

1. Number and Operations Standard

1a. Understand numbers, ways of representing numbers, relationships among numbers, and number systems

Expectations	<i>Calculus: Concepts and Applications</i>
develop a deeper understanding of very large and very small numbers and of various representations of them;	Chapter 2: Properties of Limits 2.2: Graphical and Algebraic Approaches to the Definition of Limit Chapter 6: The Calculus of Exponential and Logarithmic Functions 6.8: Limits of Indeterminate Forms: l'Hospital's Rule Chapter 12: The Calculus of Functions Defined by Power Series 12.8: Error Analysis for Series
compare and contrast the properties of numbers and number systems, including the rational and real numbers, and understand complex numbers as solutions to quadratic equations that do not have real solutions;	Not typically covered in calculus.
understand vectors and matrices as systems that have some of the properties of the real-number system;	Chapter 10: The Calculus of Motion – Averages, Extremes, and Vectors 10.7: Vector Functions for Motion in a Plane
use number-theory arguments to justify relationships involving whole numbers.	Not typically covered in calculus.

1b. Understand meanings of operations and how they relate to one another

Expectations	<i>Calculus: Concepts and Applications</i>
judge the effects of such operations as multiplication, division, and computing powers and roots on the magnitude of quantities;	Chapter 6: The Calculus of Exponential and Logarithmic Functions 6.8: Limits of Indeterminate Forms: l'Hospital's
develop an understanding of properties of, and representations for, the addition and multiplication of vectors and matrices;	Chapter 10: The Calculus of Motion – Averages, Extremes, and Vectors 10.7: Vector Functions for Motion in a Plane
develop an understanding of permutations and combinations as counting techniques.	Not typically covered in calculus.

1c. Compare fluently and make reasonable estimates

Expectations	<i>Calculus: Concepts and Applications</i>
develop fluency in operations with real numbers, vectors, and matrices using mental computation or paper-and-pencil calculations for simple cases and technology for more-complicated cases;	Chapter 10: The Calculus of Motion – Averages, Extremes, and Vectors 10.7: Vector Functions for Motion in a Plane 10.8: Chapter Review and Test
judge the reasonableness of numerical computation and their results.	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.5: Limit of a Function Chapter 2: Properties of Limits 2.1: Numerical Approach to the Definition of Limit 2.2: Graphical and Algebraic Approaches to the Definition

2. Algebra Standard

2a. Understand patterns, relations, and functions

Expectations	<i>Calculus: Concepts and Applications</i>
generalize patterns using explicitly defined and recursively defined functions;	Chapter 12: The Calculus of Functions Defined by Power Series 12.2: Geometric Sequences and Series as Mathematical Models 12.3: Power Series for an Exponential Function 12.4: Power Series for Other Elementary Functions 12.5: Taylor and Maclaurin Series, and Operations on These Series
understand relations and functions and select, convert flexibly among, and use various representations of them;	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.1: The Concept of Instantaneous Rate Chapter 4: Products, Quotients, and Parametric Functions 4.8: Graphs and Derivatives of Implicit Relationships
analyze functions of one variable by investigating rates of change, intercepts, zeros, asymptotes, and local and global behavior;	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.2: Rate of Change by Equation, Graph or Table Chapter 2: Properties of Limits 2.4: Continuity Chapter 8: The Calculus of Plane and Solid Figures 8.2: Critical Points and Points of Inflection 8.10: Chapter Review and Test
understand and perform transformations such as arithmetically combining, composing, and inverting commonly used functions, using technology to perform such operations on more-complicated symbolic expressions;	Chapter 4: Products, Quotients, and Parametric Equations 4.2: Derivative of a Product of Two Functions 4.5: Derivatives of Inverse Trigonometric Functions Chapter 6: The Calculus of Exponential and Logarithmic Functions 6.7: The Natural Exponential Function: The Inverse of \ln Chapter 9: Algebraic Calculus Techniques for the Elementary Functions 9.8: Integrals of the Inverse Trigonometric Functions 9.9: Calculus of the Hyperbolic and Inverse Hyperbolic Functions
understand and compare the properties of classes of functions, including exponential, polynomial, rational, logarithmic, and periodic functions;	Chapter 6: The Calculus of Exponential and Logarithmic Functions 6.8: Limits of Indeterminate Forms: l'Hospital's Rule Chapter 9: Algebraic Calculus Techniques for the Elementary Functions 9.10: Improper Integrals
interpret representations of functions of two variables.	Chapter 4: Products, Quotients and Parametric Functions Chapter 8: The Calculus of Plane and Solid Figures 8.3: Maxima and Minima in Plane and Solid Figures 4.7: Derivative of a Parametric Function

