# High School: Functions

# *Linear, Quadratic, & Exponential Models\**

This learning progression will take place in a 9th grade Algebra class at Ellensburg High School. These lessons will align with the mathematics content standards HSF.LE.A.1-3. The learning progression will also be aligned with these mathematical practices: [MP4](http://www.corestandards.org/Math/Practice/MP4/) Model with mathematics, [MP6](http://www.corestandards.org/Math/Practice/MP6/) Attend to precision, [MP7](http://www.corestandards.org/Math/Practice/MP7/) Look for and make use of structure.

Students have spent the year learning about and working with linear functions. They have used their skills and knowledge to find linear representations for data from charts and graphs, For this learning progression they will be using their skills to reason and problem solve to find equations that represent different types of data, pictorial or symbolic and numerical sequences as well as from graphs and charts. The students will use old and new skills to discover not all patterns can be represented by linear functions and will discover and form exponential and quadratic functions to represent the data where linear functions fail.

These lessons will be taught using cooperative and inquiry-based learning. Students will be given direct instruction with examples and ideas to guide their discoveries, but the majority of the learning will take place in small groups where students can guide one anther through their thought processes, self assess and self correct as well as assess and correct each other. Instructor assistance will be available and given frequently to aide and guide thought processes and steps to find equations.

#### Construct and compare linear, quadratic, and exponential models and solve problems.

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

For the purpose of scaffolding the learning progression and building on the sudents knowledge, the learning progression will start with graphs and charts, content and problems similar to that which they have mastered. Before breaking into groups, the class will go over some vocabulary necessary for understanding one another’s’ thoughts**MP6** in this type of group discussion, such as: sequence, pattern, number in sequence *n*, function, equation, and the class will also discuss and come up with some rules for how they will speak to each other when if and when they disagree. For their first activity, students will take a list of data from a table and graph the points and find the equation of the line through the points as they have done before to determine the data is linear, as they have done before in previous lessons. Next students will be given pictorial sequences, where they will be asked to relate the number of the image in the sequence to the number of pieces or shapes that make up the sequence, students may find patterns to create equations, or to make a table of the numbers and graph to find the equation. The purpose of the bench mark assessment for the first lesson is to see that when given a non-linear data set, students can distinguish that a linear equation will not represent the data, while recognizing that there is a pattern to the data**HSF.LE.A.1.A-C**.

**HSF.LE.A.1.A-C**
Distinguish between situations that can be modeled with linear functions and with exponential functions.

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

**CCSS.MATH.PRACTICE.**[**MP7**](http://www.corestandards.org/Math/Practice/MP7/)**:**Look for and make use of structure.

**Benchmark Assessment** for the first lesson: Graph the data

|  |  |
| --- | --- |
| x | y |
| 1 | 2 |
| 2 | 4 |
| 3 | 8 |
| 4 | 16 |
| 5 | 32 |
| 6 | 64 |

Can this data be fit with a liner function? Could it be represented by another type of function? Why or why not? Explain your reasoning.

The second lesson in this learning progression will begin with a student led review of the pictorial sequences from the previous day, to address misconceptions and make sure all students are at similar levels of understanding. Instructor will introduce math tiles to aide students in finding patterns in the sequences**MP7**. These tiles will be helpful to the student because this day’s sequences will not be linear and, while students know how to approximate these with linear functions, they will be asked to identify patterns and build functions that perfectly fit these series**HSF.LE.A.2.** These will turn out to be quadratic functions. After students work together using the tiles, they will be given a data table. This is more difficult to do with tiles so they may wish to graph the points and compare to the previous quadratic graphs and equations they have found, and work out the equation by comparison and using tiles**MP4**. Instructor help and hints will likely be a big aid for many groups, guiding questions and nudges in the right direction should be enough to help students get to correct answers. The Benchmark Assessment for the second lesson is to assess whether or not students can describe using precise mathematical language, describe a pattern they found in a quadratic sequence and how it differs from a patternfound in a linear sequence.

**CCSS.MATH.PRACTICE.**[**MP7**](http://www.corestandards.org/Math/Practice/MP7/)**:**Look for and make use of structure.

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

**Benchmark Assessment** for the second lesson: Using precise mathematical language, describe a pattern you noticed in a quadratic sequence and how it differs from the patterns of a linear sequence.

**[HSF.LE.A.2](http://www.corestandards.org/Math/Content/HSF/LE/A/2/)**
Construct linear, quadratic and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).

The third lesson will again begin with a student discussion of their knowledge of quadratic formulas, and go over the benchmark assessment from the previous day. Then, students will again work with their group to find equations to fit a set of data; this lesson’s equations will be exponential. Students will be given a data table to find an equation for. They will have the use of the math tiles again, to help them find the pattern**HSF.LE.A.2 MP7**, but they may find it easier to see a pattern between numbers rather than shapes. Again, instructor help will be available to the groups, but by this lesson the students should be more comfortable trying new things and working together to solve a problem. The purpose of the benchmark assessment is for students to be able to compare the three different types of functions**HSF.LE.A.3**, and describe their understanding using the vocabulary**MP6**.

**[HSF.LE.A.3](http://www.corestandards.org/Math/Content/HSF/LE/A/3/)**
Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.

**Benchmark Assessment** for the third lesson: On a sheet of graph paper, graph the functions in different colored pencils:

f(x)=2x

f(x)=x^2

f(x)=2^x

Discuss using precise mathematical language the behavior of the lines (higher, lower, or equal to) in relation to each other before x=1, at x=2, and after x=4.