Mathematics Handbook

Algebra 2

2015-2016

STAMFORD BOARD OF EDUCATION
2015-2016

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Directions for the Algebra 2 Handbook

There is a great deal of information contained in this handbook which will enhance the implementation of the Algebra II curriculum. It is imperative to take time in the beginning of the school year to read the entire handbook to familiarize yourself with its components.

Please tab or mark pages in the handbook that will serve as necessary references. These include the curriculum with pacing for the units, the grading practice, and notebook set-up. District assessments are not included in this handbook but will be distributed from Central Office in a timely manner.

During the first days of school, set aside time for classroom organization and math notebook set-up. Classroom expectations should be reviewed and posted; student texts should be numbered and recorded when distributed; students should set up their notebook which should be used on a daily basis; the district grading practice should be reviewed and implemented.

Before the start of each unit, it is necessary to review each unit in the curriculum. The curriculum has been written for each course and it is intended to guide each teacher through the year in terms of required topics and pacing for all levels of instruction. The length of time for each unit is stated within the curriculum, can be found on the timeline page, and is specific to this school year**.** The time frames for the units should be adhered to and any issues that may arise can be documented on the feedback template and/or forwarded to the respective committee members.

NOTE: There are some changes to the curriculum and pacing guide based on the CCSS and teacher feedback for the 2015-2016 academic year. Instead of ten units, there are now seven units. The linear function has been removed and replaced with a 5 day introduction to Algebra 2, the quadratic unit and the Algebraic Expressions unit were merged into one unit, and the exponential and logarithms unit has been merged into one unit. The statistics unit has been modified and limited. In the teacher strategies and notes column, the committee added examples from the State of CT. Our district assessments this year are district pretest, midterm, and final. There is no first or third quarter formative assessment this year. The pretest is a formative assessment comprised of 50 short answers. The pretest covers material from the whole year. The midterm will cover material through polynomials. The final will cover material from the whole year, with a heavy emphasis on the second semester.

The handbook references projects and activities that can be found in the public folder. The public folder has not been up been updated for the activities. If you are having trouble, consult your department head or a committee member. Teachers will be required to include at least one project/performance based assessment per quarter. Within each school, Algebra 2 teachers should work in conjunction with each other to determine which projects/performance based assessments should be used. Appendix B provides some projects/activities to be used in class. Please forward any additional projects/activities that you have used in your classes to the HS Math Committee or to your Math Department Head so that they may be added to this section of the handbook.

The activities in this handbook should not just be photocopied and used as “worksheets” for students to complete individually. Instead, they should be used in the workshop model. This means that small groups of students work on the activity collaboratively or certain parts of the activity are assigned to certain groups of students. While students are working, the teacher should be helping each group and determining which students will present their work and solutions to the class. If teachers feel that they need help with the workshop model, they can contact their Math Department Head.

The HS Math Committee will supply two assessments for Algebra 2 throughout the school year. These assessments are the Midterm and Final Exam. All other assessments will be generated by teachers collaboratively (by school). Since the committee is looking towards a guide that will contain all assessments for each unit and/or section, it is the intention that in time, all courses in a school have similar assessments. Teachers should begin discussions and/or work together and share ideas when possible on these assessments as they will eventually become part of the curriculum guide. All input is essential and necessary for a successful curriculum.

This handbook is a working document created by Stamford Public School math teachers who value your feedback. At any time, you are encouraged to forward ideas, feedback, suggestions and/or comments to any member of the HS Math Committee. Please make notes/comments on the Course Feedback Document provided (Appendix A) and/or give any suggestions to your Math Department Head. These curricular documents are all "works-in progress" which need attention from all teachers. Together we can make these curricula the best that they can be. Be vocal and be committed!

Thank you,

High School Mathematics Curriculum Committee
Summer 2015

STAMFORD PUBLIC SCHOOLS

21st Century Mathematics
Learning and Instruction

Vision
All SPS students will participate in a rigorous, standards-based mathematics program and will be prepared for college-level mathematics coursework and competition in the global workforce.

Goal
All students will achieve at or above "goal" on the State of Connecticut's mathematics assessments.

Guiding Principles
- Higher-level mathematics for everyone
- Learning mathematics by doing mathematics
- Student-centered teaching and learning
- Systematic, on-going job-embedded learning opportunities for teachers

High Quality Mathematics Learning and Instruction
Teachers will:
- project a belief that all students can successfully achieve in mathematics
- acknowledge divergent ideas of and multiple perspectives by students
- shift from a traditional approach to mathematics to a more student-centered approach
- receive ongoing, embedded content and instructional professional development
- identify and emphasize interdisciplinary connections
- provide assessment *of* and assessment *for* student learning
- infuse instructional technology to enhance instruction and learning

Students will:
- learn by doing through the use of manipulatives, interactive technology or other mathematics tools in the classroom
- work both individually and collaboratively with a partner or in a group
- be engaged in and actively do mathematics
- maintain mathematics journals
- be independent learners and thinkers
- use technology for learning

Parents will:

- Provide a supportive learning environment at home,
- Be actively involved with student learning and achievement,
- Establish early and open communication with teacher
- Review student assignments for daily completion
- Support and encourage extra help when necessary
- Encourage good organizational skills and positive in-class behavior

Traditional vs. Student-Centered Teaching and Learning of Mathematics

Traditional Math Instruction	**Student-Centered Math Instruction**
• Students work individually • Students discuss only the answer to the problem • Students are shown one way to solve a problem (the algorithm) • Math problems and examples do not always relate to the real world or to the way students think about mathematics • Procedural knowledge is emphasized • Teacher leads, directs, or dictates • Some students are "good" at math and others just are not	• Students work in pairs and groups as well as individually • Students discuss mathematical ideas and processes to understand the "how" and "why" of mathematics • Students use a variety of materials to develop their own mathematical understanding • There is a focus on making sense of the math and how it applies to real world situations • There is a balance between procedural and conceptual knowledge • Teacher facilitates and guides • All students are capable of succeeding in mathematics

Professional Development will:

- focus on standards-based mathematics
- focus on effective instructional practices as well as content
- be designed based on student outcome data and teacher needs
- be designed collaboratively with teachers and administrators
- be timely, responsive, and flexible

Implementation and Action Plan

We outline three stages in the implementation of a high quality mathematics program for all SPS students.

Stage One: Standardized Mathematics Curriculum

- identify grade-level mathematics standards and expectations
- identify available mathematics resources at each school
- identify appropriate technology hardware and software resources to support teaching and learning

Stage Two: Develop and Share Best Practices in Mathematics Teaching and Learning

- identify best practices in mathematics instruction
- identify high quality mathematics instructional materials
- develop and implement classroom assessments to provide students with on-going feedback

Stage Three: Continuous Learning

- foster continual learning opportunities for students
- develop innovative and relevant courses (e.g., statistics of sport, architectural design, biometrics, etc.)
- organize continual professional development opportunities for teachers

Professional Development Protocol

Classroom-embedded PD is:

- NON-EVALUATIVE
- to provide individualized feedback to each teacher reading pedagogy

Expectations

The consultant will

- carry out the role with professionalism, integrity, and courtesy
- provide constructive oral feedback to individual teachers by providing at least one suggestion of what to work on for next time (e.g. putting students in groups with specific roles)
- respect the confidentiality of the information gained

The teacher will:

- know dates of visit in advance and not schedule tests/quizzes on these dates
- carry out the role with professionalism, integrity, and courtesy
- accept oral feedback and suggestions
- practice implementing suggestions in between visits
- provide math topic to DH in advance of visit (timeline for identifying topic to be determined with DH)
- debrief the classroom visit with the consultant during the contractual day and during his/her scheduled collateral duty

The Math Administrator/DH will:

- carry out the role with professionalism, integrity, and courtesy
- develop a schedule in advance of the visit and send schedule/math topic of the lessons to the Curriculum Associate in Central Office
- schedule time for teachers to individually debrief the classroom visit with the consultant during the contractual day and during his/her scheduled collateral duty

Central Office will:

- carry out the role with professionalism, integrity, and courtesy
- set up dates for visits with the provider
- schedule substitutes to cover teachers' collateral duty during debrief
- send schedule/math topic to the provider in advance of visit
- ask teachers, DHs, Math Administrators for feedback about PD

CCSS Shifts, Mathematical Practices, & Webb's DOK

CCSS Three Shifts in Mathematics:

1. **FOCUS strongly where the Standards focus**

2. **COHERENCE: Think across grades, and link to major topics within grades**

3. **RIGOR: In major topics pursue conceptual understanding, procedural skill and fluency, and application with equal intensity**

Common Core State Standards for Mathematics: Mathematical Practices

The Standards for Mathematical Practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on important "processes and proficiencies" with longstanding importance in mathematics education. The first of these are the NCTM process standards of problem solving, reasoning and proof, communication, representation, and connections. The second are the strands of mathematical proficiency specified in the National Research Council's report Adding It Up: adaptive reasoning, strategic competence, conceptual understanding (comprehension of mathematical concepts, operations and relations), procedural fluency (skill in carrying out procedures flexibly, accurately, efficiently and appropriately), and productive disposition (habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy).

1. **Make sense of problems and persevere in solving them.**
   Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, "Does this make sense?" They can understand the approaches of others to solving complex problems and identify correspondences between different approaches.

2. **Reason abstractly and quantitatively.**
   Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.

3. **Construct viable arguments and critique the reasoning of others.**
   Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions, communicate them to others,

and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. Elementary students can construct arguments using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to determine domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.

4. Model with mathematics.

Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

5. Use appropriate tools strategically.

Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They are able to use technological tools to explore and deepen their understanding of concepts.

6. Attend to precision.

Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school they have learned to examine claims and make explicit use of definitions.

7. Look for and make use of structure

Mathematically proficient students look closely to discern a pattern or structure. Young students, for example, might notice that three and seven more is the same amount as seven and three more, or they may sort a collection of shapes according to how many sides the shapes have. Later, students will see 7×8 equals the well-remembered $7 \times 5 + 7 \times 3$, in preparation for learning about the distributive property. In the expression $x2 + 9x + 14$, older students can see the 14 as 2×7 and the 9 as $2 + 7$. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see $5 – 3(x – y)^2$ as 5 minus a positive number times a square and use that to realize that its value cannot be more than 5 for any real numbers x and y.

8. Look for and express regularity in repeated reasoning.

Mathematically proficient students notice if calculations are repeated, and look both for general methods and for shortcuts. Upper elementary students might notice when dividing 25 by 11 that they are repeating the same calculations over and over again, and conclude they have a repeating decimal. By paying attention to the calculation of slope as they repeatedly check whether points are on the line through (1, 2) with slope 3, middle school students might abstract the equation $(y – 2)/(x – 1) = 3$. Noticing the regularity in the way terms cancel when expanding $(x – 1)(x + 1)$, $(x – 1)(x2 + x + 1)$, and $(x – 1)(x3 + x2 + x + 1)$ might lead them to the general formula for the sum of a geometric series. As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results.

CCSS Mathematical Practices (Version 1.0)

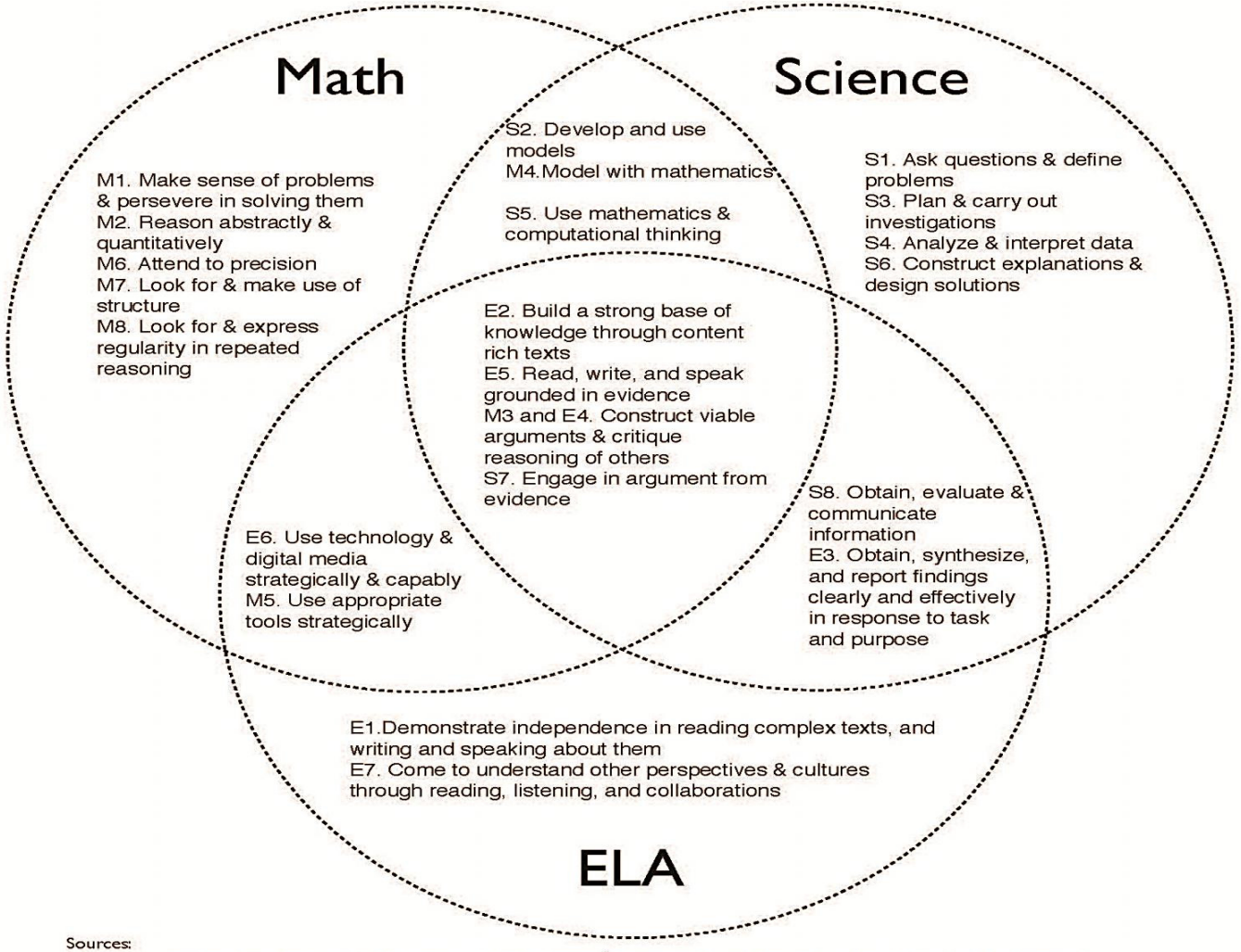
CCSS – Mathematical Practice	Strands of Mathematical Proficiency (NCTM Processes)	Look-For: Teacher	Look-For: Student
Make sense of problems and persevere in solving them.	Strategic, Competence, **(Problem Solving)**	Provides time for and facilitates the discussion of problem solutions.	Are actively engaged in solving problems.
Reason abstractly and quantitatively.	Adaptive Reasoning **(Reasoning & Proof)**	Provides a range of representations of mathematical ideas and problem situations and encourages varied solution paths.	Use varied representations and approaches when solving problems.
Construct viable arguments and critique the reasoning of others.	Adaptive Reasoning **(Reasoning & Proof)**	Provides opportunities for students to listen to or read the conclusions and arguments of others.	Understand and use prior learning in constructing arguments.
Model with mathematics.	Strategic Competence **(Connections)**	Provides a variety of contexts for students to apply the mathematics learned.	Apply mathematics learned to problems they solve and reflect on results.
Use appropriate tools strategically.	Strategic competence & Conceptual Understanding **(Representation)**	Use appropriate tools (manipulatives) instructionally to strengthen the development of mathematical understanding.	Use technological tools to deepen understanding.
Attend to precision.	Procedural Fluency **(Communication)**	Emphasizes the importance of mathematical vocabulary and models precise communication.	Based on a problem's expectation, students calculate with accuracy and efficiency.
Look for and make use of structure.	Strategic Competence **(Connections)**	Provides time for applying and discussing properties.	Look for, develop, and generalize arithmetic expressions.
Look for and express regularity in repeated reasoning.	Adaptive Reasoning **(Reasoning & Proof)**	Models and encourages students to look for and discuss regularity in reasoning.	Use repeated applications to generalize properties.

