Algebra 2 – UNIT 2
Structure in Expressions and Arithmetic with Polynomials

Critical Area: Students connect the polynomial operations with the background knowledge of the algorithms found in multi-digit integer operations. Students realize that the operations on rational expressions (the arithmetic of rational expressions) are governed by the same rules as the arithmetic of rational numbers. Students analyze the structure in expressions and write them in equivalent forms. By modeling students expand the scope of algebraic operations to solve a wide variety of polynomial equations and real world problems. Students identify zeros of polynomials, including complex zeros of quadratic polynomials, and make connections between zeros of polynomials and solutions of polynomial equations. The role of factoring, as both an aid to the algebra and to the graphing of polynomials, is explored.

CLUSTERS	COMMON CORE STATE STANDARDS
(m)Interpret the structure of expressions. **(m)Write expressions in equivalent forms to solve problems.**	**Algebra – Seeing Structure in Expressions** **A-SSE.1.** Interpret expressions that represent a quantity in terms of its context. ★ a. Interpret parts of an expression, such as terms, factors, and coefficients. ★ b. Interpret complicated expressions by viewing one or more of their parts as a single entity. *For example, interpret* $P(1 + r)^n$ *as the product of P and a factor not depending on P.* ★ **A-SSE.2.** Use the structure of an expression to identify ways to rewrite it. **A-SSE.4.** Derive the formula for the sum of a finite geometric series (when the common ratio is not 1), and use the formula to solve problems. *For example, calculate mortgage payments.* ★
(m)Perform arithmetic operations on polynomials.	**Algebra – Arithmetic with Polynomials and Rational Expressions** **A-APR.1.** Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.
Understand the relationship between zeros and factors of polynomials.	**A-APR.2.** Know and apply the Remainder Theorem: For a polynomial $p(x)$ and a number a, the remainder on division by $x – a$ is $p(a)$, so $p(a) = 0$ if and only if $(x – a)$ is a factor of $p(x)$. **A-APR.3.** Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.
Use polynomial identities to solve problems.	**A-APR.4.** Prove polynomial identities and use them to describe numerical relationships. *For example, the polynomial identity* $(x^2 + y^2)^2 = (x^2 – y^2)^2 + (2xy)^2$ *can be used to generate Pythagorean triples.* **A-APR.5.** Know and apply the Binomial Theorem for the expansion of $(x + y)^n$ in powers of x and y for a positive integer n, where x and y are any numbers, with coefficients determined for example by Pascal's Triangle.**(+)**
Rewrite rational expressions.	**A-APR.6.** Rewrite simple rational expressions in different forms; write $a(x)/b(x)$ in the form $q(x)$ +

CLUSTERS	COMMON CORE STATE STANDARDS
	$r(x)/b(x)$, where $a(x)$, $b(x)$, $q(x)$, and $r(x)$ are polynomials with the degree of $r(x)$ less than the degree of $b(x)$, using inspection, long division, or, for the more complicated examples, a computer algebra system. **(+)A-APR.7.** Understand that rational expressions form a system analogous to the rational numbers, closed under addition, subtraction, multiplication, and division by a nonzero rational expression; add, subtract, multiply, and divide rational expressions.
MATHEMATICAL PRACTICES	
1. Make sense of problems and persevere in solving them. **2. Reason abstractly and quantitatively.** 3. Construct viable arguments and critique the reasoning of others. **4. Model with mathematics.** 5. Use appropriate tools strategically. 6. Attend to precision. **7. Look for and make use of structure.** 8. Look for and express regularity in repeated reasoning.	Emphasize Mathematics Practices 1, 2, 4, and 7 in this unit.

