Class Notes

Name Key

5.1 Use Properties of Exponents- *Day 1*

	Expanded Form	Simplified
1. $a^5 \bullet a^2$	aaaaaaa	a^7
2. $(a^5)^2$	$(a^5)(a^5) =$ aaaaaaaaaa	a^{10}
3. $(4a^2)^3$	$(4a^2)(4a^2)(4a^2) = 4 \cdot 4 \cdot 4$ aaaaaa	$64a^6$
4. $(3a^2b^3)^4$	$(3a^2b^3)(3a^2b^3)(3a^2b^3)(3a^2b^3)$	$81a^8b^{12}$

Remember: An exponent affects what is to its immediate left!!!

$3 \bullet 4^2 = 3 \cdot 16 = 48$ $\qquad$ $(3 \bullet 4)^2 = (12)^2 = (12)(12) = 144$

$(-3 \bullet 4)^2 = (-12)^2 \rightarrow (-12)(-12) = 144$ $\qquad$ $-(3 \bullet 4)^2 = -1(12)^2 = -1(144) = -144$

Rules for Multiplying Monomials

Product of Powers	$a^m \bullet a^n$	a^{m+n}
Power of a Power	$(a^m)^n$	a^{mn}
Power of Products	$(ab)^m$	$a^m b^m$
Power of a Monomial	$(a^m b^n)^p$	$a^{mp} b^{np}$

Examples- Simplify the following:

5. $\left(\frac{1}{2}a^2b\right)^3 \rightarrow (\frac{1}{2})(\frac{1}{2})(\frac{1}{2})a^6b^3$ $\frac{1}{8}a^6b^3$ or $\frac{a^6b^3}{8}$	6. $(2a^4)(3a^3b)(-4a^2b^3)^2$ $(2a^4)(3a^3b)(16a^4b^6)$ $96a^{11}b^7$
7. $9\left(\frac{1}{3}a^3b^4\right)^2$ $\quad 9(\frac{1}{9}a^6b^8)$ a^6b^8	8. $(-4x^5)^3$ $\quad (-4 \cdot (-4)(-4))x^{15}$ $-64x^{15}$
9. $(-5a^3)^2 + (3a)^3$ $25a^6 + 27a^3$	10. $(5a^3)^2 + (2a^2)^3$ $25a^6 + 8a^6$ $33a^6$

	Expanded Form	Simplified
11. $\frac{a^5}{a^3}$	$\frac{\cancel{a}\cancel{a}\cancel{a}aa}{\cancel{a}\cancel{a}\cancel{a}} = 1\cdot1\cdot1\cdot a\cdot a \to a^2$	a^2
12. $\frac{a^3}{a^5}$ a^{-2}	$\frac{\cancel{a}\cdot\cancel{a}\cdot\cancel{a}}{\cancel{a}\cdot\cancel{a}\cdot\cancel{a}\cdot a\cdot a} \to \frac{1\cdot1\cdot1}{a\cdot a} \to \frac{1}{a^2}$	$\frac{1}{a^2}$
13. $\frac{4a^2b^3}{8ab^5}$ $\frac{1ab^{-2}}{2}$	$\frac{\cancel{2}\cdot\cancel{2}\,\cancel{a}a\,\cancel{b}\cancel{b}\cancel{b}}{\cancel{2}\cdot\cancel{2}\cdot2\,\cancel{a}\,\cancel{b}\cancel{b}\cancel{b}bb} \to \frac{a}{2b^2}$	$\frac{a}{2b^2}$
14. $\frac{a^4}{a^4}$ a^0	$\frac{\cancel{a}\cdot\cancel{a}\cdot\cancel{a}\cdot\cancel{a}}{\cancel{a}\cdot\cancel{a}\cdot\cancel{a}\cdot\cancel{a}} = 1$	

Rules for Dividing Monomials

Quotient of Powers	$\frac{a^m}{a^n}$	a^{m-n}
Zero Exponent	a^0	1
Negative Exponent	a^{-1}	$\frac{1}{a}$

Examples– Simplify the following:

