| Quarter 1 | Quarter 2 | | Quarter 3 | | Quarter 4 | |
|---|---|---|---|---|---|---|
| Various Functions & Their Graphs, Polynomials & Polynomial Functions, Inverse Functions | Trigonometric Functions and Their Graphs, Unit Circle, Inverse Trigonometric Functions, Law of Sines, Law of Cosines, Trigonometric Identities | | Exponential and Logarithmic Functions, Conic Sections | | Systems of Equations and Matrices, Polar Coordinates and Complex Numbers, Sequences and Series, Limits and Introduction to Integrals | |
| August 6 2018 – October 5, 2018 | October 15, 2018 – December 19, 2018 | | January 7, 2019 – March 8, 2019 | | March 18, 2019 – May 23, 2019 | |
| P.F.IF.A.1 | P. G.AT.A.1 | P.F.GT.A.8 | P.A.PE.A.1 | P.N.NE.A.2 | P. A. REI.A.1 | P.A.S.A.1 |
| P.F.IF.A.2 | P.G.AT.A.3 | P.G.TI.A.2 | P.A.PE.A.2 | | P. A. REI.A.2 | P.A.S.A.2 |
| P.F.IF.A.4 | P.G.AT.A.5 | | P. A.C.A.2 | | P. N. VM.A.1 | P.A.S.A.3 |
| P.F.IF.A.5 | P.G.AT.A.6 | | P. A.C.A.3 | | P. N. VM.A.2 | P.A.S.A.4 |
| P.F.IF.A.6 | P.F.TF.A.1 | | P.F.IF.A.2 | | P. N. VM.A.3 | P.A.S.A.5 |
| P.F.IF.A.7 | P.F.TF.A.2 | | P.F.IF.A.3 | | P. N. VM.B.4 | P. N. VM.C.13 |
| P.F.BF.A.1 | P.F.GT.A.3 | | P.F.IF.A.5 | | P. N. VM.B.5 | Calculus C.F.LF.A.2 |
| P.F.BF.A.3 | P.F.GT.A.4 | | P.S.MD.A.1 | | P. N. VM.B.6 | Calculus C.F.UI.A.3 |
| P.F.BF.A.5 | P.F.GT.A.5 | | P.S.MD.A.2 | | P.G.PC.A.1 | |
| P.F.BF.A.6 | P.F.GT.A.6 | | P.S.MD.A.3 | | P.G.PC.A.2 | |
| P.N.CN.B.7 | P.F.GT.A.7 | | P.N.NE.A.1 | | P.G.PC.A.3 | |
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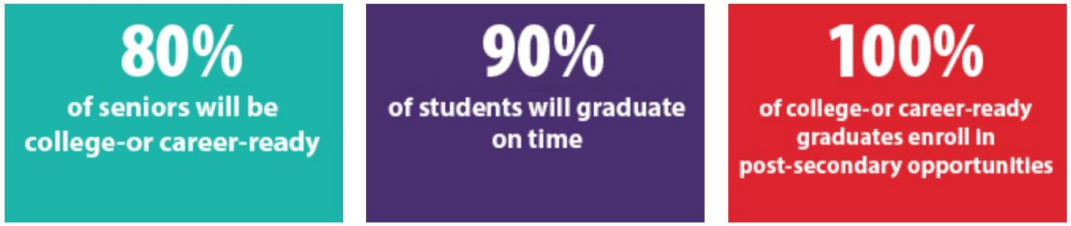
| | | | | | | |

Tennessee Academic Standards for Mathematics

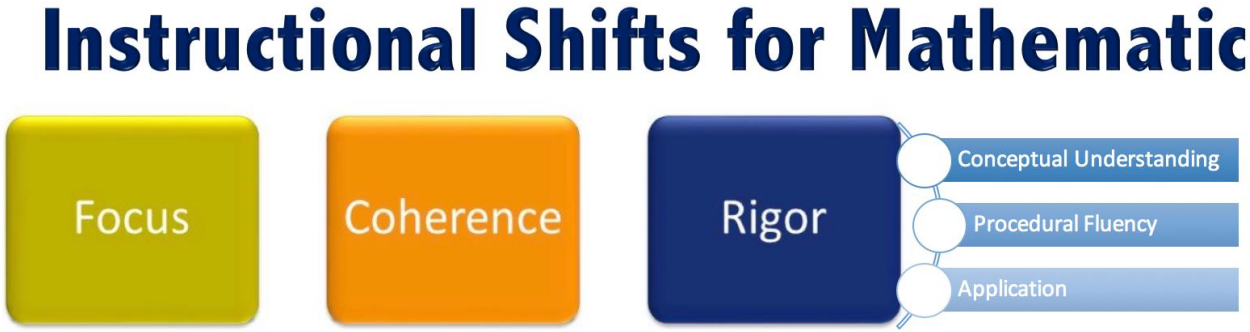
## Introduction

Destination 2025, Shelby County Schools' 10-year strategic plan, is designed not only to improve the quality of public education, but also to create a more knowledgeable, productive workforce and ultimately benefit our entire community.

