Algebra I : **This is the same Algebra Nation. Answer key will be on teacher website. Be sure to look on algebranation.com to see videos for step by step instruction.**

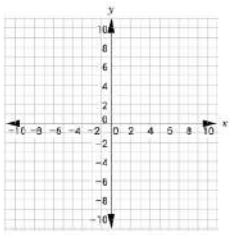
Section 8: Summary of Functions

Section 8 – Topic 1
Comparing Linear, Quadratic, and Exponential Functions – Part 1

Complete the table below to describe the characteristics of linear functions.

Linear Functions	
Equation	
Shape	
Rate of Change	
Number of x-intercepts	
Number of y-intercepts	
Number of vertices	
Domain	
Range	

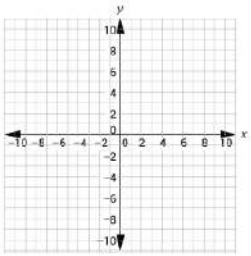
Sketch the graphs of three linear functions that show all the possible combinations above.



Complete the table below to describe the characteristics of quadratic functions.

Quadratic Functions	
Equation	
Shape	
Rate of Change	
Number of x-intercepts	
Number of y-intercepts	
Number of vertices	
Domain	
Range	

Sketch the graphs of three quadratic functions that show all the possible combinations above.



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Section 8: Summary of Functions

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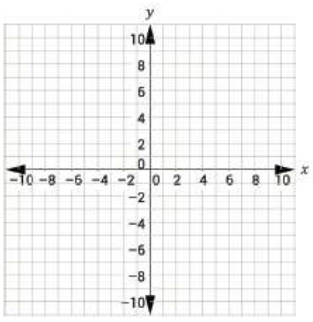
Complete the table below to describe the characteristics of exponential functions.

Exponential Functions	
Equation	
Shape	
Rate of Change	
Number of x-intercepts	
Number of y-intercepts	
Number of vertices	
Domain	
Range	

Sketch the graphs of two exponential functions that show all the possible combinations above.



Consider the following tables that represent a linear and a quadratic function and find the differences.

Linear Function	
x	$f(x)$
0	5
1	7
2	9
3	11
4	13

Quadratic Function	
x	$f(x)$
0	3
1	4
2	7
3	12
4	19

How can you distinguish a linear function from a quadratic function?

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Section 8: Summary of Functions

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Consider the following table that represents an exponential function.

Exponential Function	
x	$f(x)$
0	1
1	3
2	9
3	27
4	81
5	243

How can you determine if a function is exponential by looking at a table?

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Section 8: Summary of Functions

Section 8 – Topic 2
Comparing Linear, Quadratic, and Exponential Functions – Part 2

Let's Practice!

1. Identify whether the following key features indicate a model could be linear, quadratic, or exponential.

Key Feature	Linear	Quadratic	Exponential
Rate of change is constant.	○	○	○
2nd differences, but not 1st, are constant.	○	○	○
Graph has a vertex.	○	○	○
Graph has no x-intercept.	○	○	○
Graph has two x-intercepts.	○	○	○
Graph has one y-intercept.	○	○	○
Domain is all real numbers.	○	○	○
Range is $\{y \mid y > 0\}$.	○	○	○
Range is $\{y \mid y \leq 0\}$.	○	○	○
Range is all real numbers.	○	○	○

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Try It!

2. Determine whether each table represents a linear, quadratic, or exponential function.

x	y
0	1
1	2
2	5
3	10
4	17

o Linear
o Quadratic
o Exponential

x	y
0	7
3	13
6	19
9	25
15	37

o Linear
o Quadratic
o Exponential

x	y
0	2
1	6
2	18
3	54
4	162

o Linear
o Quadratic
o Exponential

BEAT THE TEST!