CCSS Mathematical Practices (Version 2.0)

Standards for Mathematical Practice	Students:	Teachers:
1. Make sense of problems and persevere in solving them.	• Analyze information and explain the meaning of the problem • Actively engaged in problem solving (Develop, carry out, and refine a plan) • Show patience and positive attitudes • Ask if their answers make sense • Check their answers with a different method	• Pose rich problems and/or ask open-ended questions • Provide wait-time for processing/finding solutions • Circulate to pose probing questions and monitor student progress • Provide opportunities and time for cooperative problem solving and reciprocal teaching
2. Reason abstractly and quantitatively.	• Represent a problem symbolically • Explain their thinking • Use numbers and quantities flexibly by applying properties of operations and place value • Examine the reasonableness of their answers/calculations	• Ask students to explain their thinking regardless of accuracy • Highlight flexible use of numbers • Facilitate discussion through guided questions and representations • Accept varied solutions/representations
3. Construct viable arguments and critique the reasoning of others.	• Make conjectures to explore their ideas • Justify solutions and approaches • Listen to the reasoning of others, compare arguments, and decide if the arguments of others makes sense • Ask clarifying and probing questions	• Provide opportunities for students to listen to or read the conclusions and arguments of others • Establish a safe environment for discussion • Ask clarifying and probing questions • Avoid giving too much assistance (e.g., providing answers or procedures)
4. Model with mathematics.	• Apply prior knowledge to new problems and reflect • Use representations to solve real life problems • Apply formulas and equations where appropriate • Ask questions about the world around them and attempt to attach meaningful mathematics to the world	• Pose problems connected to previous concepts • Provide a variety of real world contexts • Use intentional representations • Provide students the space to ask questions and pose problems about the world around them
5. Use appropriate tools strategically.	• Select and use tools strategically (and flexibly) to visualize, explore, and compare information • Use technological tools and resources to solve problems and deepen understanding	• Make appropriate tools available for learning (calculators, concrete models, digital resources, pencil/paper, compass, protractor, etc.) • Embed tools with their instruction
6. Attend to precision.	• Calculate accurately and efficiently • Explain thinking using mathematics vocabulary • Use appropriate symbols and specify units of measure	• Recognize and model efficient strategies for computation • Use (and challenging students to use) mathematics vocabulary precisely and consistently
7. Look for and make use of structure.	• Look for, develop, and generalize relationships and patterns • Apply conjectures about patterns and properties to new situations	• Provide time for applying and discussing properties • Ask questions about the application of patterns • Highlight different approaches for solving problems
8. Look for and make use of regularity in repeated reasoning.	• Look for methods and shortcuts in patterns in repeated calculations • Evaluate the reasonableness of intermediate results and solutions	• Provide tasks and problems with patterns • Ask about possible answers before, and reasonableness after computations

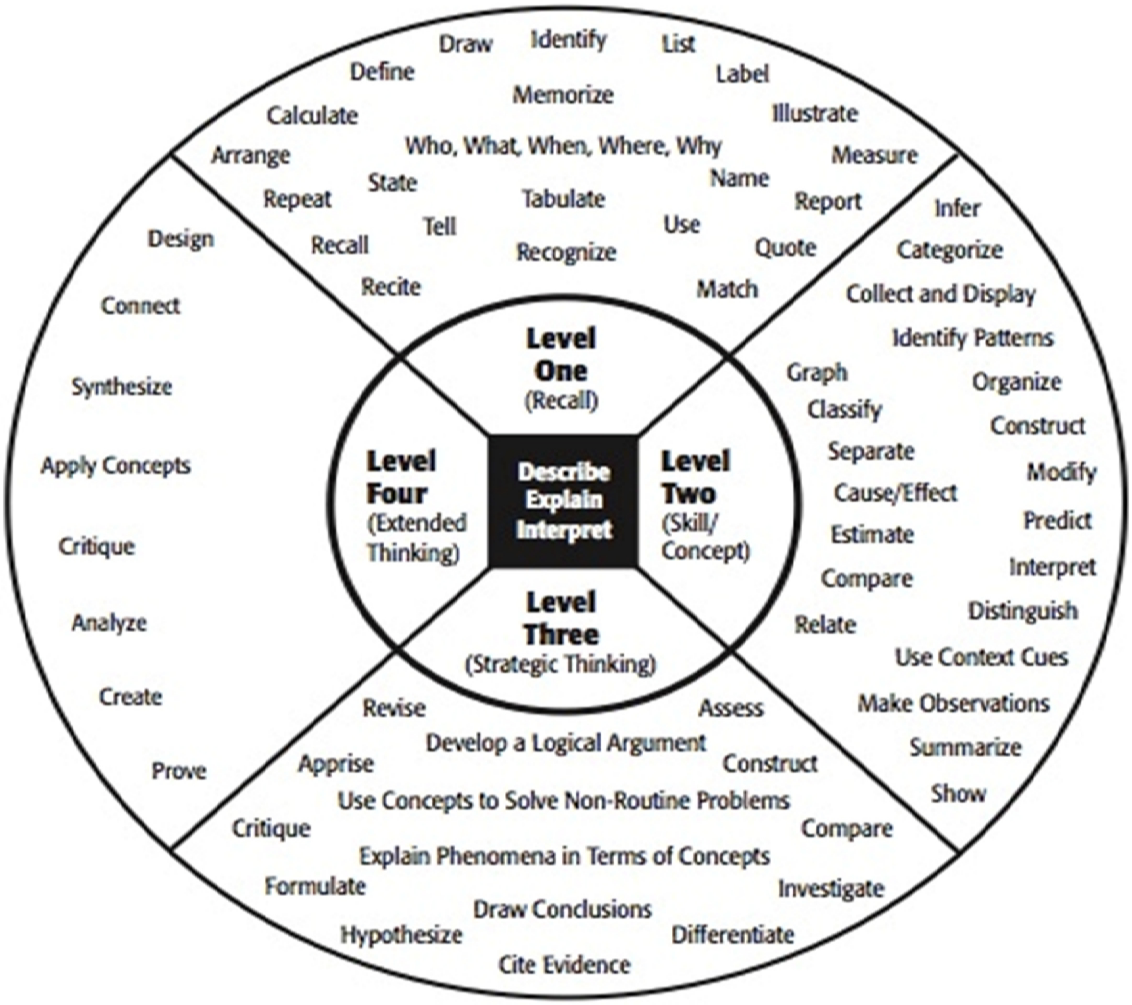
Relationships and Convergences Found in the Common Core State Standards in Mathematics (practices), Common Core State Standards in ELA/Literacy*(student portraits), and A Framework for K-12 Science Education (science & engineering practices)

These student practices and portraits are grouped in a Venn diagram. The letter and number set preceding each phrase denotes the discipline and number designated by the content standards or framework. The Science Framework will be used to guide the production of the Next Generation Science Standards.



Sources:
Common Core State Standards for English Language Arts & Literacy* in History/Social Studies, Science, and Technical Subjects, p7.
Common Core State Standards for Mathematical Practice p6-8.
A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, ES-3 and chapter 3: 1-32.

Depth of Knowledge (DOK) Levels



Level One Activities	Level Two Activities	Level Three Activities	Level Four Activities
Recall elements and details of story structure, such as sequence of events, character, plot and setting.	Identify and summarize the major events in a narrative.	Support ideas with details and examples.	Conduct a project that requires specifying a problem, designing and conducting an experiment, analyzing its data, and reporting results/ solutions.
Conduct basic mathematical calculations.	Use context cues to identify the meaning of unfamiliar words.	Use voice appropriate to the purpose and audience.	Apply mathematical model to illuminate a problem or situation.
Label locations on a map.	Solve routine multiple-step problems.	Identify research questions and design investigations for a scientific problem.	Analyze and synthesize information from multiple sources.
Represent in words or diagrams a scientific concept or relationship.	Describe the cause/effect of a particular event.	Develop a scientific model for a complex situation.	Describe and illustrate how common themes are found across texts from different cultures.
Perform routine procedures like measuring length or using punctuation marks correctly.	Identify patterns in events or behavior.	Determine the author's purpose and describe how it affects the interpretation of a reading selection.	Design a mathematical model to inform and solve a practical or abstract situation.
Describe the features of a place or people.	Formulate a routine problem given data and conditions.	Apply a concept in other contexts.	
	Organize, represent and interpret data.		

Webb, Norman L., and others. "Web Alignment Tool" 24 July 2005. Wisconsin Center of Educational Research, University of Wisconsin-Madison. 2 Feb. 2006. <http://www.wcer.wisc.edu/WAT/index.aspx>

Table 1: *Math Descriptors* – Applying Depth of Knowledge Levels for Mathematics (Webb, 2002) & NAEP 2002 Mathematics Levels of Complexity (M. Petit, Center for Assessment 2003, K. Hess, Center for Assessment, updated 2006)

Level 1 Recall	Level 2 Skills/Concepts	Level 3 Strategic Thinking	Level 4 Extended Thinking
a. Recall, observe, or recognize a fact, definition, term, or property b. Apply/compute a well-known algorithm (e.g., sum, quotient) c. Apply a formula d. Determine the area or perimeter of rectangles or triangles given a drawing and labels e. Identify a plane or three dimensional figure f. Measure g. Perform a specified or routine procedure (e.g., apply rules for rounding) h. Evaluate an expression i. Solve a one-step word problem j. Retrieve information from a table or graph k. Recall, identify, or make conversions between and among representations or numbers (fractions, decimals, and percents), or within and between customary and metric measures l. Locate numbers on a number line, or points on a coordinate grid m. Solve linear equations n. Represent math relationships in words, pictures, or symbols o. Read, write, and compare decimals in scientific notation	a. Classify plane and three dimensional figures b. Interpret information from a simple graph c. Use models to represent mathematical concepts d. **Solve a routine problem** requiring multiple steps/decision points, or the application of multiple concepts e. Compare and/or contrast figures or statements f. Construct 2-dimensional patterns for 3-dimensional models, such as cylinders and cones g. Provide justifications for steps in a solution process h. Extend a pattern i. Retrieve information from a table, graph, or figure and use it solve a problem requiring multiple steps j. Translate between tables, graphs, words and symbolic notation k. Make direct translations between problem situations and symbolic notation l. Select a procedure according to criteria and perform it m. Specify and explain relationships between facts, terms, properties, or operations n. Compare, classify, organize, estimate, or order data	a) Interpret information from a complex graph b) Explain thinking when more than one response is possible c) Make and/or justify conjectures d) Use evidence to develop logical arguments for a concept e) Use concepts to solve non-routine problems f) Perform procedure with multiple steps and multiple decision points g) Generalize a pattern h) Describe, compare, and contrast solution methods i) Formulate a mathematical model for a complex situation j) Provide mathematical justifications k) Solve a multiple- step problem and provide support with a mathematical explanation that justifies the answer l) Solve 2-step linear equations/inequalities in one variable over the rational numbers, interpret solution(s) in the original context, and verify reasonableness of results m) Translate between a problem situation and symbolic notation that is not a direct translation n) Formulate an original problem, given a situation o) Analyze the similarities and differences between procedures p) Draw conclusion from observations or data, citing evidence	a) Relate mathematical concepts to other content areas b) Relate mathematical concepts to real-world applications in new situations c) Apply a mathematical model to illuminate a problem, situation d) Conduct a project that specifies a problem, identifies solution paths, solves the problem, and reports results e) Design a mathematical model to inform and solve a practical or abstract situation f) Develop generalizations of the results obtained and the strategies used and apply them to new problem situations g) Apply one approach among many to solve problems h) Apply understanding in a novel way, providing an argument/justification for the application ***NOTE**: Level 4 involves such things as complex restructuring of data or establishing and evaluating criteria to solve problems.*

GEF CCSS Classroom Rubric				
	PREPARING	**GETTING STARTED**	**MOVING ALONG**	**IN PLACE**
Instructional Shifts				
Alignment of Content	❑ None of the content in the lesson is found in the appropriate grade level standards. ❑ Learning intentions/targets and success criteria are not posted.	❑ Some of the content in the lesson is found in the appropriate grade level standards. ❑ Learning intentions/targets and success criteria are posted but not tied to the CCSS.	❑ Most of the content in the lesson is found in the appropriate grade level standards. ❑ Learning intentions/targets and success criteria are posted and tied to the CCSS.	❑ All of the content in the lesson is found in the appropriate grade level standards. ❑ Learning intentions/targets and success criteria are posted, clearly tied to the CCSS, and used during the lesson.
Connections	❑ The content of the lesson is not connected to the major mathematical topics at the grade level. ❑ There are no connections to other grade level content.	❑ The content of the lesson is minimally connected to the major mathematical topics at the grade level. ❑ There are only tangential connections to other grade level content.	❑ The content of the lesson is moderately connected to the major mathematical topics at the grade level. ❑ There are some connections to other grade level content.	❑ The content of the lesson is clearly connected to the major mathematical topics at the grade level. ❑ There are strong connections to other grade level content.
Cognitive demand of lesson content	❑ The content of the lesson is not conceptually demanding for students. ❑ The lesson focuses on memorization of mathematical facts and procedures.	❑ The content of the lesson is somewhat conceptually demanding. ❑ The lesson may introduce conceptual understanding but focuses primarily on practicing procedures during learning activities. ❑ Teacher asks low level questions and does not require students to explain their thinking.	❑ The content of the lesson is conceptually demanding. ❑ The mathematics involved is primarily conceptual in nature or involves procedures with explicit underlying conceptual connections. ❑ Teacher asks a mix of higher and lower level questions that limit students opportunity to explain their thinking.	❑ The content of the lesson is very conceptually demanding. ❑ The teacher maintains high cognitive demand throughout the lesson, requiring students to deeply engage with making sense of the mathematics and justifying their thinking. ❑ Teacher consistently asks higher-level questions that require students to explain their thinking. ❑ Teacher begins lesson with a review of critical prerequisite skills and concepts.

	PREPARING	GETTING STARTED	MOVING ALONG	IN PLACE
Procedural Skill and Fluency	❑ Few students know the procedural skills needed to solve mathematical problems. ❑ Students demonstrate a lack of fluency of math facts.	❑ Some students have learned procedural skills. ❑ Students have limited fluency of math facts and are slow when solving mathematical problems.	❑ Many students have learned procedural skills. ❑ Students are fluent in their math facts but unable to use those facts effectively within higher-level procedures and/or when solving problems of a conceptual nature.	❑ Most students have learned the procedural skills required by the Standards. ❑ Students demonstrate fluency of math facts and are able to apply those facts to higher-level procedures and mathematical thinking when problem-solving.
Application	❑ Teacher makes no connection between the topic of the lesson and real world situations.	❑ Teacher makes some attempts to connect the topic of the lesson with real world situations.	❑ Teachers consistently make connections between the topic of the lesson and real world situations.	❑ Teachers and students co-construct the application of math concepts to real world situations.
1. Mathematical Practices				
Making sense of problems & persevering in solving them	❑ Not observed	❑ Limited and only tangential attention or use is more of an afterthought.	❑ Some evidence of use, but inconsistent, missed opportunities to use or without focus or emphasis.	❑ Teachers take every opportunity to develop number sense by ask for estimates, mental calculations, and equivalent forms of numbers. ❑ Students persevere in solving difficult and worthwhile problems. ❑ Teachers elicit, value, and celebrate alternative approaches to solving problems; students are taught that mathematics is a sense making process for understanding.
Reason abstractly and quantitatively	❑ Not observed	❑ Limited and only tangential attention or use is more of an afterthought.	❑ Some evidence of use, but inconsistent, missed opportunities to use or without focus or emphasis.	❑ Students make sense of quantities and their relationships in problem situations ❑ Student use varied representations and approaches when solving problems. ❑ Students know and flexibly use different properties of operations and objects.

	PREPARING	GETTING STARTED	MOVING ALONG	IN PLACE
Construct viable arguments and critique the reasoning of others	❑ Not observed	❑ Limited and only tangential attention or use is more of an afterthought.	❑ Some evidence of use, but inconsistent, missed opportunities to use or without focus or emphasis.	❑ Students explain their thinking. ❑ Students build upon their own and others' thinking. ❑ Students critique the arguments and reasoning of others.
Model with mathematics	❑ Not observed	❑ Limited and only tangential attention or use is more of an afterthought. ❑	❑ Some evidence of use, but inconsistent, missed opportunities to use or without focus or emphasis.	❑ Students apply the mathematics they know to solve problems arising in everyday life and the workplace. ❑ Students analyze mathematical relationships to draw conclusions. ❑ Students can apply what they know and are comfortable making assumptions and approximations.
Use appropriate tools strategically	❑ Not observed	❑ Limited and only tangential attention or use is more of an afterthought.	❑ Some evidence of use, but inconsistent, missed opportunities to use or without focus or emphasis.	❑ Teachers provide multiple ❑ Teachers provide multiple representations (models, number lines, tables, graphs, as well as symbols) to support visualization of skills and concepts. ❑ Students consider the available tools when solving a mathematical problem.
Attend to precision	❑ Not observed	❑ Limited and only tangential attention or use is more of an afterthought.	❑ Some evidence of use, but inconsistent, missed opportunities to use or without focus or emphasis.	❑ Teachers and students use mathematical terminology and vocabulary with precision.
Look for and make sense of structure	❑ Not observed	❑ Limited and only tangential attention or use is more of an afterthought.	❑ Some evidence of use, but inconsistent, missed opportunities to use or without focus or emphasis. .	❑ Students can look for, develop, generalize and describe a pattern orally, symbolically, graphically, and in written form.
Look for regularity in repeated reasoning	❑ Not observed	❑ Limited and only tangential attention or use is more of an afterthought. ❑	❑ Some evidence of use, but inconsistent, missed opportunities to use or without focus or emphasis.	❑ Students notice if calculations are repeated and look both for general methods and for short cuts. ❑ Students maintain oversight of the mathematical process while attending to detail.

	PREPARING	GETTING STARTED	MOVING ALONG	IN PLACE
3. Level of Student Engagement				
	❑ Teacher does not appear to have control of classroom management. ❑ Few students are on task during the course of the lesson. ❑ Lesson allows students little opportunity to engage with the lesson content. ❑ Teacher does not facilitate any classroom discussion among students.	❑ Class is organized and routines are evident. ❑ Some students are on task; others are off-task and some are being disruptive. ❑ Lesson allows students some opportunity to engage with the lesson content. ❑ Students have some opportunities to participate in classroom discussions.	❑ Class routines are clearly established and followed. ❑ Most students are actively engaged in lesson activities. Some students may be off task when working independently. ❑ Most aspects of the lesson provide students with opportunities to engage with the lesson's central content. ❑ Students make some connections to others' thinking during classroom discussions.	❑ Class routines are working effectively to facilitate learning. ❑ All students are actively engaged in lesson activities. Students are on task even when working independently. ❑ All aspects of the lesson provide opportunities for students to engage with the central content. ❑ Students engage in productive classroom discussions making connections and collaborating with others. ❑ Teachers have carefully planned tasks, activities, questions, and assessments for coherence.
4. Differentiation				
	❑ There is little evidence of differentiation. Instruction is oriented toward a single level of difficulty. ❑ There is little evidence of varied learning activities/instructional strategies. ❑ There is little evidence of varied assessment methods.	❑ Instruction is differentiated for some students. Instruction is primarily oriented toward a single level of difficulty. ❑ Different learning activities/instructional strategies are provided for groups. ❑ Some different assessment methods are used.	❑ Instruction is differentiated for all students. Instruction is oriented to more than one level of difficulty. ❑ Some choices are available for student learning. A range of different instructional strategies is used. ❑ Different assessment methods are offered to students.	❑ Instruction is oriented toward multiple levels of difficulty. All students are working at an appropriate level. ❑ Multiple activities and choices are available for student learning. A comprehensive set of strategies is used. ❑ Students choose how they will demonstrate their learning. ❑ Teachers use formative assessment to consistently to check on lesson objectives/targets.