2b. Represent and analyze mathematical situations and structures using algebraic symbols

Expectations	<i>Calculus: Concepts and Applications</i>
understand the equivalent forms of expressions, equations, inequalities, and relations;	Chapter 4: Products, Quotients and Parametric Functions 4.8: Graphs and Derivatives of Implicit Relationships
write equivalent forms of equations, inequalities, and systems of equations and solve them with fluency-mentally or with paper and pencil in simple cases and using technology in all cases;	Chapter 8: The Calculus of Plane and Solid Figures 8.3: Maxima and Minima in Plane and Solid Figures Chapter 10: The Calculus of Motion – Averages, Extremes, and Vectors 10.5: Minimal Path Problems 10.6: Maximum and Minimum Problems in Motion and Elsewhere
use symbolic algebra to represent and explain mathematical relationships;	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.1: The Concept of Instantaneous Rate Chapter 8: The Calculus of Plane and Solid Figures 8.3: Maxima and Minima in Plane and Solid Figures Chapter 10: The Calculus of Motion – Averages, Extremes, and Vectors 10.5: Minimal Path Problems 10.6: Maximum and Minimum Problems in Motion and Elsewhere
use a variety of symbolic representations, including recursive and parametric equations, for functions and relations;	Chapter 4: Products, Quotients and Parametric Functions 4.8: Graphs and Derivatives of Implicit Relationships Chapter 8: The Calculus of Plane and Solid Figures 8.9: Lengths and Areas in Polar Coordinates
judge the meaning, utility, and reasonableness of the results of symbol manipulations, including those carried out by technology.	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.5: The Limit of a Function Chapter 2: Properties of Limits 2.5: Limits Involving Infinity Chapter 12: The Calculus of Functions Defined by Power Series 12.2: Geometric Sequences and Series as Mathematical Models

2c. Use mathematical models to represent and understand quantitative relationships

Expectations	<i>Calculus: Concepts and Applications</i>
identify essential quantitative relationships in a situation and determine the class or classes of functions that might model the relationships;	Chapter 6: The Calculus of Exponential and Logarithmic Functions 6.1: Integral of the Reciprocal Function: A Population Growth Problem 6.7: The Natural Exponential Function: The Inverse of ln Chapter 7: The Calculus of Growth and Decay 7.1: Direct Proportion Property of Exponential Functions 7.2: Exponential Growth and Decay
use symbolic expressions, including iterative and recursive forms, to represent relationships arising from various contexts;	Chapter 8: The Calculus of Plane and Solid Figures 8.5: Volume of a Solid by Plane Slicing 8.6: Volume of a Solid of Revolution by Cylindrical Shells
draw reasonable conclusions about a situation being modeled.	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.1: The Concept of Instantaneous Change 1.3: One Type of Integral of a Function

2d. Analyze change in various contexts

Expectations	<i>Calculus: Concepts and Applications</i>
approximate and interpret rates of change from graphical and numerical data.	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.1: The Concept of Instantaneous Change 1.2: Rate of Change by Equation Graph or Table Chapter 3: Derivatives, Antiderivatives, And Indefinite Integrals 3.1: Graphical Interpretation of the Derivative

3. Geometry Standard

3a. Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships

Expectations	<i>Calculus: Concepts and Applications</i>
analyze properties and determine attributes of two- and three dimensional objects;	Chapter 8: The Calculus of Plane and Solid Figures 8.5: Volume of a Solid by Plane Slicing 8.6: Volume of a Solid of Revolution by Cylindrical Shells 8.8: Area of a Surface of Revolution Chapter 9: Algebraic Calculus Techniques for the Elementary Functions 9.9: Calculus of the Hyperbolic and Inverse Hyperbolic Functions
explore relationships (including congruence and similarity) among classes of two- and three dimensional geometric objects, make and test conjectures about them, and solve problems involving them;	Chapter 10: The Calculus of Motion – Averages, Extremes, and Vectors 10.4: Related Rates
establish the validity of geometric conjectures using deduction, prove theorems, and critique arguments made by others;	Not typically covered in calculus.
use trigonometric relationships to determine lengths and angle measures.	Chapter 3: Derivatives, Antiderivatives, and Indefinite Integrals 3.8: Proof and Application of Sine and Cosine Derivatives Chapter 10: The Calculus of Motion: Averages, Extremes, and Vectors 10.5: Minimal Path Problems