1. Identify whether the following real-world examples should be modeled by a linear, quadratic, or exponential function.

Real-World Example	Linear	Quadratic	Exponential
Growing a culture of bacteria	○	○	○
The distance a Boeing 737 MAX can travel at a certain speed over a given period of time	○	○	○
Kicking a ball into the air	○	○	○
Running a race at a constant speed	○	○	○
A pumpkin decaying	○	○	○
Jumping from a high dive	○	○	○

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Section 8: Summary of Functions

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2. Complete the following table so that $f(x)$ represents a linear function and $g(x)$ represents an exponential function.

x	$f(x)$	$g(x)$
-5		
-4		
-3		
-2		
-1		

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Section 8 – Topic 3
Comparing Arithmetic and Geometric Sequences

The founder of a popular social media website is trying to inspire gifted algebra students to study computer programming. He is offering two different incentive programs for students.

Option 1: Students will earn one penny for completing their first math, science, or computer-related college course. The amount earned will double for each additional course they complete.

Option 2: Students will earn one penny for completing their first math, science, or computer-related college course. Students will earn \$100.00 for each additional course they complete.

Write an explicit formula for each option.

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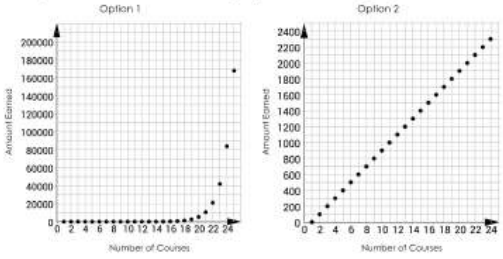
Compare the two scholarship options in the tables below.

Option 1	
Course	Amount
1	\$0.01
2	\$0.02
3	\$0.04
4	\$0.08
5	\$0.16
6	\$0.32
7	\$0.64
8	\$1.28
9	\$2.56
10	\$5.12
11	\$10.24
12	\$20.48
13	\$40.96
14	\$81.92
15	\$163.84
16	\$327.68
17	\$655.36
18	\$1,310.72
19	\$2,621.44
20	\$5,242.88
21	\$10,485.76
22	\$20,971.52
23	\$41,943.04
24	\$83,886.08
25	\$167,772.16

Option 2	
Course	Amount
1	\$0.01
2	\$100.01
3	\$200.01
4	\$300.01
5	\$400.01
6	\$500.01
7	\$600.01
8	\$700.01
9	\$800.01
10	\$900.01
11	\$1,000.01
12	\$1,100.01
13	\$1,200.01
14	\$1,300.01
15	\$1,400.01
16	\$1,500.01
17	\$1,600.01
18	\$1,700.01
19	\$1,800.01
20	\$1,900.01
21	\$2,000.01
22	\$2,100.01
23	\$2,200.01
24	\$2,300.01
25	\$2,400.01

Compare the two scholarship options in the graphs below.



Option 1 is a geometric sequence.

- Consecutive terms in this sequence have a common _____.
- This geometric sequence follows a(n) _____ pattern.
- Evaluate the domain of this function.

Option 2 is an arithmetic sequence.

- Consecutive terms in this sequence have a common _____.
- Arithmetic sequences follow a(n) _____ pattern.
- Evaluate the domain of this function.

What can be said about the domain of arithmetic and geometric sequences?

Mar 13-6:24 PM

Let's Practice!

1. Consider the two scholarship options for studying computer science.

   a. Which scholarship option is better if your college degree requires 10 math, engineering, or programming courses?

   b. What if your degree requires 25 math, engineering, or programming courses?

   c. Do you think that these graphs represent discrete or continuous functions? Justify your answer.

   d. Do you think Option 1 would ever be offered as a scholarship? Why or why not?

Try It!

2. Pablo and Lily are saving money for their senior trip next month. Pablo's goal is to save one penny on the first day of the month and to triple the amount he saves each day for one month. Lily's goal is to save $10.00 on the first day of the month and increase the amount she saves by $5.00 each day.

   a. Pablo's savings plan is an example of a(n)

   o arithmetic sequence.
   o geometric sequence.

   b. Lily's savings plan is an example of a(n)

   o arithmetic sequence.
   o geometric sequence.

   c. Which person do you think will be able to meet his/her goal? Explain.

3. Circle the best answers to complete the following statement.

   Arithmetic sequences follow a(n) linear | exponential | quadratic pattern, whereas geometric sequences follow a(n) linear | exponential | quadratic pattern, and the domain of both sequences is a subset of the integers | radicals | exponents.