15. $\frac{144x^5y^{-3}z^4}{12x^6y^2z^4}$ $12x^{-1}y^{-5}z^0$ $\frac{12}{xy^5}$	16. $\frac{(3x^5)^2}{(-2x^3)^{-3}} \to (9x^{10})(-2x^3)^3 \to (9x^{10})(-8x^9) \to -72x^{19}$
17. $\frac{x^5y^2}{xy^3}$ x^4y^{-1} $\frac{x^4}{y}$	18. $\left(\frac{2a^3}{b^{-4}}\right)^{-2}$ $\left(\frac{b^{-4}}{2a^3}\right)^2 \to \frac{b^{-8}}{4a^6}$ $\frac{1}{4a^6b^8}$
19. $\frac{(x^4y^{-7})^0}{(-3)^2} = \frac{1}{9}$	20. $\frac{1}{x^0 + y^0} = \frac{1}{1+1}$ $\frac{1}{2}$

Name ____________________

5.1 Use Properties of Exponents- Homework Day 1

Simplify each expression.

1. $\left(4^0w^2\right)^{-5}$	2. $\dfrac{y^4}{y^{-7}}$	3. $\dfrac{x^8}{x^4}$	4. $\left(3^2s^3\right)^6$
5. $\left(y^4z^2\right)\cdot\left(y^{-3}z^{-5}\right)$	6. $\left(2m^3n^{-1}\right)\left(8m^4n^{-2}\right)$	7. $\left(7c^7d^2\right)^{-2}$	8. $\left(5g^4h^{-3}\right)^{-3}$
9. $\dfrac{x^5y^{-8}}{x^5y^{-6}}$	10. $\dfrac{16p^0r^{-6}}{4p^{-3}r^{-7}}$	11. $\dfrac{12a^{-3}b^9}{21a^2b^{-5}}$	12. $\dfrac{8e^{-4}f^{-2}}{18ef^{-5}}$

13. $\frac{x^2y^3}{2} \cdot \frac{2x^4}{y^3}$	14. $\frac{4m^4}{-6m^{-1}n^5} \cdot \frac{3n^{-1}}{m^{-2}}$	15. $\frac{\left(c^4\right)^3}{4} \cdot \frac{12d^{-6}}{\left(15cd\right)^{-1}}$	16. $\frac{w^{-3}}{v^{-5}} \cdot \frac{v^{-5}}{w^{-3}}$
17. $\left(\frac{x^7y^{-2}}{3y^{-3}}\right)^{-2}$	18. $\left(\frac{qr^2s}{3r^4}\right)^{-3}$	19. $\left[\left(z^{-2}\right)^2\right]^3$	20. $\left[\left(b^0\right)^{-1}\right]^{-2}$

Write an expression that makes each statement true.

21. $\left(2m^3n^2\right)^6 = \underline{\ ?\ } \cdot 4m^{12}n^{-5}$	22. $\frac{?}{9x^2y^6z} = \frac{2x}{3y^2}$

Algebra 2 Notes Name ____________________

5.1 Use Properties of Exponents- *Scientific Notation*

Scientific Notation:

A number is written in scientific notation if it is in the form of $c \times 10^n$, where $1 \le c < 10$ and n is an integer. Remember each time you move a decimal point you are multiplying or dividing by a power of 10.

Scientific Notation	Decimal Form
1. 4.58×10^6	
2. 4.58×10^{-3}	
	3. 381,000
	4. .000102

Examples- Simplify Using Scientific Notation

5. 234.6×10^9	6. $(4.5 \times 10^{-5})(1.6 \times 10^{-2})$
7. $(8.5 \times 10^7)(1.2 \times 10^3)$	8. $\dfrac{8.1 \times 10^{12}}{5.4 \times 10^{-2}}$
9. $\dfrac{3.2 \times 10^{-6}}{6.4 \times 10^2}$	10. $\dfrac{.000000441}{.0098}$

Algebra 2 Name ____________________

5.1 Review Worksheet

Simplify the following. Don't leave any negative exponents in your final answer.