LEARNING PROGRESSION
High School Progression on Algebra http://commoncoretools.me/wp-content/uploads/2013/07/ccss_progression_algebra_2013_07_03.pdf

[1] **Major Clusters – area of intensive focus where students need fluent understanding and application of the core concepts.**

[2] **Supporting/Additional Clusters – designed to support and strengthen areas of major emphasis/expose students to other subjects.**

★**Indicates a modeling standard linking mathematics to everyday life, work, and decision-making.**

(+) Indicates additional mathematics to prepare students for advanced courses.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS	KEY VOCABULARY
• Expressions that represent a quantity in terms of its context can be interpreted and its structure identified and rewritten. • The formula for the sum of a finite geometric series (when the common ratio is not 1) is derived and used to solve problems. • Polynomials form a system analogous to the integers which are closed under the operations of addition, subtraction, and	1) What does the graph of a function represent? 2) How can you represent the zeroes of a function? 3) How can you describe and show the ways you can find the zeroes (roots) of a function? 4) How can the formula for the sum of a finite geometric series be derived and used to solve problems?	• Binomial Theorem • Coefficient • Exponential • Factors • Factorization • Finite • Function • Geometric Series • Infinite • Interpret

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS	KEY VOCABULARY
multiplication and polynomial identities are proven to describe numerical relationships. • Remainder Theorem can be applied for a polynomial p(x). • Zeros of polynomials are identified when suitable factorizations are available and used to construct a rough graph of the function defined by the polynomial. • Binomial Theorem is for the expansion of $(x + y)^n$ in powers of x and y for a positive integer n, where x and y are any numbers and known and applied.	5) How can you use the Binomial Theorem to expand powers of expressions?	• Logarithmic • Polynomial • Relation • Remainder Theorem • Terms • Zeros

RESOURCES	INSTRUCTIONAL STRATEGIES	ASSESSMENT
LAUSD Adopted Textbooks and Programs • Big Ideas Learning - Houghton Mifflin Harcourt, 2015: Big Ideas Algebra 2 • College Preparatory Mathematics, 2013: Core Connections, Algebra 2 • The College Board, 2014:Springboard Algebra 2 **Illustrative Mathematics** • Animal Populations: A-SSE.1, 2 http://www.illustrativemathematics.org/illustrations/436 • Sum of Even and Odd: A-SSE.2 http://www.illustrativemathematics.org/illustrations/198 • Seeing Dots: A-SSE.1, 2 http://www.illustrativemathematics.org/illustrations/21 • Zeroes and factorization of a quadratic polynomial I: A-APR.2 http://www.illustrativemathematics.org/illustrations/787 • Zeroes and factorization of a quadratic polynomial II: A-APR.2	• Have students create their own expressions that meet specific criteria (e.g., number of terms factorable, difference of two squares, etc.) and verbalize how they can be written and rewritten in different forms. Additionally, pair/group students to share their expressions and rewrite one another's expressions. • Students may use hands-on or manipulatives, such as algebra tiles, to establish a visual understanding of algebraic expressions and the meaning of terms, factors and coefficients. Technology may be useful to help a student recognize that two different expressions represent the same relationship. • Provide multiple real-world examples of exponential functions. For instance, to illustrate exponential growth, in the equation for the value of an investment over time $A(t) = 15{,}000(1.04)^t$, where the base is 1.04 and is greater than 1; and the $15,000 represents the value of an investment when increasing in value by 4% per year for x years.	**Formative Assessment** **LAUSD Assessments** The district will be using the SMARTER Balanced Interim Assessments. Teachers would use the Interim Assessment Blocks (IAB) to monitor the progress of students. Each IAB can be given twice to show growth over time. **State Assessments** California will be administering the SMARTER Balance Assessment as the end of course for grades 3-8 and 11. There is no assessment for Algebra 1. The 11th grade assessment will include ítems from Algebra 1, Geometry, and Algebra 2 standards. For examples, visit the SMARTER Balance Assessment at: http://www.smarterbalanced.org/

RESOURCES	INSTRUCTIONAL STRATEGIES	ASSESSMENT
http://www.illustrativemathematics.org/illustrations/789 • Zeroes and factorization of a non-polynomial function: A-SSE.2 http://www.illustrativemathematics.org/illustrations/796 • Trina's Triangles:A-SSE.4 http://www.illustrativemathematics.org/illustrations/594 • Egyptian Fraction II: A-SSE.6 http://www.illustrativemathematics.org/illustrations/1346		

LANGUAGE GOALS for **low achieving, high achieving, students with disabilities and English Language Learners**

- Students will explain orally and in writing how to interpret parts of an expression, such as terms, factors, and coefficients
  Example: I will interpret $P(1 + r)^n$ as ______ P and a ________ not depending on _____.