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BEAT THE TEST!

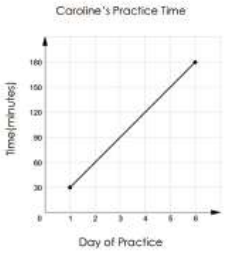
1. Caroline and Chris have a piano recital in six days. They are discussing their plans to increase the frequency of practice. Caroline's practice plans are listed in the table below. Chris plans to practice half of Caroline's time on Day 1, but will double his practice time every day for the remaining five days.

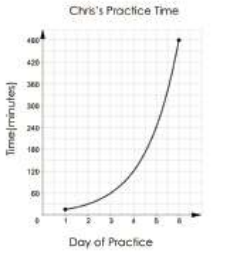
   Part A: List Caroline's and Chris's practice times on the tables below.

Caroline's Practice Times (in Minutes)	
Day 1	30
Day 2	60
Day 3	90
Day 4	120
Day 5	150
Day 6	180

Chris's Practice Times (in Minutes)	

Part B: Compare the graphs of Caroline's and Chris's practice times. Identify each graph as linear or exponential.





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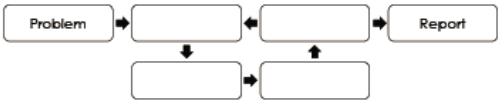
Section 8 – Topic 4
Modeling with Functions

Let's discuss the modeling cycle process.

Consider and complete the following diagram that displays the modeling cycle process.



Let's Practice!

1. The table below represents the population estimates (in thousands) of the Cape Coral-Fort Myers metro area in years since 2010. Employ the modeling cycle to create a graph and a function to model the population growth. Use the function to predict the population in 2020.

x	0	1	2	3	4	5	6
$f(x)$	619	631	645	661	679	699	721

Problem – Identify the variables in the situation and select those that represent essential features.

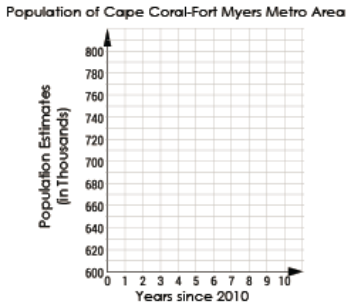
a. What are the variables in this situation and what do they represent?

Formulate a model by creating and selecting geometric, graphical, tabular, algebraic, or statistical representations that describe relationships between the variables.

b. Determine what type of function models the context.

Compute – Analyze and perform operations on these relationships to draw conclusions.

c. Sketch the graph and find the function that models the table.



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d. Use the model to predict the population in the year 2020.

Interpret the results of the mathematics in terms of the original situation.

e. What do the results tell you about the population growth in Cape Coral-Fort Myers metro area as it relates to the original table?

Validate the conclusions by comparing them with the situation, and then either improve the model, or, if it is acceptable, move to the reporting phase.

f. What methods can we use to validate the conclusions?

Report on the conclusions and the reasoning behind them.

g. What key elements should be included in your report?

Try It!

2. According to Florida's Child Labor Law, minors who are 14 or 15 years old may work a maximum of 15 hours per week, and minors that are 16 or 17 years old may work a maximum of 30 hours per week. The relationship between the number of hours that a 15-year old minor in Florida works and his total pay is modeled by the graph below. What is the maximum amount that he can earn in a week?

Phase 1: _____

a. Identify the variables in the situation and what they represent.

Phase 2: _____

b. What type of function can be represented by this graph?

c. Describe the end behavior of the graph.

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d. What does the end behavior tell you about the function?

Phase 3: _____

e. What strategy will you use to create the model for this situation?

f. Find the function of the graph.

Phase 4: _____

g. Complete the following statement.

The domain that best describes this situation is

{x|x ∈ o rational numbers}.
o natural numbers}.
o whole numbers}.

h. What constraints on the domain would exist for a 14-year old? A 17-year old?

i. How much does the student make per hour? Justify your answer algebraically.

Phase 5: _____

j. Verify that your function accurately models the graph.

k. Are there other ways to validate your function?