### What will success look like?




In order to achieve these ambitious goals, we must collectively work to provide our students with high quality, college and career ready aligned instruction. The Tennessee State Standards provide a common set of expectations for what students will know and be able to do at the end of a grade. The State of Tennessee provides two sets of standards, which include the Standards for Mathematical Content and The Standards for Mathematical Practice. The Content Standards set high expectations for all students to ensure that Tennessee graduates are prepared to meet the rigorous demands of mathematical understanding for college and career. The eight Standards for Mathematical Practice describe the varieties of expertise, habits of mind, and productive dispositions that educators seek to develop in all students. The Tennessee State Standards also represent three fundamental shifts in mathematics instruction: **focus, coherence and rigor**.




Tennessee Academic Standards for Mathematics

The **Standards for Mathematical Practice** describe varieties of expertise, habits of minds and productive dispositions that mathematics educators at all levels should seek to develop in their students. These practices rest on important National Council of Teachers of Mathematics (NCTM) "processes and proficiencies" with longstanding importance in mathematics education. Throughout the year, students should continue to develop proficiency with the eight Standards for Mathematical Practice. The following are the eight Standards for Mathematical Practice:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of them.
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.

This curriculum map is designed to help teachers make effective decisions about what mathematical content to teach so that ultimately our students can reach Destination 2025. Throughout this curriculum map, you will see resources as well as links to tasks that will support you in ensuring that students are able to reach the demands of the standards in your classroom. In addition to the resources embedded in the map, there are some high-leverage resources around the content standards and mathematical practice standards that teachers should consistently access. For a full description of each, click on the links below.

Tennessee Mathematics Content Standards

Standards for Mathematical Practice

Literacy Skills for Mathematical Proficency

Tennessee Academic Standards for Mathematics

## Structure of the Standards

Structure of the TN State Standards include:

- **Content Standards** - Statements of what a student should know, understand, and be able to do.
- **Clusters** - Groups of related standards. Cluster headings may be considered as the big idea(s) that the group of standards they represent are addressing. They are therefore useful as a quick summary of the progression of ideas that the standards in a domain are covering and can help teachers to determine the focus of the standards they are teaching.
- **Domains** - A large category of mathematics that the clusters and their respective content standards delineate and address. For example, Number and Operations – Fractions is a domain under which there are a number of clusters (the big ideas that will be addressed) along with their respective content standards, which give the specifics of what the student should know, understand, and be able to do when working with fractions.
- **Conceptual Categories** – The content standards, clusters, and domains in the 9th-12th grades are further organized under conceptual categories. These are very broad categories of mathematical thought and lend themselves to the organization of high school course work. For example, Algebra is a conceptual category in the high school standards under which are domains such as Seeing Structure in Expressions, Creating Equations, Arithmetic with Polynomials and Rational Expressions, etc.



Tennessee Academic Standards for Mathematics

# How to Use the Maps

**Overview**
An overview is provided for each quarter and includes the topics, focus standards, intended rigor of the standards and foundational skills needed for success of those standards.

**Your curriculum map contains four columns that each highlight specific instructional components. Use the details below as a guide for information included in each column.**

**Tennessee State Standards**
TN State Standards are located in the left column. Each content standard is identified as Major Content or Supporting Content (for Algebra I, Algebra II & Geometry only). A key can be found at the bottom of the map.

**Content**
This section contains learning objectives based upon the TN State Standards. Best practices tell us that clearly communicating measurable objectives lead to greater student understanding. Additionally, essential questions are provided to guide student exploration and inquiry.

**Instructional Support & Resources**
District and web-based resources have been provided in the Instructional Support & Resources columns. You will find a variety of instructional resources that align with the content standards. The additional resources provided should be used as needed for content support and scaffolding. The inclusion of vocabulary serves as a resource for teacher planning and for building a common language across K-12 mathematics. One of the goals for Tennessee State Standards is to create a common language, and the expectation is that teachers will embed this language throughout their daily lessons.