- Students will discuss how to derive and solve problems with the formula for the sum of a finite geometric series.

- Students will explain how the zeros of polynomials are identified when suitable factorizations are available and construct a rough graph of the function defined by the polynomial.

- Students will orally and in writing explain how to expand $(x + y)^n$ in powers of x and y for a positive integer *n*.

PERFORMANCE TASKS

Illustrative Mathematics

- Course of Antibiotics: A-SSE.4 http://www.illustrativemathematics.org/illustrations/805
- Cantor Set: A-SSE.4 http://www.illustrativemathematics.org/illustrations/929
- A Lifetime of Savings: A-SSE.4 http://www.illustrativemathematics.org/illustrations/1283
- Combined Fuel Efficiency: A-SSE.6 http://www.illustrativemathematics.org/illustrations/825

Mathematics Assessment Project

Representing Polynomials: A-APR http://map.mathshell.org/materials/download.php?fileid=1271
Interpreting Algebraic Expressions: A-APR http://map.mathshell.org/materials/download.php?fileid=694

LAUSD Mathematics website – http://math.lausd.net
Parabola Activity

DIFFERENTIATION 🕮		
UDL/FRONT LOADING	ACCELERATION	INTERVENTION
Have students review how to interpret parts of an expression, such as terms, factors, and coefficients. Design an activity for students to practice graphing both linear and simple quadratics equations such as: $y = x^2$.	Shirley and her colleague are trying to develop a simple algorithm for adding consecutive numbers (1, 2, 3,…, n). Her colleague suggested that they can add the numbers by using the following expression (1+n)*n/2. Show how this is possible. Here the students would recognize that this is Gauss rule of adding numbers. Can this relationship or rule be true for adding consecutive odd numbers, such as: 1, 3, 5, … n-1? Could this work for adding any consecutive even numbers, such as 2, 4, 6,…, n+1? Have students prove the equation of a parabola using the Parabola Paper Folding Activity. Show that the sum of *n* odd natural numbers is n^2.	• Use of real context examples to demonstrate the meaning of quadratics equation, such rocket trajectory, basketball path when thrown to the hoop, etc. • Have students use technology, such as graphing calculator, graphing apps, and other software to graph both a linear function and quadratic function on the same plane. Engage them in a discussion to identify the zeros of polynomials and use the zeros to construct a rough graph of the function and discuss what that means. • Provide a situation that uses realia to further demonstrate the meaning of zeros of polynomial function, such as quadratic.

References:

1. National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards (Mathematics)*. Washington D.C.: National Governors Association Center for Best Practices, Council of Chief State School Officers.
2. McCallum, W., Zimba, J., Daro, P. (2011, December 26 Draft). *Progressions for the Common Core State Standards in Mathematics*. Cathy Kessel (Ed.). Retrieved from http://ime.math.arizona.edu/progressions/#committee.
3. Engage NY. (2012). New York Common Core Mathematics Curriculum. Retrieved from http://engageny.org/sites/default/files/resource/attachments/a-story-of-ratios-a-curriculum-overview-for-grades-6-8.pdf.
4. Mathematics Assessment Resource Service, University of Nottingham. (2007 - 2012). Mathematics Assessment Project. Retrieved from http://map.mathshell.org/materials/index.php.
5. Smarter Balanced Assessment Consortium. (2012). Smarter Balanced Assessments. Retrieved from http://www.smarterbalanced.org/.
6. Partnership for Assessment of Readiness for College and Career. (2012). PARCC Assessments. Retrieved from http://www.parcconline.org/parcc-assessment.
7. California Department of Education. (2013). Draft Mathematics Framework Chapters. Retrieved from http://www.cde.ca.gov/be/cc/cd/draftmathfwchapters.asp.
8. National Council of Teachers of Mathematics (NCTM) Illuminations. (2013). Retrieved from http://illuminations.nctm.org/Weblinks.aspx.
9. The University of Arizona. (2011-12). Progressions Documents for the Common Core Math Standards. Retrieved from http://ime.math.arizona.edu/progressions.