Syllabus Development Guide: AP® Calculus BC

The guide contains the following sections and information:

Curricular Requirements	The curricular requirements are the core elements of the course. Your syllabus must provide clear evidence that each requirement is fully addressed in your course.
Scoring Components	Some curricular requirements consist of complex, multipart statements. These particular requirements are broken down into their component parts and restated as “scoring components.” Reviewers will look for evidence that each scoring component is included in your course.
Evaluation Guideline(s)	These are the evaluation criteria that describe the level and type of evidence required to satisfy each scoring component.
Key Term(s)	These ensure that certain terms or expressions, within the curricular requirement or scoring component that may have multiple meanings, are clearly defined.
Samples of Evidence	For each scoring component, three separate samples of evidence are provided. These statements provide clear descriptions of what acceptable evidence should look like.

Syllabus Development Guide Contents

Curricular Requirement 1	**The course is structured around the enduring understandings within the four big ideas described in the *AP Calculus Course and Exam Description*.**
Scoring Component 1a	The course is structured around the enduring understandings within Big Idea 1: Limits.
Evaluation Guideline(s)	The syllabus must specifically mention limits and continuity.
Key Term(s)	None at this time.
Samples of Evidence	1. The syllabus includes a list of section titles from the textbook, among which are "Computing Limits Graphically and Numerically" and "Continuity." 2. The syllabus lists a textbook chapter and a subsection titled "Limits" and "Continuity," respectively. 3. The four big ideas are directly listed in the syllabus, and continuity is specifically referenced in a later, more detailed section.

Curricular Requirement 1	**The course is structured around the enduring understandings within the four big ideas described in the *AP Calculus Course and Exam Description*.**
Scoring Component 1b	The course is structured around the enduring understandings within Big Idea 2: Derivatives.
Evaluation Guideline(s)	The syllabus must specifically mention derivatives and the Mean Value Theorem.
Key Term(s)	None at this time.
Samples of Evidence	1. The syllabus includes a list of section titles from the textbook, among which are "Defining the Derivative" and "The Mean Value Theorem." 2. The syllabus lists a textbook chapter and a subsection titled "Derivatives" and "The Mean Value Theorem," respectively. 3. The four big ideas are directly listed in the syllabus, and the Mean Value Theorem is specifically referenced in a later, more detailed section.

Curricular Requirement 1	**The course is structured around the enduring understandings within the four big ideas described in the *AP Calculus Course and Exam Description*.**
Scoring Component 1c	The course is structured around the enduring understandings within Big Idea 3: Integrals and the Fundamental Theorem of Calculus.
Evaluation Guideline(s)	The syllabus must specifically mention integrals and both parts of the Fundamental Theorem of Calculus.
Key Term(s)	**Fundamental Theorem of Calculus must include both of the following:**

If *f* is continuous on [*a,b*] then the function *g* defined by

$$g(x) = \int_a^x f(t)dt$$

is an antiderivative of *f*. That is, $g'(x) = f(x)$ for $a < x < b$.

And

If *f* is continuous on [*a,b*], then

$$\int_a^b f(x)dx = F(b) - F(a)$$

where *F(x)* is any antiderivative of *f(x).*

Samples of Evidence

1. The syllabus includes a list of section titles from the textbook, among which are “Defining the Definite Integral,” “The First Fundamental Theorem of Calculus,” and “The Second Fundamental Theorem of Calculus.”

2. The syllabus lists a textbook chapter and a subsection titled “Integrals” and “Fundamental Theorem of Calculus - Parts I and II,” respectively.

3. The four big ideas are directly listed in the syllabus, and both forms of the Fundamental Theorem of Calculus are specifically referenced in a later, more detailed section.

Curricular Requirement 1

The course is structured around the enduring understandings within the four big ideas described in the *AP Calculus Course and Exam Description*.

Scoring Component 1d

The course is structured around the enduring understandings within Big Idea 4: Series.

Evaluation Guideline(s)

The syllabus must specifically mention series, power series, and Taylor polynomials.

