AP® Calculus AB
Syllabus

Course Description

AP® Calculus AB is a yearlong, college-level course designed to prepare students for the Advanced Placement (AP) Calculus AB exam. Major topics of study in this full-year course include a review of pre-calculus; the use of limits, derivatives, definite integrals, and mathematical modeling of differential equations; and the applications of these concepts. Emphasis is placed on the use of technology to solve problems and draw conclusions. The course uses a multi-representative approach to calculus, with concepts and problems expressed numerically, graphically, verbally, and analytically. This course is aligned to the new College Board AP Calculus AB course description that was introduced in 2016.

Classroom Requirements

This AP course requires that a highly qualified math teacher be responsible for administering the course. This teacher is expected to interact with students regularly (either face to face or via chat and e-mail) and grade open-ended student responses. The teacher also should set up online discussions in the Collaboration Corner. In addition, he or she should provide instruction and coaching in calculator use as needed.

Course Materials

Textbook

Finney, Ross L., Franklin D. Demana, Bet K. Waits, and Daniel Kennedy. *Calculus: Graphical, Numerical, Algebraic*, 5th ed. Boston: Pearson, 2016. **[CR 4]**

Calculator

On-screen teachers will use an online graphing calculator tool for demonstration purposes. Students must have access to an AP-approved calculator both in the classroom and at home. Many assignments, projects, and practice exam questions will require the use of an AP-approved calculator. **[CR 3a]**

Classroom teachers are expected to demonstrate the use of graphing calculators to their students as needed.

Approach

Throughout the course, students are required to use multiple approaches to ensure their understanding of course content. In each lesson, students are required to use their graphing calculators to solve problems. In addition, students are required to graph problems by hand in order to supplement their understanding of calculus concepts.

Students will use their graphing calculators experimentally to determine possible solutions to problems. They will also learn to use their calculators to justify their conclusions and to support the solutions that they have developed using an analytical approach. **[CR 3a] [CR 3b]**

Application problems requiring the use of analytical techniques in differential and integral calculus are included in each unit. Students will solve problems requiring numerical solutions both by hand and with their calculators. Students are expected to check the reasonableness of their numerical solutions by using other approaches as well.

Students are required to explain calculus problems and techniques verbally and in writing. They will use the Collaboration Corner course feature to facilitate in-class discussions.

Every unit test mirrors the format of the AP exam. In each unit, students will answer multiple-choice questions and complete two free-response questions. Some of these questions will require a calculator and some will not. Students will also complete two full-length practice exams at the end of the course. **[CR 3b]**

Course Outline

Unit 1: Pre-Calculus Review

Lessons:

- Intro to AP Calculus
- Lines
- Functions and Graphs
- Exponential Functions
- Parametric Equations
- Functions and Logarithms
- Trigonometric Functions

Unit 2: Limits and Continuity

Lessons:

- Introduction to Limits and Continuity **[CR 1a]**
- Rates of Change, Limits, and the Squeeze Theorem **[CR 1a]**
- Limits Involving Infinity and Vertical and Horizontal Asymptotes
- Continuous Functions and the Intermediate Value Theorem **[CR 1a] [CR 2a]**
- Slope, Tangent Line, and Normal Line

Sample Activities:

Students will practice computing limits both algebraically and graphically. They will also practice analyzing functions for intervals of continuity and points of discontinuity. They will use limits to find instantaneous rates of change, slopes of tangent lines, and sensitivity to change. In addition, students will solve problems using the extreme value theorem. **[CR 1a] [CR 2a] [CR 2e] [CR 3b] [CR 4]**

Unit 3: Derivatives

Lessons:

- Introduction to Derivatives
- Derivatives of Functions **[CR 1b]**

- Derivatives and Continuity **[CR 1a]**
- Differentiation Rules
- Applications of Derivatives
- Differentiating Trigonometric Functions

Sample Activities:
Given the equation for the movement of a particle, students will find the particle's average velocity over an interval, derive an expression for the particle's velocity, and determine when the particle changes direction. Students must show their work and provide a written explanation of the thought process used to solve the problem. **[CR 1b] [CR 2c] [CR 2e] [CR 2f] [CR 3b]**

Students will practice graphing f from f', and vice versa.