Tennessee Academic Standards for Mathematics

## Topics Addressed in Quarter

- **Various Functions & Their Graphs**
- **Polynomials & Polynomial Functions**
- **Inverse Functions**

### Overview

Students develop conceptual knowledge of functions that set the stage for the learning of other standards in Precalculus. Students apply the standards in Interpreting Functions and Building Functions in the cases of polynomial functions of degree greater than two, more complicated rational functions, the reciprocal trigonometric functions, and inverse trigonometric functions. Students will examine end behavior of functions and learn how to find asymptotes. Students further their understanding of inverse functions and construct inverse functions by appropriately restricting domains.

| TN STATE STANDARDS | CONTENT | INSTRUCTIONAL SUPPORT & RESOURCES | |
|---|---|---|---|
| **GLENCOE - Chapter 1: Functions from a Calculus Perspective**<br>**SULLIVAN – Chapter 2: Functions & Their Graphs Chapter 5: Exponential & Logarithmic Functions**<br>**(Allow approximately 6 weeks for instruction, review, and assessment)** | | | |
| **Domain:** Interpreting Functions<br>**Cluster:** Analyze functions using different representations.<br>**P.F.IF.A.1** Determine whether a function is even, odd, or neither.<br>**P.F.IF.A.2** Analyze qualities of exponential, polynomial, logarithmic, trigonometric, and rational functions and solve real world problems that can be modeled with these functions (by hand and with appropriate technology). ★<br>**P.F.IF.A.4** Identify the real zeros of a function and explain the relationship between the real zeros and the x-intercepts of the graph of a function (exponential, polynomial, logarithmic, trigonometric, and rational). | **Essential Question(s):**<br>• How can functions describe real-world situations, model predictions and solve problems?<br>• How can you use the number of sign changes in a function to determine the number and type of real zeros of a function?<br><br>**Objective(s):**<br>Students will:<br>• Identify and evaluate functions and state their domains in symbolic and verbal forms.<br>• Use graphs of functions to estimate function values and find domains, ranges, y-intercepts, and zeros of | **Glencoe**<br>1-1: Functions<br>1-2: Analyzing Graphs of Functions and Relations<br>1-3: Continuity, End Behavior, and Limits<br>**Sullivan**<br>2.1: Functions<br>2.2: The Graph of a Function<br>2.3: Properties of Functions<br><br>**Tasks:**<br>Illustrative Math: Identifying Even and Odd Functions | **Vocabulary:** set-builder notation, interval notation, implied domain, piecewise-defined function, relevant domain, continuous, limit discontinuous, infinite, jump, point, removable and non-removable discontinuities, end behavior<br><br>**Writing in Math:**<br>• Write two things you already know about functions.<br><br>• Give an example of a real-life situation that is a function, and explain the type of function (linear, quadratic) it is. Explain whether and how the domain and range of the function are restricted, given the situation. Explain what |