Key Term(s)

None at this time.

Samples of Evidence

1. The syllabus includes a list of section titles from the textbook, some of which are "Taylor Polynomials," "Convergence Tests for Series," and "Power Series as Functions."
2. The syllabus lists a textbook chapter and subsections titled "Power Series," "Taylor Series," and "Taylor Polynomials," respectively.
3. The four big ideas are directly listed in the syllabus, and power series and Taylor polynomials are specifically referenced in a later, more detailed section.

Curricular Requirement 2	**The course provides students opportunities to apply the six Mathematical Practices for AP Calculus as they engage in the learning objectives described in the *AP Calculus Course and Exam Description*.**
Scoring Component 2a	The course provides opportunities for students to reason with definitions and theorems.
Evaluation Guideline(s)	The syllabus must describe how students reason with definitions and theorems in a lesson, activity, or assignment designed to meet at least one learning objective.
Key Term(s)	None at this time.
Samples of Evidence	1. Students participate in a group activity in which several functions on specified domains are given, and each student tries to decide if the hypotheses of the Intermediate Value Theorem and the Mean Value Theorem apply. Students then compare their answers and try to resolve any differences. 2. In a class activity, students examine limits in the context of graphical and analytical representations of rational functions to determine if and when L'Hospital's Rule applies (LO 1.1C: Determine limits of functions). Then the students document their findings in a shared online document. 3. The teacher presents the following scenario: given that $f(0) = 0$ and $f(2) = 5$, a student claims that for some value $c, 0 < c < 2, f(c) = 3$ by the Intermediate Value Theorem. Then the class has a discussion about whether the student is correct and why.

Curricular Requirement 2	**The course provides students opportunities to apply the six Mathematical Practices for AP Calculus as they engage in the learning objectives described in the *AP Calculus Course and Exam Description.***
Scoring Component 2b	The course provides opportunities for students to connect concepts and processes.
Evaluation Guideline(s)	The syllabus must describe how students connect concepts or processes in a lesson, activity, or assignment designed to meet at least one learning objective.
Key Term(s)	**Concepts**: e.g., rate of change and accumulation. **Processes**: e.g., differentiation and its inverse process antidifferentiation.
Samples of Evidence	1. Each student sketches a graph of f given the formulas for f' and f''; students then exchange papers, compare their answers, and try to come to agreement. 2. In a classroom activity, students use calculus to find the rate of change of the height of an inverted conical pile of sand when sand is being poured at a specified rate and the radius is twice the height. (LO 2.3C: Solve problems involving related rates, optimization, rectilinear motion, (BC) and planar motion). 3. Students are asked to create examples (or state that no such example exists) of a function that is continuous but not differentiable, a function that is differentiable but not continuous, a function that is neither differentiable nor continuous, and a function that is both differentiable and continuous. They discuss the results in small groups.

Curricular Requirement 2	**The course provides students opportunities to apply the six Mathematical Practices for AP Calculus as they engage in the learning objectives described in the *AP Calculus Course and Exam Description.***
Scoring Component 2c	The course provides opportunities for students to implement algebraic/computational processes.
Evaluation Guideline(s)	The syllabus must describe how students implement algebraic/computational processes in a lesson, activity, or assignment designed to meet at least one learning objective.
Key Term(s)	**Algebraic**: non-numeric symbols (variables or formulas). **Computational**: numerical operations.
Samples of Evidence	1. A pre-exam review sheet contains a problem in which students are given a table of values of a function f and are asked to compute the right-hand and left-hand Riemann sums. 2. In a classroom activity, students use algebraic rules and procedures for differentiation to find the cylinder of maximum volume that can be inscribed in a cone of given dimensions. 3. For homework, students are given a worksheet and asked to find the limits for a variety of problems, some of which involve the indeterminate forms $0/0$ and ∞/∞ and require using L'Hospital's Rule. (LO 1.1C: Determine limits of functions)

