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Calculus,

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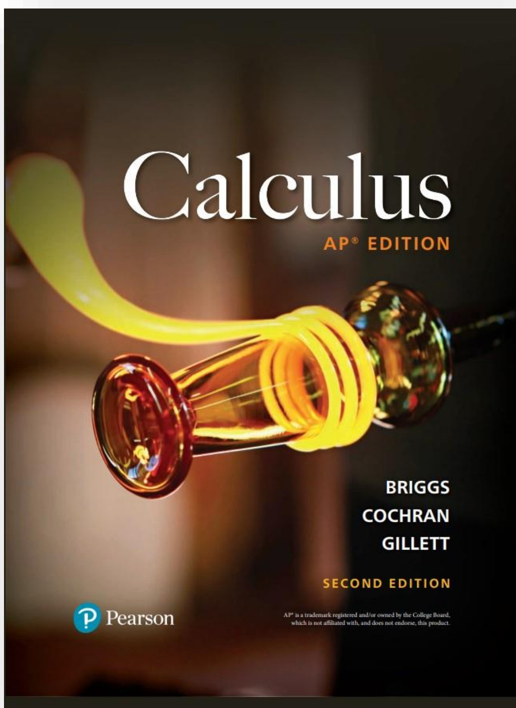

to the

AP® Calculus AB – AP® Students | College Board

Correlation Guide for Calculus, 2nd Edition, AP® Edition © 2018

Unit 1: Limits and Continuity

Topic	**ENDURING UNDERSTANDING**	**LEARNING OBJECTIVE**	**ESSENTIAL KNOWLEDGE**	***Calculus* AP Edition 2e**
TOPIC 1.1 Introducing Calculus: Can Change Occur at an Instant?	CHA-1: Calculus allows us to generalize knowledge about motion to diverse problems involving change.	CHA-1.A: Interpret the rate of change at an instant in terms of average rates of change over intervals containing that instant.	CHA-1.A.1: Calculus uses limits to understand and model dynamic change.	Sect. 2.1 Sect. 2.2 Sect. 2.3 Sect. 2.4 Sect. 2.6
			CHA-1.A.2: Because an average rate of change divides the change in one variable by the change in another, the average rate of change is undefined at a point where the change in the independent variable would be zero.	Sect. 2.1 Sect. 2.2 Sect. 2.3 Sect. 2.4 Sect. 2.6
			CHA-1.A.3: The limit concept allows us to define instantaneous rate of change in terms of average rates of change.	Sect. 2.1 Sect. 2.2 Sect. 2.3 Sect. 2.4 Sect. 2.6 Sect. 2.7
TOPIC 1.2 Defining Limits and Using Limit Notation	LIM-1: Reasoning with definitions, theorems, and properties can be used to justify claims about limits.	LIM-1.A: Represent limits analytically using correct notation. LIM-1.B: Interpret limits expressed in analytic notation.	LIM-1.A.1 Given a function f, the limit of f (x) as x approaches c is a real number R if f (x) can be made arbitrarily close to R by taking x sufficiently close to c (but not equal to c). If the limit exists and is a real number, then the common notation is f x R lim x c ( )= → .	Sect. 2.1 Sect. 2.2

			LIM-1.B.1 A limit can be expressed in multiple ways, including graphically, numerically, and analytically.	Sect. 2.1 Sect. 2.2
TOPIC 1.3 Estimating Limit Values from Graphs	LIM-1 Reasoning with definitions, theorems, and properties can be used to justify claims about limits.	LIM-1.C Estimate limits of functions.	LIM-1.C.1 The concept of a limit includes one sided limits.	Sect. 2.3
			LIM-1.C.2 Graphical information about a function can be used to estimate limits.	Sect. 2.3
			LIM-1.C.3 Because of issues of scale, graphical representations of functions may miss important function behavior.	Sect. 2.3
			LIM-1.C.4 A limit might not exist for some functions at particular values of x. Some ways that the limit might not exist are if the function is unbounded, if the function is oscillating near this value, or if the limit from the left does not equal the limit from the right.	Sect. 2.3
TOPIC 1.4 Estimating Limit Values from Tables	LIM-1: Reasoning with definitions, theorems, and properties can be used to justify claims about limits.	LIM-1.C Estimate limits of functions.	LIM-1.C.5 Numerical information can be used to estimate limits.	Sect. 2.3
TOPIC 1.5 Determining Limits Using Algebraic	LIM-1: Reasoning with definitions, theorems, and	LIM-1.D Determine the limits of functions using	LIM-1.D.1 One-sided limits can be determined analytically	Sect. 2.3