1. $-4x^3 \bullet -2x^4$	2. $\left(-5a^2b^2\right)\left(3a^{-4}b^7\right)$
3. $\left(-2mn^7\right)^5$	4. $(5x)^3 \bullet (-3x)^2$
5. $\dfrac{b^{13}c^4}{b^3c}$	6. $\dfrac{12x^2y^5}{4x^6y}$
7. $\dfrac{2\left(x^3y^{-8}z^{10}\right)^0}{\left(2\right)^{-3}}$	8. $\dfrac{15a^5b^2c^4}{25a^3b^3c^4}$
9. $\left(3a^2b^{-5}\right)\left(2a^{-3}b^4\right)^{-3}$	10. $\dfrac{\left(2x^{-3}y\right)^2}{4x^{-9}y^8}$

Write the following expressions in Scientific Notation:

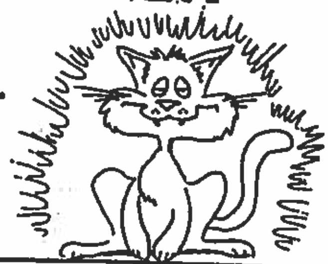
11. .00075 cm (diameter of a red blood cell)	**12.** 326,000,000 cubic miles (volume of water on Earth)
13. $.00176 \times 10^{-7}$	**14.** $\left(5.2 \times 10^{6}\right)\left(1.7 \times 10^{-9}\right)$
15. $\dfrac{2.7 \times 10^{6}}{9 \times 10^{10}}$	**16.** $\dfrac{\left(7.5 \times 10^{8}\right)\left(4.5 \times 10^{-4}\right)}{1.5 \times 10^{7}}$

Challenge: Simplify the following expression.

$$\cfrac{1}{x^0 + \cfrac{1}{x^0 + \cfrac{1}{x^0 + \cfrac{1}{x^0}}}}$$

What Is Special About a Radioactive Cat?

Choose the correct answer for each exercise and circle the letter pair next to it. Write the uppercase letter in the box containing the lowercase letter.



In Exercises 1-2, choose the number that is written in scientific notation.

1. r • Y 34.5×10^5 m • E 3.45×10^6 y • P 0.345×10^7
2. b • G 0.77×10^{-3} i • R $7.7 + 10^{-4}$ s • L 7.7×10^{-4}

In Exercises 3-6, find the value of *n*.

3. $94{,}000{,}000 = 9.4 \times 10^n$
4. $555{,}500{,}000{,}000 = 5.555 \times 10^n$
5. $0.00006 = 6 \times 10^n$
6. $0.0000000000375 = 3.75 \times 10^n$

n • O 8   e • A 7
i • I 11   k • C 10
w • S −4   j • G −11
f • U −12   y • E −5

In Exercises 7-12, write the number in decimal form.

7. 3.8×10^5
8. 3.8×10^{-5}
9. 3.80×10^7
10. 6.25×10^4
11. 6.25×10^{-3}
12. 6.25×10^{-8}

r • A 38,000,000   p • R 0.00038
d • L 3,800,000   w • I 380,000
b • T 0.000038   o • D 38,000
a • A 0.000000625   n • E 62,500
v • M 625,000   k • H 0.0000000625
z • S 0.00625   h • L 0.00062

In Exercises 13-18, write the number in scientific notation.

13. 72,000
14. 7,200,000,000,000
15. 0.00000072
16. 41,900,000
17. 0.00419
18. 0.0000000000419

q • F 7.2×10^{10} q • W 7.2×10^5
f • S 7.2×10^{12} o • N 7.2×10^{-7}
a • I 7.2×10^4 t • D 7.2×10^{-6}
v • L 4.19×10^{-3} x • T 4.19×10^{-5}
l • R 4.19×10^{-10} d • H 4.19×10^7
c • S 4.19×10^6 h • E 4.19×10^{-11}

In Exercises 19-22, write the number in scientific notation.

19. 22.2×10^3
20. 0.222×10^8
21. 0.54×10^{-4}
22. 54×10^{-15}

p • O 2.22×10^5 l • T 2.22×10^7
t • F 2.22×10^4 c • S 2.22×10^9
g • L 5.4×10^{-6} u • P 5.4×10^{-16}
q • H 5.4×10^{-14} x • V 5.4×10^{-5}

a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z

Algebra 2 Notes
5.2 Polynomial Functions Intro

Name ____________________

POLYNOMIAL FUNCTION: A monomial or a sum of monomials.

Written in the form: $f(x) = a_n x^n + a_{n-1}x^{n-1} + \ldots + a_1 x + a_0$, where $a_n \neq 0$, the <u>exponents are all **whole numbers**</u>, and the <u>coefficients are all **real numbers**</u>.

