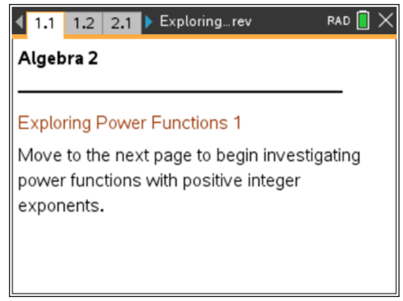


Math Objectives

- Students will be able to describe the end behaviors of functions of the form y = x^n where *n* is a positive integer.
- Students will be able to justify why the three points (–1, –1), (0, 0), and (1, 1) are common to any function of the form $y = x^n$ where n is an even integer.
- Students will be able to justify why the three points (–1, –1), (0, 0), and (1, 1) are common to any function of the form $y = x^n$ where *n* is an odd integer.
- Students will be able to identify the symmetry in even and odd power functions and describe the line or point of symmetry.
- Students will construct viable arguments & critique the reasoning of others (CCSS Mathematical Practice).
- Students will use appropriate tools strategically (CCSS Mathematical Practice).

Vocabulary

- end behavior
- symmetry
- power/exponent

About the Lesson

- This lesson involves examining the graphs of power functions with even and odd positive integer exponents. End behavior, key points, and symmetry are explored.
- As a result, students will:
  - Be able to describe the shape, end behavior, and key points of power functions with positive integer exponents.
  - Be able to describe the symmetry of even and odd power functions.

TI-Nspire™ Navigator™ System

- Screen Capture and Live Presenter can be used to monitor student progress and allow students to share their investigations.
- The student TI-Nspire document file could be sent with TI-Navigator to effectively begin the lesson.
- Quick Poll can be used to guide instruction.

TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Grab and drag a point
- Click on a slider

Tech Tips:

- Make sure the font size on your TI-Nspire handheld is set to Medium.
- In the Graphs page, you can retrieve the entry line by pressing ctrl G.

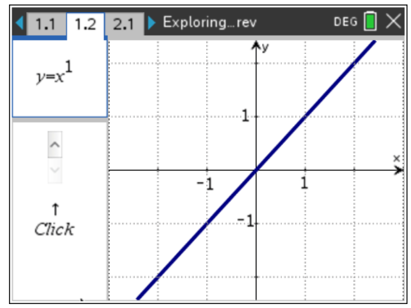
Lesson Materials:
Student Activity
Exploring_Power_Functions_1.pdf
Exploring_Power_Functions_1.doc
TI-Nspire document
Exploring_Power_Functions_1.tns

Visit www.mathnspired.com for lesson updates and tech tip videos.

Discussion Points and Possible Answers

TI-Nspire Navigator Opportunity: ***File Transfer***
See Note 1 at the end of this lesson.

Move to page 1.2.



1. Click the slider along the left side of the screen to change the value of *p* to odd values from 1 to 15. The graph will change as the value of *p* changes.

   a. Describe the appearance of the graph as *p* changes. How are the graphs similar? How are they different?

   Sample answer: Answers may vary, but should include reference to the graph increasing or "going up" from left to right. Also, students should notice that the graph appears to get "steeper" as *p* increases. They may also discuss that the graph starts as a line but begins to curve as the value of *p* increases.

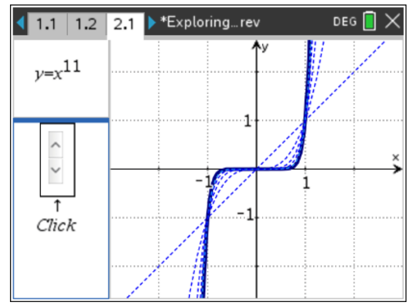
   b. Why are the *y*-values negative for negative *x*-values?

   Answer: Students should discuss that when you raise a negative value to an odd power, the result will be a negative number. For example, $(–3)^3 = –27$. This happens for all the negative values along the *x*-axis.

   Teacher Tip: Allow students time to explore. The graphs update faster on the computer than on the handhelds. Be sure to give students enough time to work through all pages and questions.

TI-Nspire Navigator Opportunity: ***Screen Capture*** **or** ***Live Presenter***
See Note 2 at the end of this lesson.

Move to page 2.1.



2. Click the slider along the left side again. This time a "trail" of graphs remains as p changes to odd values.

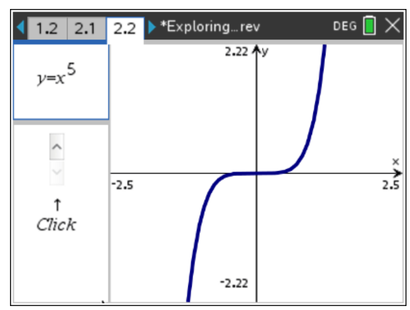
   a. What points are common to all the graphs on this page?