Properties of Limits	properties can be used to justify claims about limits.	limit theorems.	or graphically.	
			LIM.1.D.2 Limits of sums, differences, products, quotients, and composite functions can be found using limit theorems.	Sect. 2.3
TOPIC 1.6 Determining Limits Using Algebraic Manipulation	LIM-1: Reasoning with definitions, theorems, and properties can be used to justify claims about limits.	LIM-1.E Determine the limits of functions using equivalent expressions for the function or squeeze theorem.	LIM-1.E.1 It may be necessary or helpful to rearrange expressions into equivalent forms before evaluating limits.	Sect. 2.3
TOPIC 1.7 Selecting Procedures for Determining Limits				Sect. 2.3
TOPIC 1.8 Determining Limits Using the Squeeze Theorem	LIM-1 Reasoning with definitions, theorems, and properties can be used to justify claims about limits.	LIM-1.E Determine the limits of functions using equivalent expressions for the function or squeeze theorem.	LIM-1.E.2 The limit of a function may be found by using the squeeze theorem.	Sect. 2.3
TOPIC 1.9 Connecting Multiple Representations of Limits				Sect. 2.3
TOPIC 1.10 Exploring Types of Discontinuities	LIM-2 Reasoning with definitions, theorems, and properties can be used to justify claims about continuity.	LIM-2.A Justify conclusions about continuity at a point using the definition	LIM-2.A.1 Types of discontinuities include removable discontinuities, jump discontinuities, and discontinuities due to vertical asymptotes.	Sect. 2.6

TOPIC 1.11 Defining Continuity at a Point	LIM-2 Reasoning with definitions, theorems, and properties can be used to justify claims about continuity.	LIM-2.A Justify conclusions about continuity at a point using the definition	LIM-2.A.2 A function f is continuous at x = c provided that f(c) exists, lim f x ( ) exists, and lim → f (x)= f (c).	Sect. 2.6
TOPIC 1.12 Confirming Continuity over an Interval	LIM-2 Reasoning with definitions, theorems, and properties can be used to justify claims about continuity.	LIM-2.B Determine intervals over which a function is continuous.	LIM-2.B.1 A function is continuous on an interval if the function is continuous at each point in the interval.	Sect. 2.6
			LIM-2.B.2 Polynomial, rational, power, exponential, logarithmic, and trigonometric functions are continuous on all points in their domains.	Sect. 2.6
TOPIC 1.13 Removing Discontinuities	LIM-2 Reasoning with definitions, theorems, and properties can be used to justify claims about continuity.	LIM-2.C Determine values of x or solve for parameters that make discontinuous functions continuous, if possible.	LIM-2.C.1 If the limit of a function exists at a discontinuity in its graph, then it is possible to remove the discontinuity by defining or redefining the value of the function at that point, so it equals the value of the limit of the function as x approaches that point.	Sect. 2.6
			LIM-2.C.2 In order for a piecewise-defined function to be continuous at a boundary to the partition of its domain, the value of the expression defining the function on one side of the boundary must equal the value of	Sect. 2.6

			the expression defining the other side of the boundary, as well as the value of the function at the boundary.	
TOPIC 1.14 Connecting Infinite Limits and Vertical Asymptotes	LIM-2 Reasoning with definitions, theorems, and properties can be used to justify claims about continuity.	LIM-2.D Interpret the behavior of functions using limits involving infinity.	LIM-2.D.1 The concept of a limit can be extended to include infinite limits.	Sect. 2.4
			LIM-2.D.2 Asymptotic and unbounded behavior of functions can be described and explained using limits.	Sect. 2.4
TOPIC 1.15 Connecting Limits at Infinity and Horizontal Asymptotes	LIM-2 Reasoning with definitions, theorems, and properties can be used to justify claims about continuity.	LIM-2.D Interpret the behavior of functions using limits involving infinity.	LIM-2.D.3 The concept of a limit can be extended to include limits at infinity	Sect. 2.5
			LIM-2.D.4 Limits at infinity describe end behavior.	Sect. 2.5
			LIM-2.D.5 Relative magnitudes of functions and their rates of change can be compared using limits.	Sect. 2.5
TOPIC 1.16 Working with the Intermediate Value Theorem (IVT)	FUN-1 Existence theorems allow us to draw conclusions about a function's behavior on an interval without precisely locating that behavior.	FUN-1.A Explain the behavior of a function on an interval using the Intermediate Value Theorem.	FUN-1.A .1 If f is a continuous function on the closed interval [a, b] and d is a number between f (a) and f (b), then the Intermediate Value Theorem guarantees that there is at least one number c between a and b, such that f(c) = d.	Sect. 2.6
Unit 2: Differentiation: Definition and Fundamental Properties				
TOPIC 2.1 Defining Average and Instantaneous Rates of Change at a Point	CHA-2 Derivatives allow us to determine rates of change at an instant by applying limits to	CHA-2.A Determine average rates of change using difference quotients.	CHA-2.A.1 The difference quotients f (a+h)-f(a)/h and f (x)-f(a)/x-a express the average rate of change of a function	Sect. 3.1