EX1] Polynomials or not? Explain.

$f(x) = 3x^2 + 2x - 10$	$f(x) = x^{\frac{1}{2}} - 4ix - 10$	$f(x) = -2x^{10} + \sqrt{\pi}\, x^7 + 4x - 1$

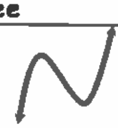
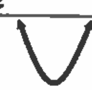
DEGREE: The highest exponent (power) of the variable x.
The degree indicates the total number of zeros for the polynomial (*Real & Imaginary*).

LEADING COEFFICIENT: The coefficient of the term with the highest exponent.

EX2] $f(x) = -x^4 + 3x^3 - x + 1$

Degree: **Leading Coefficient:** **Total Number of Zeros:**

END BEHAVIOR: The direction the graph goes as $x \to -\infty$ (x approaches big negative numbers) or as $x \to +\infty$ (x approaches big positive numbers).

	Odd Degree	Even Degree
Positive Leading Coefficient	Example: $2x^3$  $x \to +\infty,\ f(x) \to$ ______ $x \to -\infty,\ f(x) \to$ ______	Example: $2x^2$  $x \to +\infty,\ f(x) \to$ ______ $x \to -\infty,\ f(x) \to$ ______
Negative Leading Coefficient	Example: $-2x^3$  $x \to +\infty,\ f(x) \to$ ______ $x \to -\infty,\ f(x) \to$ ______	Example: $-2x^2$  $x \to +\infty,\ f(x) \to$ ______ $x \to -\infty,\ f(x) \to$ ______
	If the degree is ODD, then the tails go in <u>opposite</u> directions.	If the degree is EVEN, then the tails go in the <u>same</u> direction.

<u>EXAMPLES:</u>
State End Behavior

3] $f(x) = \boxed{3x^4} + 2x^2 - 1$

$x \to +\infty,\ f(x) \to$ ______

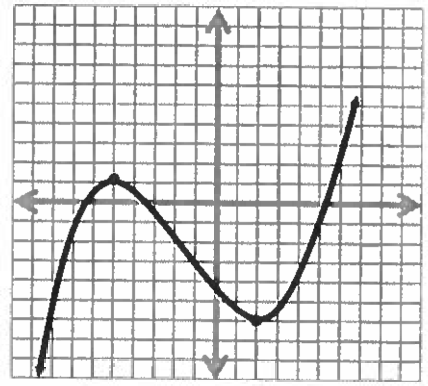
$x \to -\infty,\ f(x) \to$ ______

4] $f(x) = \boxed{-x^5} + 3x^4 - 2x^3 - 4x - 1$

$x \to +\infty,\ f(x) \to$ ______

$x \to -\infty,\ f(x) \to$ ______

Relative (Local) Maximum: The turning point of the function that is higher than all nearby points



Relative (Local) Minimum: The turning point of the function that is lower than all nearby points

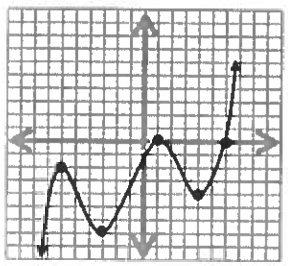
List all **relative extrema** (maxima/minima) as **ordered pairs**

Real Zeros: Will also be the x-values of the x-intercepts

Practice: Use the graph or function to determine the given information

5]

Degree: Odd Even



Leading Coeff. sign: ________

Relative Maxima:

____

Relative Minima:

____

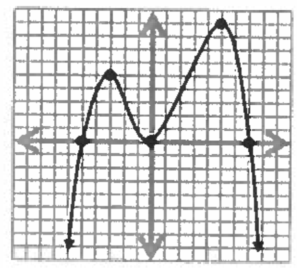
Real zeros: ____________________

End Behavior:

Domain: __________ Range: __________

6]

Degree: Odd Even



Leading Coeff. sign: ________

Relative Maxima:

____

Relative Minima:

____

Real zeros: ____________________

End Behavior:

Domain: __________ Range: __________

7] $f(x) = -x^3 + 2x^2 + 15x + 2$

Degree:__________

Leading Coefficient Value: __________

Total Number of Zeros: __________

End Behavior:

Domain: __________

8] $f(x) = 2x^4 - 3x^3 - 2x^2 + 7x + 1$

Degree:__________

Leading Coefficient Value: __________

Total Number of Zeros: __________

End Behavior:

Domain: __________

Algebra 2

5.2 Practice WS #1

Name______________________

Given the functions on the right side, answer the following for each question:

1. a) Is the degree of the polynomial even or odd?

   b) Would the leading coefficient be positive or negative?