Phase 6: _____

l. What would you report?

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BEAT THE TEST!

1. Dariel employed the modeling cycle to solve the following problem.

Hannah's uncle works at the BMW plant in Spartanburg, South Carolina. He purchased a 2017 BMW M2 for Hannah at the manufacturer's suggested retail price (MSRP) of $52,500. Suppose over the next ten years, the car will depreciate an average of 9% per year. Hannah wishes to sell the car when it is valued at $22,000. When should she sell the car?

When Dariel got to the compute phase, he knew something was wrong. His work is shown below.

Problem: The variables in the situation are the number of years Hannah has owned the car and the value of the car after a given number of years.

Let x = number of years Hannah has owned the car.

Let f(x) = current value of the car when Hannah has owned it x years.

Formulate: An exponential function should be used to model the context because the car is depreciating at a common ratio.

Compute: The function f(x) 52,500(.09)^x models the context where x is the years since 2017 and f(x) is the value of the car. I am going to use a table of values starting at year 2 to try to determine when the car is worth 15,000.

x	f(x)
2	$425.25

Ugh! This cannot be correct. A 2017 BMW M2 can't be worth just $425.25. HELP!!

Part A: Critique his reasoning and give feedback on where he went wrong.

Part B: Complete the modeling cycle.

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BEAT THE TEST!

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Section 8 – Topic 5
Understanding Piecewise-Defined Functions

What is a ***piecewise function***?

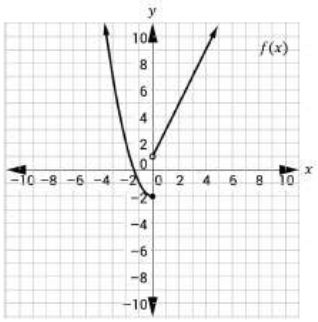
- A function made up of distinct "_____" based on different rules for the _____.
- The "pieces" of a piecewise function are graphed together on the same coordinate plane.
- The ***domain*** is the _____, or the x-values.
- The ***range*** is the ____-values, or output.
- Since it is a function, all "pieces" pass the vertical line test.

Describe an example of a piecewise function used in our daily lives.

Consider the following piecewise-defined function.

$$f(x) = \begin{cases} x^2 - 2, \text{when } x \leq 0 \\ 2x + 1, \text{when } x > 0 \end{cases}$$

- Each function has a defined _____ value, or rule.
  - x is less than or equal to zero for the first function.
  - x is greater than zero for the second function.
- Both of these functions will be on the same graph. They are the "pieces" of this completed piecewise-defined function.



Label the "pieces" of $f(x)$ above.

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Let's note some of the features of the graph.

- The domain of the piecewise graph can be represented with intervals. If we define the first interval as $x \leq 0$, the second interval would be _____.
- The graph is nonlinear (curved) when the domain is _____.
- The graph is linear when the domain is _____.
- There is one closed endpoint on the graph, which means that the particular domain value, zero, is _____ in that piece of the function. This illustrates the inclusion of zero in the function _____.
- There is one open circle on the graph, which means that the particular value, zero, is _____ _____ in that piece of the function. This illustrates the constraint that $x > 0$ for the function _____.

Let's Practice!

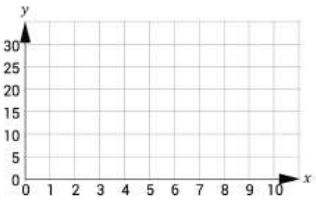
1. Airheadz, a trampoline gym, is open seven days a week for ten hours a day. Their prices are listed below:

   Two hours or less: \$15.00
   Between two and five hours: \$25.00
   Five or more hours: \$30.00

   The following piecewise function represents their prices:

$$f(x) = \begin{cases} 15, \text{when } 0 < x \leq 2 \\ 25, \text{when } 2 < x < 5 \\ 30, \text{when } 5 \leq x \leq 10 \end{cases}$$

   Graph the above function on the following grid.



Mar 13-6:26 PM

- $f(x)$ is a special type of piecewise function known as a _____ function, which resembles a series of steps.
- Step functions pair every x-value in a given interval (particular section of the _____) with a single value in the range (_____-value).