	knowledge about rates of change over intervals.		over an interval.	
		CHA-2.B Represent the derivative of a function as the limit of a difference quotient.	The instantaneous rate of change of a function at x = a can be expressed by + − lim → f (a + h)-f(a)/h or lim → f (x) – f (a)/x-a provided the limit exists. These are equivalent forms of the definition of the derivative and are denoted f′(a).	Sect. 3.1
TOPIC 2.2 Defining the Derivative of a Function and Using Derivative Notation	CHA-2 Derivatives allow us to determine rates of change at an instant by applying limits to knowledge about rates of change over intervals.	CHA-2.B Represent the derivative of a function as the limit of a difference quotient.	The derivative of f is the function whose value at x is + − lim f(x+h)-f(x)/h, provided this limit exists.	Sect. 3.1 Sect. 3.2
		CHA-2.C Determine the equation of a line tangent to a curve at a given point.	CHA-2.B.3 For y = f(x), notations for the derivative include dy/dx, f′(x), and y′.	Sect. 3.1 Sect. 3.2
			CHA-2.B.4 The derivative can be represented graphically, numerically, analytically, and verbally.	Sect. 3.1 Sect. 3.2
			CHA-2.C.1 The derivative of a function at a point is the slope of the line tangent to a graph of the function at that point	Sect. 3.1 Sect. 3.2
TOPIC 2.3 Estimating Derivatives of a Function at a Point	CHA-2 Derivatives allow us to determine rates of change at an instant by applying limits to knowledge about rates of change over intervals.	CHA-2.D Estimate derivatives.	CHA-2.D.1 The derivative at a point can be estimated from information given in tables or graphs.	Sect. 3.2
			CHA-2.D.2 Technology can be used to calculate or estimate the value of a derivative of a function	Sect. 3.2

			at a point.	
TOPIC 2.4 Connecting Differentiability and Continuity: Determining When Derivatives Do and Do Not Exist	FUN-2 Recognizing that a function's derivative may also be a function allows us to develop knowledge about the related behaviors of both.	FUN-2.A Explain the relationship between differentiability and continuity.	FUN-2.A.1 If a function is differentiable at a point, then it is continuous at that point. In particular, if a point is not in the domain of f, then it is not in the domain of f '.	Sect. 3.1 Sect. 3.2
			FUN-2.A.2 A continuous function may fail to be differentiable at a point in its domain.	Sect. 3.1 Sect. 3.2
TOPIC 2.5 Applying the Power Rule	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.A Calculate derivatives of familiar functions.	FUN-3.A.1 Direct application of the definition of the derivative and specific rules can be used to calculate the derivative for functions of the form f (x)=x^r	Sect. 3.3
TOPIC 2.6 Derivative Rules: Constant, Sum, Difference, and Constant Multiple	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.A Calculate derivatives of familiar functions.	FUN-3.A.2 Sums, differences, and constant multiples of functions can be differentiated using derivative rules.	Sect. 3.3
			FUN-3.A.3 The power rule combined with sum, difference, and constant multiple properties can be used to find the derivatives for polynomial functions.	Sect. 3.3
TOPIC 2.7 Derivatives of cos x, sin x, ex, and ln x	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.A Calculate derivatives of familiar functions.	FUN-3.A.4 Specific rules can be used to find the derivatives for sine, cosine, exponential, and logarithmic functions.	Sect. 3.5 Sect. 3.9
	LIM-3 Reasoning with definitions, theorems, and properties can be used to determine a limit.	LIM-3.A Interpret a limit as a definition of a derivative.	LIM-3.A.1 In some cases, recognizing an expression for the definition of the derivative of a function whose derivative is known offers a strategy	Sect. 3.5 Sect. 3.9

			for determining a limit.	
TOPIC 2.8 The Product Rule	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.B Calculate derivatives of products and quotients of differentiable functions.	FUN-3.B.1 Derivatives of products of differentiable functions can be found using the product rule.	Sect. 3.4
TOPIC 2.9 The Quotient Rule	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.B Calculate derivatives of products and quotients of differentiable functions.	FUN-3.B.2 Derivatives of quotients of differentiable functions can be found using the quotient rule.	Sect. 3.4
TOPIC 2.10 Finding the Derivatives of Tangent, Cotangent, Secant, and/or Cosecant Functions	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.B Calculate derivatives of products and quotients of differentiable functions.	FUN-3.B.3 Rearranging tangent, cotangent, secant, and cosecant functions using identities allows differentiation using derivative rules.	Sect. 3.5
Unit 3: Differentiation: Composite, Implicit, and Inverse Functions				
TOPIC 3.1 The Chain Rule	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.C Calculate derivatives of compositions of differentiable functions.	FUN-3.C.1 The chain rule provides a way to differentiate composite functions.	Sect. 3.7 Sect. 3.8
TOPIC 3.2 Implicit Differentiation	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.D Calculate derivatives of implicit implicitly defined functions.	FUN-3.D.1 The chain rule is the basis for implicit differentiation.	Sect. 3.8
TOPIC 3.3 Differentiating Inverse Functions	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.E Calculate derivatives of inverse and inverse trigonometric functions.	FUN-3.E.1 The chain rule and definition of an inverse function can be used to find the derivative of an inverse function, provided the derivative exists.	Sect. 3.10
TOPIC 3.4 Differentiating Inverse Trigonometric Functions	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.E Calculate derivatives of inverse and inverse trigonometric functions.	FUN-3.E.2 The chain rule applied with the definition of an inverse function, or the formula for the derivative of an inverse function, can be used to find the derivatives of inverse	Sect. 3.8

