**Unit 15: Exponential Growth and Decay**

**(*Same as Algebra 1 Unit 7*)**

**(4 weeks)**

**UNIT PLAN**

**Storyline**

This unit builds on the concepts of a function and patterns of change. Students work with interesting and significant relationships that are exponential in nature. Many of the contexts explored affect their daily lives. The unit begins with the topic of world population growth and food supply to compare the growth rates of exponential and linear models. This context follows the theme of world hunger and nutrition from the previous unit. Students begin to recognize that real world data is a bit messy and data patterns over restricted domains may be modeled with different functions.

In Investigation 2 students study the rules of exponents and develop meanings for negative and rational exponents. They are thus able to appreciate exponential functions. The power of exponential growth is brought home in the classic example of the doubling of grains of rice on a chess board.

In Investigation 3 students develop an understanding of the parameters of an exponential function. They look at functions which model exponential growth and decay. They learn informal methods of fitting an exponential function to a set of data.

Investigation 4 continues the exploration of growth and decay with additional hands-on activities that model change as well as data collection and simulation that models radioactive decay.

In Investigation 5 the relationship between percentage rate of change and exponential growth or decay is explored. Compound interest and prescription drug decay also are explored and modeled by doubling and half-life applications.

The final investigation centers on global warming and temperature change. This theme connects back to the sea rise investigation from Unit 7. It also connects to the Performance Task, where students investigate and debate possible relationships between carbon dioxide levels and global warming and pose potential consequences. Students will gain an appreciation for the power of mathematics in identifying and addressing solutions and making predictions and decisions about significant real world problems.

**Essential Questions**

What characterizes exponential growth and decay?

What are real world models of exponential growth and decay?

What are the limitations of exponential growth models?

How can one differentiate an exponential model from a linear model given a real world data set?

**Enduring Understandings**

When comparing an exponential model with a linear model, the question is not *if* the exponential model will generate very large or very small inputs, but rather *when*.

With real data, sometimes deciding whether data is linear or non-linear is more complex than just looking at a graph, differences ( yn – yn-1), or an r-value; it is important to examine differences that are approximately the same more carefully to see if there is a pattern of increasing or decreasing values that, because the pattern is exponential, soon begins to produce outputs of remarkable values.

**Unit Contents**

Investigation 1: A New Function Family—World Population Growth (2 days)

Investigation 2: Exponential Growth and Exponents (4 days)

Investigation 3: Exploring Parameters of Exponential Functions (3 days)

Investigation 4: Modeling Exponential Data (2 days)

Investigation 5: Exponential Patterns and Per Cent Change (3 days)

Investigation 6: Exponential Functions and Climate Change (2 days)

Performance Task: The Consequences Global Warming (2 days)

Review for Unit Test (1 day)

End of Unit Test (1 day)

**Common Core Standards**

*Mathematical Practices #1 and #3* *describe a classroom environment that encourages thinking mathematically and are critical for quality teaching and learning. Practices in bold are to be emphasized in the unit.*

**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.

**Standards Overview**

Extend the properties of exponents to rational exponents.

Interpret the structure of expressions

Write expressions in equivalent forms to solve problems

Analyze functions using different representations

Build a function that models a relationship between two quantities

Construct and compare linear and exponential models and solve problems

Interpret expressions for functions in terms of the situation they model

**Content Standards**

N-RN 1. Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents. *For example, we define 51/3 to be the cube root of 5* *because we want (51/3)3 = 5(1/3)3 to hold, so (51/3)3 must equal 5.*

N-RN 2. Rewrite expressions involving radicals and rational exponents using the properties of exponents.

A-SSE 1b. Interpret complicated expressions by viewing one or more of their parts as a single entity. *For example, interpret P*(1+*r*)n *as the product* *of P and a factor not depending on P.*

A-SSE 3c. Use the properties of exponents to transform expressions for exponential functions. For example the expression 1.15*t* can be rewritten as [1.15 (1/12)](12t) ≈1.012(12t) to reveal the approximate equivalent monthly interest rate if the annual rate is 15%.

F-IF 7. Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.\*

e. Graph exponential ... functions, showing intercepts and end behavior... F-IF 8b. 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) 12*t*, y = (1.2) (*t*/10), and classify them as representing exponential functions.

F-BF 2. Write ... geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms.\*

F-LE 1. Distinguish between situations that can be modeled with linear functions and with exponential functions.

a. Prove ... that exponential functions grow by equal factors over equal intervals....

c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.

F-LE 2. Construct linear 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).

F-LE 3. Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly...

F-LE 5. Interpret the parameters in a ... exponential function in terms of a context.

**Vocabulary**

Exponential Function

Exponential Growth

Exponential Decay

Growth Factor

Decay Factor

Per Cent rate of change

Doubling Time

Half life

Compound Interest

Asymptote

Laws of Exponents

**Assessment Strategies**

**Performance Task: The Consequences of Global Warming.** Students will research some phenomenon that may be impacted by climate change, find a data set, fit a function to the data and make predictions based on their model**.**

**Other Evidence (Formative and Summative Assessments)**

* Exit slips
* Class work
* Homework assignments
* Math journals
* Unit 7 Test