   Answer: This page should help students recognize that (1, 1), (0, 0), and (–1, –1) are common to all graphs.

   b. Why are they common to all the graphs?

   Answer: These points are common regardless of the exponent because when 1, 0, or –1 is raised to any odd power, the result is 1, 0, or –1, respectively.

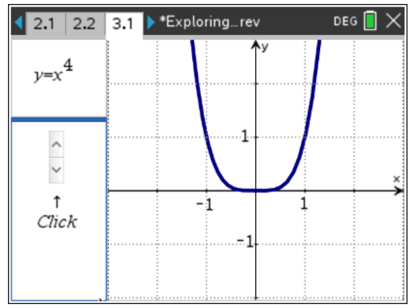
Move to page 2.2.



3. Clicking the slider along the left side will zoom in or zoom out on the graph of $y = x^5$. Recall that the end behavior of a graph is how the y-values of the graph behave for very large or very small values of x. What do you notice about the end behavior of this graph?

   Answer: This page is designed to allow students to visualize the end behavior of the graph. Their answers should make reference to the fact that the graph increases as x increases and decreases as x decreases, or that the graph rises as x increases and falls as x decreases.

Move to page 3.1.



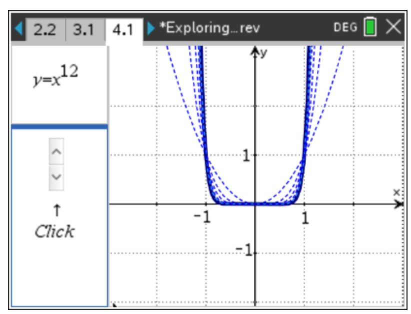
4. Clicking the slider along the left side of the screen will change the value of *p*. This time, even exponents will be used.
   a. Describe the appearance of the graphs as *p* changes. Why do the graphs have this shape?

      Answer: The graph appears to be "U-shaped" with the bottom getting "flatter" as *p* increases. When you raise a negative number to an even power, you get a positive result. Also, when you raise a number (between –1 and 1) to an even power greater than or equal to 2, the result will be smaller but will remain positive.

   b. Why are the *y*-values positive when the *x*-values are negative?

      Answer: When the values of *x* are negative, the values of *y* are positive. When you raise a negative number to an even power, the result is a positive number.

Move to page 4.1.



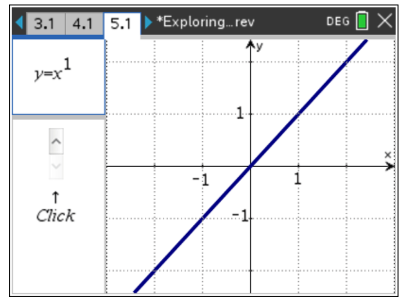
5. Click the slider along the left side again. A "trail" of graphs should remain as *p* changes to even values from 2 to 12.
   a. When the graph is of the form $y = x^p$ and *p* is even and greater than or equal to 2, what points do each function have in common?

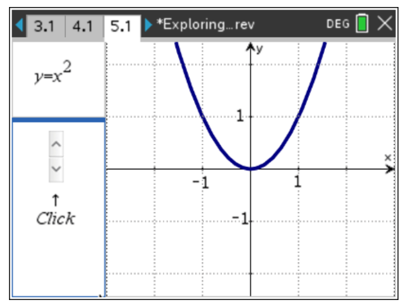
   Answer: This page is similar to 2.1 but with even powers. The common points are (1, 1), (0, 0), and (–1, 1)

b. Why are the points different than when *p* was odd?

Answer: When you raise –1 to an even power, the result is 1. When you raise 0 and 1 to an even power, the results are 0 and 1, respectively.

Move to page 5.1.





6. Clicking the slider will show the graphs for all values of *p* from 1 to 15.
   a. Describe how the shape and end behavior of the graphs change as *p* changes.

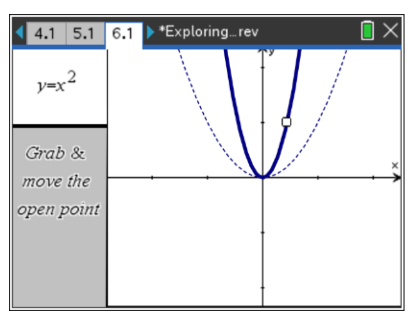
   Sample answer: Student answers may vary, but they should include that the graphs alternate between "U-shaped" and "rising graphs," or similar comparisons. They should also discuss that even powers produce graphs in the first and second quadrants while the odd powers produce graphs in the first and third quadrants.

   b. Why do the graphs change as you alternate between even and odd values of *p?*

   Answer: The major difference happens on the negative side of the *x*-axis. When the power is even, the negative *x*-values are positive. When the power is odd, the negative *x*-values are negative. This is illustrated by the graph "alternating" between the second and third quadrants.

