Lesson Title: Exponential Growth **Date:_____**

Subject: Algebra I or Algebra II	T**opic:** Exponential Functions
Grade: 8 - 11	**Designer:** Jessica Ulcickas

Stage 1 – Desired Results

Lesson Overview: This activity teaches students about exponential decay in real-life situations. The activity walks students through identifying various exponential decay equations for situations involving compound interest and population growth. By the end of the activity, students will have had exposure to two different equations used for situations involving exponential decay: $A = P(1 - r)^t$ and $A = Pe^{rt}$ where, in each case, r is negative. When the activity is completed, students will be able to identify an appropriate equation for various exponential decay situations and be able to read and identify important portions of the graphs of exponential functions.

Standards Addressed:

CCSS.MATH.CONTENT.HSF.IF.C.7.E
Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.

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 $y = (1.02)^t$, $y = (0.97)^t$, $y = (1.01)12^t$, $y = (1.2)^t/10$, and classify them as representing exponential growth or decay.

CCSS.Math.Content.HSF-BF.B.3 Identify the effect on the graph of replacing $f(x)$ by $f(x) + k$, $k\,f(x)$, $f(kx)$, and $f(x + k)$ for specific values of k (both positive and negative); find the value of k given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. Include recognizing even and odd functions from their graphs and algebraic expressions for them.

Enduring Understanding:	**Essential Questions**:
Exponential decay functions can be used to model various everyday situations. One use of exponential decay functions is to observe depreciation in the value of everyday items such as a car. Another use is to model radioactive decay. The decay of Carbon-14 can be used to determine the age of ancient artifacts. The two equations used in exponential decay are $A = P(1 - r)^t$ and $A = Pe^{rt}$ where r is negative in each case.	What types of situations can be modeled using exponential decay? How can you use graphs of exponential functions to predict information about the future? Why, when using exponential functions, is the y-intercept so important?

Students will need to know:	**Students will be able to**:
Students will need to have basic knowledge of functions and what their graphical representations are. Students should also be familiar with function transformations and how the graphical representation of a function changes when the equation is changed. Students should also become familiar with the formulas $A = P(1 - r)^t$ and $= Pe^{rt}$ where r is negative. Students should already be familiar with the number e.	• Identify the mathematical model to be used given a specific exponential decay situation. • Identify how much money something will be worth at a given time using graphs of exponential decay functions. • Identify how long it will take the value of something to depreciate by a particular value using graphs of exponential decay functions. • Identify the time at which a substance will decay to a certain amount using graphs of exponential decay functions. • Identify how much of a given substance will be left after a certain amount of time using graphs of exponential decay functions.

Stage 2 – Assessment Evidence

Performance Tasks:	**Other Evidence**:
In this activity: • Asking students to identify the mathematical model to be used given a specific exponential decay situation. • Asking students to identify how much money something will be worth at a given time using graphs of exponential decay functions. • Asking students to identify how long it will take the value of something to depreciate to a certain amount using graphs of exponential decay functions. • Asking students to identify the time at which a substance will decay to a certain amount using graphs of exponential decay functions. • Asking students to identify how much of a given substance will be left after a certain amount of time using graphs of exponential decay functions.	• To be decided by the teacher.

<table>
<tr><th colspan="2">Stage 3 – Learning Plan</th></tr>
<tr><td>Lesson Procedure:

<u>Many Days Before</u>:

Students will be introduced to the topic of exponential functions and their graphs. Students will also be introduced to the number e and the two exponential decay formulas ($A = P(1 - r)^t$ and $A = Pe^{rt}$ where r is negative.)

<u>Day Of</u>:
Students will go to the computer lab in order to complete this activity. For the duration of the activity, the teacher will monitor student progress to ensure that students complete the activity properly and do not simply click to complete. It is recommended that students take notes during the activity to help with their enduring understanding of the topic. The activity will not take all class period, so the remainder of the class period will be at the discretion of the classroom teacher.</td><td>Required Materials:

• Computers for each student.
• Notebooks for each student.</td></tr>
<tr><td>Possible Discussion Questions for Students:

• Oftentimes answers to questions involving exponential growth and decay are rounded. Why?

• You identified how long it takes a substance to decay to half as much as its initial quantity. Does this time change if you change the initial amount of the substance?</td><td>Sample Answers to Discussion Questions:

• Usually you are talking about something that has to be rounded. Money has to be rounded to two decimal places. You can’t have half of a person so population questions have to be rounded. Also, these equations are all exponential models, which means they are not perfect. They are giving estimates for the future, not exact values.

• No, the half-life will be the same no matter how much of a given substance you begin with.</td></tr>
</table>

• A car was given as an example of an item whose value depreciates over time. What other items that you purchase might this occur with? What type of investment might grow in value?	• Answers may vary. Sample answer: Anything technological may decline in value because new items are continuously invented that decrease the value of other ones. For example, televisions and phones keep improving; therefore older models will lose value. Houses and artwork are items that typically appreciate in value; however housing depends on market conditions.