	PREPARING	GETTING STARTED	MOVING ALONG	IN PLACE
5. Classroom Environment				
	❑ Room contains mostly generic educational posters. No actual student work is posted in the room. ❑ Room contains limited resources (e.g. word walls, academic language, procedural explanations) for students.	❑ Examples of student work are posted in the classroom, but many are outdated or with no teacher commentary or connection to the standards. ❑ Room contains some resources (e.g. word walls, academic language, procedural explanations) that can be used by students	❑ Reasonably current student work is posted in the classroom with some teacher commentary. No connections to the Standards are evident. ❑ Room contains multiple resources that can be used by students.	❑ Current student work is posted in the classroom with teacher commentary. Teacher comments show connections to the Standards. ❑ Room contains multiple resources that can be used by students AND there is evidence that students regularly access these resources.
6. Culturally Responsive Teaching				
Students' lives	❑ No evidence of students' lives, interests, families, communities and/or cultures are connected to the standards being taught.	❑ Little evidence of students' lives, interests, families, communities and/or cultures are connected to the standards being taught.	❑ Some evidence of students' lives, interests, families, communities and/or cultures are connected to the standards being taught.	❑ Strong evidence that students' lives, interests, families, communities and/or cultures are connected to the standards being taught.
Diverse experiences	❑ Delivery of content does not support diverse experiences and perspectives.	❑ Delivery of content occasionally supports diverse experiences and perspectives.	❑ Delivery of content inconsistently supports diverse experiences and perspectives.	❑ Delivery of content is consistently supports diverse experiences and perspectives.
Respect and rapport	❑ Limited evidence of respect and rapport among students and between teacher and students.	❑ Some evidence of respect and rapport is among students and between teacher and students.	❑ Most interactions among students and between teacher and students are positive and supportive.	❑ Interactions among students and between teacher and students are consistently positive and supportive.

The "Four C's" for 21st Century Education

The "Four Cs" for 21st Century Education

CRITICAL THINKING

Make Judgments and Decisions Using Evidence

- Analyze and evaluate evidence, arguments, claims and beliefs, including multiple points of view
- Synthesize information and arguments
- Interpret information and draw conclusions
- Reflect critically on learning experiences to improve

Problem Solve

- Solve problems in a variety of ways
- Identify, ask, and answer clarifying and/or probing questions

CREATIVITY

Think Creatively

- Use a variety of creative strategies (such as brainstorming, analyzing sources, experimentation) to generate ideas (i.e. models, an argument, a visual, solutions, etc.)
- Elaborate, refine, analyze, and evaluate ideas
- Demonstrate originality

Work Creatively with Others

- Develop and communicate new ideas to others
- Be open and responsive to new and diverse perspectives (incorporate group input and feedback into the work)
- Demonstrate originality and inventiveness in work and explore real world limits
- View failure as an opportunity to learn; creativity is a process of small successes and frequent mistakes

COMMUNICATION

- Articulate thoughts and ideas using oral, written, and/or nonverbal communication skills
- Listen actively (consider and respond)
- Use communication for a range of purposes (e.g., to inform, instruct, motivate, and persuade) and audiences
- Utilize multiple media and technologies, and determine their effectiveness as well as their impact

COLLABORATION

- Establish roles and responsibilities
- Demonstrate ability to work respectfully with others
- Value individual contributions and accept shared responsibility for work
- Exercise willingness to compromise in order to achieve a common goal

Stamford Public Schools
EXCELLENCE IS THE POINT.

The 4Cs in a 21st Century Education

CRITICAL THINKING

Make Judgments and Decisions Using Evidence

- Analyze and evaluate evidence, arguments, claims and beliefs, including point(s) of view
- Interpret information and draw conclusions
- Synthesize information and arguments
- Reflect critically on learning experiences to advance critical thinking skills

Solve Problems

- Solve problems in a variety of ways
- Identify, ask, and answer clarifying and/or probing questions

CREATIVITY

Think Creatively

- Use a variety of creative strategies
- Elaborate, refine, analyze, and evaluate ideas
- Demonstrate originality

Work Creatively with Others

- Develop and communicate new ideas
- Be open and responsive to new and diverse perspectives
- Assess and evaluate real world limits
- View failure as an opportunity to learn; creativity is a process of small successes and frequent mistakes

COMMUNICATION

- Articulate thoughts and ideas using oral, written, and/or nonverbal communication skills
- Listen actively
- Communicate for a range of purposes
- Utilize multiple media and technologies, and determine effectiveness as well as impact

COLLABORATION

- Establish roles and responsibilities
- Demonstrate ability to work respectfully with others
- Value individual contributions and accept shared responsibility for work
- Exercise willingness to compromise in order to achieve a common goal

Algebra 2 Syllabus

Algebra 2 Syllabus

Introduction:

All Stamford Public Schools students will participate in a rigorous, standards-based mathematics program and will be prepared for college-level mathematics coursework and competition in the global economy. Stamford Public Schools has created a curriculum that allows students to become mathematical problem solvers, learn to communicate mathematically, learn to reason mathematically, learn to value mathematics, and become confident in their ability to do mathematics. This curriculum has been developed through recommendations of the National Council of Teachers of Mathematics (NCTM), Program for International Student Assessment (PISA), and Trends in International Mathematics and Science Study (TIMSS). These organizations encourage school systems to provide students with greater focus and more depth in the context of real world situations.

Stamford Public Schools Department of Mathematics follows a blended curriculum that is technology based and application driven. This means that although there is a specific focus for each mathematics course, problems are introduced which cause students to revisit other strands of the mathematics curriculum. This highlights and reinforces the connections among different math topics and courses. Technology is used throughout the curriculum enabling teachers to provide visual and physical components to abstract mathematical concepts. This gives students the opportunity to learn more quickly and in more depth. Application driven approaches provide students with problems relating the objectives to real world situations.

Textbook:

Larson, Boswell, Kanold, Stiff (2004, 2007). Algebra 2. McDougal Littell

- This textbook is available online at www.classzone.com

Introduction to Algebra 2 (5days)

- Pre assessment
- Order of Operations
- Properties of Exponents
- Properties of Addition and Multiplication
- Solving Multistep Equation

Unit 1: Functions and Inverses (25 days)

- Compare relations and functions
- Domain and range of functions
- Library of Parent Functions & characteristics
- Transformations of Parent Functions
- Find inverse functions algebraically (linear and simple quadratic)
- Construct an inverse graph

Unit 2:Quadratic Functions (25 days)

- Distributive Property – multiplication and factoring
- Operations on Imaginary & Complex Numbers
- Solve quadratic equations
    - Take the square
    - Factoring
    - Quadratic Formula
    - Complete the Square
- Graph quadratic functions
- Use quadratic functions to solve real-life problems

Unit 3: Polynomial Functions (25 days)

- Operations on polynomials
- Graph polynomial functions
- Solve polynomial equations
- Write an equation of a graph
- Connect the relationship among zeros, factors, roots, and intercepts
- Fundamental Theorem of Algebra
- Interpret and solve problems involving polynomial functions

Unit 4: Radicals (10 days)

- Convert between radical and rational exponent expressions
- Solve radical and rational exponent equations
- Graph radicals functions
- Use radical and rational equations in real world situations

Unit 5: Rational Functions (20 days)

- Operations on rational expressions – add, subtract, multiply, divide.
- Solve rational equations
- Graph rational functions
- Apply equations to model and solve word problems

Unit 6: Exponential and Logarithmic Functions (30 days)

- Graph exponential functions and describe characteristics
- Transformations on graphs of exponential functions
- Use exponential functions in applications involving growth or decay.
- Investigate the natural base, e, and its applications.
- Solve exponential equations by rewriting in the same base, and using properties of exponents.
- Make predictions using exponential mathematical models from given information
- Convert between logarithmic and exponential form
- Find the inverse function
- Graph logarithmic functions including transformations, and describe the characteristics.
- Apply properties of logarithms to simplify expressions.
- Solve logarithmic equations.
- Make predictions using logarithmic mathematical models from given information

Unit 7: Statistics and Modeling (15 days)

- Visual representations of data
- Calculate appropriate statistical summaries
- Differentiate symmetric, asymmetric/skewed distributions
- Normal distribution and the use of area under the curve.
- Calculate percentiles
- Normal Distribution
- Empirical rule
- Regression
    - Linear
    - Quadratic
    - Exponential

Algebra 2 Curriculum Map

Grade Level	September	October	November	December	January	February	March	April	May	June
Alg 2	Intro to Algebra 2 Aug 31 – Sept 4 **Intro Topics:** Pre-Assessment, Order of Operations, Properties of Exponents, Properties of Add & Mult, Distributive property, Solve multi-step equations	Functions and Inverses cont' Unit 1: Functions and Inverses Sept 8 – Oct 16 **Unit 1 Topics:** Domain, Range, Function Notation, Relation, Function, Inverse, Transformations, Translations, Parent Functions, Function Composition, Function Operations	Quadratics cont' Unit 2: Quadratics Functions Oct 19 – Nov 24 **Unit 2 Topics:** Roots, Zeros, Intercepts, Vertex Form, Standard Form, Quadratic Formula, Completing the Square, Solving Quadratic Equations, Complex Numbers, Applications	Polynomials cont' Unit 3: Polynomial Functions Nov 30 – Jan 12 **Unit 3 Topics:** Roots, Zeros, Intercepts, Solving Polynomial Equations, Graphing Polynomial Equations, End Behavior, Intervals of Increasing and Decreasing, Graph Behavior, Polynomial Algebra	Polynomials cont' Unit 4: Radical Functions Jan 25 – Feb 5 **Unit 4 Topics:** Index of Radical, Rational Exponent, Powers, Roots, Extraneous Solution, Least Common Denominator, Average Cost, Solving Proportions **Midterm Review** **Jan 13th – Jan 15th** **Midterm Exam** **Jan 19th –Jan 22rd**	Radicals cont' Unit 5: Rational Functions Feb 8 – Mar 9 **Unit 5 Topics:** Domain, Range, Vertical Asymptotes, Horizontal Asymptotes, Holes, End Behavior, Intercepts, Roots, Zeros, Least Common Denominator, Factoring, Extraneous Solutions, Simplifying Expressions	Rationals cont' Unit 6: Exp & Log Functions Mar 10 – Apr 29 **Unit 6 Topics:** Base, Power, Exponent, Growth, Decay, Exponential Function, Logarithmic Function, Inverse, Asymptotes, Solving Exponential and Logarithmic Functions, Compound Interest, Continuous Compounding	Exps & Logs cont' **Unit 7 Topics:** Shape, Center, Spread; Mean, Median, Mode, Standard Deviation, Range, Upper Quartile, Lower Quartile, boxplot, Normal Curve, Empirical Rule, Z-score, Linear, Quadratic, Exponential Regression	Stats and Modeling Unit 7: Statistics & Modeling May 2 – May 20 **Final Exam Review** **May 31 - Jun 3**	**Final Exam** **Jun 6 - Jun 10**

Math Class Expectations

All students will:

- Communicate their reasoning and justifications for mathematical ideas with their peers and the teacher
- Use mathematical vocabulary during discussions
- Be engaged during the explore section of the lesson
- Use concrete representations or manipulatives when appropriate for the problem
- Provide multiple methods and solutions for problems
- Use technology when appropriate for the problem
- Organize their materials in a notebook
- Use math talk and explain their thinking
- Show confidence in explaining their solutions
- Show mathematics proficiency in understanding, computing, applying, and reasoning
- Be engaged throughout the lesson
- Be empowered to *THINK!*

All teachers will:

- Be knowledgeable about their mathematics content standards and expectations,
- Use common mathematical language,
- Understand and incorporate student-centered instructional practices,
- Continually assess student learning using a variety of strategies,
- Implement school and district mathematics initiatives,
- Integrate technology to enhance instruction.

All parents will:

- Provide a supportive learning environment at home,
- Be actively involved with student learning and achievement,
- Establish early and open communication with teacher,
- Review student assignments for daily completion,
- Support and encourage extra help when necessary,
- Encourage good organizational skills and positive in-class behavior.

Grading Practice

The following is a range for each portion of the grading practice for Algebra II. The actual percentage for each part of the grade will be determined by the individual school's math department for each high school mathematics course.

I. Formal Assessments:	
Tests & Quizzes	50-65%
II. Homework	10%
III. Alternative Assessments:	25-40%
Projects, Performance Tasks, Class Activities	
Math Notebooks (evidence of student learning)	
Presentations	

Timeline for Algebra II

		Instructional Periods
Intro:	**Introduction to Algebra 2**	**5**
Unit I:	**Functions and Inverses**	**25**
Unit II:	**Quadratic Functions**	**25**
Unit III:	**Polynomials**	**25**
Unit IV:	**Radical Functions**	**10**
Unit V:	**Rational Functions**	**20**
Unit VI:	**Exponential and Logarithmic Functions**	**30**
Unit VII:	**Statistics and Modeling**	**15**

Algebra 2 Curriculum

Algebra 2

Introduction to Algebra 2

Book Reference: none	**Timeframe:** 5 instructional periods

Depth of Knowledge 	**Essential Questions For Unit**
	1. How are different equations and functions used to understand/represent the Universe we live in? 2. What are the key characteristics of functions?
	Enduring Understandings
	1. A variety of numerical representations can be used to describe quantitative relationships. 2. The way that data is collected, organized and displayed influences interpretation.
	Content Knowledge Objectives
Recall Describe, Draw, Identify, Label, Locate, Match, Measure, Evaluate, Compute, Perform, Retrieve	
Skill/Concept Categorize, Classify, Compare, Contrast, Describe Cause/Effect, Describe Patterns, Describe Relationships, Estimate, Generalize, Infer, Interpret, Make Observations, Predict, Summarize, Organize, Collect and Display	
Strategic Thinking Revise, Assess, Critique, Draw Conclusion, Investigate, Differentiate, Hypothesize, Cite Evidence	
Extended Thinking Analyze, Apply Concepts, Connect, Prove, Synthesize, Create, Connect	

VOCABULARY

Variable	Equation	Multi-Step Equation
Term	Expression	

MATHEMATICAL PRACTICES

Mathematical Practices #1 and #3 describe a classroom environment that encourages thinking mathematically and are critical for quality teaching and learning.

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.

REQUIRED ACTIVITIES, SUGGESTED RESOURCES and ACTIVITIES

Pre- Assessment Test, See Public Folders and List of Possible Websites

ASSESSMENTS/FORMATIVE ASSESSMENTS

Pretest/Post Test
Quizzes (individual and partner)
Teacher-generated assessments
Notebook quizzes
Exit slips
Participation sheets

Introduction to Algebra 2

C.9-12. …. Standard – (Indicators)	Expectations ‘ Student will….’	Teacher Strategies and Notes:
A-REI.1. Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method. A-REI.3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.	• Pre Assessment • Properties of Addition and Multiplication Closure Commutative Associative Identity Inverse Distributive $[a(b+c)=ab+ac]$ • Order of operation • Properties of Exponents Product of Powers: $a^m \cdot a^n = a^{m+n}$ Power of a Power: $(a^m)^n = a^{mn}$ Power of a Product: $(ab)^m = a^m b^m$ Negative Exponents: $a^{-m} = \frac{1}{a^m},\ a \neq 0$ Zero Exponents: $a^0 = 1,\ a \neq 0$ Quotient of Powers: $\frac{a^m}{a^n} = a^{m-n},\ a \neq 0$ Powers of a Quotient: $\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$ • Solve multistep equations	• Instructional Period = 1 class period. Block period = 2 instructional periods. • Students should come prepared with knowledge of Properties of Addition and Multiplication, Order of operations, Properties of Exponents, and Solving Equations. Emphasize should be on reactivating student’s memories. • Students should come prepared with knowledge of linear equations including calculating slope, graphing lines, etc. No class time should be spent doing review of this material. • Multistep equations: $-2x+9=2x-7$ $-4(3x+5)=-2(5-x)$

Algebra 2
Unit 1: Functions and Inverses

Book Reference:
Algebra 2 (2004) Chapter 2.1, 7.3, 7.4, 7.5
Algebra 2 (2007) Chapter 2.1, 2.7, 6.3, 6.4

Timeframe:
25 Instructional Periods

Depth of Knowledge	Essential Questions For PreK-12 Mathematics
	1. What is a function and how can one be identified and represented? 2. What is functional notation and how does it represent the relationship between input and output variables? 3. How can we create new or altered functions through operations or composition of existing functions? 4. How can we identify and distinguish families of functions through modeling, graphing, and notation? 5. What is the inverse of a function? How can an inverse be displayed graphically?
	Enduring Understandings
	1. There are sets of basic functions, called families. There are transformations that can be applied to each family to produce transformed functions of that family. 2. For a function to have an inverse function, the original function must be one to one.
	Content Knowledge Objectives
Recall Describe, Draw, Identify, Label, Locate, Match, Measure, Evaluate, Compute, Perform, Retrieve	1. Identify a particular function family via notation and graph. 2. Identify the independent and dependent variables; input, output and the "rule."
Skill/Concept Categorize, Classify, Compare, Contrast, Describe Cause/Effect, Describe Patterns, Describe Relationships, Estimate, Generalize, Infer, Interpret, Make Observations, Predict, Summarize, Organize, Collect and Display	1. Describe how to produce new functions from given parent functions. 2. Categorize relations as functions and non-functions through various means, i.e. ordered pairs, mappings, tables, and graphs. 3. Describe the relationship between the various methods of representing one particular function. 4. Generalize the domain and range beyond (x,y) to represent the variables in context of the application. 5. Generalize the effect of the transformation to the independent and dependent variable. 6. Describe the effect(s) of transformation(s) on a function. 7. Describe piecewise functions and the different representations.
Strategic Thinking Revise, Assess, Critique, Draw Conclusion, Investigate, Differentiate, Hypothesize, Cite Evidence	1. Assess the domain of a function.
Extended Thinking Analyze, Apply Concepts, Connect, Prove, Synthesize, Create, Connect	1. Apply concepts of transformations to alter a parent function to obtain a particular function. 2. Analyze solutions to problems (make sure that the solution makes sense to the problem and determine extraneous roots)

Vocabulary

Relation	Increasing Interval	Reflections
Function	Decreasing Interval	Inverse
Function Notation	Absolute Value Function	Inverse Relation
Mapping	Square Root Function	Inverse Function
Input	Cube Root Function	One-to-One
Output	Cubic Function	Vertical line test
Independent Variable	Transformations	Horizontal line test
Dependent Variable	Translations	Even Functions
Domain	Dilations	Odd Functions
Range		Extraneous Roots / Solutions

Mathematical Practices

Mathematical Practices #1 and #3 describe a classroom environment that encourages thinking mathematically and are critical for quality teaching and learning.

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.

Standards Overview

Analyze functions using different representations.
Build a function that models a relationship between two quantities.
Build new functions from existing functions.

