HIGH SCHOOL

Calculus I (Dual Credit)

Mathematical Practices

The Standards for Mathematical Practice are essential in the extension of mathematical thinking. Students develop these habits of mind through specific, intentional experiences of writing, reading, talking, and reasoning that connect mathematics to their daily lives and career situations. All of the Standards are important for all quality math courses:

- Make sense of problems and persevere in solving them (MP.1)
- Reason abstractly and quantitatively (MP.2)
- Construct viable arguments and critique the reasoning of others (MP.3)
- Modeling with mathematics (MP.4)
- Use appropriate tools strategically (MP.5)
- Attend to precision (MP.6)
- Look for and make use of structure (MP.7)
- Look for and express regularity in repeated reasoning (MP.8)

There is an understanding that students who wish to take calculus are seeking to further their education in a STEM (science, technology, engineering, or medicine) field. With this assumption, they have already shown great competency in the pre-calculus course in a prior year. As with all courses there is the expectation that review work from the prior mathematics course is not only needed but expected, thus the first unit to complete in calculus stems from rational expressions and their factoring, as well as using the difference quotient, which is a specific example of function arithmetic.

Content Area: Pre-Calculus Review		
Fluency 1: Rational Expressions • Real number system is built on rational and irrational numbers, and represents all points on the number line • Quantitative reasoning and mathematical modeling needs attention to units of measurement		
Standards	**Strands**	**Goals and Performance Objectives**
HSA.APR.D.6	1 Limits	Rewrite simple rational expression in different forms: using inspection, long division, or, for more complicated examples, technology.

HSA.APR.D.7	1 Limits	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.
HSA.CED.A.2	1 Limits	Create equations in two or more variables to represent relationships between quantities; graph equation on coordinate axes with labels and scales
HSA.REI.B4b	1 Limits	Solve quadratic equations by inspection, 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 as **a±bi** for real numbers **a** and **b**.
HSA.REI.d.10	1 Limits	Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).
HSF.BF.A.1b	1 Limits	Combine standard functions types using arithmetic operations
HSF.BF.A.1c	1 Limits	Compose functions
HSF.BF.B.3	1 Limits	Identify the effect on the graph of replacing f(x) by f(x)+k, k f(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 that 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.
HSF.BF.B.5	1 Limits	Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.
HSF.IF.A.2	1 Limits	Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.
HSF.IF.B.4	1 Limits	For a function that models a relationship between two quantities, interpret key features of graphs and tables in relationship

HSF.IF.B.5	1 Limits	Relate the domain of a function to its graph and , where applicable, to the quantitative relationship it describes
HSF.IF.C.7	1 Limits	Graph linear, quadratic, square root, cube root, piecewise-defined, absolute value, step function, rational, exponential, logarithmic, and trigonometric functions - showing all critical extreme like roots, asymptotes, intercepts, maximum and minimum values, showing end behavior, period, amplitude, and midline.
HSN.RN.A.1	1 Limits	Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents.
MAO1.1	1 Limits	The student will describe various types of functions including trigonometric functions and their properties algebraically.
MAO8.1	1 Limits	The student will graph and analyze the graphs of functions on the coordinate plane.

Fluency 2: Using Difference Quotient to Find Limits

- Using function operations to complete the difference quotient
- Finding the limit by using the secant line
- Evaluate functions
- Calculate limits

Standards	**Strands**	**Goals and Performance Objectives**
MAO1.2	1 Limits	The student will calculate limits algebraically and through graphs, tables and limit theorems.
MAO2.1	1 Limits	The student will be able to define a limit and gain an intuitive understanding of the limiting process.

MAO5.5	1 Limits	The student will be able to approximate rate of change from graphs of functions and tables of values
MAO8.2	1 Limits	The student will understand the behavior of and be able to calculate limits approaching infinity.
MAO5.1	1 Limits	The student will understand continuity and be able to define and recognize a continuous function.
MAO.5.3	1 Limits	The student will be able to define a differentiable function as a limit of the function for all values in the domain of the function.

The next process in the development of calculus is learning how to use derivative rules to find the slope of a tangent line at a particular point. Students will use their algebraic skills to find the equation of the tangent line. Following some expertise in finding the derivative, students will solve for the consecutive derivatives.

Content Area:Derivatives		
Fluency 1: Derivative Rules • Calculate derivatives of functions • Compute derivatives using the product and quotient rules.		
Standards	**Strand**	**Goals and Performance Objectives**
MAO5.2	2 Derivatives	The student will define a derivative at a particular point on a function as the slope for the tangent line by using the definition of a limit.
MAO5.6	2 Derivatives	The student will use the power rule for calculating derivatives of polynomial functions and the special rules for the derivatives of the trigonometric functions.