			trigonometric functions.	
TOPIC 3.5 Selecting Procedures for Calculating Derivatives				Sect. 3.2 Sect. 3.3 Sect. 3.4
TOPIC 3.6 Calculating Higher-Order Derivatives	FUN-3 Recognizing opportunities to apply derivative rules can simplify differentiation.	FUN-3.F Determine higher order derivatives of a function.	FUN-3.F.1 Differentiating f ′ produces the second derivative f ″, provided the derivative of f ′ exists; repeating this process produces higher order derivatives of f.	Sect. 3.6
			FUN-3.F.2 n Higher-order derivatives are represented with a variety of notations. For y = f (x), notations for the second derivative include d2y/dx2, f ″(x), and y ″. Higher-order derivatives can be denoted dy/dx or f^(n)(x)	Sect. 3.6
Unit 4: Contextual Applications of Differentiation				
TOPIC 4.1 Interpreting the Meaning of the Derivative in Context	CHA-3 Derivatives allow us to solve real-world problems involving rates of change.	CHA-3.A Interpret the meaning of a derivative in context.	CHA-3.A.1 The derivative of a function can be interpreted as the instantaneous rate of change with respect to its independent variable.	Sect. 3.6
			CHA-3.A.2 The derivative can be used to express information about rates of change in applied contexts.	Sect. 3.6
			CHA-3.A.3 The unit for f'(x) is the unit for f divided by the unit for x.	Sect. 3.6
TOPIC 4.2 Straight-Line Motion: Connecting Position, Velocity, and Acceleration	CHA-3 Derivatives allow us to solve real-world problems involving rates of change.	CHA-3.B Calculate rates of change in applied contexts.	CHA-3.B.1 The derivative can be used to solve rectilinear motion problems involving position, speed, velocity, and acceleration.	Sect. 3.6
TOPIC 4.3 Rates of Change in	CHA-3 Derivatives allow us to solve	CHA-3.C Interpret rates of change in	CHA-3.C.1 The derivative can be used to solve	Sect. 3.6

Applied Contexts Other Than Motion	real-world problems involving rates of change.	applied contexts.	problems involving rates of change in applied contexts.	
TOPIC 4.4 Introduction to Related Rates	CHA-3 Derivatives allow us to solve real-world problems involving rates of change.	CHA-3.D Calculate related rates in applied contexts.	CHA-3.D.1 The chain rule is the basis for differentiating variables in a related rates problem with respect to the same independent variable.	Sect. 3.11
			CHA-3.D.2 Other differentiation rules, such as the product rule and the quotient rule, may also be necessary to differentiate all variables with respect to the same independent variable.	Sect. 3.11
TOPIC 4.5 Solving Related Rates Problems	CHA-3 Derivatives allow us to solve real-world problems involving rates of change.	CHA-3.E Interpret related rates in applied contexts.	CHA-3.E.1 The derivative can be used to solve related rates problems; that is, finding a rate at which one quantity is changing by relating it to other quantities whose rates of change are known.	Sect. 3.11
TOPIC 4.6 Approximating Values of a Function Using Local Linearity and Linearization	CHA-3 Derivatives allow us to solve real-world problems involving rates of change	CHA-3.F Approximate a value on a curve using the equation of a tangent line.	CHA-3.F.1 The tangent line is the graph of a locally linear approximation of the function near the point of tangency.	Sect. 4.5
			CHA-3.F.2 For a tangent line approximation, the function's behavior near the point of tangency may determine whether a tangent line value is an underestimate or an overestimate of the corresponding function value.	Sect. 4.5
TOPIC 4.7 Using L'Hospital's Rule for Determining Limits of Indeterminate Forms	LIM-4 L'Hospital's Rule allows us to determine the limits of some indeterminate forms.	LIM-4.A Determine limits of functions that result in indeterminate forms.	LIM-4.A.1 When the ratio of two functions tends to $0/0$ or ∞/∞ in the limit, such forms are said to be indeterminate.	Sect. 4.7

			LIM-4.A.2 Limits of the indeterminate forms 0 0 or ∞/∞ may be evaluated using L'Hospital's Rule.	Sect. 4.7
Unit 5: Analytical Applications of Differentiation				
TOPIC 5.1 Using the Mean Value Theorem	FUN-1 Existence theorems allow us to draw conclusions about a function's behavior on an interval without precisely locating that behavior.	FUN-1.B Justify conclusions about functions by applying the Mean Value Theorem over an interval.	FUN-1.B.1 If a function f is continuous over the interval [a, b] and differentiable over the interval (a, b), then the Mean Value Theorem guarantees a point within that open interval where the instantaneous rate of change equals the average rate of change over the interval.	Sect. 4.6
TOPIC 5.2 Extreme Value Theorem, Global Versus Local Extrema, and Critical Points	FUN-1 Existence theorems allow us to draw conclusions about a function's behavior on an interval without precisely locating that behavior.	FUN-1.C Justify conclusions about functions by applying the Extreme Value Theorem.	FUN-1.C.1 If a function f is continuous over the interval (a, b), then the Extreme Value Theorem guarantees that f has at least one minimum value and at least one maximum value on [a, b].	Sect. 4.1
			FUN-1.C.2 A point on a function where the first derivative equals zero or fails to exist is a critical point of the function.	Sect. 4.1
			FUN-1.C.3 All local (relative) extrema occur at critical points of a function, though not all critical points are local extrema.	Sect. 4.1
TOPIC 5.3 Determining Intervals on Which a Function Is Increasing or Decreasing	FUN-4 A function's derivative can be used to understand some behaviors of the function.	FUN-4.A Justify conclusions about the behavior of a function based on the behavior of its derivatives.	FUN-4.A.1 The first derivative of a function can provide information about the function and its graph, including intervals where the function is increasing or	Sect. 4.2