Required Activities, Suggested Resources and Activities

See Public Folders and List of Possible Websites

Assessments/Formative Assessments

Pretest/Post Test
Quizzes (individual and partner)
Teacher-generated assessments
Notebook quizzes
Exit slips
Participation sheets

Unit 1 – Functions and Inverses

C.9-12. …. Standard – (Indicators)	Expectations ‘ Student will….’	Teacher Strategies and Notes:
CC.9-12.F.BF.1 Write a function that describes a relationship between two quantities. CC.9-12.F.BF.1c (+) Compose functions. For example, if T(y) is the temperature in the atmosphere as a function of height, and h(t) is the height of a weather balloon as a function of time, then T(h(t)) is the temperature at the location of the weather balloon as a function of time. CC.9-12.F.BF.3 Identify the effect on the graph of replacing f(x) by f(x) + k, kf(x), f(kx), and f(x + k) for specific values of k (both positive and negative); find the value of k given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. Include recognizing even and odd functions from their graphs and algebraic expressions for them. CC.9-12.F.IF.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function CC.9-12.F.IF.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. CC.9-12.F.IF.7b Graph square root, cube	Relation vs. Function: • Determine if a relation is a function • Differentiate between function and non-function relationships when using a table of values, a graph, a word description or algebraic equation. • Represent functions verbally, graphically, by mapping, and algebraically. • Find domain and range of a function • Utilize the vertical line test to verify if a relation is a function • Read and write with function notation • Evaluate using function notation • Evaluate square root, cube root, and absolute value from a graph or equation by hand and calculator. • Represent relationships through equations. • Model a relationship between two quantities using functions.	Relations and Functions: • Students were introduced to what a function is and function notation in Algebra 1. • Limit inverse function to linear and simple quadratic functions. Revisit inverse function in radical, rational, and exponential units. • Students will analyze a given problem to determine the function expressed by identifying patterns in the function’s rate of change. They will specify intervals of increase, decrease, constancy, and, if possible, relate them to the function’s description in words or graphically. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to model functions. Graphing Functions: • Emphasize in transformations – students should be fluent in transforming the parent functions of $f(x) = c,\ f(x) = x,\quad f(x) = x^2, f(x) = x^3,$ $f(x) = \sqrt{x}, f(x) = \sqrt[3]{x}, f(x) = \lvert x\rvert, f(x) = \frac{1}{x},$ $f(x) = e^x$ using $g(x) = af(x - h) + k$ • Some of these functions have not been introduced, emphasize the shape only for these and how the a, h and k move the shape. • When transforming functions use the words : Vertical translation Horizontal translation Dilation Reflection • Key characteristics include but are not limited to

root, and piecewise-defined functions, including step functions and absolute value functions.

CC.9-12.F.IF.9 Compare properties of two functions each represented in a different way (algebraically, graphic
ally, numerically in tables, or by verbal descriptions). For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.

CC.9-12.A.CED.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

CC.9-12.F.BF.4 Find inverse functions

CC.9-12.F.BF.4a Solve an equation of the form f(x) = c for a simple function f that has an inverse and write an expression for the inverse. For example, f(x) =2(x3) for x > 0 or f(x) = (x+1)/(x-1) for x ≠ 1 (x not equal to 1).

CC.9-12.F.BF.4b (+) Verify by composition that one function is the inverse of another

CC.9-12.F.BF.4c (+) Read values of an inverse function from a graph or a table, given that the function has an inverse.
CC.9-12.F.BF.4d (+) Produce an invertible function from a non-invertible function by restricting the domain.

Graphing Functions:

- Graph functions given algebraic function, table, or ordered pairs.
- Identify general shapes of graphs of parent functions (constant, linear, absolute, quadratic, square root, cubic, cube root, reciprocal, exponential)
- Graph functions (constant, linear, absolute, quadratic, square root, cubic, cube root, reciprocal, exponential) with labels and scales.
- Identify:
  extrema (local maxima and minima)
  Intercepts (x and y)
  end behavior $f(x) \rightarrow \_\_\_, x \rightarrow +\infty$
  $f(x) \rightarrow \_\_\_, x \rightarrow -\infty$
  increasing/decreasing intervals (interval notation)
- Identify functions as even, odd, or neither from the graph and algebraic expression
- Graph a function undergoing transformations: $af(bx-h)+k$
  $f(x)$ = parent
  a = vertical dilation and reflection
  b = horizontal reflection
  h = horizontal translation
  k = vertical translation
- Identify transformations that a function has undergone from graph and algebraic expression.
- Write an equation in transformation form from a transformed graph, or written descriptions of the transformations.

maxima, minima, intercepts, symmetry, end behavior, and asymptotes. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions.

- Students will apply transformations to functions and recognize functions as even and odd. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions.

<u>Inverses</u>

- Inverses are limited in this unit due to students skills. Students should be able to find inverses of quadratic, cubic, radicals by the end of the year.
- Simple quadratic = $x^2 - 9$ (no factoring required)

<u>Examples from Connecticut's Curriculum:</u>

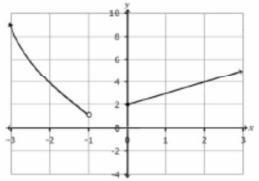
CC.9-12.F.IF.7

Key characteristics include but are not limited to maxima, minima, intercepts, symmetry, end behavior, and asymptotes. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions.

Examples:

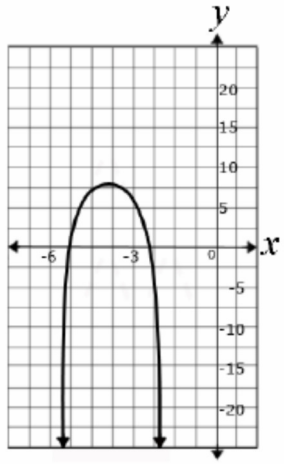
- Describe key characteristics of the graph of $f(x) = |x-3| + 5$.
- Sketch the graph and identify the key characteristics of the function described below.

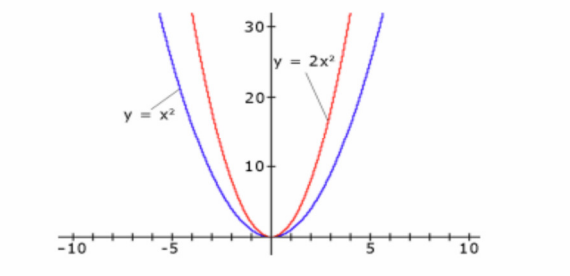
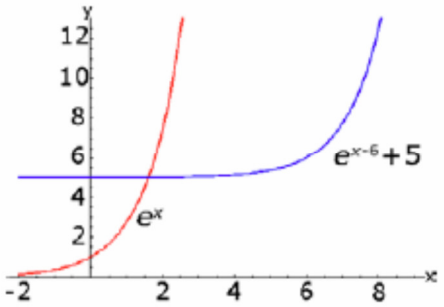
$$F(x) = \begin{cases} x+2 \text{ for } x \geq 0 \\ -x^2 \text{ for } x < -1 \end{cases}$$



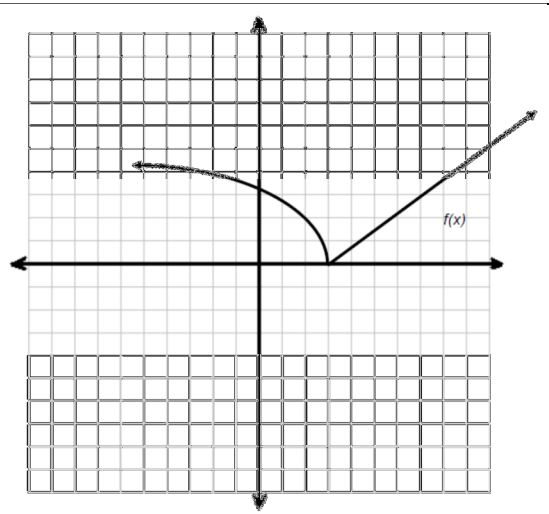
- Graph the function $f(x) = 2^x$ by creating a table of values. Identify the key characteristics of the graph.
- Graph $f(x) = 2 \tan x - 1$. Describe its domain, range, intercepts, and asymptotes.
- Draw the graph of $f(x) = \sin x$ and $f(x) = \cos x$. What are the similarities and differences between the two graphs?

CC.9-12.F.BF.4**, CC.9-12.F.BF.4a,** CC.9-12.F.BF.4d (+) and

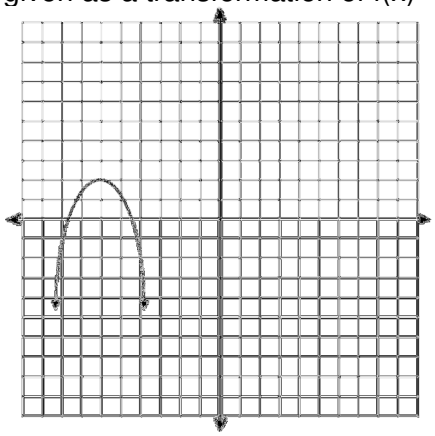
	• Determine the domain and range of a function. • Compare key components of different functions expressed in different forms (i.e. domains, ranges, extrema) Inverse Functions: • Find algebraic inverses (linear and simple quadratic*) • Restrict the domain of a non-invertible function to produce an invertible function • Determine domain and range of the inverse. • Use horizontal line test to determine if the inverse is a function • Construct the inverse graph given the graph of a function Function Operations: • Addition $f(x) + g(x)$ $(f + g)(x)$ • Subtraction $f(x) - g(x)$ $(f - g)(x)$ • Multiplication $f(x) \cdot g(x)$ $(f \cdot g)(x)$ • Division $\frac{f(x)}{g(x)}$ $(f/g)(x)$ • Composition of Functions $f(g(x))$ $(f \circ g)(x)$	CC.9-12.F.BF.4c (+) Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to model functions. Examples: • For the function $h(x) = (x-2)^3$, defined on the domain of all real numbers, find the inverse function if it exists or explain why it doesn't exist. • Graph $h(x)$ and $h^{-1}(x)$ and explain how they relate to each other graphically. • Find a domain for $f(x) = 3x^2 + 12x - 8$ on which it has an inverse. Explain why it is necessary to restrict the domain of the function. CC.9-12.F.BF.3 Students will apply transformations to functions and recognize functions as even and odd. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions. CC.9-12.F.IF.5 Students may explain orally, or in written format, the existing relationships. CC.9-12.F.IF.9 Examine the functions below. Which function has the larger maximum? How do you know? $f(x) = -2x^2 - 8x + 20$  CC.9-12.F.BF.3

		Students will apply transformations to functions and recognize functions as even and odd. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions. Examples: • Is $f(x) = x^3 - 3x^2 + 2x + 1$ even, odd, or neither? Explain your answer orally or in written format. • Compare the shape and position of the graphs of $f(x) = x^2$ and $g(x) = 2x^2$, and explain the differences in terms of the algebraic expressions for the functions  • Describe effect of varying the parameters *a, h,* and *k* have on the shape and position of the graph of $f(x) = a(x-h)^2 + k$. • Compare the shape and position of the graphs of $f(x) = e^x$ to $g(x) = e^{x-6} + 5$, and explain the differences, orally or in written format, in terms of the algebraic expressions for the functions  • Describe the effect of varying the parameters

		a, h, and *k* on the shape and position of the graph $f(x) = ab^{(x + h)} + k.$, orally or in written format. What effect do values between 0 and 1 have? What effect do negative values have? CC.9-12.F.BF.1 and CC.9-12.F.BF.1c (+) Students will analyze a given problem to determine the function expressed by identifying patterns in the function's rate of change. They will specify intervals of increase, decrease, constancy, and, if possible, relate them to the function's description in words or graphically. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to model functions. Examples: ● You buy a $10,000 car with an annual interest rate of 6 percent compounded annually and make monthly payments of $250. Express the amount remaining to be paid off as a function of the number of months, using a recursion equation. ● A cup of coffee is initially at a temperature of 93º F. The difference between its temperature and the room temperature of 68º F decreases by 9% each minute. Write a function describing the temperature of the coffee as a function of time. The radius of a circular oil slick after *t* hours is given in feet by $r = 10t^2 - 0.5t$, for $0 \leq t \leq 10$. Find the area of the oil slick as a function of time. Find a domain for $f(x) = 3x^2 + 12x - 8$ on which it has an inverse. Explain why it is necessary to restrict the domain of the function. Given the graph of a function, *f(x)*, below, sketch a graph of *f(x-3) + 7*.



Write the equation of the function whose graph is given as a transformation of $f(x) = x^2$.



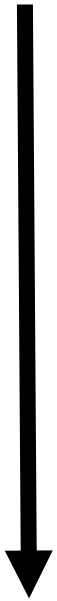
Algebra 2

Unit 2: Quadratic Functions

Teacher Reference:
Algebra 2 (2004) Chapter 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7 5.8
Algebra 2 (2007) Chapter 4.1 – 4.10

Timeframe:
25 Instructional Periods

Depth of Knowledge



Essential Questions For Unit

1. How can you represent the same mathematical idea in different ways?
2. What is the most efficient way to solve this problem?
3. How does graphing an equation make it easier to draw conclusions?
4. What can minimums and maximums tell us about equations?
5. How would you use an equation and a graph to get your point across?
6. How are properties related to Algebra?
7. How can exponents be used to rewrite a numerical value with a very large or small magnitude?
8. Do I have an understanding of the real number systems and the basic operations that can be performed on these real numbers?
9. Why are complex numbers necessary?
10. How are operations and properties of complex numbers related to those of real numbers?

Enduring Understandings

1. There are different methods to solving quadratic functions.
2. Changing the parameters of quadratic function changes the graph in predictable ways.
3. Quadratic equations are used in many other disciplines and real world situations.
4. There is a specific order of operations in the real number system that must be followed for all computations.
5. Powers can be used to shorten the representation of repeated multiplication.
6. Multiplying and factoring polynomials are related.
7. Factor polynomials by applying general patterns including difference of squares, sum and difference of cubes, and perfect square trinomials.
8. An algebraic expression can be simplified by combining the parts of the expression that are alike
9. A complex number multiplied by its conjugate is a real number.

Content Knowledge Objectives

Recall
Describe, Draw, Identify, Label, Locate, Match, Measure, Evaluate, Compute, Perform, Retrieve

1. Draw a parabola; axis of symmetry through mirror points; identify vertex.
2. Identify physical phenomena & define applications that model quadratic functions.
3. Simplify using the distributive property of multiplication over addition and subtraction.
4. Apply the distributive property and will simplify polynomials by adding like terms.
5. Recognize that the square root of –1 is represented as i

Skill/Concept Categorize, Classify, Compare, Contrast, Describe Cause/Effect, Describe Patterns, Describe Relationships, Estimate, Generalize, Infer, Interpret, Make Observations, Predict, Summarize, Organize, Collect and Display	1. Examine the vertex as max/min of applications 2. Utilize multiple methods to determine or predict outputs for specific inputs or vice versa. 3. Relate the zero product property to the x – intercepts. 4. Utilize the quadratic formula in applications. 5. Interpret factoring as undoing distribution. 6. Rewrite expressions with exponents in simplified form 7. Rewrite expressions in equivalent factored form. 8. Perform operations with complex numbers 9. Classify complex numbers
Strategic Thinking Revise, Assess, Critique, Draw Conclusion, Investigate, Differentiate, Hypothesize, Cite Evidence	1. Extend the process of finding zeros to completing the square and ultimately the quadratic formula. 2. Investigate the relationship between zeros and x-intercepts. 3. Interpret factoring as undoing distribution. 4. Rewrite expressions with exponents in simplified form 5. Rewrite expressions in equivalent factored form. 6. Perform operations with complex numbers 7. Classify complex numbers
Extended Thinking Analyze, Apply Concepts, Connect, Prove, Synthesize, Create, Connect	1. Analyze the advantages of a quadratic function in vertex form and in standard form. What characteristics of quadratic functions are important? 2. Analyze and apply appropriate methods of solving application problems 3. Prove the multiplying and factoring produce equivalent expressions. 4. Place the following sets of numbers in a hierarchy of subsets: complex, pure imaginary, real, rational, irrational, integers, whole, and natural.

Vocabulary

Quadratic function	Vertex	Zero
Quadratic	Maximum Value	Factored form
Linear	Minimum Value	Completing the Square
Constant Terms	Quadratic Equations	Quadratic Formula
Parabola	Standard Form	Discriminant
Axis of Symmetry	Root	Vertex Form
Distributive property	Constant	Equivalent numerical expressions
Coefficient	Like Terms	Equivalent variable expressions
Term	Evaluate	Greatest common factor
FOIL method	Pure Imaginary Unit	Factoring
Imaginary unit	Complex Number	Factored form
		Complex Conjugates

Mathematical Practices

Mathematical Practices #1 and #3 describe a classroom environment that encourages thinking mathematically and are critical for quality teaching and learning.

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.

Standards Overview

Use properties of rational and irrational numbers
Write expressions in equivalent forms to solve problems
Perform arithmetic operations on polynomials
Solve equations and inequalities in one variable
Interpret functions that arise in applications in terms of the context
Analyze functions using different representations
Use complex numbers in polynomial identities and equations.

Required Activities, Suggested Resources and Activities

See Public Folders and List of Possible Websites

Assessments/Formative Assessments

Pretest/Post Test
Quizzes (individual and partner)
Teacher-generated assessments
Notebook quizzes
Exit slips
Participation sheets

Unit 2 – Quadratic Functions

C.9-12. …. Standard – (Indicators)	Expectations ' Student will….'	Teacher Strategies and Notes:
N-RN 3. Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational. 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.	Distributive Property • Multiplying Polynomials 1. Multiply a monomial and a binomial 2. Multiply a monomial and a trinomial 3. multiply two binomials (FOIL) 4. Multiply a binomial and a trinomial 5. Multiply a trinomial and a trinomial 6. Multiply polynomials that result in special products • Factoring 1. Factor GCF 2. Factor by Grouping 3. Factoring General Trinomials ▪ Factor general trinomials whose squared term has a coefficient of 1 $x^2 + bx + c$ (a = 1) ▪ Factor general trinomial whose square term has a coefficient other than 1 $ax^2 + bx + c$ (a≠ 1) 4. Factoring Special Products ▪ Recognize and factor the difference of two perfect squares. ▪ Recognize and factor a perfect-square trinomial.	• Before factoring trinomials, expand distribution property to include the product of two binomials and square of binomials. (concept is not done in Alg. 1) • Emphasize that zeros of a function can be real or imaginary numbers • Transformations should be done in the Unit 3 – Functions and Inverses • All students must learn complete the square and quadratic formula. Only the "extend the process…" is Honor students • N-RN 3 : Since every difference is a sum and every quotient is a product, this includes differences and quotients as well. Explaining why the four operations on rational numbers produce rational numbers can be a review of students understanding of fractions and negative numbers. Explaining why the sum of a rational and an irrational number is irrational, or why the product is irrational, includes reasoning about the inverse relationship between addition and subtraction (as well as multiplication and division)

A-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

a Factor a quadratic expression to reveal the zeros of the function it defines. b. Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines.

b Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines.