MAO5.7	2 Derivatives	The student will be able to find the derivatives of more complex, trigonometric, rational and inverse functions by using the product, quotient and chain rules.
MAO5.8	2 Derivatives	The student will be able to calculate higher derivatives of polynomial, rational and trigonometric functions.
MAO5.9	2 Derivatives	The student will learn the special set of rules for finding derivatives of exponential and logarithmic functions.
MAO5.10	2 Derivatives	The student will differentiate between implicit and explicit functions and be able to find derivatives of implicit functions.

After students have learned, practiced, and adapted the algorithms for finding derivatives, they will use the consecutive derivatives in applications. Curve sketching requires students to know how to recognize critical points, such as roots, intercepts, & asymptotes. Students will be expected to use techniques learned in previous mathematics classes to find those points. Students will use consecutive derivatives to determine intervals on the function where the graph increases and decreases. They will also determine concavity with the second derivative. In essence, students will perform the necessary calculations and procedures to produce the graph of any type of function by hand.

Content Area: Graphical Representation of Functions		
Fluency 1: Curve Sketching • Correlate mathematical modeling and curve sketching • Employ techniques for finding roots and identifying asymptote		
Standards	**Strand**	**Goals and Performance Objectives**
MAO1.3	3 The Graphical Behavior of Functions	The student will use derivatives of functions, by various methods, to determine maximum and minimum values of a function.
MAO1.4	3 The Graphical Behavior of Functions	The student will compare, contrast and interpret corresponding graphs of a function and its first and second derivatives.

MAO2.4	3 The Graphical Behavior of Functions	The student will identify the relationship between the increasing and decreasing behavior of a function and the sign of its derivative.
MAO2.5	3 The Graphical Behavior of Functions	The student will determine the concavity and inflection points of a function by examining the second derivative of a function.
MAO2.6	3 The Graphical Behavior of Functions	The student will use the Mean Value Theorem and Rolle's Theorem to help interpret specific relationships in a function.
MAO11.1	3 The Graphical Behavior of Functions	The student will apply the concept of calculating maximum and minimums by the derivative to real-life problem solving situations.

The purpose of calculus is to mathematically explain and predict physical models. Understanding the relationship between derivatives and related rates is absolutely necessary. Geometric models are used in related rates to determine the rates of change.

Content Area: Applications of the Derivatives
Fluency 1: Related Rates • Employ derivatives to optimize • Evaluate the first and second derivatives and their applied applications

Standards	Strand	Goals and Performance Objectives
MAO5.18	4 Applications of the Derivative	The student will determine rates of change, average values, and distances when given only a table of values and not the particular equation of a function.
MAO5.15	4 Applications of the Derivative	The student will apply antidifferentiation techniques to solving specific problems when initial conditions are given, in particular those involving distance, velocity and acceleration.
MAO5.5	4 Applications of the Derivative	The student will be able to approximate the rate of change from graphs of functions and tables of values.
MAO5.11	4 Applications of the Derivative	The student will find rates of change that are relevant to time by using derivatives in related rate problem solving situations.
MAO5.12	4 Applications of the Derivative	The student will interpret the derivative as a rate of change in varied applied contexts, specifically those of velocity, speed and acceleration.

Calculus is usually taught in 3 semesters in college, with emphasis on differentiation and then on integration. In the one year dual credit course in high school, students will spend some time on basic integration skills and some related rates. The integration will be not only by algorithmic rules, general antidifferentiation, and by substitution.

Content Area: The Antiderivative

Fluency 1: General Antiderivative

- Use general algorithms to create the antiderivative
- Use substitution to find integral

Standards	Strand	Goals and Performance Objectives
MAO2.5	5 Integration 6 Techniques of Antidifferentiation	The student will apply the concept of the definite integral to finding the area bounded by a function.
MAO2.10	5 Integration 6 Techniques of Antidifferentiation	The student will apply integration to finding both the distance and displacement of a particle as it moves along a line within a specific interval.
MAO5.13	5 Integration 6 Techniques of Antidifferentiation	The student will use the Fundamental Thm of Calculus to evaluate definite integrals.
MAO5.14	5 Integration 6 Techniques of Antidifferentiation	The student will calculate indefinite integrals by using basic integration techniques and also integration by substitution.
MAO5.15	5 Integration 6 Techniques of Antidifferentiation	The student will apply antidifferentiation techniques to solving specific problems when initial conditions are given, in particular those involving distance, velocity and acceleration.
MAO9	5 Integration 6 Techniques of Antidifferentiation	The student will use integration to find volumes of solids with known cross-sections by various methods on the coordinate plane.