			decreasing.	
TOPIC 5.4 Using the First Derivative Test to Determine Relative (Local) Extrema	FUN-4 A function's derivative can be used to understand some behaviors of the function.	FUN-4.A Justify conclusions about the behavior of a function based on the behavior of its derivatives.	FUN-4.A.2 The first derivative of a function can determine the location of relative (local) extrema of the function.	Sect. 4.2
TOPIC 5.5 Using the Candidates Test to Determine Absolute (Global) Extrema	FUN-4 A function's derivative can be used to understand some behaviors of the function.	FUN-4.A Justify conclusions about the behavior of a function based on the behavior of its derivatives	FUN-4.A.3 Absolute (global) extrema of a function on a closed interval can only occur at critical points or at endpoints.	Sect. 4.1
TOPIC 5.6 Determining Concavity of Functions over Their Domains	FUN-4 A function's derivative can be used to understand some behaviors of the function.	FUN-4.A Justify conclusions about the behavior of a function based on the behavior of its derivatives.	FUN-4.A.4 The graph of a function is concave up (down) on an open interval if the function's derivative is increasing (decreasing) on that interval.	Sect. 4.2
			FUN-4.A.5 The second derivative of a function provides information about the function and its graph, including intervals of upward or downward concavity.	Sect. 4.2
			FUN-4.A.6 The second derivative of a function may be used to locate points of inflection for the graph of the original function.	Sect. 4.2
TOPIC 5.7 Using the Second Derivative Test to Determine Extrema	FUN-4 A function's derivative can be used to understand some behaviors of the function.	FUN-4.A Justify conclusions about the behavior of a function based on the behavior of its derivatives.	FUN-4.A.7 The second derivative of a function may determine whether a critical point is the location of a relative (local) maximum or minimum.	Sect. 4.2
			FUN-4.A.8 When a continuous function has only one critical point on an interval on its domain and the critical point corresponds to a relative	Sect. 4.2

			(local) extremum of the function on the interval, then that critical point also corresponds to the absolute (global) extremum of the function on the interval.	
TOPIC 5.8 Sketching Graphs of Functions and Their Derivatives	FUN-4 A function's derivative can be used to understand some behaviors of the function.	FUN-4.A Justify conclusions about the behavior of a function based on the behavior of its derivatives.	FUN-4.A.9 Key features of functions and their derivatives can be identified and related to their graphical, numerical, and analytical representations.	Sect. 4.3
			FUN-4.A.10 Graphical, numerical, and analytical information from f' and f" can be used to predict and explain the behavior of f.	Sect. 4.3:
TOPIC 5.9 Connecting a Function, Its First Derivative, and Its Second Derivative	FUN-4 A function's derivative can be used to understand some behaviors of the function.	FUN-4.A Justify conclusions about the behavior of a function based on the behavior of its derivatives.	FUN-4.A.11 Key features of the graphs of f, f', and f" are related to one another	Sect. 4.3:
TOPIC 5.10 Introduction to Optimization Problems	FUN-4 A function's derivative can be used to understand some behaviors of the function.	Calculate minimum and maximum values in applied contexts or analysis of functions.	FUN-4.B.1 The derivative can be used to solve optimization problems; that is, finding a minimum or maximum value of a function on a given interval.	Sect. 4.4
TOPIC 5.11 Solving Optimization Problems	FUN-4 A function's derivative can be used to understand some behaviors of the function.	FUN-4.C Interpret minimum and maximum values calculated in applied contexts.	FUN-4.C.1 Minimum and maximum values of a function take on specific meanings in applied contexts.	Sect. 4.4
TOPIC 5.12 Exploring Behaviors of Implicit Relations	FUN-4 A function's derivative can be used to understand some behaviors of the function.	FUN-4.D Determine critical points of implicit relations.	FUN-4.D.1 A point on an implicit relation where the first derivative equals zero or does not exist is a critical point of the function.	Sect. 4.2
		FUN-4.E Justify conclusions about the behavior of an	FUN-4.E.1 Applications of derivatives can be extended to implicitly	Sect. 4.2