| TN STATE STANDARDS | CONTENT | INSTRUCTIONAL SUPPORT & RESOURCES | |
|---|---|---|---|
| **P.F.IF.A.5** Identify characteristics of graphs based on a set of conditions or on a general equation such as $y = ax^2 + c$.<br>**P.F.IF.A.7** Graph rational functions, identifying zeros, asymptotes (including slant), and holes (when suitable factorizations are available) and showing end-behavior. | functions.<br>• Determine symmetry of graphs and identify even and odd functions.<br>• Determine intervals on which a function is continuous.<br>• Describe end behavior of functions. | **Additional Resources:**<br>Function Notation: Even and Odd<br>Khan Academy: Recognizing Even and Odd Functions<br>Functions and Graphs Videos | the x-intercept and the *y*-intercept represent in the situation. |
| **Domain:** Interpreting Functions<br>**Cluster:** Analyze functions using different representations.<br>**P.F.IF.A.6** Visually locate critical points on the graphs of functions and determine if each critical point is a minimum, a maximum, or point of inflection. Describe intervals where the function is increasing or decreasing and where different types of concavity occur. | **Essential Question(s):**<br>How can we use the definite integral in real-world applications?<br><br>**Objective(s):**<br>Students will:<br>• Determine intervals on which functions are increasing, constant, or decreasing, concave up or concave down, maxima, minima, and points of inflection. | **Glencoe**<br>1-4: Extrema and Average Rates of Change<br>**Sullivan**<br>2.3: Properties of Functions<br><br>**Task(s):**<br>Inside Math: Quadratics Performance Task<br><br>**Additional Resources**:<br>Engage NY: End Behavior of Rational Functions<br>Curve Sketching Tutorial<br>Functions and Graphs Videos | **Vocabulary:** increasing, decreasing, constant, maximum, minimum, extrema, average rate of change, secant line<br><br>**Writing in Math:**<br>Describe how the average rate of change of a function relates to a function when it is increasing, decreasing, and constant on an interval. |
| **Domain:** Building Functions<br>**Cluster:** Build new functions from existing functions.<br>**P.F.BF.A.1**: Understand how the algebraic properties of an equation transform the geometric properties of its graph. *For example, given a function, describe the transformation of the graph resulting from the manipulation of the algebraic properties of the equation (i.e., translations, stretches, reflections and changes in periodicity and amplitude).* | **Essential Question(s):**<br>• How can changing the values of a function affect the shape of the graph of the function?<br><br>**Objective(s):**<br>Students will:<br>• Identify, describe, and graph transformations of parent functions. | **Glencoe**<br>1-5: Parent Functions and Transformations<br>**Sullivan**<br>2.4: Library of Functions<br>2.5: Graphing Techniques: Transformations<br><br>**Additional Resource(s):**<br>Functions and Graphs Videos | **Vocabulary:** parent function, constant function, zero function, identity function, quadratic function, cubic function, square root function, reciprocal function, absolute value function, step function, greatest integer function, transformation, translation, reflections, dilation<br><br>**Writing in Math:**<br>Use words, graphs, tables and equations to relate parent functions and transformations. Show this relationship through a specific example. |

| TN STATE STANDARDS | CONTENT | INSTRUCTIONAL SUPPORT & RESOURCES | |
|---|---|---|---|
| **Domain:** Building Functions<br>**Cluster:** Build new functions from existing functions.<br>**P.F.IF.A.2**: Develop an understanding of functions as elements that can be operated upon to get new functions: addition, subtraction, multiplication, division, and composition of functions.<br>**P.F.BF.A.3** 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.* | . **Essential Question(s):**<br>• What relationships exist between quantities that can be modeled by functions?<br><br>**Objective(s):**<br>Students will:<br>• Perform arithmetic operations with functions.<br>• Compose compositions of functions. | **Glencoe**<br>**1**-6: Function Operations and Composition of Functions<br>**Sullivan**<br>5-1: Composite Functions<br><br>**Task(s):**<br>Illustrative Math: Compose Functions<br><br>**Additional Resources:**<br>Engage NY Lesson 16: Function Composition<br>Engage NY Lesson 17: Solving Problems by Function Composition<br>Composite Functions Applications<br>TI Nspire Composite Functions Activity<br>How to Add, Subtract, Multiply and Divide Functions<br>Functions and Graphs Videos | **Vocabulary:** compose, composite function<br><br>**Writing in Math:**<br>Explain how to determine the output of a composition of functions, given the input. |
| **Domain:** Building Functions<br>**Cluster:** Build new functions from existing functions.<br>**P.F.BF.A.5** Find inverse functions (including exponential, logarithmic and trigonometric).<br>a. Calculate the inverse of a function, $f(x)$, with respect to each of the functional operations; in other words, the additive inverse, $-f(x)$, the multiplicative inverse, 1/f(x), and the inverse with respect to composition, $f^{-1}(x)$. Understand the algebraic and graphical implications of each type. | **Essential Question(s):**<br>• What are inverse functions and what are they being used for?<br>• How do we restrict the domain of a non-invertible function to produce an invertible function?<br><br>**Objective(s):**<br>Students will:<br>• Use the horizontal line test to determine whether a function has an inverse function.<br>• Find inverse functions algebraically and graphically.<br>• Verify inverse functions algebraically | **Glencoe**<br>1-7: Inverse Relations and Functions<br>**Sullivan**<br>5.2: One-to-One Functions; Inverse Functions<br><br>**Task(s):**<br>Illustrative Math: Invertible or Not<br>Graphs of Compositions<br><br>**Additional Resources:**<br>Engage NY Lessons: Inverse Functions (Lessons 18-21)<br>Inverse Functions Concept Development Activity<br>Functions and Graphs Videos | **Vocabulary:** inverse function, one-to-one, invertible<br><br>**Writing in Math:**<br>Explain what it means for a function to be "one-to-one" and describe two methods for determining whether or not a function is one-to-one.<br><br>Justify the identity function, y= x, being the line of reflection for a function and its inverse. |