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.

CC.9-12.A.CED.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.

A-CED 2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

CC.9-12.A.REI.4 Solve quadratic

5. Cubic
   - Difference of two cubes
   - Sum of two cubes

Complex Numbers

- Define Imaginary Numbers
- Define Complex Numbers
- Simplify numbers of the form $\sqrt{-b}$ where b > 0
- Perform operations with pure imaginary numbers (powers of *i)*
- Perform operations with complex numbers (Addition, Subtraction, Multiplication, Division)
- Simplify radical expressions containing negative rational numbers and express in a+bi form

- Solve quadratic equations
  1. Taking the square
  2. Factoring and Zero Product Property
  3. Completing the Square
  4. Quadratic Formula
  5. Calculator
  6. Use complex numbers to describe solutions to quadratic equations
  7. Use the determinant to determine the number and type of roots of a quadratic equation
  8. Estimate solutions of quadratic

Examples from Connecticut's Curriculum:

N-RN 3:

If a, b, and c are all rational numbers then the solutions to the equation $ax^2 + bx + c = 0$ are given by , $x = -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a}$

Recognizing that the first term is always rational, we may conclude that whenever the second term is irrational then the solutions must also be irrational.

CC.9-12.N.CN.2

Example:

- Simplify the following expression. Justify each step using the commutative, associative and distributive properties. (3 - 2*i*)(-7 + 4*i*)

Solutions may vary; one solution follows:

(3 - 2*i*)(-7 + 4*i*)

3(-7 + 4*i*) -2*i*(-7 + 4*i*) Distributive Property

-21 + 12*i* + *14i* - $8i^2$ Distributive Property

-21 + (12*i* + *14i*) - $8i^2$ Associative Property

-21 + *i*(12 + 14) - $8i^2$ Distributive Property

-21 + 26*i* - $8i^2$ Computation

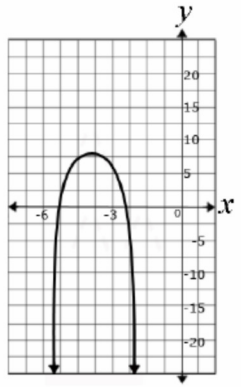
-21 + 26*i* - 8(-1) $i^2 = -1$

-21 + 26*i* + 8 Computation

-21 + 8 + 26*i* Commutative Property

-13 + 26*i* Computation

equations in one variable a. Use the method of completing the square to transform any quadratic equation in *x* into an equation of the form $(x - p)^2 = q$ that has the same solutions. Derive the quadratic formula from this form. CC.9-12.A.REI.4b Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as a ± bi for real numbers a and b	equations by graphing • Graph quadratic functions 1. Graph from standard form, vertex form, and intercept form 2. Identify the opening/direction 3. Identify axis of symmetry $\left(y = \frac{-b}{2a}\right)$ mirror image: each point yields a symmetric point 4. Identify vertex $\left(\frac{-b}{2a}, f\left(\frac{-b}{2a}\right)\right)$ 5. Identify the zeros 6. Interpret the maximum and minimum values of a quadratic function 7. Determine reasonable domain and range values of quadratic functions	CC.9-12.N.CN.9 (+) Examples: • How many zeros does $-2x^2 + 3x - 8$ have? Find all the zeros and explain, orally or in written format, your answer in terms of the Fundamental Theorem of Algebra. • How many complex zeros does the following polynomial have? How do you know? $p(x) = (x^2 - 3)(x^2 + 2)(x - 3)(2x - 1)$
F-IF 4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries... *	• Solve quadratic inequalities in one variable • graph quadratic inequalities in two variables • Write a quadratic function in vertex form, intercept form, and standard form. • Determine a quadratic function from its zeroes and other known parts. • Analyze situations involving quadratic functions and formulate quadratic	A-SSE 3a. Three forms of the quadratic function reveal different features of its graph. Standard form: $f(x) = ax^2 + bx + c$ reveals the y intercept, (0, c). Vertex form: $f(x) = a(x - h)^2 + k$ reveals the vertex (h, k) and thus the maximum or minimum value of the function. Factored form: $f(x) = a(x - x_1)(x - x_2)$ reveals the x-intercepts $(x_1, 0)$ and $(x_2, 0)$. A-APR 1. The product of two binomials of degree one is generally a trinomial of degree two; the process of expanding this product may be reversed to produce the factored form of the polynomial.
F-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. a. Graph linear and quadratic		

functions and show intercepts, maxima, and minima. F-IF.C.8 Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context. F-IF 9 Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum. CC.9-12.N.CN.1 Know there is a complex number i such that $i^2 = \sqrt{-1}$, and every complex number has the form a + b*i* with a and b real. CC.9-12.N.CN.2 Use the relation i2 = -1 and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers CC.9-12.N.CN.7 Solve quadratic equations with real coefficients that have complex solutions. CC.9-12.N.CN.8 (+) Extend polynomial identities to the complex numbers. For example, rewrite x2 + 4 as (x + 2i)(x - 2i).	equations and inequalities to solve problems • Use quadratic functions to solve real-life problems 1. Maximum/minimum 2. Intercepts 3. Prediction based on quadratic regression 4. Projectile motion 5. Area and Perimeter 6. Consecutive numbers	Examine the functions below. Which function has the larger maximum? How do you know? $f(x) = -2x^2 - 8x + 20$  CC.9-12.N.CN.7 Within which number system can $x^2 = -2$ be Solved? Explain how you know. Solve $x^2 + 2x + 2 = 0$ over the complex numbers. Find all solutions of $2x^2 + 5 = 2x$ and express them in the form a + bi. Are the roots of $2x^2 + 5 = 2x$ real or complex? How many roots does it have? Find all solutions of the equation. What is the nature of the roots of $x^2 + 6x + 10 = 0$? Solve the equation using the quadratic formula and completing the square. How are the two methods related? CC.9-12.A.REI.4b Students should solve by factoring, completing the

CC.9-12.A.CED.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.

square, and using the quadratic formula. The zero product property is used to explain why the factors are set equal to zero. Students should relate the value of the discriminant to the type of root to expect. A natural extension would be to relate the type of solutions to $ax^2 + bx + c = 0$ to the behavior of the graph of $y = ax^2 + bx + c$.

Value of Discriminant	**Nature of Roots**	**Nature of Graph**
$b^2 - 4ac = 0$	1 real roots	intersects x-axis once
$b^2 - 4ac > 0$	2 real roots	intersects x-axis twice
$b^2 - 4ac < 0$	2 complex roots	does not intersect x-axis

F-BF 3

Lava coming from the eruption of a volcano follows a parabolic path. The height h in feet of a piece of lava t seconds after it is ejected from the volcano is given by $h(t) = -t^2 + 16t + 936$. After how many seconds does the lava reach its maximum height of 1000 feet?

F-IF 7a

A rocket is launched from 180 feet above the ground

		at time $t = 0$. The function that models this situation is given by $h = -16t^2 + 96t + 180$, where t is measured in seconds and h is height above the ground measured in feet. 1. What is a reasonable domain restriction for t in this context? 2. Determine the height of the rocket two seconds after it was launched. 3. Determine the maximum height obtained by the rocket. 4. Determine the time when the rocket is 100 feet above the ground. 5. Determine the time at which the rocket hits the ground. **6.** How would you refine your answer to the first question based on your response to the second and fifth questions? CC.9-12.A.REI.4 Students should solve by factoring, completing the square, and using the quadratic formula. The zero product property is used to explain why the factors are set equal to zero. Students should relate the value of the discriminant to the type of root to expect. A natural extension would be to relate the type of solutions to $ax^2 + bx + c = 0$ to the behavior of the graph of $y = ax^2 + bx + c$.

Algebra 2
Unit 3: Polynomials

Book Reference:	**Timeframe:**
Algebra 2 (2004) Chapter 6.1, 6.2, 6.3, 6.4, 6.5, 6.6 (exclude p/q), 6.7, 6.8,6.9, 7.3(operations only) Algebra 2 (2007) Chapter 5.1, 5.2, 5.3, 5.4, 5.5, 5.6(exclude p/q), 5.7, 5.8, 5.9, 6.3(operations only)	25 Instructional Periods

Depth of Knowledge 	**Essential Questions For Unit**
	1. How do polynomial functions model real-world problems and their solutions? 2. How do we build the definition and characteristics of polynomials utilizing prior knowledge of monomials and/or functions and their graphs? 3. How can we extend our understanding of x-intercepts to encompass the determination of all zeros?
	Enduring Understandings
	1. Polynomials are accurate models of many real life situations 2. There are many ways to solve problems, but some are better than others
	Content Knowledge Objectives
Recall Describe, Draw, Identify, Label, Locate, Match, Measure, Evaluate, Compute, Perform, Retrieve	1. Identify the polynomial's algebraic structure holistically and specifically around the leading term. 2. Identify root multiplicities.
Skill/Concept Categorize, Classify, Compare, Contrast, Describe Cause/Effect, Describe Patterns, Describe Relationships, Estimate, Generalize, Infer, Interpret, Make Observations, Predict, Summarize, Organize, Collect and Display	1. Apply properties of exponents to simplify monomials and expressions 2. Compare and Contrast x-intercepts and zeros. 3. Compare and Contrast polynomials of odd vs. even degree positive and negative coefficients and roots of even/odd multiplicities 4. Generalize intercepts into zeros into the Fundamental Theorem of Algebra
Strategic Thinking Revise, Assess, Critique, Draw Conclusion, Investigate, Differentiate, Hypothesize, Cite Evidence	1. Through investigation of groups of polynomials of the same degree begin to link the global graph to the local. 2. Investigate the possible/impossible quantities of x-intercepts for groups of polynomials of same degree by sketching graphs. 3. Investigate the global graphical properties of polynomials.
Extended Thinking Analyze, Apply Concepts, Connect, Prove, Synthesize, Create, Connect	1. Discuss and analyze the concept of continuity.

VOCABULARY

Product of Powers
Quotient of Powers
Negative Exponent
Power of a Power
Power of a Product
Power of a Quotient
Zero Power
Simplify
Degree of Polynomial
Synthetic Division
Polynomial in one variable
Leading Coefficient
Polynomial Function
End Behavior
Relative Maximum (local Maxima)
Relative Minimum (local Minima)
Extrema
Turning Points
Quadratic Form
Synthetic substitution
Monomial
Binomial
Polynomial
Trinomial
Square root

Mathematical Practices

Mathematical Practices #1 and #3 describe a classroom environment that encourages thinking mathematically and are critical for quality teaching and learning.

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.

Standards Overview

Create equations that describe numbers or relationships.
Analyze functions using different representations.

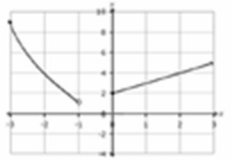
Required Activities, Suggested Resources and Activities

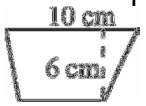
See Public Folders and List of Possible Websites

Assessments/Formative Assessments

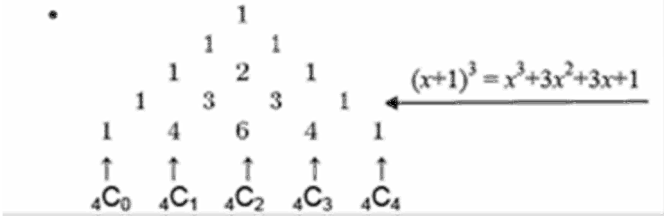
Pretest/Post Test
Quizzes (individual and partner)
Teacher-generated assessments
Notebook quizzes
Exit slips
Participation sheets

Unit 3 – Polynomials

C.9-12. …. Standard – (Indicators)	Expectations ‘ Student will….’	Teacher Strategies and Notes:
CC.9-12.A.CED.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions. CC.9-12.A.CED.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.	• Define polynomial function 1. constant term 2. leading coefficient 3. degree 4. type 5. standard form • Classify polynomials 1. By degree 2. By terms • Identify polynomial functions 1. Exponents are whole numbers 2. Coefficients are real numbers • Evaluate polynomial functions 1. by substitution 2. synthetic division • Add, subtract, and multiply polynomials • Divide polynomials 1. long division 2. synthetic division • Graph polynomial functions	• When solving polynomials, use examples that include using the quadratic formula. • Add, subtract, and multiply polynomials Use function notation as in section 7.3 /6.3 of the textbooks. • (**Honors**) Write the equation when ‘a’ ≠ 1. Usually it is the y-intercept that is shown or provided in order to calculate the leading coefficient. **Examples from Conncticut Curriculum** Let f(x) = 5x3 – x2 – 5x + 1. Graph the function and identify end behavior and any intervals of constancy, increase, and decrease. CC.9-12.F.IF.7 Key characteristics include but are not limited to maxima, minima, intercepts, symmetry, end behavior, and asymptotes. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions. Examples: • Describe key characteristics of the graph of $f(x) = \|x-3\| + 5$. • Sketch the graph and identify the key characteristics of the function described below. $F(x) = \begin{cases} x+2 \text{ for } x \geq 0 \\ -x^2 \text{ for } x < -1 \end{cases}$  • Graph the function $f(x) = 2^x$ by creating a table of values. Identify the key characteristics of the graph. • Graph $f(x) = 2 \tan x - 1$. Describe its domain, range, intercepts, and asymptotes. • Draw the graph of $f(x) = \sin x$ and $f(x) = \cos x$. What are the similarities and differences between the two graphs?
CC.9-12.F.IF.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.* CC.9-12.F.IF.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.*		
CC.9-12.F.IF.7c Graph polynomial		CC.9-12.A.CED.1

functions, identifying zeros when suitable factorizations are available, and showing end behavior CC.9-12.F.LE.3 Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.	1. Sketch polynomial functions with specified quantities of x-intercepts and turning points 2. Create a sketch of a polynomial given in factored form • Identify and describe key characteristics of the graph of a polynomial functions 3. Identify general shapes of graphs of polynomial functions 4. Calculate and locate zeroes 5. end behavior $f(x) \rightarrow$____as $x \rightarrow$____ 6. find the relative maxima and minima of polynomial functions (utilizing calculator) 7. increasing and decreasing intervals 8. continuity of a polynomial function • Factor polynomials - Given a factor/zero • Use a graphing calculator to find approximate solutions for polynomial equations • Solve polynomial equations 1. by factoring 2. using graphs 3. in quadratic form (**Honors**) • Apply the remainder theorem • Apply the factor theorem	Equations can represent real world and mathematical problems. Include equations and inequalities that arise when comparing the values of two different functions, such as one describing linear growth and one describing exponential growth. Examples: • Given that the following trapezoid has area 54 cm^2, set up an equation to find the length of the base, and solve the equation.  Lava coming from the eruption of a volcano follows a parabolic path. The height *h* in feet of a piece of lava *t* seconds after it is ejected from the volcano is given by $h(t)= -t^2 + 16t + 936.$ After how many seconds does the lava reach its maximum height of 1000 feet? CC.9-12.A.SSE.2 Students should extract the greatest common factor (whether a constant, a variable, or a combination of each). If the remaining expression is quadratic, students should factor the expression further. Example: Factor $x^3 - 2x^2 - 35x$
A.SSE.1 Interpret expressions that represent a quantity in terms of its context.		
A.SSE.1a. Interpret parts of an expression, such as terms, factors, and coefficients.		
A.SSE. 1b Interpret complicated expressions by viewing one or more of their parts as a single entity.		
CC.9-12.A.SSE.2 Use the structure of an expression to identify ways to rewrite it. For example, see $x^4 - y^4$ as $(x^2)^2 - (y^2)^2$, thus recognizing it as a difference of squares that can be factored as $(x^2 - y^2)(x^2 + y^2)$.		
CC.9-12.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. CC.9-12.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). CC.9-12.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. CC.9-12.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 CC.9-12.A.APR.5 (+) Know and apply that the Binomial Theorem gives 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. (The Binomial Theorem can be proved by mathematical induction or by a combinatorial argument.)	• Determine whether a binomial is a factor of a polynomial by using synthetic division • Write an equation (usually of least degree) that fits the graph • (**Honors**) Write the equation when 'a' ≠ 1. • Find the zeros of a polynomial function • Connect the relationship among zeros, factors, roots, and intercepts • Conclude the Fundamental Theorem of Algebra including recognize that the number of zeros of a polynomial equals the degree of the polynomial • Differentiate zeros as distinct, repeated (multiplicity), and/or imaginary-complex • Determine the number and type of roots for a polynomial equation (real and imaginary) • Interpret and solve problems involving polynomial functions • Use a polynomial function to model real world data.	CC.9-12.A.APR.6 The polynomial q(x) is called the quotient and the polynomial r(x) is called the remainder. Expressing a rational expression in this form allows one to see different properties of the graph, such as horizontal asymptotes. Examples: Find the quotient and remainder for the rational expression $\frac{x^3-2x^2+x-6}{x^2+2}$ and use them to write the expression in different form. CC.9-12.A.APR.2 The Remainder theorem says that if a polynomial $p(x)$ is divided by $x - a$, then the remainder is the constant $p(a)$. That is, $p(x)=q(x)(x-a)+p(a)$. So if p(a) = 0 then p(x) = q(x)(x-a). Let $p(x)=x^5-3x^4+8x^2-9x+30$. Evaluate p(-2). What does your answer tell you about the factors of p(x)? [Answer: p(-2) = 0 so x+2 is a factor.] CC.9-12.A.APR.3 Graphing calculators or programs can be used to generate graphs of polynomial functions. Example: Factor the expression $x^3 + 4x^2 - 59x - 126$ and explain how your answer can be used to solve the equation $x^3 + 4x^2 - 59x - 126 = 0$. Explain why the solutions to this equation are the same as the x-intercepts of the graph of the function $f(x) = x^3 + 4x^2 - 59x = 126$. CC.9-12.A.APR.4 Examples:

CC.9-12.A.APR.6 Rewrite simple rational expressions in different forms; write $a(x)/b(x)$ in the form $q(x) + r(x)/b(x)$, 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		Use the distributive law to explain why $x^2 - y^2 = (-y)(x + y)$ for any two numbers x and y. Derive the identity $(x - y)^2 = x^2 - 2xy + y^2$ from $(x + y)^2 = x^2 + 2xy + y^2$ by replacing y by $-y$. Use an identity to explain the pattern $2^2 - 1^2 = 3$ $3^2 - 2^2 = 5$ $4^2 - 3^2 = 7$ $5^2 - 4^2 = 9$ [Answer: $(n + 1)^2 - n^2 = 2n + 1$ for any whole number n.]
CC.9-12.N.CN.9 (+) Know the Fundamental Theorem of Algebra; show that it is true for quadratic polynomials.		CC.9-12.A.APR.5 (+) Examples: • Use Pascal's Triangle to expand the expression $(2x-1)^4$. • Find the middle term in the expansion of $(x^2+2)^{18}$. •  CC.9-12.N.CN.9 (+) Examples: ● How many zeros does $-2x^2+3x-8$ have? Find all the zeros and explain, orally or in written format, your answer in terms of the Fundamental Theorem of Algebra. ● How many complex zeros does the following polynomial have? How do you know? $p(x)=(x^2-3)(x^2+2)(x-3)(2x-1)$

Algebra 2

Unit 4: Radical Functions

Book Reference:	**Timeframe:**
Algebra 2 (2004) Chapter: Radical & Rational Exponent: 7.1, 7.2, 7.3, 7.6; Algebra 2 (2007) Chapter: Radical & Rational Exponent: 6.1, 6.2, 6.3, 6.6;	10 Instructional Periods

Depth of Knowledge ↓	**Essential Questions For Unit** 1. How do radical functions model real-world problems and their solutions? **Enduring Understandings** 1. You can write a radical expression in an equivalent form using a rational exponents instead of a radical symbol. **Content Knowledge Objectives**
Recall Describe, Draw, Identify, Label, Locate, Match, Measure, Evaluate, Compute, Perform, Retrieve	1. Solve rational exponents and radical equations. 2. Simplifying radical expressions 3. Graph radical functions. 4. Apply radical functions to solve real world problems.
Skill/Concept Categorize, Classify, Compare, Contrast, Describe Cause/Effect, Describe Patterns, Describe Relationships, Estimate, Generalize, Infer, Interpret, Make Observations, Predict, Summarize, Organize, Collect and Display	1. Compare rational exponents with radical expressions. 2. Generalize how the domain and range is restricted.
Strategic Thinking Revise, Assess, Critique, Draw Conclusion, Investigate, Differentiate, Hypothesize, Cite Evidence	1. Investigate how radical expressions model real world situations.
Extended Thinking Analyze, Apply Concepts, Connect, Prove, Synthesize, Create, Connect	1. Analyze solutions to problems (make sure that the solution makes sense to the problem and determine extraneous solutions).

VOCABULARY

Radical	Extraneous solution	Square root
Radicand	Factoring and simplifying	Perfect square
Index of radical		Cube root
Rational exponent		Perfect cube
Power		Root

Mathematical Practices

Mathematical Practices #1 and #3 describe a classroom environment that encourages thinking mathematically and are critical for quality teaching and learning.

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.

Standards Overview

Understand solving equations as a process of reasoning and explain the reasoning.
Analyze functions using different representations.

Required Activities, Suggested Resources and Activities

See Public Folders and List of Possible Websites

Assessments/Formative Assessments

Pretest/Post Test
Quizzes (individual and partner)
Teacher-generated assessments
Notebook quizzes
Exit slips
Participation sheets

Unit 4 - Radical Functions

C.9-12. …. Standard – (Indicators)	Expectations 'Student will….'	Teacher Strategies and Notes:
CC.9-12.A-RN.2 Rewrite expressions involving radicals and rational exponents using the properties of exponents. CC.9-12.A.REI.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method. CC.9-12.A.REI.2 Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise	• Expand knowledge of square roots to higher index numbers and varied exponents • Simplify radical expressions Integers Rational numbers Variables Using conjugates With rational exponents By rationalizing the denominator • Simplify expressions involving square roots by removing perfect square factors • Perform operations with radicals and write in simplest form Add Subtract Multiply Distributive property Division • Find real nth roots of a number either with, or when appropriate, without a calculator • Express radicals as rational exponents • Evaluate expressions with rational exponents	**Examples from Conncticut Curriculum** CC.9-12.A.REI.2 Examples: • $\sqrt{x+2}=5$ • $\frac{7}{8}\sqrt{2x-5}=21$ • $\frac{x+2}{x+3}=2$Solv • $\sqrt{3x-7}=-4$ 8.EE.2 Examples: • $3^2=9$ and $\sqrt{9}=\pm 3$ • $\left(\frac{1}{3}\right)^3=\left(\frac{1^3}{3^3}\right)=\frac{1}{27}$ and $\sqrt[3]{\frac{1}{27}}=\frac{\sqrt[3]{1}}{\sqrt[3]{27}}=\frac{1}{3}$ • Solve $x^2=9$ Solution: $x^2=9$ $\sqrt{x^2}=\pm\sqrt{9}$ $x=\pm 3$ • Solve $x^3=8$ Solution: $x^3=8$ $\sqrt[3]{x^3}=\sqrt[3]{8}$ $x=2$
F.IF.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.*		
8.EE.2 Use square root and cube root symbols to represent solutions to equations of the form $x^2 = p$ and $x^3 = p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know		

that √2 is irrational.	• Express rational exponents as radicals • Apply properties of rational exponents a. Simplify radicals b. Add and Subtract like radicals and roots c. Simplify expressions involving variables d. Write variable expressions in simplest form e. Add and subtract expressions involving variables • Solve radical and rational exponent equations. • Given a formula for a real world situation, evaluate & solve radical equations.	

Algebra 2

Unit 5: Rational Functions

Book Reference:	**Timeframe:**
Algebra 2 (2004) Chapter: Rational Expressions & Equations: 9.2, 9.4, 9.5, 9.6, Honors 9.3 Algebra 2 (2007) Chapter: Rational Expressions & Equations: 8.2, 8.4, 8.5, 8.6, Honors 8.3	20 Instructional Periods

Depth of Knowledge ↓	**Essential Questions For Unit**
	1. How do rational functions model real-world problems and their solutions?
	Enduring Understandings
	1. To solve certain real world problems, we must model them with rational functions. 4. You can use much of what you know about adding, subtracting, multiplying and dividing fractions to do the same with rational expressions.
	Content Knowledge Objectives
Recall Describe, Draw, Identify, Label, Locate, Match, Measure, Evaluate, Compute, Perform, Retrieve	1. Simplify rational expressions 2. Graph rational functions.
Skill/Concept Categorize, Classify, Compare, Contrast, Describe Cause/Effect, Describe Patterns, Describe Relationships, Estimate, Generalize, Infer, Interpret, Make Observations, Predict, Summarize, Organize, Collect and Display	1. Compare simplification of rational expressions to rational numbers. 2. Relate vertical and horizontal asymptotes to domain and range restrictions.
Strategic Thinking Revise, Assess, Critique, Draw Conclusion, Investigate, Differentiate, Hypothesize, Cite Evidence	1. Critique which real world problems need quadratic versus polynomial versus rational functions.
Extended Thinking Analyze, Apply Concepts, Connect, Prove, Synthesize, Create, Connect	1. Discuss and analyze the concept of continuity. 2. Apply rational functions to solve real world problems.

VOCABULARY

Rational Function	Simplified form of a rational expression	Extraneous solution
Domain	Reciprocal	Factoring and simplifying
Range	Complex fraction	Cross multiplying
End Behavior	Asymptote	Least common denominator (LCD)
Excluded Value	Hole in graph	Horizontal asymptote
Average cost	Rationalizing the denominator	Vertical asymptote

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5. Use appropriate tools strategically.
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7. Look for and make use of structure.
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Teacher-generated assessments
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Exit slips
Participation sheets

Unit 5 - Rational Functions

C.9-12. …. Standard – (Indicators)	Expectations 'Student will….'	Teacher Strategies and Notes:
CC.9-12.A.REI.2 Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise CC.9-12.A.SSE.1 Interpret expressions that represent a quantity in terms of its context.* CC.9-12.A.SSE.1b 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 CC.9-12.A.APR.6 Rewrite simple rational expressions in different forms; write $a(x)/b(x)$ in the form $q(x) + r(x)/b(x)$, 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 CC.9-12.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 CC.9-12.A.CED.1 Create equations and inequalities in one variable and use them to solve problems. *Include*	Rational Functions • Identify rational equations • Simplify rational expressions • Perform operations on rational expressions 1. Multiply 2. Divide 3. Complex fractions 4. Add 5. Subtract • Solve rational equations 1. Cross multiply 2. Multiply by LCD (least common denominator) 3. Determine extraneous solutions. • Graph rational functions (simple and general) 1. Holes 2. Vertical asymptotes 3. Horizontal asymptotes 4. Y- intercepts 5. X-intercepts 6. Zeros 7. Domain and range 8. End behavior	• Horizontal Asymptotes can be crossed by the graph of a rational function. The ends approach the asymptote. • IMPORTANT: use the graphing calculator or other technology for graphing rational functions and concentrate on interpretation. **Examples from Connecticut Curriculum** CC.9-12.A.SSE.1 & CC.9-12.A.SSE.1b Students should understand the vocabulary for the parts that make up the whole expression and be able to identify those parts and interpret there meaning in terms of a context. CC.9-12.A.APR. The polynomial $q(x)$ is called the quotient and the polynomial $r(x)$ is called the remainder. Expressing a rational expression in this form allows one to see different properties of the graph, such as horizontal asymptotes. Examples: • Find the quotient and remainder for the rational expression $\frac{x^3-3x^2+x-6}{x^2+2}$ and use them to write the expression in a different form. • Express $f(x)=\frac{2x+1}{x-1}$ in a form that reveals the horizontal asymptote of its graph. [Answer: $f(x)=\frac{2x+1}{x-1}=\frac{2(x-1)+2}{x-1}=2+\frac{2}{x-1}$, so the horizontal asymptote is $y = 2$.] CC.9-12.A.APR.7 Use the formula for the sum of two fractions to explain why the sum of two rational expressions is another rational expression. Express $\frac{1}{x^2+1}-\frac{1}{x^2-1}$ in form $\frac{a(x)}{b(x)}$, where a(x) and b(x) are polynomials.

equations arising from linear and quadratic functions, and simple rational and exponential functions. CC.9-12.A.CED.3 Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.*	• Model and solve applications 1. Average cost word problems 2. Percentage Mixture 3. Distance, speed and time problems Work Problems	CC.9-12.A.CED.3 Example: ● A club is selling hats and jackets as a fundraiser. Their budget is $1500 and they want to order at least 250 items. They must buy at least as many hats as they buy jackets. Each hat costs $5 and each jacket costs $8. ○ Write a system of inequalities to represent the situation. ○ Graph the inequalities. ○ If the club buys 150 hats and 100 jackets, will the conditions be satisfied? What is the maximum number of jackets they can buy and still meet the conditions?
CC.9-12.F.IF.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.* CC.9-12.F.IF.7d (+) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior		CC.9-12.F.IF.7 Key characteristics include but are not limited to maxima, minima, intercepts, symmetry, end behavior, and asymptotes. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions
CC.9-12.A.REI.11 Explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.*		CC.9-12.A.REI.11 Students need to understand that numerical solution methods (data in a table used to approximate an algebraic function) and graphical solution methods may produce approximate solutions, and algebraic solution methods produce precise solutions that can be represented graphically or numerically. Students may use graphing calculators or programs to generate tables of values, graph, or solve a variety of functions

CC.9-12.F.BF.3 Identify the effect on the graph of replacing $f(x)$ by $f(x) + k$, $kf(x)$, $f(kx)$, and $f(x + k)$ for specific values of k (both positive and negative); find the value of k given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. Include recognizing even and odd functions from their graphs and algebraic expressions for them		CC.9-12.F.BF.3 Students will apply transformations to functions and recognize functions as even and odd. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions. Describe effect of varying the parameters *a, h,* and *k* have on the shape and position of the graph of $f(x) = a(x-h)^2 + k$. Compare the shape and position of the graphs of $f(x) = \frac{1}{x}$ to $g(x) = \frac{1}{x-6} + 5$, and explain the differences, orally or in written format, in terms of the algebraic expressions for the functions

Algebra 2

Unit 6: Exponential and Logarithmic Functions

Book Reference:	**Timeframe:**
Algebra 2 (2004) Chapter: 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7 Algebra 2 (2007) Chapter: 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7	30 Instructional Periods

Depth of Knowledge ↓	**Essential Questions For Unit**
	1. What characterizes exponential growth and decay? 2. What are real world models of exponential growth and decay? 3. How can one differentiate an exponential model from a linear model given a real world set of data? 4. How do logarithmic functions model real-world problems and their solutions? 5. How do we build the definition and characteristics of logarithmic functions utilizing prior knowledge of functions and their graphs? 6. How do you use the inverse relationship between exponential and logarithmic functions to solve equations?
	Enduring Understandings
	1. The characteristics of exponential functions and their properties are useful in solving real-world problems. 2. Linear functions have a constant difference, whereas exponential functions have a constant ratio 3. The characteristics of logarithmic functions and their properties are useful in solving real-world problems.
	Content Knowledge Objectives
Recall Describe, Draw, Identify, Label, Locate, Match, Measure, Evaluate, Compute, Perform, Retrieve	1. Evaluate simple logarithmic expressions 2. Graph logarithmic functions. 3. Solve logarithmic equations. 4. Solve exponential equations using logarithms 5. Determine the amount of time needed for a specific amount. 6. Evaluate simple exponential expressions 7. Graph exponential functions. 8. Solve exponential equations. 9. Determine the amount of a quantity after a specific amount of time
Skill/Concept Categorize, Classify, Compare, Contrast, Describe Cause/Effect, Describe Patterns, Describe Relationships, Estimate, Generalize, Infer, Interpret, Make Observations, Predict, Summarize, Organize, Collect and Display	1. Distinguish between growth and decay models by base and exponent 2. Describe the inverse process for exponential functions in logarithmic notation. 3. Rewrite equations between logarithmic and exponential form
Strategic Thinking Revise, Assess, Critique, Draw Conclusion, Investigate, Differentiate, Hypothesize, Cite Evidence	1. Differentiate between linear, quadratic, and exponential models and know when to use them in solving problems. 2. Investigate the nature of the rate of change of an exponential function; and discover some interesting properties of the numerical value *e*.

Extended Thinking Analyze, Apply Concepts, Connect, Prove, Synthesize, Create, Connect	1. Apply exponential functions to solve real world problems 2. Determine algebraically any exponential function as inverse to solve logarithmic applications 3. Apply logarithmic functions to solve real world problems

VOCABULARY

Exponent	Multiplier	Discrete
Power	Growth factor	Continuous
Base	Decay factor	Population growth
Euler's number, e	Asymptote	Population decay
Exponential function	Exponential growth	Appreciation
Growth function	Exponential decay	Depreciation
Decay function	Initial value	Exponential form
Logarithm	Compound interest	Properties of logarithms
Natural logarithm	Common logarithm	Product property of logarithms
Natural base e	Exponential form	Quotient property of logarithms
	Logarithmic form	Power property of logarithms

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Participation sheets

Unit 6: Exponential and Logarithmic Functions		
CC.9-12….Standard – (Indicators)	Expectations 'Student will….'	Teacher Strategies and Notes:
CC.9-12.F.IF.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.* CC.9-12.F.IF.7e Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude. CC.9-12.F.IF.8 Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. CC.9-12.F.IF.8b Use the properties of exponents to interpret expressions for exponential functions. For example, identify percent rate of change in functions such as $y = (1.02)^t$, $y = (0.97)^t$, $y = (1.01)^{12t}$, $y = (1.2)^{(t/10)}$, and classify them as representing exponential growth or decay CC.9-12.A.SSE.1 Interpret expressions that represent a quantity in terms of its context.* CC.9-12.A.SSE.1b 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	• Define what is a multiplier, growth factor or decay factor. • Evaluate exponential functions • Classify an exponential function as representing exponential growth or exponential decay. • Graph exponential functions 1. domain and range 2. increasing 3. decreasing 4. end behaviors 5. asymptotes 6. zeros • Describe the effect of transformations on graphs of exponential functions $f(x) = a(b)^{x-h} + k.$ • Use exponential functions in applications involving growth or decay. 1. future value 2. present value 3. rate 4. population growth 5. compound interest • Investigate how e is used to model continuously compounded interest and continuous growth rates.	**Examples from Connecticut Curriculum** CC.9-12.A.SSE.1 and CC.9-12.A.SSE.1b Students should understand the vocabulary for the parts that make up the whole expression and be able to identify those parts and interpret there meaning in terms of a context CC.9-12.A.SSE.4 Example: In February, the Bezanson family starts saving for a trip to Australia in September. The Bezanson's expect their vacation to cost $5375. They start with $525. Each month they plan to deposit 20% more than the previous month. Will they have enough money for their trip? CC.9-12.A.CED.1 Equations can represent real world and mathematical problems. Include equations and inequalities that arise when comparing the values of two different functions, such as one describing linear growth and one describing exponential growth. CC.9-12.F.IF.7 and CC.9-12.F.IF.7e Key characteristics include but are not limited to maxima, minima, intercepts, symmetry, end behavior, and asymptotes. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions. CC.9-12.F.IF.4 Students may be given graphs to interpret or produce graphs given an expression or table for the function, by hand or using technology.