		implicitly defined function based on evidence from its derivatives.	defined functions.	
			FUN-4.E.2 Second derivatives involving implicit differentiation may be relations of x, y, and dy/dx.	Sect. 4.2
Unit 6: Integration and Accumulation of Change				
TOPIC 6.1 Exploring Accumulations of Change	CHA-4 Definite integrals allow us to solve problems involving the accumulation of change over an interval.	CHA-4.A Interpret the meaning of areas associated with the graph of a rate of change in context.	CHA-4.A.1 The area of the region between the graph of a rate of change function and the x axis gives the accumulation of change.	Sect. 5.1 Sect. 6.1
			CHA-4.A.2 In some cases, accumulation of change can be evaluated by using geometry.	Sect. 5.1 Sect. 6.1
			CHA-4.A.3 positive (negative). If a rate of change is positive (negative) over an interval, then the accumulated change is	Sect. 5.1 Sect. 6.1
			CHA-4.A.4 The unit for the area of a region defined by rate of change is the unit for the rate of change multiplied by the unit for the independent variable.	Sect. 5.1 Sect. 6.1
TOPIC 6.2 Approximating Areas with Riemann Sums	LIM-5 Definite integrals can be approximated using geometric and numerical methods.	LIM-5.A Approximate a definite integral using geometric and numerical methods	LIM-5.A.1 Definite integrals can be approximated for functions that are represented graphically, numerically, analytically, and verbally.	Sect. 5.2
			LIM-5.A.2 Definite integrals can be approximated using a left Riemann sum, a right Riemann sum, a midpoint Riemann sum,	Sect. 5.2

			or a trapezoidal sum; approximations can be computed using either uniform or nonuniform partitions.	
			LIM-5.A.3 Definite integrals can be approximated using numerical methods, with or without technology	Sect. 5.2
			LIM-5.A.4 Depending on the behavior of a function, it may be possible to determine whether an approximation for a definite integral is an underestimate or overestimate for the value of the definite integral.	Sect. 5.2
TOPIC 6.3 Riemann Sums, Summation Notation, and Definite Integral Notation	LIM-5 Definite integrals can be approximated using geometric and numerical methods.	LIM-5.B Interpret the limiting case of the Riemann sum as a definite integral.	LIM-5.B.1 The limit of an approximating Riemann sum can be interpreted as a definite integral.	Sect. 5.2 Sect. 5.3
		LIM-5.C Represent the limiting case of the Riemann sum as a definite integral.	LIM-5.B.2 A Riemann sum, which requires a partition of an interval I, is the sum of products, each of which is the value of the function at a point in a subinterval multiplied by the length of that subinterval of the partition.	Sect. 5.2 Sect. 5.3
			LIM-5.C.1 The definite integral of a continuous function.	Sect. 5.2 Sect. 5.3
			LIM-5.C.2 A definite integral can be translated into the limit of a related Riemann sum, and the limit of a Riemann sum can be written as a definite integral.	Sect. 5.2 Sect. 5.3
TOPIC 6.4 The Fundamental	FUN-5 The Fundamental	FUN-5.A Represent accumulation	FUN-5.A.1 The definite integral can be used to	Sect. 5.4

Theorem of Calculus and Accumulation Functions	Theorem of Calculus connects differentiation and integration.	functions using definite integrals.	define new functions.	
			FUN-5.A.2 If f is a continuous function on an interval.	Sect. 5.4
TOPIC 6.5 Interpreting the Behavior of Accumulation Functions Involving Area	FUN-5 The Fundamental Theorem of Calculus connects differentiation and integration.	FUN-5.A Represent accumulation functions using definite integrals.	FUN-5.A.3 = Graphical, numerical, analytical, and verbal representations of a function f provide information about the function g defined as g (x) = ∫ xa f(t)dt.	Sect. 5.4
TOPIC 6.6 Applying Properties of Definite Integrals	FUN-6 Recognizing opportunities to apply knowledge of geometry and mathematical rules can simplify integration.	FUN-6.A Calculate a definite integral using areas and properties of definite integrals.	FUN-6.A.1 In some cases, a definite integral can be evaluated by using geometry and the connection between the definite integral and area.	Sect. 5.5
			FUN-6.A.2 Properties of definite integrals include the integral of a constant times a function, the integral of the sum of two functions, reversal of limits of integration, and the integral of a function over adjacent intervals.	Sect. 5.5
			FUN-6.A.3 The definition of the definite integral may be extended to functions with removable or jump discontinuities.	Sect. 5.5
TOPIC 6.7 The Fundamental Theorem of Calculus and Definite Integrals	FUN-6 Recognizing opportunities to apply knowledge of geometry and mathematical rules can simplify integration.	FUN-6.B Evaluate definite integrals analytically using the Fundamental Theorem of Calculus.	FUN-6.B.1 An antiderivative of a function f is a function g whose derivative is f.	Sect. 5.4
			FUN-6.B.2 If a function f is continuous on an interval containing a, the function defined by = Fx f t dt ( ) ( ) ∫ a x in the interval. is an antiderivative of f for x	Sect. 5.4
			FUN-6.B.3 If f is continuous on the	Sect. 5.4