Try It!

2. Consider the previous graph in exercise 1.
   a. How many pieces are in the step function? Are the pieces linear or nonlinear?
   b. How many intervals make up the step function? What are the interval values?
   c. Why are open circles used in some situations and closed circles in others?
   d. How do you know this is a function?
   e. What is the range of this piecewise function?

BEAT THE TEST!

1. Evaluate the piecewise-defined function for the given values of x by matching the domain values with the range values.

$$f(x) = \begin{cases} x - 1, & x \leq -2 \\ 2x - 1, & -2 < x \leq 4 \\ -3x + 8, & x > 4 \end{cases}$$

x	$f(x)$
8	7
−2	3
4	−3
2	−16
−5	−6
0	−1

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2. Complete the following sentences by choosing the correct answer from each box.

Part A: Piecewise-defined functions are represented by

- o one function
- o at least one function
- o at least two functions

that must correspond to

- o different domain values.
- o different range values.
- o real numbers.

Part B: When evaluating piecewise-defined functions, choose which equation to use based on the

- o constant,
- o x-value,
- o slope,

then substitute and evaluate using

- o exponent rules.
- o order of operations.
- o your instincts.

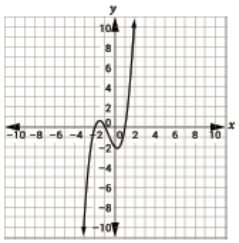
Section 8 – Topic 6
Finding Zeros of Polynomial Functions of Higher Degree

How can you find zeros when given the graph of a polynomial function?

How can you find zeros when given the equation of a polynomial function in factored form?

How do you determine if x is a solution or zero for $f(x)$?

Consider the following graph of $f(x)$.



What are the zeros of $f(x)$?

Mar 13-6:26 PM

Consider the following fourth degree polynomial function.

$$g(x) = x^4 - 4x^2$$

Find the range of $g(x)$ for the given domain $\{-2, -1, 0, 1, 2\}$.

Does the above domain contain zeros of $g(x)$? Justify your answer.

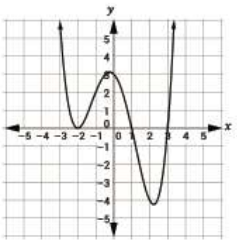
Consider the following third degree polynomial function.

$$h(x) = -x^3 - 5x^2$$

Find the zeros of the function $h(x)$.

Let's Practice!

1. Consider the following graph of $f(x)$.



What are the zeros of $f(x)$?

2. What are the zeros of $g(x) = x(x+1)(x-2)^2$?

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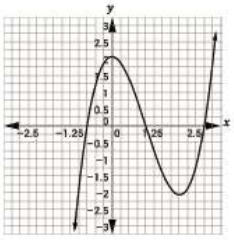
Try It!

3. Consider the function $h(x) = x^3 - 3x^2 + 2$.

   a. Find the range of $h(x)$ given domain $\{-1, 1, 3\}$.

   b. Are any zeros of $h(x)$ found in the above domain? Justify your answer.

   c. Consider the graph of $h(x)$.

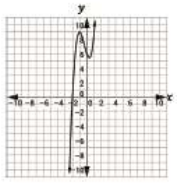


What are the other zeros of $h(x)$?

BEAT THE TEST!

1. Which of the graphs has the same zeros as the function $f(x) = 2x^3 + 3x^2 - 9x$?

Ⓐ



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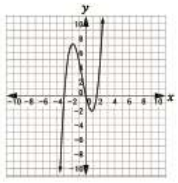

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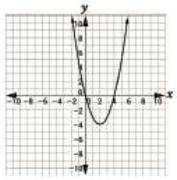

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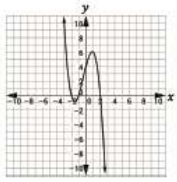

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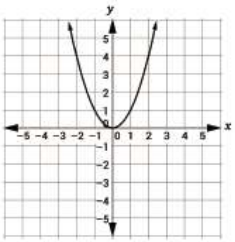
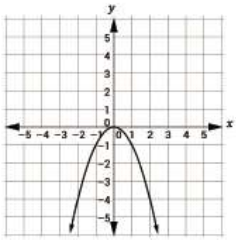
Section 8 – Topic 7
End Behavior of Graphs of Polynomial Functions

Make observations about the end behavior of the following graphs.