Curricular Requirement 2	**The course provides students opportunities to apply the six Mathematical Practices for AP Calculus as they engage in the learning objectives described in the *AP Calculus Course and Exam Description.***
Scoring Component 2d	The course provides opportunities for students to engage with graphical, numerical, analytical, and verbal representations and demonstrate connections among them.
Evaluation Guideline(s)	The syllabus must describe how students work with each of the representations (graphical, numerical, analytical, and verbal) in one or more lessons, activities, or assignments designed to meet a learning objective. The syllabus must describe how students connect at least two of the representations in a lesson, activity, or assignment.
Key Term(s)	**Graphical representation:** one that is drawn as a set of points on a pair of coordinate axes. Limits, derivatives, and integrals could be represented in graphical form. **Numerical representation**: one whose values are given as discrete data. For example, as numbers in a table, as coordinates of points (e.g., $(2,3)$ or $f(2) = 3$), or in some similar fashion. **Analytical representation**: one that is given as what typically is considered a formula such as $f(x) = \sin(3x)$. **Verbal representation:** one that is described in words rather than mathematical symbols.
Samples of Evidence	1. Each pair of students is given a real-world physical situation in words (such as a description of the temperature of a cooling cup of coffee) and asked to represent it as a differential equation involving variables, then solve the equation and graph the solution; students present their results to the class for discussion. [verbal, analytical, graphical and connection between verbal and analytical] In a

Samples of Evidence

(continued)

separate assignment, students are asked to collect a table of speedometer values while in a car driven by someone else and then estimate the distance driven. [numerical]

2. Students work on an assignment where they are asked to graph a function given the formula and estimate the area of a region bounded by the function, the x-axis, $x = 2$, and $x = 6$ using the midpoint Riemann sums with four subintervals of equal length. [analytical, graphical, numerical, and connection between analytical and graphical]

   Students work on an assignment where they are given rates of change of various real-world quantities and asked to find the net or total change of these quantities by evaluating definite integrals. [verbal].

3. As a group project, students are asked to compare the indefinite integrals of transformations of trigonometric functions such as $\sin(3x)$ and $3\sin(x)$. [analytical]

   Students are given the graphs of the derivative of several functions and asked to find the local maxima and minima for those functions. They discuss their results in small groups. [graphical]

   As an individual assignment, students use a table of values of two functions and their derivatives to apply the chain rule to find the numerical value of the derivative of composite functions. [numerical]

   Students are given newspaper headlines that relate to calculus, such as the population growth is slowing. As a class, students discuss questions such as whether the derivative of the population function is increasing or decreasing. [verbal]

   On a homework assignment, students use information written in words about whether f, f', and f'' are positive or negative, and are asked to sketch f. [connection between verbal and graphical].

Curricular Requirement 2

The course provides students opportunities to apply the six Mathematical Practices for AP Calculus as they engage in the learning objectives described in the *AP Calculus Course and Exam Description.*

Scoring Component 2e

The course provides opportunities for students to build notational fluency.

Evaluation Guideline(s)

The syllabus must describe how students use and interpret mathematical notation in a lesson, activity, or assignment designed to meet at least one learning objective.

Key Term(s)

None at this time.

Samples of Evidence

1. As part of the review for the AP exam, students are shown the graph of a function such as $f(x) = 1/x$ and asked to write an expression for the area under the curve on a specified interval as the limit of a right-hand Riemann sum.

2. Students are asked to write the definitions of basic calculus concepts in a variety of forms such as recognizing that $\lim_{h \to 0} \frac{f(a+h)-f(a)}{h}$ is the slope of the tangent line to $y = f(x)$ at $x = a$ or that the limit of a Riemann sum can be represented as a definite integral. The teacher will select some of the student-prepared examples to make up a quiz.

3. As part of a warm-up activity, students are given $f(x) = \int_0^x e^{-t^2}\,dt$ and are asked to determine properties of the function such as its local extrema and inflection points.