			interval [a, b] and F is an antiderivative of f, then ∫ AP Calculus AB and BC Course and Exam Description a b f xdx ( ) = Fb Fa − ( ) ( ) .	
TOPIC 6.8 Finding Antiderivatives and Indefinite Integrals: Basic Rules and Notation	FUN-6 Recognizing opportunities to apply knowledge of geometry and mathematical rules can simplify integration.	FUN-6.C Determine antiderivatives of functions and indefinite integrals, using knowledge of derivatives.	FUN-6.C.1 ∫ f xdx ( ) is an indefinite integral of the function f and can be expressed as f xdx Fx C where F x f x ( ) ( ) ∫ ′ = and C is any constant.	Sect. 5.1
			FUN-6.C.2 Differentiation rules provide the foundation for f inding antiderivatives.	Sect. 5.1
			FUN-6.C.3 Many functions do not have closed-form antiderivatives.	Sect. 5.1
TOPIC 6.9 Integrating Using Substitution	FUN-6 Recognizing opportunities to apply knowledge of geometry and mathematical rules can simplify integration.	FUN-6.D For integrands requiring substitution or rearrangements into equivalent forms: (a) Determine indefinite integrals. (b) Evaluate definite integrals.	FUN-6.D.1 Substitution of variables is a technique for finding antiderivatives.	Sect. 5.6
			FUN-6.D.2 integration. For a definite integral, substitution of variables requires corresponding changes to the limits of	Sect. 5.6
TOPIC 6.10 Integrating Functions Using Long Division and Completing the Square	FUN-6 Recognizing opportunities to apply knowledge of geometry and mathematical rules can simplify integration.	FUN-6.D For integrands requiring substitution or rearrangements into equivalent forms: (a) Determine indefinite integrals. (b) Evaluate definite integrals.	FUN-6.D.3 Techniques for finding antiderivatives include rearrangements into equivalent forms, such as long division and completing the square.	Sect. 7.1
TOPIC 6.14 Selecting Techniques for Antidifferentiation				Sect. 7.1 Sect. 7.2
Unit 7: Differential Equations				
TOPIC 7.1 Modeling Situations with Differential	LIM-6.A.2 Improper integrals can be determined using	FUN-7.A Interpret verbal statements of problems as	FUN-7.A.1 Differential equations relate a function of an	Sect. 8.1

Equations	limits of definite integrals. bc only	differential equations involving a derivative expression.	independent variable and the function's derivatives.	
TOPIC 7.2 Verifying Solutions for Differential Equations	FUN-7 Solving differential equations allows us to determine functions and develop models.	FUN-7.B Verify solutions to differential equations.	FUN-7.B.1 Derivatives can be used to verify that a function is a solution to a given differential equation.	Sect. 8.1
			FUN-7.B.2 There may be infinitely many general solutions to a differential equation.	Sect. 8.1
TOPIC 7.3 Sketching Slope Fields	FUN-7 Solving differential equations allows us to determine functions and develop models.	FUN-7.C Estimate solutions to differential equations.	FUN-7.C.1 A slope field is a graphical representation of a differential equation on a finite set of points in the plane.	Sect. 8.2
			FUN-7.C.2 Slope fields provide information about the behavior of solutions to first-order differential equations.	Sect. 8.2
TOPIC 7.4 Reasoning Using Slope Fields	FUN-7 Solving differential equations allows us to determine functions and develop models.	FUN-7.C Estimate solutions to differential equations.	FUN-7.C.3 Solutions to differential equations are functions or families of functions.	Sect. 8.2
TOPIC 7.6 Finding General Solutions Using Separation of Variables	FUN-7 Solving differential equations allows us to determine functions and develop models.	FUN-7.D Determine general solutions to differential equations.	FUN-7.D.1 Some differential equations can be solved by separation of variables.	Sect. 8.3
			FUN-7.D.2 Antidifferentiation can be used to find general solutions to differential equations.	Sect. 8.3
TOPIC 7.7 Finding Particular Solutions Using Initial Conditions and Separation of Variables	FUN-7 Solving differential equations allows us to determine functions and develop models.	FUN-7.E Determine particular solutions to differential equations.	FUN-7.E.1 A general solution may describe infinitely many solutions to a differential equation. There is only one particular solution passing through a given point.	Sect. 8.3
			FUN-7.E.2 The function F	Sect. 8.3

			defined by F(x) =y0 ∫ x a f(t) dt is a particular solution to the differential equation dy/dx =f (x), satisfying F(a)= y0.	
			FUN-7.E.3 Solutions to differential equations may be subject to domain restrictions.	Sect. 8.3
TOPIC 7.8 Exponential Models with Differential Equations	FUN-7 Solving differential equations allows us to determine functions and develop models.	FUN-7.F Interpret the meaning of a differential equation and its variables in context.	FUN-7.F.1 Specific applications of finding general and particular solutions to differential equations include motion along a line and exponential growth and decay.	Sect. 8.4
			FUN-7.F.2 The model for exponential growth and decay that arises from the statement "The rate of change of a quantity is proportional to the size of the quantity" is dy/dt = ky.	Sect. 8.4
		FUN-7.G Determine general and particular solutions for problems involving differential equations in context.	FUN-7.G.1 The exponential growth and decay model, ky dy dt = , with initial condition y = y0 when t = 0, has solutions of the form y y = 0 ekt .	Sect. 8.4
Unit 8: Applications of Integration				
TOPIC 8.1 Finding the Average Value of a Function on an Interval	CHA-4 Definite integrals allow us to solve problems involving the accumulation of change over an interval.	CHA-4.B Determine the average value of a function using definite integrals.	CHA-4.B.1 The average value of a continuous function f over an interval [a, b] is 1/b-a ∫ b a f (x)dx.	Sect. 5.5
TOPIC 8.2	CHA-4 Definite	CHA-4.C Determine	CHA-4.C.1 For a particle	Sect. 6.1