CC.9-12.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.* CC.9-12.A.CED.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions. CC.9-12.A.CED.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. CC.9-12.F.BF.1 Write a function that describes a relationship between two quantities.* CC.9-12.F.BF.1b Combine standard function types using arithmetic operations. For example, build a function that models the temperature of a cooling body by adding a constant function to a decaying exponential, and relate these functions to the model CC.9-12.F.BF.3 Identify the effect on the graph of replacing $f(x)$ by $f(x) + k$, $kf(x)$, $f(kx)$, and $f(x + k)$ for specific values of k (both positive and negative); find the value of k given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. Include recognizing even and odd functions from their graphs and algebraic expressions for them.	• Solve exponential equations 1. Equating exponents (same base) 2. using the properties of exponents 3. with logarithms • Define logarithmic functions • Convert between logarithmic and exponential form • Evaluate logarithms • Find the inverse function • Graph logarithmic functions 1. domain and range 2. increasing 3. decreasing 4. end behaviors 5. asymptotes 6. zeros • Describe the effect of transformations on graphs of logarithmic functions $f(x) = a\log_b(x - h) + k.$ • Apply properties of logarithm to simplify expressions. 1. Product Property 2. Quotient Property 3. Power Property • Rewrite logarithmic equations using the change of base formula	CC.9-12.F.BF.1 and CC.9-12.A.SSE. Students will analyze a given problem to determine the function expressed by identifying patterns in the function's rate of change. They will specify intervals of increase, decrease, constancy, and, if possible, relate them to the function's description in words or graphically. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to model functions. Examples: • You buy a $10,000 car with an annual interest rate of 6 percent compounded annually and make monthly payments of $250. Express the amount remaining to be paid off as a function of the number of months, using a recursion equation. • A cup of coffee is initially at a temperature of 93º F. The difference between its temperature and the room temperature of 68º F decreases by 9% each minute. Write a function describing the temperature of the coffee as a function of time. • The radius of a circular oil slick after t hours is given in feet by $r = 10t^2 - 0.5t$, for $0 \leq t \leq 10$. Find the area of the oil slick as a function of time. CC.9-12.A.REI.11 Students need to understand that numerical solution methods (data in a table used to approximate an algebraic function) and graphical solution methods may produce approximate solutions, and algebraic solution methods produce precise solutions that can be represented graphically or numerically. Students may use graphing calculators or programs to generate tables of values, graph, or solve a variety of functions

CC.9-12.F.BF.5 (+) Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.

CC.9-12.A.REI.11 Explain why the *x*-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.*

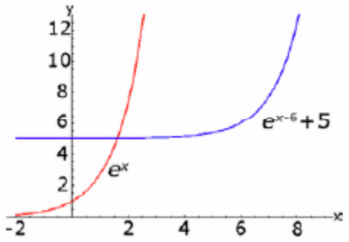
CC.9-12.F.LE.4 For exponential models, express as a logarithm the solution to $ab^{(ct)} = d$ where *a*, *c*, and *d* are numbers and the base *b* is 2, 10, or *e*; evaluate the logarithm using technology.

- Solve logarithmic equations
  1. rewrite in exponential form
  2. $log_b x = log_b k$ for x.
  3. Properties of logarithm.

- Make predictions using exponential or logarithmic mathematical models from given information.

CC.9-12.F.BF.3
Students will apply transformations to functions and recognize functions as even and odd. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions.
Example:

- Compare the shape and position of the graphs of $f(x) = e^x$ to $g(x) = e^{x-6} + 5$, and explain the differences, orally or in written format, in terms of the algebraic expressions for the functions



- Describe the effect of varying the parameters *a, h,* and *k* on the shape and position of the graph $f(x) = ab^{(x+h)} + k$., orally or in written format. What effect do values between 0 and 1 have? What effect do negative values have?

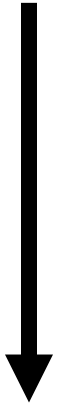
CC.9-12.F.BF.5 (+)
Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to solve problems involving logarithms and exponents.
Example:
Find the inverse of $f(x) = 3(10)^{2x}$.

		CC.9-12.F.LE.4 Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to analyze exponential models and evaluate logarithms. Example: ● Solve 200 $e0.04t = 450$ for t. Solution: We first isolate the exponential part by dividing both sides of the equation by 200. $e^{0.04t} = 2.25$ Now we take the natural logarithm of both sides. $ln\ e^{0.04t} = ln\ 2.25$ The left hand side simplifies to $0.04t$, by logarithmic identity 1. $0.04t = ln\ 2.25$ Lastly, divide both sides by 0.04 $t = ln\ (2.25) / 0.04$ $t \approx 20.3$

Algebra 2

Unit 7: Statistics and Modeling

Book Reference:	**Timeframe:**
Algebra 2 (2004) Chapter 7.7, 12.7, 2.5, 5.8, 8.7 Algebra 2 (2007) Chapter 11.1, 11.2, 11.3, 11.5	20 Instructional Periods

Depth of Knowledge	**Essential Questions For Unit**
	1. Why is a normal distribution important? 2. How can we use samples to make conclusions about populations? 3. Why are measures of central tendencies important? 4. How are real world phenomenon modeled mathematically?
	Enduring Understandings For Unit
	1. The method in which data is collected, organized, and displayed influences interpretation. 2. Data can be organized to fit mathematical models that produce reasonable predictions.
	Content Knowledge Objectives
Recall Describe, Draw, Identify, Label, Locate, Match, Measure, Evaluate, Compute, Perform, Retrieve	1. Calculate and identify measures of center and measures of spread 2. Use technology to compute data models.
Skill/Concept Categorize, Classify, Compare, Contrast, Describe Cause/Effect, Describe Patterns, Describe Relationships, Estimate, Generalize, Infer, Interpret, Make Observations, Predict, Summarize, Organize, Collect and Display	1. Interpret a piece of data on a normal curve 2. Compare and contrast mathematical models for a given set of data.
Strategic Thinking Revise, Assess, Critique, Draw Conclusion, Investigate, Differentiate, Hypothesize, Cite Evidence	1. Construct appropriate statistical displays, including box plots, dot plots, histograms, and normal curves 2. Draw conclusions from a normal curve or boxplot.
Extended Thinking Analyze, Apply Concepts, Connect, Prove, Synthesize, Create, Connect	1. Analyze outliers for their influence on measures of center and measures of spread 2. Analyze data to create an appropriate mathematical model.

VOCABULARY

Dot Plot	Mean
Histogram	Standard Deviation
Scatter Plot	Median
Regression	Mode
Correlation Coefficient	Quartile
Normal Curve	Percentile
Empirical Rule	Interquartile Range
Inference	Outlier
Normal Distribution	Box Plot
Skew	Population/Sample Standard Deviation

Mathematical Practices

Mathematical Practices #1 and #3 describe a classroom environment that encourages thinking mathematically and are critical for quality teaching and learning.

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.

Required Activities, Suggested Resources and Activities

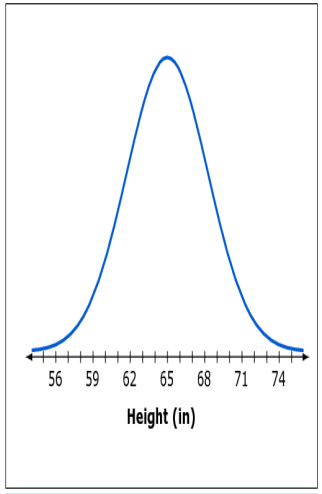
See Public Folders and List of Possible Websites

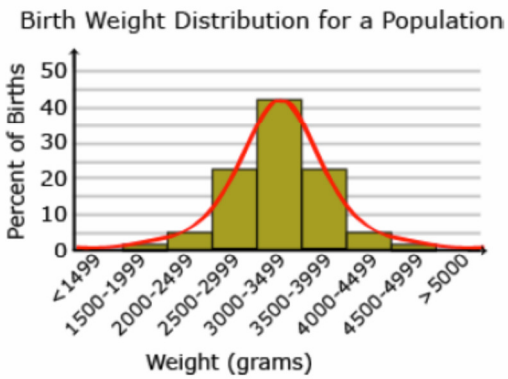
Assessments/Formative Assessments

Pretest/Post Test
Quizzes (individual and partner)
Teacher-generated assessments
Notebook quizzes
Exit slips
Participation sheets

Unit 7 – Statistics and Modeling

C.9-12. …. Standard – (Indicators)	Expectations 'Student will….'	Teacher Strategies and Notes:
S-ID.1 Represent data with plots on the real number line (dot plots, histograms, and box plots). S-ID.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets. S-ID.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). S-ID.4 Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve. S-ID.7 Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. S-ID.8 Compute (using technology) and interpret the correlation coefficient of a linear fit.	• Compare and contrast sample surveys, experiments, and observational studies • Represent data by I. Dot Plot II. Histogram • Calculate 5-number summary and interquartile range • Create a box plot • Use calculator to find descriptive statistics and graph histograms and box plots • Differentiate symmetric, asymmetric/skewed distributions • Identify an outlier via technology and formula • Calculate measures of central tendency (mean, median, mode) • Explain standard deviation • Draw a normal curve • Use the empirical rule	• Show by hand initially for recall, but the emphasis should be on interpretation for dot plot, histogram, 5-number summary, interquartile range, boxplot, measures of center and determination calculator • Identify outliers using modified boxplots on the TI calculators only • Discuss what area under curve means • Students may use computer generated simulation models based upon sample surveys results to estimate population statistics and margins of error. • Students should be able to explain techniques/applications for randomly selecting study subjects from a population and how those techniques/applications differ from those used to randomly assign existing subjects to control groups or experimental groups in a statistical experiment. • Explanations can include but are not limited to sample size, biased survey sample, interval scale, unlabeled scale, uneven scale, and outliers that distort the line-of-best-fit. In a pictogram the symbol scale used can also be a source of distortion. As a strategy, collect reports published in the media and ask students to consider the source of the data, the design of the study, and the way the data are analyzed and

	• Calculate percentiles Use calculator to create normal curves and find the area under the curve • Find the area of shaded regions under the normal curve via empirical rule	displayed. Example: A reporter used the two data sets below to calculate the mean housing price in Arizona as $629,000. Why is this calculation not representative of the typical housing price in Arizona? 1. King River area {1.2 million, 242000, 265500, 140000, 281000, 265000, 211000} 2. Toby Ranch homes {5million, 154000, 250000, 250000, 200000, 160000, 190000} Example of computer generated problems from a Common Core assessment : 18 The height of adult women in the United States is normally distributed with a mean of 65 inches and a standard deviation of 3 inches. Click on the number line to show a vertical line that approximates the height at which 25% of the women are shorter and 75% are taller.  Students may use spreadsheets, graphing

		calculators, statistical software and tables to analyze the fit between a data set and normal distributions and estimate areas under the curve. Examples: ● The bar graph below gives the birth weight of a population of 100 chimpanzees. The line shows how the weights are normally distributed about the mean, 3250 grams. Estimate the percent of baby chimps weighing 3000-3999 grams.  ● Determine which situation(s) is best modeled by a normal distribution. Explain your reasoning. ○ Annual income of a household in the U.S. ○ Weight of babies born in one year in the U.S.

CP/Honors Algebra II Grading Practice & Description of Assessments

Grading Practice

The following is the 2015-2019 grading practice for the Stamford Public Schools high school mathematics classes. A brief description of each part of the grade and a range for the percentage is given below.

The actual percentage for each part will be determined by teachers of the course with the help of the math coach/math department head.

The math coach/math department head will be able to provide you with more clarification if needed.

What is Being Graded	**Range**
1. Formal Assessments: Tests & Quizzes	50-65%
2. Homework	10%
3. Alternative Assessments: Projects, Performance Tasks, Math Notebooks (evidence of student learning, not just copying notes) Presentations	25-40%

Description of Assessments

There will be three common, district-wide assessments for this course. These assessments are not included in this handbook nor will they be in the public folders; they will be distributed to your school as the time for each assessment approaches..

The common, district-wide assessments are a:

- Pre Assessment (used to measure growth)
- Mid-term assessment (data collected),
- Final exam (data collected).

The common, district-wide assessments will include multiple choice and short answer questions . These assessments will be 90 minutes in length. The midterm will cover topics in semester 1. The final will cover topics in semester 2. Students will bubble in the answers to the multiple choice questions on the scan sheet and will answer the short answer questions directly in the test booklet. Teachers will then score the short answer questions on based upon a point system scale. Data from these exams will be collected by the district. (If teachers have a question about the score to give for a short answer items, they should see their Math Department Head or members of the committee for clarification.)

Materials for the assessments include:

- calculator,
- ruler,
- graph paper (if requested by student).

ASSESSMENT RUBRIC UPDATE

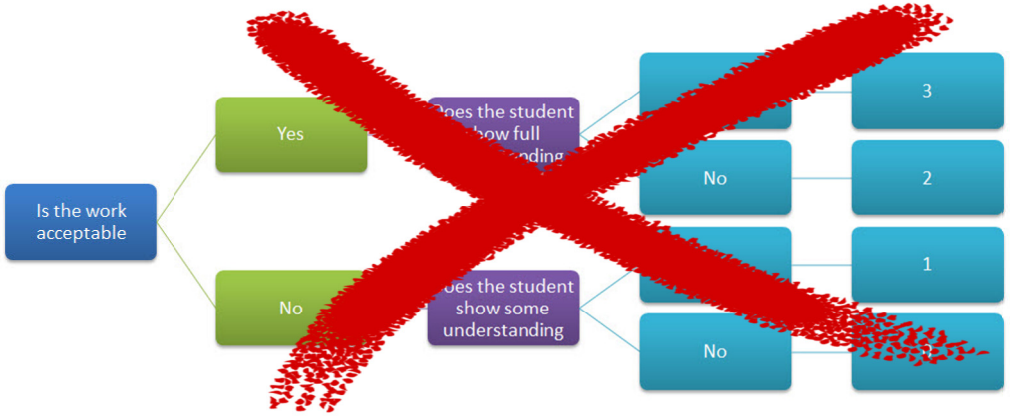
2015

Due to the recent changes with Connecticut Department of Education state assessments, the CAPT rubric will no longer be used to score the constructed response questions on the district's midterm and final exams.

This year, both middle and high school math exam questions will be scored using a point system.

Therefore, all secondary math district midterms and finals will each have a total of **100 points**.

Constructed Response Scoring Chart



Examples of Formative Assessment

Observations
Observations, sometimes called kid watching, can help teachers determine what students do and do not know. There are several instruments and techniques that teachers can use to record useful data about student learning.

- **Anecdotal Notes:** These are short notes written during a lesson as students work in groups or individually, or after the lesson is complete. The teacher should reflect on a specific aspect of the learning (sorts geometric shapes correctly) and make notes on the student's progress toward mastery of that learning target. The teacher can create a form to organize these notes so that they can easily be used for adjusting instruction based on student needs.
- **Anecdotal Notebook:** The teacher may wish to keep a notebook of the individual observation forms or a notebook divided into sections for the individual students. With this method, all of the observations on an individual student are together and can furnish a picture of student learning over time.
- **Anecdotal Note Cards:** The teacher can create a file folder with 5" x 7" note cards for each student. This folder is handy for middle and high school teachers because it provides a convenient way to record observations on students in a variety of classes.
- **Labels or Sticky Notes:** Teachers can carry a clipboard with a sheet of labels or a pad of sticky notes and make observations as they circulate throughout the classroom. After the class, the labels or sticky notes can be placed in the observation notebook in the appropriate student's section.

Questioning
Asking better questions affords students an opportunity for deeper thinking and provides teachers with significant insight into the degree and depth of student understanding. Questions of this nature engage students in classroom dialogue that expands student learning. Questions should go beyond the typical factual questions requiring recall of facts or numbers.

Discussion
Classroom discussions can tell the teacher much about student learning and understanding of basic concepts. The teacher can initiate the discussion by presenting students with an open-ended question. The goal is to build knowledge and develop critical and creative thinking skills.

Graphic Organizers

Graphic organizers are visual models that can assist students in organizing information and communicating clearly and effectively. Students can use graphic organizers to structure their writing, brainstorm ideas, assist in decision making, clarify story structure, help with problem solving, and plan research.

Peer/Self Assessments

Peer and self assessment help to create a learning community within the classroom. When students are involved in criteria and goal setting, self evaluation becomes a logical step in the learning process. Students become metacognitive and are more aware of their personal strengths and weaknesses. With peer assessment students begin to see each other as resources for understanding and checking for quality work against previously determined criteria. The teacher can examine the self assessments and the peer assessments and identify students' strengths and weaknesses. "When students are required to think about their own learning, articulate what they understand, and what they still need to learn, achievement improves." (Black and Wiliam 1998)

Visual Representations

There are several forms of visual representation, or nonlinguistic representation, but one that offers assessment data for the teacher is the use of drawing. Graphic organizers can be used as visual representations of concepts in the content areas. Many of the graphic organizers contain a section where the student is expected to illustrate his/her idea of the concept.

Kinesthetic Assessments

These examples of the formative assessment process require students to incorporate movement to demonstrate their understanding of a topic or concept. Although usually connected with the Arts (dance, playing a musical piece) or physical education (dribbling a basketball, serving a volleyball), kinesthetic assessments can be used in the core content classrooms to furnish teachers with insight into their students' understandings and misconceptions concerning a concept. Kinesthetic assessments are a good way to add movement in the classroom and allow teachers to determine the depth of student learning to inform their instructional decisions.

Individual Whiteboards

Individual slates or whiteboards are a great way to hold all students in the class accountable for the work. They actively involve students in the learning and are a terrific tool in the formative assessment process because they give the teacher immediate information about student learning. When students complete their work and hold their whiteboard up, the teacher can quickly determine who is understanding and who needs help and adjust his/her instruction accordingly.

Students meet with their half hour appointment and the teacher conducts the same informal observation and adjusts the third section of the lesson. Students continue this process until the lesson is complete. By structuring a lesson in the manner, the teacher is able to determine the current level of understanding for the class and for individual students, and make immediate adjustments to instruction to assist students in their learning.

Source: http://wvde.state.wv.us/teach21/ExamplesofFormativeAssessment.html

Mathematics Notebook

The following is a list of **basic required criteria** that high school mathematics notebooks need to include along with a brief description of each. Teachers of the course along with the math coach/math department head should together determine the set-up of the notebook.

1. Table of Contents which includes date, learning objective/topic, page number.

How to Set Up the Table of Contents (ToC)

- Students should leave the first few pages of the notebook blank for the Table of Contents (ToC).
- Students should then number each page after the blank ones left for the ToC.
- Each student's ToC will have different numbers based on the student's writing size and their work.

