# High School: Algebra *Seeing Structure in Equations*

# And

# High School: Functions *Interpreting Functions*

This learning progression will take place in a 9th/10th grade Algebra class at Ellensburg High School. These lessons will align with the mathematics content standards 8.EE.A.1., HSA.SSE.B.3.C, HSF.IF.C.7.E, and HSF.IF.C.8.B, the textbook that will be used is McDougal Littell Algebra 1 2004. The learning progression will also be aligned with these mathematical practices: [MP4](http://www.corestandards.org/Math/Practice/MP4/) Model with mathematics and [MP6](http://www.corestandards.org/Math/Practice/MP6/) Attend to precision.

Students have spent the year learning about and solving equations and expressions using the order of operations. They have used their skills and knowledge to solve linear functions and inequalities as well as find representations for data from charts and graphs. For this learning progression they will be using their skills in order of operations as well as adding new exponent properties to solve and evaluate exponential problems and eventually be able to model exponential growth and decay with their exponential skills.

These lessons will be taught using a modified direct instruction. Students will be given direct instruction with examples and ideas to guide their discoveries, but the majority of problem solving used in the examples will come from student input. If there are conflicting opinions on the next steps for the examples, students will discuss and decide how to proceed. Instructor assistance will be available and given frequently to aide students during assignment work time.

***Write expressions in equivalent forms to solve problems.***

**CCSS.MATH.PRACTICE.MP6:** Attend to precision.

For the purpose of scaffolding the learning progression and building on the students’ knowledge, this learning progression will start with Section 8.1 Multiplication Properties of Exponents in the textbook, which is an introduction to exponent properties. Students should have some prior knowledge of exponents and exponent properties as they are introduced in the 8th grade. The class will begin with an entrance activity to review the basic properties of exponents. These will be gone over in class, as it has been a while since students have dealt with exponents. Students will be given the generalized forms of one of the properties and then given an example, they will be asked for input as to how the property is interpreted and how it can be used to solve the problem**8.EE.A.1**. This will be repeated for each of the three properties, and then the students will be given a few more complex examples that use more than one property and the same student led solving of the problem will be used to solve them **HSA.SSE.B.3.C**. Students will be given a homework assignment that is a mix of problems where they will be asked to either evaluate or solve exponential equations. If students are asked to Evaluate, they will need to reduce the equation or expression to the simplest exponential form. When students are asked to solve, they will need to reduce all expressions to simplest exponential form and if there are numerical bases that have exponents, these will need to be reduced further. These definitions will be discussed when the assignment is given as it is important that the student produce the type of answer the problem requests **MP6**.

**8.EE.A.1**
Know and apply the properties of integer exponents to generate equivalent numerical expressions.

**HSA.SSE.B.3.C**Use the properties of exponents to transform expressions for exponential functions.

**Benchmark Assessment** for the first lesson:

-Fill in the blanks and give a reason for each step to complete a convincing argument that the power of a power property is true:

(a2)3 = a2 

 =

 =

-Complete the Table

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| x | 0 | 1 | 2 | 3 | 4 |
| 2x |  |  |  |  |  |
| 2x |  |  |  |  |  |

Sketch the graphs of 2x and 2x on the same graph, compare and contrast, record your observations

The second lesson in this learning progression will begin the next section in the textbook, Section 8.2 Zero and Negative Exponents. This lesson will start with an entrance activity where students will review problems using the properties from the previous lesson. The instruction will begin with students filing out an exponent chart from 25 down to 21, we will then discuss and look for a patterns, multiplying by two is a common pattern with increasing exponents, but when the exponents are decreasing it is divide by 2, we will then use this to find 20 and again with 2-1 and so on and look for a pattern in he numbers under the radical discovering the negative exponent rule. We will repeat this with a base of 3 and a base of 0 to determine that this rule works for all numbers except for 0, as well as discovering that any base to the 0 power is equal to 1. Students will be given several examples that will be worked through in class led mostly by students to help them see how the negative exponents can ‘jump the bar’ to become positive, and that we do not want to see negative exponents in the final answers **HSA.SSE.B.3.C**.. They will also have an example of how to create a chart for an exponential equation and be shown how to graph itMP4. Again students will be reminded of the difference between evaluating an expression with exponents and solving an expression or equation. This again is extremely important, as their answer needs to be in the correct formMP6.

**HSA.SSE.B.3.C**Use the properties of exponents to transform expressions for exponential functions.

**CCSS.MATH.PRACTICE.MP6:** Attend to precision.

**Benchmark Assessment** for the second lesson:

-Sketch the graphs of y = 3x and y = (1/3)x and use them to predict how the graphs of y = *b*x and y = (1/*b*)x  are related.

**HSA.SSE.B.3.C**Use the properties of exponents to transform expressions for exponential functions.

**CCSS.MATH.PRACTICE.**[**MP4**](http://www.corestandards.org/Math/Practice/MP4/)**:**Model with mathematics.

**CCSS.MATH.PRACTICE.MP6:** Attend to precision.

The third lesson will again begin with another entry task based on the previous lesson. This lesson will be based on Section 8.3 Division Properties of Exponents. Much like the first lesson in the progression, students will be given a generalized version of the quotient property of exponents and expressions they will work through together with the teacher as notesHSA.SSE.B.3.C. They will also be given a couple examples for their notes and finally be asked to solve a rather large multi-step exponential problem using many of the properties of exponents. Students will work through this together out loud with the teacher on the boardHSA.SSE.B.3.C correcting themselves and each other as they go**MP6**. They will then be given their assignment, reminded again of the difference between evaluating and solving**MP6** exponentials.

**CCSS.MATH.PRACTICE.**[**MP4**](http://www.corestandards.org/Math/Practice/MP4/)**:**Model with mathematics.

**CCSS.MATH.PRACTICE.MP6:** Attend to precision.

**CCSS.MATH.CONTENT.HSF.IF.C.8.B**
Use the properties of exponents to interpret expressions for exponential functions. For example, identify percent rate of change in functions such as y = (1.02)ᵗ, y = (0.97)ᵗ, y = (1.01)12ᵗ, y = (1.2)ᵗ/10, and classify them as representing exponential growth or decay.

**Benchmark Assessment** for the third lesson:

-Find and correct the errors

1) $6^{3}÷6=\frac{6^{3}}{6}$

 =13

=1

2) $\frac{x^{-9}}{x^{-3}}=x^{-9-3}$

 = *x*-12

 $=\frac{1}{x^{-12}}$

The fourth lesson in the learning progression will be Section 8.5 Exponential Growth Functions(Section 8.4 will be skipped and returned to later). The lesson will begin as always with an entry task over the previous lesson. As notes for this section, students will be given examples of the exponential growth model and discuss each piece of the equation, what they mean and how to find themMP4. The class will solve several real-life examplesMP4 in the notes. These examples will include growth and decay functions and the difference in the equations and how to determine which **HSF.IF.C.8.B** will also be included in note material. Students will be then able to get some practice with the assignment where they will be asked to make tables of valuesMP4, determine function models from given information **HSF.IF.C.8.B**, and graph them if necessary.

**Benchmark Assessment** for the second lesson:

-Given a graph of the length to diameter of a bluebird, determine which model represents the graph, estimate the length of an adult bluebird based on your life experience, use the exponential growth model to estimate the length of an adult bluebird, how do these compare? Is this a good model?