3b. Specify locations and describe spatial relationships using coordinate geometry and other representational systems;

Expectations	<i>Calculus: Concepts and Applications</i>
<p>use Cartesian coordinates and other coordinate systems, such as navigational, polar, or spherical systems, to analyze geometric situations;</p>	<p>Chapter 8: The Calculus of Plane and Solid Figures 8.3: Maxima and Minima in Plane and Solid Figures 8.9: Lengths and Areas for Polar Coordinates Chapter 10: The Calculus of Motion: Averages, Extremes, and Vectors 10.4: Related Rates 10.5: Minimal Path Problems</p>
<p>investigate conjectures and solve problems involving two- and three-dimensional objects represented with Cartesian coordinates.</p>	<p>Chapter 8: The Calculus of Plane and Solid Figures 8.3: Maxima and Minima in Plane and Solid Figures</p>

3c. Apply transformations and use symmetry to analyze mathematical situations

Expectations	<i>Calculus: Concepts and Applications</i>
understand and represent translations, reflections, rotations, and dilations of objects in the plane by using sketches, coordinates, vectors, function notation, and matrices;	Chapter 10: The Calculus of Motion: Averages, Extremes, and Vectors 10.7: Vector Functions for Motion in a Plane 10.8: Chapter Review and Test
use various representations to help understand the effects of simple transformations and their compositions.	Not typically covered in calculus.

3d. Use visualization, spatial reasoning, and geometric modeling to solve problems

Expectations	<i>Calculus: Concepts and Applications</i>
draw and construct representations of two- and three-dimensional geometric objects using a variety of tools;	Chapter 8: The Calculus of Plane and Solid Figures 8.5: Volume of a Solid by Plane Slicing 8.6: Volume of a Solid of Revolution by Cylindrical Shells 8.8: Area of a Surface of Revolution
visualize three-dimensional objects from different perspectives and analyze their cross sections;	Chapter 8: The Calculus of Plane and Solid Figures 8.5: Volume of a Solid by Plane Slicing 8.8: Area of a Surface of Revolution 8.10: Chapter Review and Test
use vertex-edge graphs to model and solve problems;	Not typically covered in calculus.
use geometric models to gain insight into, and answer questions in, other area of mathematics;	Chapter 8: The Calculus of Plane and Solid Figures 8.3: Maxima and Minima in Plane and Solid Figures
use geometric ideas to solve problems in, and gain insights into, other disciplines and other areas of interest such as art and architecture.	Not typically covered in calculus.

4. Measurement Standard

4a. Understand measurable attributes of objects and the units, systems, and processes of measurement

Expectations	<i>Calculus: Concepts and Applications</i>
make decisions about units and scales that are appropriate for problem situations involving measurement.	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.1: The Concept of Instantaneous Rate 1.3: One Type of Integral of a Function

4b. Apply appropriate techniques, tools, and formulas to determine measurements

Expectations	<i>Calculus: Concepts and Applications</i>
analyze precision, accuracy, and approximate error in measurement situations;	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.4: Definite Integrals by Trapezoids, from Equations and Data Chapter 5: Definite and Indefinite Integrals 5.11: Numerical Integration by Simpson's Rule and a Grapher Chapter 12: The Calculus of Functions Defined by Power Series 12.7: Convergence of Series at the Ends of the Convergence Interval 12.8: Error Analysis for Series
understand and use formulas for the area, surface area, and volume of geometric figures, including cones, spheres, and cylinders;	Chapter 8: The Calculus of Plane and Solid Figures 8.5: Volume of a Solid by Plane Slicing 8.6: Volume of a Solid of Revolution by Cylindrical Shells 8.8: Area of a Surface of Revolution Chapter 10: The Calculus of Motion: Averages, Extremes, and Vectors 10.4: Related Rates
apply informal concepts of successive approximation, upper and lower bounds, and limit in measurement situations;	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.5: Limit of a Function Chapter 2: Properties of Limits 2.1: Numerical Approach to the Definition of Limit 2.2: Graphical and Algebraic Approaches to the Definition of Limit 2.3: The Limit Theorems Chapter 5: Definite and Indefinite Integrals 5.5: Riemann Sums and the Definition of Definite Integral
use unit analysis to check measurement computations.	Chapter 10: The Calculus of Motion: Averages, Extremes, and Vectors 10.4: Related Rates