Example of the ToC:

Date	Learning Objective/Topic	Page Number
9/16	PT: 1.1 Finding Proper Factors	5-7
9/17	PT: 1.2 Prime & Composite Number	8-10

2. Notes from Math Class

These notes are the explanation, examples, etc. generated from math class.

3. Class Work from Math Class

How to Set Up the Class Work

- If students are working on problems from a book, they need to put the page and number the problems they are working on.
- If students are working on problems from a worksheet, they should put the title of the worksheet in their notebook or tape/staple the worksheet in their notebook.

4. Math Homework

How to Set Up the Math Homework

- If students are working on problems from a book, they need to put the page and number the problems they are working on.
- If students are working on problems from a worksheet, they should put the title of the worksheet in their notebook or tape/staple the worksheet in their notebook.

5. Reflection

How to Set Up a Reflection

- Students should write the reflection statement/question in their notebook and then answer it in their notebook.

OR

- Students can staple/tape the statement/question in their notebook if it is given to them separately and then answer it in their notebook.

What is Reflection in Math Class?

Reflection is:

- A way for students to make sense of what they are seeing and doing.
- Is essentially never-ending.
- Helps students answer basic questions of what, so what, and now what.
- continuous, connected, challenging, & contextualized.
- A way for teachers to understand what students know and don't know.

Possible Math Reflections

1. Use of CMP Mathematical Reflections
2. Have students explain a concept(s) in which they did well on during the post-test for unit ___ and then write which concept(s) they think they still need more practice on/with.
3. Ask students to answer a question such as:
    - After today's lesson, this week's lessons, etc., what do you feel you need more work on?
    - How would you explain _(a concept, problem in class, etc) to your friend who was absent from class today?
4. Have students complete one of the following sentences:
    - I learned that I...
    - I was surprised that I...
    - I noticed that I...
    - I discovered that I...
    - I was pleased that I...
    - Today I…
    - Describe how you feel about solving _____ problem.
    - My strategy for _____ is…
5. Have students explain familiar math ideas in their own words
    - Explain what is most important to understand about fractions
    - Explain in your own words what subtraction means.
6. Ask students to write a summary of how they reached a solution, including any "false starts" or "dead ends."
7. After a small group assignment, ask each student to write an explanation of the group's work on a problem. Have the small groups discuss the individual explanations.

Taken From:

University of Minnesota, Duluth, College of Education and Human Service Professions, *http://www.d.umn.edu/cehsp/civic-engagement/reflection.html*
Burns, M. (1995). *Writing in math class.* Sausalito, CA: Math Solutions Publications.

Mathematics Classroom Expectations

Math Classroom Expectations

Students will:

- **Communicate their reasoning and justifications for mathematical ideas with their peers and the teacher.**
- **Use mathematical vocabulary during discussions.**
- **Be engaged during the explore section of the lesson.**
- **Use concrete representations or manipulatives when appropriate for the problem.**
- **Provide multiple methods and solutions for problems.**
- **Use technology when appropriate for the problem.**
- **Organize their materials in a notebook.**
- **Use math talk and explain their thinking.**
- **Show confidence in explaining their solutions.**
- **Show mathematics proficiency in understanding, computing, applying, and reasoning.**
- **Be engaged throughout the lesson.**
- **Be empowered to *THINK!***

Standards-Based Classroom Experience Checklist

Classroom Environment

____ The desks can be easily arranged for students to be able to work together frequently.
____ Generalizations from the summarize portion of the problems are posted and visible in the classroom.
____ The environment can be described as a community of learners.
____ There is evidence of mutual respect.
____ Teacher moves around the room, not standing at the front.
____ There is evidence of a word wall.
____ There is evidence of students maintaining an organized notebook.
____ Manipulatives and/or calculators are easily accessible.
____ Unit and lesson objective(s) are posted.

Student Behavior

____ Students communicate their reasoning and justifications for mathematical ideas with their peers and the teacher.
____ Students use mathematical vocabulary during discussions.
____ Students use concrete representations or manipulatives when appropriate for the problem.
____ Students provide multiple methods and solutions for problems.
____ Students use technology when appropriate for the problem.
____ Students organize their materials in a notebook.
____ Students are empowered to think!
____ Students use math talk and explain their thinking.
____ Students show confidence in explaining their solutions.
____ Students show mathematics proficiency in understanding, computing, applying, and reasoning.
____ Students are engaged throughout the lesson (Launch, Explore, Summary).

Teacher Behavior

____ Teacher effectively launches the problem.
____ Teacher exhibits sound questioning techniques (Launch, Explore, Summary).
____ Teacher effectively facilitates the summary.
____ Teacher paces the lesson according to the Launch, Explore, Summarize model.
____ Teacher differentiates for the various learners in the classroom.
____ Teacher uses materials provided.
____ Teacher follows district curriculum and pacing guide.
____ Teacher appropriately assigns homework questions.
____ Teacher uses formative assessment to be flexible in the delivery of the lesson.
____ Teacher shows evidence that s/he believes all students can learn mathematics.
____ Teacher acts as a facilitator.
____ Teacher models activities.
____ Teacher prompts students to share different ways to solve the math.

Participation Grading Sheet

Participation Sheet

The following weekly *Participation Sheet* can be used as a way to document student participation in math class. These sheets may also provide useful information for parent conferences.

Using the *Participation Sheet*

- The *Participation Sheet* is to be used at the week
- Students should answer “yes” or “no” to each question
- Teachers may need to model the use of this form with students when used for the first time.
- If there is a discrepancy between the student’s view of his/her participation and the teacher’s view, the teacher will need to meet with that student to discuss the discrepancy.

Participation Grading Sheet

Name: _____

Week of: _____

We have completed almost a full week of math class. Think about how well you have participated in class this week

1. Answer the following questions, as they will help you give yourself a fair participation grade for this week.

   Did you participate in whole group discussions?

   Did you ask questions when you didn't understand?

   Did you come prepared to class so that you could ask questions?

   Did you LISTEN carefully to others?

2. Now count your "yes" responses.
   If you answered "yes" to ALL of them, you are doing a great job! Give yourself a **4**.
   If you answered "yes" to most of them, give yourself a **3**.
   If you answered yes to a couple of them, give yourself a **2**.
   If you answered yes to one of them, give yourself a **1** and you need to rethink your role in the class and speak to your teacher.

3. I give myself _____ for this week. Student Signature: _____

Differentiated Instruction: Ways to Reach a Variety of Math Learners

EXPEDITIONARY LEARNING

MEETING STUDENTS' NEEDS THROUGH SCAFFOLDING

Lessons that involve highly complex text require a great deal of scaffolding. Many of the suggestions we make in the Meeting Students' Needs column of the NYS lessons are scaffolds—temporary instructional supports designed to help students successfully read texts that are supposedly too hard for them. **Many scaffolds are excellent for all types of learners—English Language Learners (ELLs), students with special needs and/or students who are just generally challenged by reading.**

Scaffolding *becomes* differentiation *when students access or have access to scaffolding only when needed. Scaffolds that are provided to the whole class might be appropriate and necessary, but whole class scaffolds are not differentiation.*

FRONT-END SCAFFOLDING	
	Front-end scaffolding is defined as the actions teachers take to prepare students to better understand how to access complex text before they read it. Traditionally, front-end scaffolding has included information to build greater context for the text, front-loading vocabulary, summarizing the text, and/or making predictions about what is to be read. Close analytical reading requires that teachers greatly reduce the amount of front-end scaffolding to offer students the opportunity to read independently and create meaning and questions first. It also offers students the opportunity to own their own learning and build stamina.
	Examples of front-end scaffolding that maintain the integrity of close reading lessons include: • Using learning targets to help students understand the purpose for the reading • Providing visual cues to help students understand targets • Identifying, bolding, and writing in the margins to define words that cannot be understood through the context of the text • Chunking long readings into short passages, (literally distributing sections on index cards, for example), so that students see only the section they need to tackle • Reading the passage aloud before students read independently • Providing an audio or video recording of a teacher read-aloud that students can access when needed (such as SchoolTube, podcasts, ezPDF, or GoodReader) • Supplying a reading calendar at the beginning of longer-term reading assignments, so that teachers in support roles (special needs, ELL, AIS) and families can plan for pacing • Prehighlighting text for some learners so that when they reread independently, they can focus on the essential information • Eliminating the need for students to copy information—and if something is needed (such as a definition of vocabulary), providing it on the handout or other student materials

MEETING STUDENTS' NEEDS THROUGH SCAFFOLDING

BACK-END SCAFFOLDING	**Back-end scaffolding**, on the other hand, is defined as what teachers plan to do after students read complex text to help deepen understanding of the text. When teachers provide back-end scaffolds, they follow the "Release-Catch-Release model," allowing students to grapple with hard text FIRST, and then helping students as needed.

Examples of back-end scaffolds include, but are not limited to:

- Providing "hint cards" that help students get "unstuck" so they can get the gist—these might be placed on the chalkboard tray, for example, and students would take them only if they are super-stuck
- Encouraging/enabling students to annotate the text, or—if they can't write directly on the text—providing sticky notes or placing texts inside plastic sleeves (GoodReader is an app that allows students to mark up text on an Ipad. Adobe Reader works on a wide variety of electronic platforms)
- Supplying sentence starters so all students can participate in focused discussion
- Placing students in heterogeneous groups to discuss the text and answer text-dependent questions
- Providing task cards and anchor charts so that expectations are consistently available
- Highlighting key words in task directions
- Simplifying task directions and/or create checklists from them so that students can self-monitor their progress
- Placing students in homogeneous groups and providing more specific, direct support to the students who need it most
- If special education teachers, teachers of ELLs, teaching assistants, etc. are pushed in to the ELA block, teaching in "stations" so that students work in smaller groups
- Designing question sets that build in complexity and offer students multiple opportunities to explore the answers:
  * Students discuss the answer with peers, then write answers independently and defend answers to the whole class.
  * Provide time for students to draft write responses before asking for oral response.
- Identifying and defining vocabulary that students struggled with
- Using CoBuild (plain language) dictionaries
- Providing partially completed or more structured graphic organizers to the students who need them
- Providing sentence or paragraph frames so students can write about what they read
- **AFTER students have given it a shot:**
  * Examine a model and have students compare their work to the model and then revise.
  * Provide a teacher think-aloud about how he/she came to conclusions and have students revise based on this additional analysis.
  * Review text together as a class (smartboard or document camera) and highlight the evidence.

Teacher Tool Box for Differentiation in the Math Classroom

1. Use graphic organizers to help students organize information

http://www.teachervision.fen.com/graphic-organizers/printable/6293.html
http://www.graphic.org/goindex.html
http://www.eduplace.com/graphicorganizer/
http://www.enchantedlearning.com/graphicorganizers/

2. Assess, Assess, Assess: Use Formative Assessment to see what students know

"Formative assessment is a process used by teachers and students during instruction that provides explicit feedback to adjust ongoing teaching and learning to improve students' achievement of intended instructional outcomes.[1] Formative assessment is a method of continually evaluating students' academic needs and development within the classroom."
From the website http://www.learnnc.org/lp/pages/5212

Examples of formative assessment:

- Exit slips
- Thumbs up/down
- Have students discuss their thinking about a question or topic in pairs or small groups, then ask a representative to share the thinking with the larger group (sometimes called think-pair-share).
- Present several possible answers to a question, then ask students to vote on them.
- Ask all students to write down an answer, then read a selected few out loud.
- Have students write their understanding of vocabulary or concepts before and after instruction.
- Ask students to summarize the concepts after an activity
- Have students complete a few problems or questions at the end of instruction and check answers.
- Interview students individually or in groups about their thinking as they solve problems.
- Use of math notebooks to answer a question, explain their thinking, etc.

3. Listen to students' conversation to hear what students are thinking and what they understand

4. Assign different questions to students

5. Provide students with access to calculators

6. Pair a student with another student of similar different academic levels or learning styles

7. Group and regroup students throughout the course of the class period within the same lesson

8. Have students create similar problems/Write own story problems

9. Extend a problem by adding an additional section

10. Focus on logic, reasoning and explanations

11. Use simpler numbers in the examples

12. Minimize reading - Read aloud to certain groups or have one student read to the rest of the group

13. Break down problems- Have students do the problem in sections

14. Use of concise language (make sure that students know what is being asked)

"Keys Ideas for Successful Differentiation"

The following ideas will help provide differentiated instruction for all students:

- **Start small. Use materials that you are already working with and adjust then to response to varied needs around your objective.**
- **Promote growth for all learners: keep struggling, grade-level, and advanced students in mind.**
- **Give all students access to rich, worthwhile tasks and ideas that encourage higher-level thinking and mathematical applications.**
- **Adjust the number of tasks along with the complexity, but avoid given any group of students significantly more or fewer problems to solve.**
- **Use assessment continuously, and group flexibly according to assessed needs.**
- **Recognize that some students may have needs beyond what can be met with tiering.**

Taken from:
Little, C., Hauser, S., & Corbishley, J. Constructing complexity for differentiated learning. *Mathematics Teaching in the Middle School.* Volume 14, No.1, August 2009.

Strategies for Math Class
Originally Developed June 2010

1. Use this strategy to help students find a missing width when the perimeter and length are given (Academic Geometry).
    - $P = l + l + w + w$
    - $22 = 6 + 6 + \_\_\_ + \_\_\_\_$
    - $22 = 6 + 6 + 5 + 5$

2. To go over problems in class, have a student go to the Promethean/Smart board and to act as the teacher. The student calls on other students to work through each step of the problem asking questions of the class of students as they work through the problem. Thinking through the problem as the teacher must think through a problem leads to a greater understanding of the math.

3. Make sure that the writing on the Word Walls is large enough so that the words are easily read from anywhere in room.

4. Put answers to a quiz on the Promethean/Smart board immediately after students hand in their quiz. Students liked the immediate feedback.

5. Differentiation
    - see previous handouts
    - have the next problem ready to go for students who successfully complete the given one
    - provide a "CHALLENGE" homework assignment as an option for those students who want to stretch themselves (see handout entitled "Ways to Challenge Students in Math Class").

10 Rituals and Routines That Work

Originally Developed June 2010

1. **Use a Problem of the Day (Warm-Up/Do Now/etc.)**
   Incorporate concepts students need to review into a POD, Warm-Up, Do Now.
   To determine these concepts, look at pre-requisite skills for the unit. Doing these concepts as a warm up will help keep the concepts connected.

2. **Teach group work expectations and have students reflect on their own participation**
   Use the SPS Participation Grading Sheet to help teach students the expectations for math class and to teach them how to reflect on their work. The Participation Grading Sheet can be found in the SPS Mathematics Handbook

3. **Exit Slips for individual accountability**
   Create an Exit Question(s) on your lesson objective. All students answer this question individually before leaving class and hand in exit slip on their way out. Student responses will help guide teachers' instructional decisions. It also helps to ensure that a student is not being "carried" by their partner(s). These do not need to be graded; they are used formatively.

4. **Use RED, YELLOW, GREEN cups to monitor class needs**
   Use these when students are doing group/partner work so that the teacher can easily see which groups need assistance, which are done, and which need more time.
   Red – ALL DONE
   Yellow – WE HAVE A QUESTION
   Green – WE ARE STILL WORKING

5. **Keep homework easy to correct**
   Don't let homework eat up too much of the class time. Class time focuses on problem solving. Students still need drill to solidify concepts – do that for homework.

6. **Use the interactive white boards**
   These are the best tool for keeping both students and teachers on their learning objective.

7. Have colored pencils available for graphing of equations

Tie a red, green, and blue colored pencil together with a rubber band. Together with a regular pencil this makes four colors to work with. Discussion is made easier when everyone has graphed the first equation in red, the second in green, and the third in blue, for example.

8. Plan for the closure of the lesson while students are working in small groups

The teacher should walk around while students are working in small groups and choose students with interesting solutions to present their work during the close of the lesson. Let students know that they will be called upon and for which specific part of the problem. In order to keep track of the students and the problem they are presenting, the teacher should write down the student names and the part of the problems they are to present on a piece of paper.

9. Always have something "up your sleeve" for students who finish early

For example, if all students are doing parts A – C of a problem, those who finish early can move on to part D and/or E. Students who finish early can also work on something to present during the close of the lesson or can work on an on-going project, activity that focuses on the same concepts/topics.

10. ALWAYS have closure to a lesson

Leave a minimum of 10 minutes for the close of the lesson. Even if the class has not finished the problem, there should be a summary of what was completed so far. An exit slip and some sort of VERY short notes that students take in their notebooks are good ways to ensure closure.

Suggestions on How to Challenge Students in Math
Originally Developed June 2010

1. Teachers can post two homework assignments every day.
   For example:

   HW – p. 21 (3 – 5)
   Challenge – p. 24 (32, 33)

2. Teachers should contact parents of students consistently getting A's or better to say:
   "Your child is doing wonderfully in math and I want to make sure we are challenging him/her. I assign challenge problems every night and I would like your son/daughter to try those problems in addition to the regular homework (which they probably finish very quickly) These problems will typically cover the same topics we are studying in class, but will allow your son/daughter to explore the concepts in greater depth."

3. For these top students (when arranged with the parents) the challenge questions are **not optional**.

4. Other students may try the challenge questions if they want to as long as they are also getting their regular homework done well.

5. Teachers can put a basket out to collect the challenge homework which the teacher can correct and returned.

6. The regular homework can be corrected in class since all students are doing that assignment.

This is a simple, pro-active way to show parents that you recognize the needs of your top students and you are doing everything you can to meet those needs.

Appendix A:
Course Feedback

Curriculum Feedback

Course_____Quarter_____

I like the way the curriculum/Handbook…
If I could change something about the curriculum/Handbook, I would…
If I could add something to the curriculum/Handbook, I would…

Appendix B:
Required & Suggested Activities

How to Use the Activities/Resources Provided

There are activities included in this handbook for classroom use. The activities in the handbook should not just be photocopied and used as "worksheets" for students to complete individually. Instead, they should be used in the workshop model. This means that small groups of students work on the activity collaboratively or certain parts of the activity are assigned to certain groups of students. While students are working on these, the teacher should be circulating the room to help each group and determining which students will present their work and solutions to the class. The groups that the teacher asks to present should show a variety of ways to solve the problem/do the work.

Additional activities and projects will be given to teachers during the district Professional Development days (2015-2016). These activities and projects are to be included in the handbook and used during the school year.

If teachers feel that they need help with the workshop model, they can contact their Math Department Head.