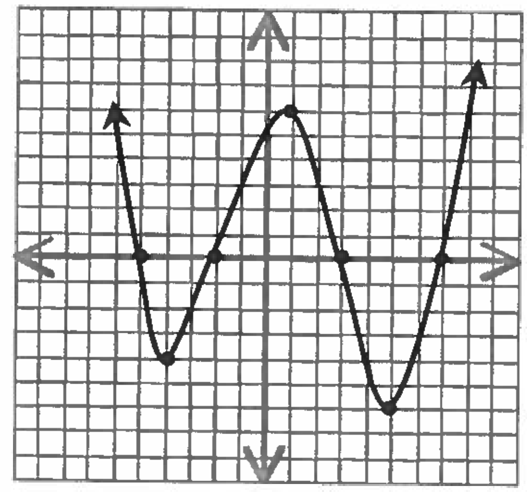
   c) Relative maxima?

   d) Relative minima?

   e) What are the real zeros?

   f) What is the domain?

   g) What is the range?



2. a) Is the degree of the polynomial even or odd?

   b) Would the leading coefficient be positive or negative?

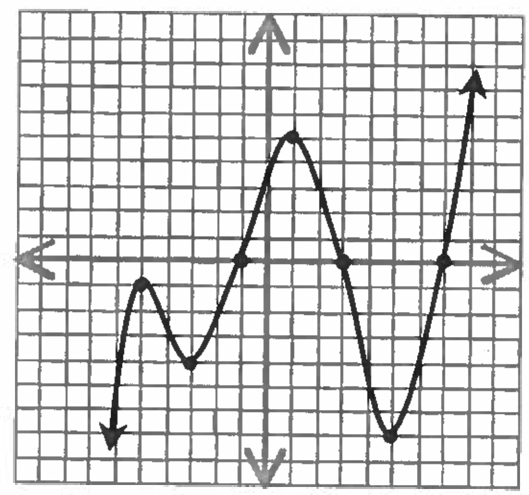
   c) Relative maxima?

   d) Relative minima?

   e) What are the real zeros?

   f) What is the domain?

   g) What is the range?



3. a) Is the degree of the polynomial even or odd?

   b) Would the leading coefficient be positive or negative?

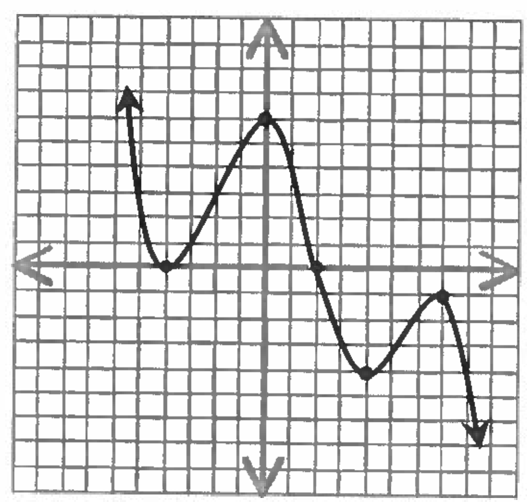
   c) Relative maxima?

   d) Relative minima?

   e) What are the real zeros?

   f) What is the domain?

   g) What is the range?



4. a) Is the degree of the polynomial even or odd?

b) Would the leading coefficient be positive or negative?

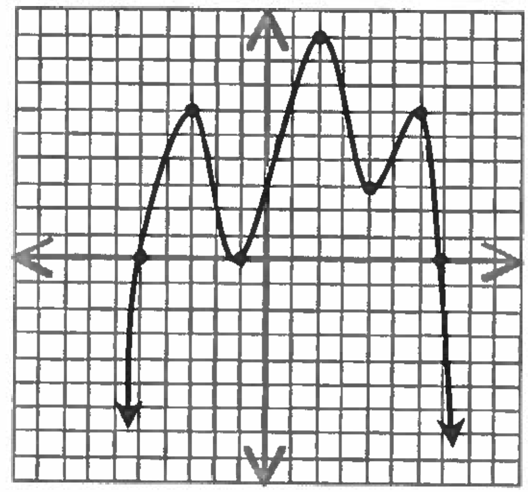
c) Relative maxima?

d) Relative minima?

e) What are the real zeros?

f) What is the domain?

g) What is the range?