5. Data Analysis and Probability Standard

5a. Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them

Expectations	<i>Calculus: Concepts and Applications</i>
understand the differences among various kinds of studies and which types of inferences can legitimately be drawn from each;	Not typically covered in calculus.
know the characteristics of well-designed studies, including the role of randomization in surveys and experiments;	Not typically covered in calculus.
understand the meaning of measurement data and categorical data, of univariate and bivariate data, and of the term variable;	Not typically covered in calculus.
understand histograms, parallel box plots, and scatterplots and use them to display data;	Not typically covered in calculus.
compute basic statistics and understand the distinction between a statistic and a parameter.	Not typically covered in calculus.

5b. Select and use appropriate statistical methods to analyze data

Expectations	<i>Calculus: Concepts and Applications</i>
for univariate measurement data, be able to display the distribution, describe its shape, and select and calculate summary statistics;	Not typically covered in calculus.
for bivariate measurement data, be able to display scatterplot, describe the shape, and determine regression coefficients, regression equations, and correlation coefficients using technological tools;	Not typically covered in calculus.
display and discuss bivariate data where at least one variable is categorical;	Not typically covered in calculus.
recognize how linear transformations of univariate data affect shape, center, and spread;	Not typically covered in calculus.
identify trends in bivariate data and find functions that model the data or transform the data so that they can be modeled.	Not typically covered in calculus.

5c. Develop and evaluate inferences and predictions that are based on data

Expectations	<i>Calculus: Concepts and Applications</i>
use simulations to explore the variability of sample statistics from a known population and to construct sampling distributions;	Not typically covered in calculus.
understand how sample statistics reflect the values of population parameters and use sampling distributions as the basis for informal inferences;	Not typically covered in calculus.
evaluate published reports that are based on data by examining the design of the study, the appropriateness of the data analysis, and the validity of conclusions;	Not typically covered in calculus.
understand how basic statistical techniques are used to monitor process characteristics in the workplace.	Not typically covered in calculus.

5d. Understand and apply basic concepts of probability

Expectations	<i>Calculus: Concepts and Applications</i>
understand the concepts of sample spaces and distributions in simple cases;	Not typically covered in calculus.
use simulations to construct empirical probability distributions;	Not typically covered in calculus.
compute and interpret the expected value of random variables in simple cases;	Not typically covered in calculus.
understand the concepts of conditional probability and independent events;	Not typically covered in calculus.
understand how to compute the probability of a compound event.	Not typically covered in calculus.

6. Problem Solving Standard

Expectations	<i>Calculus: Concepts and Applications</i>
Build new mathematical knowledge through problem solving	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.1: The Concept of Instantaneous Rate Chapter 5: Definite and Indefinite Integrals 5.1: A Definite Integral Problem Chapter 6: The Calculus of Exponential and Logarithmic Functions 6.1: Integral of the Reciprocal Function: A Population Growth Problem Chapter 10: The Calculus of Motion: Averages, Extremes, and Vectors 10.1: Introduction to Distance and Displacement for Motion along a Line
Solve problems that arise in mathematical and in other contexts	Chapter 7: The Calculus of Growth and Decay 7.3: Other Differential Equations for real-World Applications 7.7: Chapter Review Chapter 10: The Calculus of Motion-Averages, Extremes, and Vectors Chapter 11: The Calculus of Variable-Factor Products 11.3: Mass of a Variable-Density Object 11.4: Moment, Centroids, Centers of Mass, and the Theorem of Pappas
Apply and adapt a variety of appropriate strategies to solve problems	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.1: The Concept of Instantaneous Rate 1.3: One Type of Integral of A Function Chapter 7: The Calculus of Growth and Decay 7.4: Graphical Solution of Differential Equations Using Slope Fields Chapter 8: The Calculus of Plane and Solid Figures 8.10: Chapter Review and Test
Monitor and reflect on the process of mathematical problem solving	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.1: The Concept of Instantaneous Rate Chapter 5: Definite and Indefinite Integrals 5.1: A Definite Integral Problem Chapter 7: The Calculus of Growth and Decay 7.1: Direct Proportion Property of Exponential Functions 7.2: Exponential Growth and Decay 7.6: Predator-Prey Population Problems