Teacher Tip: This activity does not specifically deal with $p = 0$, but if a student brings it up, be prepared to discuss the issue. When $p = 0$, the result is $y = x^0$. The graph is similar to $y = 1$ except that it has a discontinuity (i.e., a hole) at $x = 0$ because 0^0 is undefined.

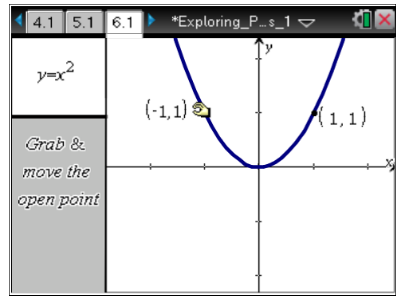
Move to page 6.1.



7. Recall that when an object has symmetry, it can be reflected, rotated, or translated and remain unchanged. The point (1, 1) is marked on an even power function graph. This point can be grabbed and moved to show symmetry. Where does the point move to? What kind of

symmetry does this curve have? Explain.

Answer: The point moves to (–1, 1), which illustrates *y*-axis, or vertical, symmetry. This is shown by the movement of the graph and the fact that the *y*-coordinate is the opposite of the initial value.



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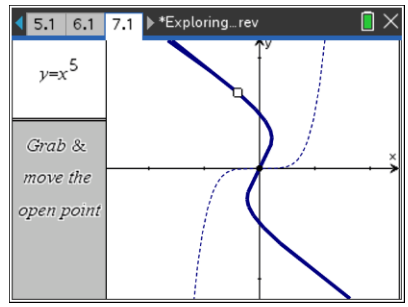
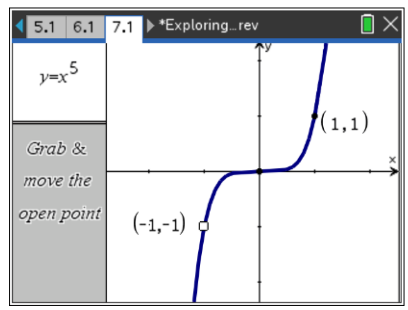
8. The point (1, 1) is marked on an odd power function graph. This point can be grabbed and moved to show symmetry. Where does the point move to? What kind of symmetry does this curve have? Explain.





Answer: The point moves to (–1, –1), which illustrates origin or rotational symmetry. This is shown by the movement of the graph and the fact that the *x*- and *y*-coordinates are the opposite of the initial values.

Note: Symmetry is a property tested by transforming the entire figure, not merely part of it. If the entire parabola is reflected in the *y*-axis, it lands exactly on itself. If a cubic graph is rotated about the origin, it lands exactly on itself.

TI-Nspire Navigator Opportunity: *Quick Poll*
See Note 3 at the end of this lesson.

Wrap Up

Upon completion of the discussion, the teacher should ensure that students understand:

- How to compare and contrast power functions with even and odd positive integer exponents.
- How to identify common points on power functions based on the exponent.
- How to identify the symmetry of a power function based on the exponent.

TI-Nspire Navigator

Note 1

Entire Document, *File Transfer:* Use *File Transfer* to efficiently send the TI-Nspire document file to students. Using TI-Navigator will allow students to receive the file without having to leave their seats or use extra cables.

Note 2

Entire Document, *ScreenCapture* or *Live Presenter:* If students experience difficulty with operation of a file or a question, use *Screen Capture* or *Live Presenter* with TI-Navigator. You can also use this as a way to facilitate student discussion.

Note 3

End of Lesson, *Quick Poll:* A *Quick Poll* can be given at the conclusion of the lesson. You can save the results and show a review of them at the start of the next class to discuss possible misunderstandings students may have.

The following are some sample questions you can use:

1. If (3, 27) is a point on a power function with rotational symmetry, which of the following points will also be on the graph?
   a. (–3, 27)
   b. (–1, 1)
   c. (0, 1)
   d. (3, –27)

2. What is the end behavior of the power function $y = x^{73}$?
   a. Both ends go up
   b. Both ends go down
   c. Right end goes up and left end goes down
   d. Right end goes down and right end goes up
3. True or False: A power function with an even positive integer exponent has *x*-axis symmetry.

   <u>Answer:</u> False