Tennessee Academic Standards for Mathematics

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|---|---|---|---|
| b. Verify by composition that one function is the inverse of another.<br>c. Read values of an inverse function from a graph or a table, given that the function has an inverse.<br>d. Recognize a function is invertible if and only if it is one-to-one. Produce an invertible function from a non-invertible function by restricting the domain.<br>**P.F.BF.A.6**: Explain why the graph of a function and its inverse are reflections of one another over the line y=x. | using a composition of functions and graphically using y=x symmetry. | | |
| **GLENCOE - Chapter 2: Power, Polynomial, & Rational Functions**<br>**SULLIVAN – Chapter 4: Polynomial & Rational Functions**<br>**(Allow approximately 3 weeks for instruction, review, and assessment)** | | | |
| **Domain:** Interpreting Functions<br>**Cluster:** Analyze functions using different representations.<br><br>**P.F.IF.A.2**: Analyze qualities of exponential, polynomial, logarithmic, trigonometric, and rational functions and solve real world problems that can be modeled with these functions (by hand and with appropriate technology). ★ | **Essential Question(s):**<br>• What relationships exist between quantities that can be modeled by functions?<br>• What are some of the characteristics of the graph of an exponential function?<br>• What are some of the characteristics of the graph of a logarithmic function?<br><br>**Objective(s):**<br>Students will:<br>• Graph and analyze power functions and radical functions.<br>• Graph polynomial functions.<br>• Model real-world data with polynomial functions. | **Glencoe**<br>2-1: Power and Radical Functions<br>2-2: Polynomial Functions<br>**Sullivan**<br>4.1: Polynomial Functions and Models<br><br>**Task(s):**<br>Writing an Exponential Function from a Description<br><br>Illustrative Math: Model with Exponential Functions<br><br>Exponential and Logarithmic Functions (tasks start on p. 12) | **Vocabulary:** power function, monomial function, extraneous solutions, polynomial function, polynomial function of degree n, leading coefficient, leading term test, quartic function, turning points, quadratic form, repeated zero, multiplicity<br><br>**Writing in Math:**<br>Describe some similarities and differences between the graphs of exponential, polynomial, logarithmic, trigonometric, and rational functions. |

| TN STATE STANDARDS | CONTENT | INSTRUCTIONAL SUPPORT & RESOURCES | |
|---|---|---|---|
| | | **Additional Resources:**<br>Analyzing-the-Graph-of-a-Rational-Function-Asymptotes-Domain-and-Range<br><br>Polynomial and Rational Functions Videos | |
| **Domain:** Interpreting Functions<br>**Cluster:** Analyze functions using different representations.<br>**P.F.IF.A.4**: Identify the real zeros of a function and explain the relationship between the real zeros and the x-intercepts of the graph of a function (exponential, polynomial, logarithmic, trigonometric, and rational).<br><br>**Domain:** Complex numbers<br>**Cluster:** Use complex numbers in polynomial identities and equations.<br>**P.N.CN.B.7** Know the Fundamental Theorem of Algebra; show that it is true for quadratic polynomials. | **Essential Question(s):**<br>• How do polynomial functions model real-world problems and their solutions?<br>• Why are complex numbers necessary?<br><br>**Objective(s):**<br>Students will:<br>• Find the real zeros of polynomial functions.<br>• Find the complex zeros of polynomial functions and know and use the Fundamental Theorem of Algebra. | **Glencoe**<br>2-3: The Remainder and Factor Theorems<br>2-4: Zeros of Polynomial Functions<br>**Sullivan**<br>4.5: The Real Zeros of a Polynomial Function<br>4.6: Complex Zeros; Fundamental Theorem of Algebra<br><br>**Task(s):**<br>Illustrative Math: Zeroes and Factorization of General Polynomials<br>Factors, Zeroes, and Roots: Oh My! (Teacher notes p. 27 and student pages start on p. 39)<br><br>**Additional Resources:**<br>Khan Academy: Fundamental Theorem of Algebra<br>Khan Academy: Zeroes or Polynomials and Their Graphs<br><br>Polynomial and Rational Functions Videos | **Vocabulary:** synthetic division, depressed polynomial, synthetic substitution, rational zero theorem, lower bound, upper bound, Decartes' Rule of Signs, Fundamental Theorem of Algebra, Linear Factorization Theorem, Conjugate Root Theorem, complex conjugate, irreducible over the reals<br><br>**Writing in Math:**<br>Explain how you can use a graphing calculator, synthetic division and factoring to completely factor a fifth-degree polynomial with rational coefficients, three integral zeroes and two non-integral, rational zeroes. |
| **Domain**: Interpreting Functions<br>**Cluster:** Analyze functions using different representations. | **Essential Questions(s):**<br>• What relationships exist between quantities that can be modeled by functions? | **Glencoe**<br>2-5: Rational Functions<br>**Sullivan**<br>4.2: Properties of Rational Functions | **Vocabulary:** rational function, asymptote, horizontal asymptote, vertical asymptote, oblique asymptote, holes |

