume of Mars is approximately 1.6×10^{11} .

- a. About how many times as great as the volume of Mars is the volume of Venus?
Round to the nearest tenth.

$$= \frac{(9.4 \times 10^{11})}{(1.6 \times 10^{11})} = \frac{9.4}{1.6} \times \frac{10^{11}}{10^{11}} = 5.876 \times 10^0 \approx 5.9 \times 10^0$$

So, the volume of Venus is approximately 5.9 times as great as the volume of Mars

- b. The volume of Earth is approximately 0.69×10^{-1} times larger than the volume of Mars. What is the approximate volume of Earth?

$$\begin{aligned} \text{volume of earth} &= (\text{volume of mars})(0.69 \times 10^{-1}) \\ &= (1.6 \times 10^{11})(6.9 \times 10^0) \\ &= (1.6 \times 6.9)(10^{11} \times 10^0) \\ &= 11.04 \times 10^{11} \\ &= 1.104 \times 10^{12} \end{aligned}$$

- c. What is the difference in volume, in cubic kilometers, between the volume of the Earth and the volume of Venus?

$$\begin{aligned} \text{Volume of Earth} - \text{Volume of Venus} &= (1.104 \times 10^{12}) - (9.4 \times 10^{11}) \\ &= (1.104 \times 10^1) \times 10^{11} - (9.4 \times 10^{11}) \\ &= (11.04 \times 10^{11}) - (9.4 \times 10^{11}) \\ &= (11.04 - 9.4) \times 10^{11} \\ &= 1.64 \times 10^{11} \end{aligned}$$

5. New York City is approximately 4.68×10^2 square miles. New York Central Park is approximately $1/355$ of the size of New York City. Los Angeles is approximately 503 square miles.

- a. How big is New York Central Park (in square miles)? Write your answer in standard notation. Round to the nearest hundredth.

$$\begin{aligned}
 &(4.68 \times 10^2)(1/355) \\
 &= (4.68 \times 10^2)(0.0028169) \\
 &= (4.68 \times 10^2)(2.8169 \times 10^{-3}) \\
 &= (4.68 \times 2.8169) \times (10^2 \times 10^{-3}) \\
 &= 13.183092 \times 10^{-1} \\
 &= 1.3183092 \times 10^0 \\
 &\approx 1.32 \text{ square miles}
 \end{aligned}$$

- b. How many times larger is the area of Los Angeles than the area of New York City? Write your answer in standard notation. Round to the nearest tenth.

$$\frac{\text{Los Angeles}}{\text{NYC}} = \frac{(5.03 \times 10^2)}{(4.68 \times 10^2)} = \frac{5.03}{4.68} \times \frac{10^2}{10^2} = 1.07478632 \times 10^0 \approx 1.8 \times 10^0$$

Los Angeles is 1.8 times larger than New York City

- c. **Challenge:** The United States of America is approximately 3.794 million square miles. New York State is approximately 54.6×10^4 square miles; California is approximately 163,700 square miles. How many square miles is the area of the USA, not including New York State and California? Write your answer in standard notation.

$$\begin{aligned}
 &\text{United States} - (\text{New York State} + \text{California}) \\
 &= (3.794 \text{ million}) - (54.6 \times 10^4 + 163,700) \\
 &= (3,794,000) - (54.6 \times 10^4 + 1.637 \times 10^5) \\
 &= (3.794 \times 10^6) - [(54.6 \times 10^4) + (1.637 \times 10^1) \times 10^4] \\
 &= (3.794 \times 10^6) - [(54.6 \times 10^4) + (16.37 \times 10^4)] \\
 &= (3.794 \times 10^2) \times 10^4 - (70.97 \times 10^4) \\
 &= 379.4 \times 10^4 - 70.97 \times 10^4 \\
 &= 308.43 \times 10^4 = 3.0843 \times 10^6 =
 \end{aligned}$$

The USA has an area of 3,084,300 square miles, not including the area of California and New York State.