7. Reasoning and Proof Standard

Expectations	<i>Calculus: Concepts and Applications</i>
Recognize reasoning and proof as fundamental aspects of mathematics	Chapter 5: Definite and Indefinite Integrals 5.6: The Mean-Value Theorem and Rolle’s Theorem 5.7: Some Very Special Riemann Sums 5.8: The Fundamental Theorem of Calculus
Develop and evaluate mathematical arguments and proofs	Chapter 3: Derivatives, Antiderivatives, and Indefinite Integrals 3.8: Proof and Application of Sine and Cosine Derivatives Chapter 5: Definite and Indefinite Integrals 5.6: The Mean-Value Theorem and Rolle’s Theorem 5.8: The Fundamental Theorem of Calculus
Select and use various types of reasoning and methods of proof	Chapter 3: Derivatives, Antiderivatives, and Indefinite Integrals 3.8: Proof and Application of Sine and Cosine Derivatives Chapter 5: Definite and Indefinite Integrals 5.6: The Mean-Value Theorem and Rolle’s Theorem 5.8: The Fundamental Theorem of Calculus

8. Communication Standard

Expectations	<i>Calculus: Concepts and Applications</i>
Organize and consolidate their mathematical thinking through communication	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.6: Calculus Journal 1.7: Chapter Review and Test
Communicate their mathematical thinking coherently and clearly to peers, teachers, and others	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.6: Calculus Journal
Analyze and evaluate the mathematical thinking and strategies of others	Not typically covered in calculus.
Use the language of mathematics to express mathematical ideas precisely	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.6: Calculus Journal Chapter 7: The Calculus of Growth and Decay 7.5: Numerical Solution of Differential Equations Using Euler's Method

9. Connections Standard

Expectations	<i>Calculus: Concepts and Applications</i>
Recognize and use connections among mathematical ideas	Chapter 5: Definite and Indefinite Integrals 5.6: The Mean-Value Theorem and Rolle’s Theorem 5.7: Some Very Special Riemann Sums 5.8: The Fundamental Theorem of Calculus
Understand how mathematical ideas interconnect and build on one another to produce a coherent whole	Chapter 5: Definite and Indefinite Integrals 5.6: The Mean-Value Theorem and Rolle’s Theorem 5.7: Some Very Special Riemann Sums 5.8: The Fundamental Theorem of Calculus
Recognize and apply mathematics in contexts outside of mathematics	Chapter 9: Algebraic Calculus Techniques for the Elementary Functions 9.7: Integration of Rational Functions by Partial Fractions Chapter 12: The Calculus of Functions Defined by Power Series 12.2: Geometric Sequences and Series as Mathematical Models Chapter 7: The Calculus of Growth and Decay 7.6: Predator-Prey Problems 7.7: Chapter Review and Test

10. Representations Standard

Expectations	<i>Calculus: Concepts and Applications</i>
Create and use representations to organize, record, and communicate mathematical ideas	Chapter 2: Properties of Limits 2.7: Chapter Review and Test
Select, apply, and translate among mathematical representations to solve problems	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.1: The Concept of Instantaneous Rate 1.2: Rate of Change by Equation, Graph, or Table 1.3: One Type of Integral of a Function 1.4: Definite Integrals by Trapezoids, from Equations and Data
Use representations to model and interpret physical, social, and mathematical phenomena	Chapter 1: Limits, Derivatives, Integrals, and Integrals 1.1: The Concept of Instantaneous Rate 1.2: Rate of Change by Equation, Graph, or Table 1.3: One Type of Integral of a Function 1.4: Definite Integrals by Trapezoids, from Equations and Data