| TN STATE STANDARDS | CONTENT | INSTRUCTIONAL SUPPORT & RESOURCES | |
|---|---|---|---|
| **P.F.IF.A.2** Analyze qualities of exponential, polynomial, logarithmic, trigonometric, and rational functions and solve real world problems that can be modeled with these functions (by hand and with appropriate technology). ★<br>**P.F.IF.A.4** Identify the real zeros of a function and explain the relationship between the real zeros and the x-intercepts of the graph of a function (exponential, polynomial, logarithmic, trigonometric, and rational).<br>**P.F.IF.A.7** Graph rational functions, identifying zeros, asymptotes (including slant), and holes (when suitable factorizations are available) and showing end-behavior. | **Objective(s):**<br>Students will:<br>• Analyze and graph rational functions, including horizontal, vertical, and oblique asymptotes, holes, and intercepts.<br>• Solve rational equalities. | 4.3: The Graph of a Rational Function<br><br>**Task(s):**<br>Illustrative Math: Graphing Rational Functions Rational Functions Tasks pgs. 6, 13 & 15<br><br>**Additional Resources:**<br>Learnzillion: Relate the domain of a function to its graph, accounting for asymptotes and restricted domains<br><br>Graphing Stories: Graphic Representations of the Real Life Situations<br><br>Polynomial and Rational Functions Videos | **Writing in Math:**<br>Explain why all of the test intervals must be in order to get an accurate graph of a rational function. |

| RESOURCE TOOLBOX | | |
|---|---|---|
| ***Textbook Resources***<br>***Glencoe Precalculus © 2011***<br>***http://connected.mcgraw-hill.com/connected/login.do***<br><br>***Sullivan Precalculus: Enhanced with Graphing Utilities, 5e © 2009.*** | ***Standards***<br>*Common Core Standards - Mathematics*<br>*Common Core Standards - Mathematics Appendix A*<br>*The Mathematics Common Core Toolbox*<br>*Common Core Lessons*<br>Tennessee Academic Standards for Mathematics | ***Videos***<br>*Khan Academy*<br>*Lamar University Tutorial*<br>*UCI Precalculus Instructional Videos* |
| ***Calculator***<br>*Texas Instruments Education*<br>*Texas Instruments - Precalculus Activities*<br>*Casio Education*<br>*TI Emulator*<br>*Math Nspired* | ***Interactive Manipulatives***<br>*http://www.ct4me.net/math_manipulatives_2.htm*<br>*Illuminations (NCTM)*<br><br>**ACT**<br>ACT College & Career Readiness Mathematics Standards<br><br>**Tasks/Lessons**<br>UT Dana Center<br>Inside Math Tasks<br>Math Vision Project Tasks<br>Better Lesson<br>Edutoolbox (formerly TNCore)<br>GSE Precalculus: Unit 1 Introduction to Trigonometric Functions<br>GSE Precalculus: Unit 2 Trigonometric Functions<br>GSE Precalculus: Unit 4 Trigonometric Identities | ***Additional Sites***<br>http://functions.wolfram.com<br>http://www.analyzemath.com/Graphing/piecewise_functions.html<br>http://www.purplemath.com/<br>http://www.onlinemathlearning.com/math-word-problems.html<br>http://education.ti.com/calculators/downloads/US/Activities/Detail?id=9530<br>Better Lesson<br>Algebra Cheat Sheet<br>Trigonometry Cheat Sheet<br>Online Algebra and Trigonometry Tutorial<br>Study Tips for Math Courses<br>Flipped Math-Precalculus |