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| **Math Objectives*** Students will explore the family of exponential functions of the form and be able to describe the effect of each parameter on the graph of *y*  *f* (*x*).
* Students will be able to determine the equation that corresponds to the graph of an exponential function.
* Students will understand that a horizontal dilation of the graph of an exponential function and a change of base of an exponential function are essentially the same.
* Students will look for and express regularity in repeated reasoning (CCSS Mathematical Practice).
* Students will look for and make use of structure (CCSS Mathematical Practice).

**Vocabulary**

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| * exponential function
 | * parameter
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| * translation
 | * reflection
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| * horizontal dilation
 | * change of base
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**About the Lesson*** This lesson involves the family of exponential functions of the form
* As a result, students will:
	+ Manipulate sliders, and observe the effect on the graph of the corresponding exponential function.
	+ Conjecture and draw conclusions about the effect of each parameter on the graph of the exponential function.
	+ Compare horizontal dilations and change of base and manipulate equations to demonstrate they are the same.
	+ Match specific exponential functions with their corresponding graphs.

**TI-Nspire™ Navigator™ System*** Transfer a File.
* Use Screen Capture to examine patterns that emerge.
* Use Live Presenter to demonstrate.
* Use Quick Poll to assess students’ understanding.
 | **TI-Nspire™ Technology Skills:*** Download a TI-Nspire document
* Open a document
* Move between pages
* Grab and drag a point

**Tech Tips:*** Make sure the font size on your TI-Nspire handhelds is set to Medium.
* You can hide the function
* entry line by pressing ctrl G

**Lesson Files:***Student Activity*Transformations\_of\_Exponential\_Functions\_Part\_2\_Student.pdf Transformations\_of\_Exponential\_Functions\_Part\_2\_Student.doc*TI-Nspire document*Transformations\_of\_Exponential\_Functions\_Part\_2.tnsVisit [www.mathnspired.com](http://www.mathnspired.com/) for lesson updates and tech tip videos. |

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| **Discussion Points and Possible Answers** |
| **Tech Tip:** To change a slider setting, right-click in the slider box, and select option 1. Consider changing the (start) value, minimum and/or maximum value, and/or the step size in order to help discover or confirmthe effect of a specific parameter. |

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| **Move to page 2.1.**1. The graph of  is shown in the right panel. For a specific value of , click the arrows to change the value of  and observe the changes in the graph of  Repeat this process for other values of a. Explain why for every value of  the graph of  passes through the point **Answer:** The graph of *y*  *bx* passes through the point (0,1) for all values of *b*  0 because *b*0  1. The graph of is the graph of  with a vertical translation of units and  |  |
| b. Is it possible for the graph of  to intersect the -axis? Explain why or why not.**Answer:** The *x* -axis, the line *y*  0, is a horizontal asymptote to the graph of *y*  *bx*. If the graph of the function has a vertical translation of  units, the graph of the function would intersect the -axis.  Possible example:  |  |
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| **Teacher Tip:** The slider for the variable *b* is set to minimized, style:vertical, and initially set such that it includes the value 1. Most definitions of an exponential function stipulate *b*  1. |
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| **TI-Nspire Navigator Opportunity: *Screen Capture and Quick Poll*****See Note 1 at the end of this lesson.** |
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| **Move to page 3.1.**2. The graph of  is shown in the right panel. For a specific value of , click the arrows to change the value of  and observe the changes in the graph of  Repeat this process for other values of a. Describe the effect of the parameter  on the graph of  Discuss the effects of both positive and negative values of **Answer:**The graph has a horizontal dilation. For | *a* | 1, the graph of  is compressed horizontally by a factor of  For | *a* | 1, the graph of is stretched horizontally by a factor of  If *a*  0, the graph is reflected across the *y* -axis. |  |
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| **TI-Nspire Navigator Opportunity: *Screen Capture and Quick Poll*****See Note 1 at the end of this lesson.** |
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| **Move to page 4.1.**3.The graph of  is shown in the right panel. For specific values of  and , click the arrows to change the value of , and observe the changes in the graph of  Repeat this process for other values of  and  a. Describe the effect of the parameter  on the graph of  Discuss the effects of both positive and negative values of **Answer:** The graph has a vertical translation. For  the graph of is translated up. For  the graph of is translated down. |  |
| **TI-Nspire Navigator Opportunity: *Screen Capture and Quick Poll*****See Note 1 at the end of this lesson.** |
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| **Move to page 5.1.**4. Display the graphs of  and  a. Describe the similarities between these two graphs. Use the properties of exponents to justify your answer. **Answer:** The graphs of these two exponential functions are the same.  b. Insert a new problem, and display the graph of  Use the properties of exponents to find a function of the form  such that the graphs of  and  are the same. Verify your answer. **Answer:**  The graphs of  and  are the same.  c. Use your answers to parts (a) and (b) to explain the relationship between a horizontal dilation of the graph of an exponential function and a change of base of an exponential function. **Answer:** A horizontal dilation of the graph of an exponential function and a change of base are essentially the same. Consider the following expression to show this analytically. where  a constant, and  This demonstrates that any horizontal dilation can also be considered a change of base of exponential functions. |  |
| 5. Without using your calculator, match each equation with its corresponding graph. Check your answers by graphing each function on your calculator.(a)  (b)  (c)  (d)  (e)  (f) Note: The function in part (e) is the “natural” exponential function and involves the number

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| (i) | A graph of a function  Description automatically generated | (ii) | A screen shot of a graph  Description automatically generated |
| (iii) | A screen shot of a graph  Description automatically generated | (iv) | A graph of a function  Description automatically generated |
|  |  |  |  |
| (v) |  | (vi) | A graph of a function  Description automatically generated |

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| **Answers:** (a) (vi); (b) (iii); (c) (ii); (d) (i); (e) (iv); (f) (v).**Wrap Up**Upon completion of the lesson, the teacher should ensure that students are able to: |
| * Graph and analyze an exponential function of the form
* Explain the concepts of dilation and translation.
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| **TI-Nspire Navigator**Note 1**Name of Feature: Screen Capture and Quick Poll**Use Screen Capture to compare student graphs for various values of each parameter.A Quick Poll can be given at several points during this lesson. It can be useful to save the results and show a Class Analysis. |
| Sample Multiple Choice questions. |
| For how many times does the graph of  cross the x-axis?1. 0
2. 1
3. 2
4. Infinitely many
 |
| **Answer: (a)** |
| How does the graph of compare to the graph of 1. Translated 3 units to the right
2. Translated 3 units to the left
3. Translated 3 units up
4. Translated 3 units down.
 |
| **Answer: (d)** |
| Which of the following is equivalent to 1.
2.
3.
4.
 |
| **Answer: (b)** |