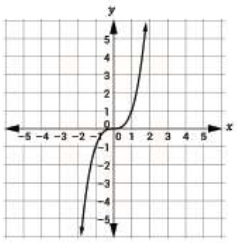
$y = x^2$



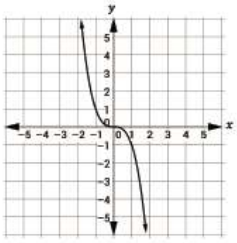
$y = -x^2$



$y = x^3$



$y = -x^3$



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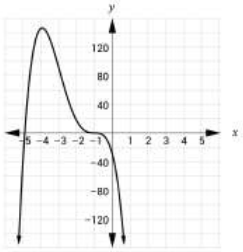
Use your observations to sketch the graphs and make conjectures to complete the table.

End Behavior of Polynomials

	Leading Coefficient is Positive	Leading Coefficient is Negative
Degree of Polynomial is Even	$f(x) = x^2$	$f(x) = -x^2$
	As $x \to \infty, f(x)$_____ As $x \to -\infty, f(x)$_____	As $x \to \infty, f(x)$_____ As $x \to -\infty, f(x)$_____
Degree of Polynomial is Odd	$f(x) = x^3$	$f(x) = -x^3$
	As $x \to \infty, f(x)$_____ As $x \to -\infty, f(x)$_____	As $x \to \infty, f(x)$_____ As $x \to -\infty, f(x)$_____

Let's Practice!

1. Consider the following graph of $f(x)$.



   a. Does the function $f(x)$ have an even or odd degree? Justify your answer.

   b. Is the leading coefficient of $f(x)$ positive or negative? Justify your answer.

2. Describe the end behavior of the function $g(x) = -5x^3 + 8x^2 - 9x$.

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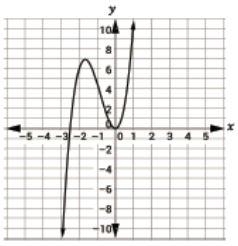
Try It!

3. Consider the following graph of $f(x)$.



   a. Does the function $f(x)$ have an even or odd degree? Justify your answer.

   b. Is the leading coefficient of $f(x)$ positive or negative? Justify your answer.

4. Describe the end behavior of the function below.

$$p(x) = \frac{1}{2}x^6 - x^5 - x^4 + 2x^3 - 2x + 2$$

BEAT THE TEST!

1. Determine which of the following statements is true for the function $f(x) = 3x^5 + 7x - 4247$.

   Ⓐ As $x \to \infty, f(x) \to \infty$ and as $x \to -\infty, f(x) \to \infty$.
   Ⓑ As $x \to \infty, f(x) \to -\infty$ and as $x \to -\infty, f(x) \to -\infty$.
   Ⓒ As $x \to \infty, f(x) \to -\infty$ and as $x \to -\infty, f(x) \to \infty$.
   Ⓓ As $x \to \infty, f(x) \to \infty$ and as $x \to -\infty, f(x) \to -\infty$.

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Section 8 – Topic 8
Multiplicity of Roots in Repeated Factors

Consider the polynomial function $p(x) = x^5 - 2x^4 + x^3$.

Determine the factors of $p(x)$.

How many times does each factor appear in $p(x)$?

Determine the roots of $p(x)$.

The "_____" of a root refers to the number of times the corresponding factor appears in a polynomial.

Determine the multiplicity of each root for $p(x)$.

Let's Practice!

Determine the root(s) and their multiplicity for the polynomial functions:

1. $f(x) = x^2 + 12x + 36$

2. $g(x) = (x^2 - 49)(x^2 + 8x + 7)(x^2 - 6x - 7)$

Try It!