Curricular Requirement 2	**The course provides students opportunities to apply the six Mathematical Practices for AP Calculus as they engage in the learning objectives described in the *AP Calculus Course and Exam Description.***
Scoring Component 2f	The course provides opportunities for students to communicate mathematical ideas in words, both orally and in writing.
Evaluation Guideline(s)	The syllabus must describe how students communicate mathematical ideas both orally and in written sentences in one or more lessons, activities, or assignments designed to meet at least one learning objective.
Key Term(s)	None at this time.
Samples of Evidence	1. At the end of the year, each student writes an essay (using proper grammar and complete sentences) explaining how limits are used in calculus. They then make an oral presentation of their essays to the students who will be taking AP Calculus in the following year. 2. Students are asked to describe in well-written sentences the main ideas in the chapter on the Fundamental Theorem. Students explain their reasoning to each other in small groups. 3. In a group project, students are asked to design a cylindrical can that will hold 1.2 liters of liquid for a manufacturer. They are asked to determine the dimensions of the can that will minimize the amount of material needed in its construction. They write a report using complete sentences and correct grammar and present the report orally to the class, explaining the procedures used and their recommendations to the manufacturer.

Curricular Requirement 3	**Students have access to graphing calculators and opportunities to use them to solve problems and to explore and interpret calculus concepts.**
Scoring Component 3a	Students have access to graphing calculators.
Evaluation Guideline(s)	The syllabus must indicate that students have access to graphing calculators.
Key Term(s)	None at this time.
Samples of Evidence	1. The syllabus states that each student will have his or her own graphing calculator to use throughout the year. 2. The syllabus states that if a student does not own a graphing calculator, the school will provide one for them. 3. The syllabus indicates that students have access to a classroom set of graphing calculators for use both inside and outside the classroom.

Curricular Requirement 3	**Students have access to graphing calculators and opportunities to use them to solve problems and to explore and interpret calculus concepts.**
Scoring Component 3b	Students have opportunities to use calculators to solve problems.
Evaluation Guideline(s)	The syllabus must describe how students use graphing calculators to solve problems in a lesson, activity, or assignment.
Key Term(s)	None at this time.
Samples of Evidence	1. A worksheet on finding area between curves requires students to use the calculator to find the points of intersection of the curve and then to evaluate the definite integrals numerically using the calculator's integration feature. 2. On a classroom assignment, students are asked to use their calculators to determine the absolute extrema of $f(x) = 3x^3 + 2x^2 - 10x + 4$ on $[-4,2]$. 3. The teacher prepares a lesson in which students learn to name functions and enter them into their calculators for use later in performing numerical differentiation.

Curricular Requirement 3

Students have access to graphing calculators and opportunities to use them to solve problems and to explore and interpret calculus concepts.

Scoring Component 3c

Students have opportunities to use a graphing calculator to explore and interpret calculus concepts.

Evaluation Guideline(s)

The syllabus must describe how students use graphing calculators to explore or interpret calculus concepts in a lesson, assignment, or activity designed to develop an understanding beyond simply solving problems. Use of the calculator to check answers found analytically will not suffice.

Key Term(s)

None at this time.

Samples of Evidence

1. As part of an in-class exploratory exercise, students graph various functions and their derivatives on the calculator and make conjectures about the relationships between the characteristics of f and f'.

2. On a worksheet to explore limits of functions, students are asked to use the table feature on their calculator to examine the function $f(x) = \frac{2x^2-14x+24}{x^2-3x}$ near $x = 4$.

3. As part of a worksheet, students analytically determine that a derivative of $f(x)$ does not exist at a certain x-value, and then they interpret their result by graphing the function on their calculators in order to understand why the derivative fails to exist.

Curricular Requirement 4	**Students and teachers have access to a college-level calculus textbook.**
Evaluation Guideline(s)	The syllabus must list the title and author of a college-level calculus textbook.
Key Term(s)	None at this time.
Samples of Evidence	1. The syllabus mentions a college-level calculus textbook by title and author. 2. The syllabus states that students have access to an online, college-level calculus textbook from the example textbook list. 3. The syllabus indicates that students have access to a college-level calculus textbook in the classroom from the AP Calculus Example Textbook List.