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Integer Exponents and Scientific Notation

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¹ Each lesson is ONE day and ONE day is considered a 45 minute period.

Grade 8 • Module 1

Integer Exponents and Scientific Notation

OVERVIEW

In Module 1, students' knowledge of operations on numbers will be expanded to include operations on numbers in integer exponents. Module 1 also builds on students' understanding from previous grades with regard to transforming expressions. Students were introduced to exponential notation in Grade 5 as they used whole number exponents to denote powers of ten (**5.NBT.2**). In Grade 6, students expanded the use of exponents to include bases other than ten as they wrote and evaluated exponential expressions limited to whole-number exponents (**6.EE.1**). Students made use of exponents again in Grade 7 as they learned formulas for the area of a circle (**7.G.4**) and volume (**7.G.6**).

In this module, students build upon their foundation with exponents as they make conjectures about how zero and negative exponents of a number should be defined and prove the properties of integer exponents (**8.EE.1**). These properties are codified into three Laws of Exponents. They make sense out of very large and very small numbers, using the number line model to guide their understanding of the relationship of those numbers to each other (**8.EE.3**).

Having established the properties of integer exponents, students learn to express the magnitude of a positive number through the use of scientific notation and to compare the relative size of two numbers written in scientific notation (**8.EE.3**). Students explore use of scientific notation and choose appropriately sized units as they represent, compare, and make calculations with very large quantities, such as the U.S. national debt, the number of stars in the universe, and the mass of planets; and very small quantities, such as the mass of subatomic particles (**8.EE.4**).

The Mid-Module Assessment follows Topic A. The End-of-Module Assessment follows Topic B.

Focus Standards

Work with radicals and integer exponents.

- 8.EE.1** Know and apply the properties of integer exponents to generate equivalent numerical expressions. *For example, $3^2 \times 3^{-5} = 3^{-3} = 1/3^3 = 1/27$.*
- 8.EE.3** Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. *For example, estimate the population of the United States as 3×10^8 and the population of the world as 7×10^9 , 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.

Foundational Standards

Understand the place value system.

- 5.NBT.2** Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10.

Apply and extend previous understandings of arithmetic to algebraic expressions.

- 6.EE.1** Write and evaluate numerical expressions involving whole-number exponents.

Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.

- 7.G.4** Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.
- 7.G.6** Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

Focus Standards for Mathematical Practice

- MP.2 Reason abstractly and quantitatively.** Students use concrete numbers to explore the properties of numbers in exponential form and then prove that the properties are true for all positive bases and all integer exponents using symbolic representations for bases and exponents. As lessons progress, students use symbols to represent integer exponents and make sense of those quantities in problem situations. Students refer to symbolic notation in order to contextualize the requirements and limitations of given statements (e.g., letting m , n represent positive integers, letting a , b represent all integers, both with respect to the properties of exponents).

- MP.3 Construct viable arguments and critique the reasoning of others.** Students reason through the acceptability of definitions and proofs (e.g., the definitions of x^0 and x^{-b} for all integers b and positive integers x). New definitions, as well as proofs, require students to analyze situations and break them into cases. Further, students examine the implications of these definitions and proofs on existing properties of integer exponents. Students keep the goal of a logical argument in mind while attending to details that develop during the reasoning process.
- MP.6 Attend to precision.** Beginning with the first lesson on exponential notation, students are required to attend to the definitions provided throughout the lessons and the limitations of symbolic statements, making sure to express what they mean clearly. Students are provided a hypothesis, such as $x < y$, for positive integers x , y , and then asked to evaluate whether a statement, like $-2 < 5$, contradicts this hypothesis.
- MP.7 Look for and make use of structure.** Students understand and make analogies to the distributive law as they develop properties of exponents. Students will know $x^m \cdot x^n = x^{m+n}$ as an analog of $mx + nx = (m + n)x$ and $(x^m)^n = x^{m \times n}$ as an analog of $n \times (m \times x) = (n \times m) \times x$.
- MP.8 Look for and express regularity in repeated reasoning.** While evaluating the cases developed for the proofs of laws of exponents, students identify when a statement must be proved or if it has already been proven. Students see the use of the laws of exponents in application problems and notice the patterns that are developed in problems.

Terminology

New or Recently Introduced Terms

- **Scientific Notation** (The scientific notation for a finite decimal is the representation of that decimal as the product of a decimal s and a power of 10, where s satisfies the property that it is at least 1, but smaller than 10, or in symbolic notation, $1 \leq s < 10$. For example, the scientific notation for 192.7 is 1.927×10^2 .)
- **Order of Magnitude** (The order of magnitude of a finite decimal is the exponent in the power of 10 when that decimal is expressed in scientific notation. For example, the order of magnitude of 192.7 is 2, because when 192.7 is expressed in scientific notation as 1.927×10^2 , 2 is the exponent of 10^2 . Sometimes we also include the number 10 in the definition of order of magnitude and say that the order of magnitude of 192.7 is 10^2 .)

Familiar Terms and Symbols²

- Exponential Notation
- Base, Exponent, Power
- Integer
- Whole Number
- Expanded Form (of decimal numbers)
- Square and Cube (of a number)
- Equivalent Fractions

Suggested Tools and Representations

- Scientific Calculator

Assessment Summary

Assessment Type	Administered	Format	Standards Addressed
Mid-Module Assessment Task	After Topic A	Constructed response with rubric	8.EE.1
End-of-Module Assessment Task	After Topic B	Constructed response with rubric	8.EE.3, 8.EE.4

² These are terms and symbols students have seen previously.