Determine the root(s) and their multiplicity for the polynomial functions:

3. $m(x) = x(x^2 + 4x - 5)(x + 5)$

4. $r(x) = (x - 9)^3(x + 2)^4(x - 6)^2$

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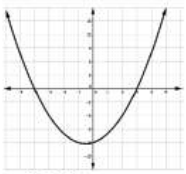
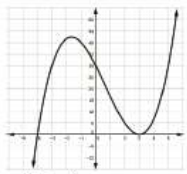
Consider the following graphs. Determine the multiplicity of the roots of each function:

$b(x) = (x - 3)(x + 4)$



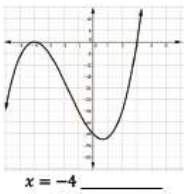
$x = -4$ _____
$x = 3$ _____

$c(x) = (x - 3)^2(x + 4)$



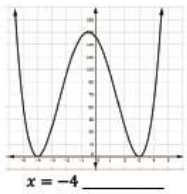
$x = -4$ _____
$x = 3$ _____

$d(x) = (x - 3)(x + 4)^2$



$x = -4$ _____
$x = 3$ _____

$e(x) = (x - 3)^2(x + 4)^2$



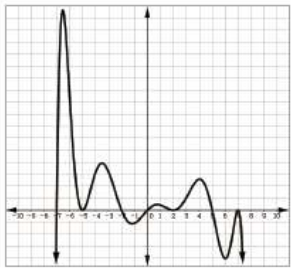
$x = -4$ _____
$x = 3$ _____

What does the multiplicity of the zero tell us about the graph?

Explain why the graph does not cross the x –axis when the multiplicity is an even number.

Let's Practice!

5. The following graph shows a tenth-degree polynomial.



List the polynomial's zeros with their multiplicities.

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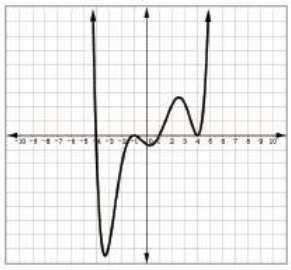
Try It!

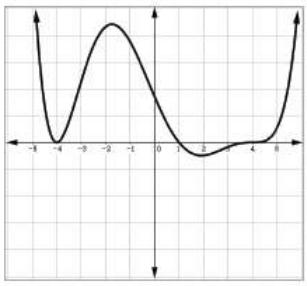
6. The following graph shows a sixth-degree polynomial.



List the polynomial's zeros with their multiplicities.

BEAT THE TEST!

1. Consider the following graph.



Which of the following polynomials have the same zeros as the graph? Select all that apply.

- ☐ $f(x) = (x+4)^2(x-4)^3(x-1)$
- ☐ $f(x) = (x-1)(x+4)(x-4)^2$
- ☐ $f(x) = (x-4)^2(x+4)^2(x-1)$
- ☐ $f(x) = (x+4)^4(x-1)^3(x-4)^5$
- ☐ $f(x) = (x-4)^2(x-1)^4(x+4)$
- ☐ $f(x) = (x-1)^5(x-4)^3(x+4)$

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Section 8 – Topic 9
Graphing Polynomial Functions of Higher Degree

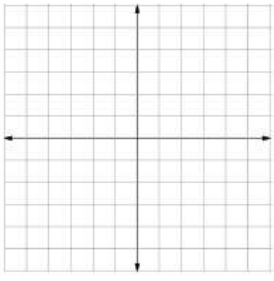
Consider the following function.

$$g(x) = -(x+3)(x-1)(x-2)$$

Describe the end behavior of the graph of $g(x)$.

Find the zeros of $g(x)$.

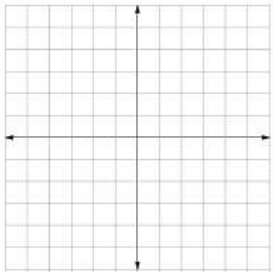
Use the end behavior and zeros to sketch the graph of $g(x)$.



Let's Practice!

1. Sketch the graph of the following polynomial.

$$f(x) = (x-2)(x+3)(x+5)$$



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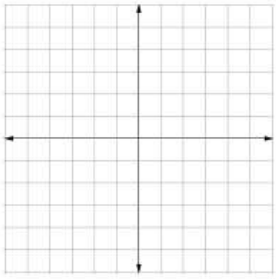
2. Sketch the graph of the following polynomial.