From the given functions, determine the given information:

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

Degree: ________

Leading Coefficient Value: ________

Total Number of Zeros: ________

End Behavior:

Domain: ________

6. $g(x) = 5x^3 - 2x^2 + 7x + 1$

Degree: ________

Leading Coefficient Value: ________

Total Number of Zeros: ________

End Behavior:

Domain: ________

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

Degree: ________

Leading Coefficient Value: ________

Total Number of Zeros: ________

End Behavior:

Domain: ________

8. $f(x) = 2x^4$

Degree: ________

Leading Coefficient Value: ________

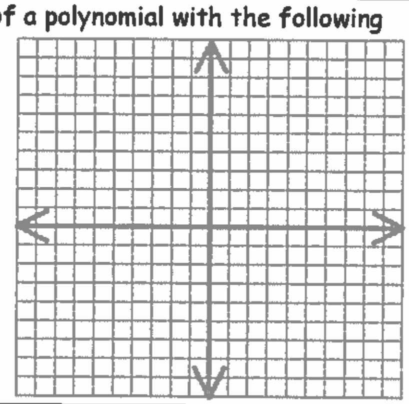
Total Number of Zeros: ________

End Behavior:

Domain: ________

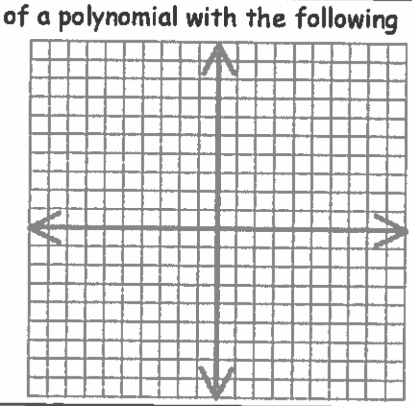
9. Sketch the graph of a polynomial with the following characteristics:

- Even degree
- Positive leading Coefficient
- 1 real zero with a multiplicity of two



10. Sketch the graph of a polynomial with the following characteristics:

- Odd degree
- Negative leading coefficient
- 2 x-intercepts
- 3 Real zeros



Algebra 2 Notes Name ______________________
5.2 Polynomial Functions- Day 2

Recap of Old Vocabulary:

Polynomial Function: A monomial or a sum of monomial where the exponents are all ______________________, and the coefficients are all ______________________.

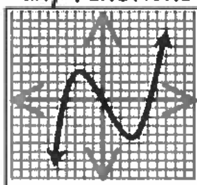
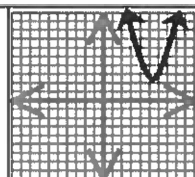
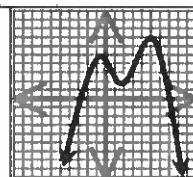
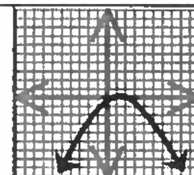
Real Zeros: Real zeros exist when the graph crosses/touches the x-axis.

Imaginary Zeros: Imaginary zeros exist when the graph does NOT touch the x-axis

Double Zeros: Occur when the graph just touches (bounces off) the x-axis then turns away.

Polynomial of Least Degree: The smallest degree of a polynomial that will fit the give graph or zeros.

EX1] State the types of zeros contained in the following polynomials of least degree. Also, are there any functions that have double zeros?

EX2] Relationship between Factors and Zeroes:
$(x-c)$ is a factor of a polynomial with **integral** coefficients if and only if **c** is a zero.

Fill the table at the right by listing each factor and it corresponding zero.

Zero	Factor
	$(x-11)$
	$(3x+7)$
-4	
0	
$\frac{1}{2}$	

Common Polynomial Functions

Degree	Type	Example
0		
1		
2		
3		
4		

Any degree **larger than 4** is generally called a **polynomial**. A polynomial function is in **Standard Form** if its terms are written in descending order of exponents from left to right.