Connecting Position, Velocity, and Acceleration of Functions Using Integrals	integrals allow us to solve problems involving the accumulation of change over an interval.	values for positions and rates of change using definite integrals in problems involving rectilinear motion.	in rectilinear motion over an interval of time, the definite integral of velocity represents the particle's displacement over the interval of time, and the definite integral of speed represents the particle's total distance traveled over the interval of time.	
TOPIC 8.3 Using Accumulation Functions and Definite Integrals in Applied Contexts	CHA-4 Definite integrals allow us to solve problems involving the accumulation of change over an interval.	CHA-4.D Interpret the meaning of a definite integral in accumulation problems.	CHA-4.D.1 A function defined as an integral represents an accumulation of a rate of change	Sect. 5.4
			CHA-4.D.2 The definite integral of the rate of change of a quantity over an interval gives the net change of that quantity over that interval.	Sect. 5.4
		CHA-4.E Determine net change using definite integrals in applied contexts.	CHA-4.E.1 The definite integral can be used to express information about accumulation and net change in many applied contexts.	Sect. 5.4
TOPIC 8.4 Finding the Area Between Curves Expressed as Functions of x	CHA-5 Definite integrals allow us to solve problems involving the accumulation of change in area or volume over an interval.	CHA-5.A Calculate areas in the plane using the definite integral.	CHA-5.A.1 Areas of regions in the plane can be calculated with definite integrals.	Sect. 6.2
TOPIC 8.5 Finding the Area Between Curves Expressed as Functions of y	CHA-5 Definite integrals allow us to solve problems involving the accumulation of change in area or volume over an interval.	CHA-5.A Calculate areas in the plane using the definite integral.	CHA-5.A.2 Areas of regions in the plane can be calculated using functions of either x or y	Sect. 6.2
TOPIC 8.6 Finding the Area Between Curves That	CHA-5 Definite integrals allow us to solve problems	CHA-5.A Calculate areas in the plane using the definite	CHA-5.A.3 Areas of certain regions in the plane may be calculated	Sect. 6.2

Intersect at More Than Two Points	involving the accumulation of change in area or volume over an interval.	integral.	using a sum of two or more definite integrals or by evaluating a definite integral of the absolute value of the difference of two functions.	
TOPIC 8.7 Volumes with Cross Sections: Squares and Rectangles	CHA-5 Definite integrals allow us to solve problems involving the accumulation of change in area or volume over an interval.	CHA-5.B Calculate volumes of solids with known cross sections using definite integrals.	CHA-5.B.1 Volumes of solids with square and rectangular cross sections can be found using definite integrals and the area formulas for these shapes.	Sect. 6.3
TOPIC 8.8 Volumes with Cross Sections: Triangles and Semicircles	CHA-5 Definite integrals allow us to solve problems involving the accumulation of change in area or volume over an interval.	CHA-5.B Calculate volumes of solids with known cross sections using definite integrals.	CHA-5.B.2 Volumes of solids with triangular cross sections can be found using definite integrals and the area formulas for these shapes.	Sect. 6.3
			CHA-5.B.3 Volumes of solids with semicircular and other geometrically defined cross sections can be found using definite integrals and the area formulas for these shapes.	Sect. 6.3
TOPIC 8.9 Volume with Disc Method: Revolving Around the x- or y-Axis	CHA-5 Definite integrals allow us to solve problems involving the accumulation of change in area or volume over an interval	CHA-5.C Calculate volumes of solids of revolution using definite integrals.	CHA-5.C.1 Volumes of solids of revolution around the x- or y-axis may be found by using definite integrals with the disc method.	Sect. 6.4
TOPIC 8.10 Volume with Disc Method: Revolving Around Other Axes	CHA-5 Definite integrals allow us to solve problems involving the accumulation of change in area or volume over an interval.	CHA-5 Definite integrals allow us to solve problems involving the accumulation of change in area or volume over an interval.	CHA-5.C.2 Volumes of solids of revolution around any horizontal or vertical line in the plane may be found by using definite integrals with the disc method.	Sect. 6.4
TOPIC 8.11 Volume with Washer Method: Revolving	CHA-5 Definite integrals allow us to solve problems	CHA-5.C Calculate volumes of solids of revolution using	CHA-5.C.3 Volumes of solids of revolution around the x- or y-axis	Sect. 6.3

Around the x- or y-Axis	involving the accumulation of change in area or volume over an interval.	definite integrals.	whose cross sections are ring shaped may be found using definite integrals with the washer method.	
TOPIC 8.12 Volume with Washer Method: Revolving Around Other Axes	CHA-5 Definite integrals allow us to solve problems involving the accumulation of change in area or volume over an interval.	CHA-5.C Calculate volumes of solids of revolution using definite integrals.	CHA-5.C.4 Volumes of solids of revolution around any horizontal or vertical line whose cross sections are ring shaped may be found using definite integrals with the washer method.	Sect. 6.3