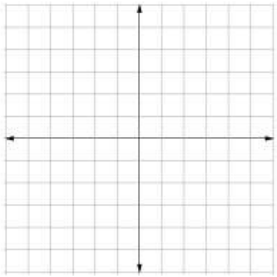
$$f(x) = -(x-5)(x+4)(3x-1)(x+2)$$



Try It!

3. Sketch a graph of the following polynomial.

$$f(x) = (x-1)(x+2)(x-3)(x+1)$$



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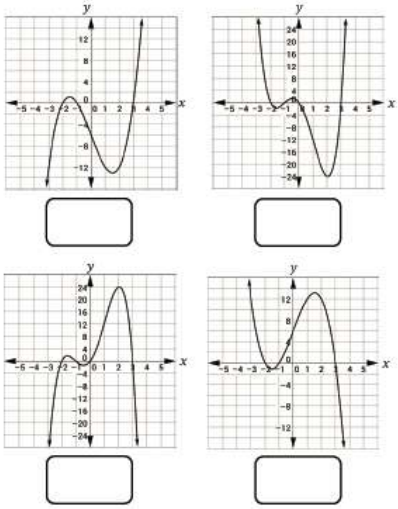
BEAT THE TEST!

1. Match each equation with its corresponding graph.

A. $y = (x+1)(x-3)(x+2)$ B. $y = -(x+1)(x-3)(x+2)$

C. $y = -x(x+1)(x-3)(x+2)$ D. $y = x(x+1)(x-3)(x+2)$



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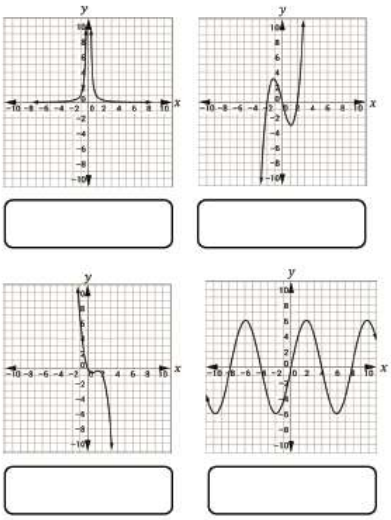
Section 8 – Topic 10
Recognizing Even and Odd Functions

An even function has symmetry about the _____.

An odd function has symmetry about the _____.

Consider the following graphs. Label each graph as even, odd, or neither in the space provided.



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If a function is even, then $f(-x) =$ _____.

If a function is odd, then $f(-x) =$ _____.

To determine if a function is even or odd

- Substitute $(-x)$ into the function.
- If the resulting polynomial is the same, then the function is_____.
- If the resulting polynomial is the exact opposite, then the function is _____.
- If the resulting polynomial is neither the same nor the exact opposite, the function is not even nor odd.

Let's Practice!

1. Complete the table below to determine if the following functions are even, odd, or neither.

Function	Value of $f(-x)$	Even, Odd, or Neither?
$f(x) = x^4 + x^3$		
$f(x) = x^6 + 1$		
$f(x) = 6x^5 - x^3$		

Try It!

2. Give an example of a polynomial function that is an even function.

3. Give an example of a polynomial function that is an odd function.

4. Give an example of a polynomial function that is neither odd nor even.

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BEAT THE TEST!

1. Use the following functions to complete the table below.

$$f(x) = x^2$$
$$g(x) = x^3$$
$$h(x) = x^3 - 4x$$

Function	Even	Odd	Neither
$f(x) \cdot g(x)$	O	O	O
$g(x) \cdot h(x)$	O	O	O
$f(x) + h(x)$	O	O	O
$g(x) + h(x)$	O	O	O

Test Yourself! Practice Tool

Great job! You have reached the end of this section. Now it's time to try the "Test Yourself! Practice Tool," where you can practice all the skills and concepts you learned in this section. Log in to Algebra Nation and try out the "Test Yourself! Practice Tool" so you can see how well you know these topics!

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