EX3] Decide whether the function is a polynomial function. If so, write it in **standard form** and state its **degree**, **type**, and **leading coefficient**.

A. $h(x) = -\frac{1}{4}x^2 + x^3 + 3$

B. $k(x) = x + \frac{2}{x} - 0.6x^5$

C. $g(x) = 7x - \sqrt{3} + \pi x^2$

Evaluating Polynomial Functions by Direct Substitution: Substitute the given input value in for x and solve for the output value y or $f(x)$

Remember… every input is paired up with exactly one output!

EX4] For each function, determine the **degree**, **leading coefficient**, **number of zeros**, and the **end behavior**. Then **evaluate** for the given input using direct substitution.

A] $p(x) = -3x^3 + x^2 - 12x - 5,\ x = 2$

B] $q(x) = 2x^4 - 5x^3 - 4x + 8;\ q(-3)$

Algebra 2 Name ______________________

5.2 Practice Worksheet #2

Decide whether the function is a polynomial function. If it is, write the function in standard form.

1. $f(x) = 2 + 7x - x^2$	2. $h(x) = x^4 + x^{-3}$
3. $f(x) = 5^x + 1$	4. $g(x) = -2x + x^3 + 8$

State the degree, type, and leading coefficient of the polynomial.

5. $y = 2x^2 - 4x + 9$	6. $f(x) = -7 + 3x$
7. $h(x) = 3x^2 - \frac{1}{2}x^4 - x$	8. $y = 5 + 7x - x^3$

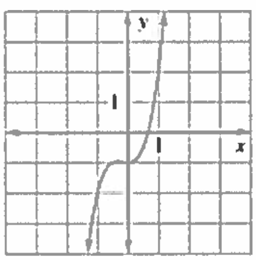
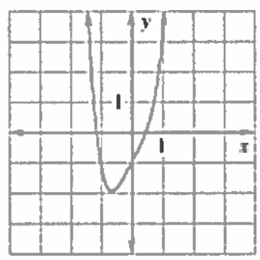
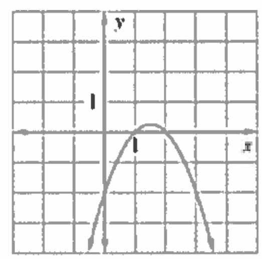
Describe the end behavior of the graph of the polynomial function.

9. $y = -5x^3$	10. $f(x) = 2x^8 + 9x^7 + 10$
11. $g(x) = -12x^6 - 2x + 5$	12. $f(x) = 2x^5 - 7x^2 - 4x$

Evaluate the polynomial function for the given value of x.

13. $f(x) = -5x^3 + x - 9;\ x = 0$	14. $h(x) = x^3 - 8x + 6;\ x = -3$
15. $f(x) = -x^4 + x - 10;\ f(-2)$	16. $g(x) = x^5 + 3x^2 - 2x - 9;\ g(2)$

Use what you know about end behavior to match the polynomial function with its graph.

17. $f(x) = 2x^4 + 2x - 1$	18. $f(x) = -x^2 + 3x - 2$	19. $f(x) = 2x^3 + x^2 - 1$
A. 	B. 	C. 

Use the given function or graph to answer the following information.

20. $f(x) = -5x^8 + x^6 + x$

Degree: ____________

Leading Coefficient Value: ___________

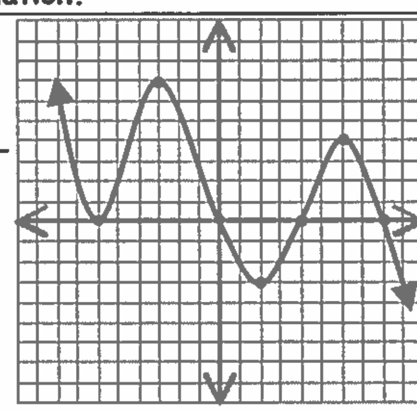
Total Number of Zeros: ______________

End Behavior: ________________________

____

21.

Degree: Odd Even



Leading Coeff. Sign: ____________

Relative Maxima:

____

Relative Minima:

____

Real Zeros: ____

Known Factors: ____

End Behavior: ___________________________

____

Algebra 2
5.2 Homework- Book Problems
Pages 341-342: 3-8 (all), 10-14 (even), 20-36 (even)

POLYNOMIAL FUNCTIONS **Decide whether the function is a polynomial function. If so, write it in standard form and state its degree, type, and leading coefficient.**

3. $f(x) = 8 - x^2$
4. $f(x) = 6x + 8x^4 - 3$
5. $g(x) = \pi x^4 + \sqrt{6}$
6. $h(x) = x^3\sqrt{10} + 5x^{-2} + 1$
7. $h(x) = -\frac{5}{2}x^3 + 3x - 10$
8. $g(x) = 8x^3 - 4x^2 + \frac{2}{x}$

DIRECT SUBSTITUTION **Use direct substitution to evaluate the polynomial function for the given value of x.**

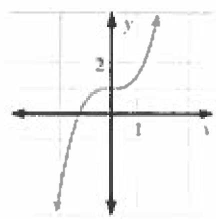
9. $f(x) = 5x^3 - 2x^2 + 10x - 15;\ x = -1$
10. $f(x) = 8x + 5x^4 - 3x^2 - x^3;\ x = 2$
11. $g(x) = 4x^3 - 2x^5;\ x = -3$
12. $h(x) = 6x^3 - 25x + 20;\ x = 5$
13. $h(x) = x + \frac{1}{2}x^4 - \frac{3}{4}x^3 + 10;\ x = -4$
14. $g(x) = 4x^5 + 6x^3 + x^2 - 10x + 5;\ x = -2$

SYNTHETIC SUBSTITUTION **Use synthetic substitution to evaluate the polynomial function for the given value of x.**

Just continue to use direct substitution to evaluate 20 & 22.

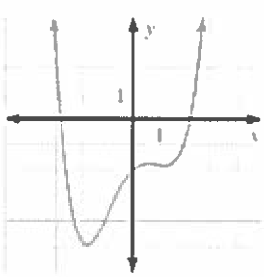
15. $f(x) = 5x^3 - 2x^2 - 8x + 16;\ x = 3$
16. $f(x) = 8x^4 + 12x^3 + 6x^2 - 5x + 9;\ x = -2$
17. $g(x) = x^3 + 8x^2 - 7x + 35;\ x = -6$
18. $h(x) = -8x^3 + 14x - 35;\ x = 4$
19. $f(x) = -2x^4 + 3x^3 - 8x + 13;\ x = 2$
20. $g(x) = 6x^5 + 10x^3 - 27;\ x = -3$
21. $h(x) = -7x^3 + 11x^2 + 4x;\ x = 3$
22. $f(x) = x^4 - 3x - 20;\ x = 4$

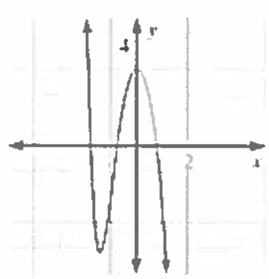
24. ★ **MULTIPLE CHOICE** The graph of a polynomial function is shown. What is true about the function's degree and leading coefficient?

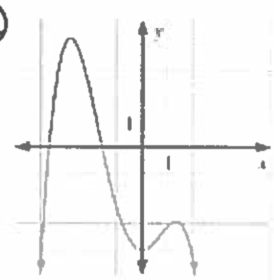


(A) The degree is odd and the leading coefficient is positive.
(B) The degree is odd and the leading coefficient is negative.
(C) The degree is even and the leading coefficient is positive.
(D) The degree is even and the leading coefficient is negative.

USING END BEHAVIOR ***Describe*** **the degree and leading coefficient of the polynomial function whose graph is shown.**

25.


26.


27.


DESCRIBING END BEHAVIOR ***Describe*** **the end behavior of the graph of the polynomial function by completing these statements: $f(x) \to$? as $x \to -\infty$ and $f(x) \to$? as $x \to +\infty$.**

28. $f(x) = 10x^4$
29. $f(x) = -x^6 + 4x^3 - 3x$
30. $f(x) = -2x^3 + 7x - 4$
31. $f(x) = x^7 + 3x^4 - x^2$
32. $f(x) = 3x^{10} - 16x$
33. $f(x) = -6x^5 + 14x^2 + 20$
34. $f(x) = 0.2x^3 - x + 45$
35. $f(x) = 5x^8 + 8x^7$
36. $f(x) = -x^{273} + 500x^{271}$