Given a real-world problem involving two people traveling along a path, students will use a data table to estimate the value of a derivative, calculate the people's acceleration and velocity, and determine at what time the distance between the two reaches a certain point. **[CR 1b] [CR 2c] [CR 2f]**

Designing a Roller Coaster Project: Students will design the first drop of a new roller coaster. First, they will conduct research and determine the optimal slopes for the ascent and descent portions. Then, they will write and solve equations that connect the two segments with a parabola and ensure that the track remains smooth. Next, they will sketch the lines representing the ascent and descent and the parabola that connects the two. Finally, they will use a calculator to plot the parabola using the equations they developed, and compare that plot to their sketch. Students will be required to present their findings both graphically and numerically. They must provide an annotated diagram of their design, as well as step-by-step written solutions and justifications to all of the problems to be solved. **[CR 2c] [CR 2d] [CR 2f] [CR 3b] [CR 3c]**

Unit 4: More Derivatives
Lessons:

- Introduction to More Derivatives **[CR 1b]**
- Differentiating Functions Using the Chain Rule
- Differentiating Functions Using Implicit Differentiation
- Differentiating Functions Containing Inverse Functions and Inverse Trigonometric Functions
- Differentiating Exponential and Logarithmic Function

Sample Activities:

Given a real-world problem involving water flowing in and out of a reservoir, students will calculate average rate of change, use the chain rule to calculate a derivative, and compare rates of change to the average rate of change. Students must show their work and provide a written explanation of the thought process used to solve the problem. **[CR 1b] [CR 2b] [CR 3c]**

Given an equation, students will use the chain rule to find its derivative and the equation of the line tangent to the curve at a given point. Students must show their work and provide a written explanation of the thought process used to solve the problem. **[CR 1b] [CR 2e] [CR 2f]**

Unit 5: Applications of Derivatives

Lessons:

- Introduction to Applications of Derivatives
- Relative and Absolute Extrema
- The Mean Value Theorem [CR 1b]
- The First and Second Derivative Tests
- Application Problem-Solving
- Newton's Method, Linearization, and Differentials
- Applications of Implicit Differentiation

Sample Activities:

Using the graph of the derivative of a function, students will determine key features of the function, such as increasing and decreasing intervals, local extrema, points of inflection, and concavity intervals. Students solve application problems, including related rates and optimization problems. **[CR 1b] [CR 2b] [CR 2c]**

[CR 2f]

Students will use implicit differentiation to solve a real-world related rate problem. Students must show their work and provide a written explanation of the thought process used to solve the problem. **[CR 1b] [CR 2b] [CR 2c] [CR 2f]**

Soda Can Optimization Project: Students will solve an optimization problem to find the most economical dimensions for a soda can, given a specific volume that the can must hold. Students will provide step-by-step written solutions, diagrams, and justifications to all of the problems to be solved to achieve the can's optimization. In addition, students will conduct research to identify real-world examples and non-examples of their optimized can design and write a report about their findings. Students will present their findings to the class. **[CR 1b] [CR 2b] [CR 2c] [CR 2f]**

Unit 6: Definite Integrals

Lessons:

- Introduction to Definite Integrals
- Estimating with Finite Sums
- Definite Integrals **[CR 1c]**
- Definite Integrals and Antiderivatives
- The Fundamental Theorem of Calculus (Parts I and II) **[CR 1c]**
- The Trapezoidal Rule

Sample Activities:

Students will practice estimating with finite sums and finding definite integrals and antiderivatives, including in problems with initial conditions. They will also calculate the areas under curves using various techniques, including rectangular approximation methods and the trapezoidal rule. In addition, students will calculate the average value of a function over a closed interval and use this concept to understand the mean value theorem. Students will interpret the area under a graph as a net accumulation of a rate of change. **[CR 1c] [CR 2a] [CR 2e] [CR 3b] [CR 4]**

Students will apply the first part of the fundamental theorem of calculus to solve problems and the second part to calculate integrals analytically. **[CR 1c]**

Wind Turbine Project: In this project, students will use calculus to determine the energy of a potential offshore wind turbine in the Gulf of Mexico. Using NOAA buoy data, students will extrapolate a table to determine the potential wind energy available, and then calculate the energy produced by a hypothetical wind turbine. Students will provide the calculations they used to generate their answers, as well as a table that models the energy produced over a set interval (power as a function of time).

Unit 7: Mathematical Modeling Using Differential Equations

Lessons:

- Introduction to Mathematical Modeling Using Differential Equations
- Slope Fields
- Antidifferentiation by Substitution
- Exponential Growth and Decay

Sample Activities:

Students will practice using slope fields to analyze and construct solutions to differential equations. They will also practice finding antiderivatives of functions and solving separable differential equations, including those coming from problems involving exponential growth, and exponential decay. [CR 1c] [CR 2a] [CR 2e] [CR 3b] [CR 4]

Unit 8: Applications of Definite Integrals

Lessons:

- Introduction to Applications of Definite Integrals
- Integral as Net Change
- Areas in the Plane
- Volumes
- Applications from Science and Statistics
- L'Hopital's Rule and Other Applications **[CR 2a]**

Sample Activities:

Students will practice applying the definite integral to solve problems involving accumulation, displacement, total distance, net change, areas, work, fluid pressure, and probability distribution, and justify their findings in writing. [CR 1c] [CR 2c] [CR 2f]

Students will calculate the volume of a solid generated by revolving a line or curve around a given line and by revolving a region bounded by two or more lines or curves. They will also calculate the volume of a solid using cross-sections. **[CR 1c]**

Students will make connections between Riemann sums and definite integrals by including the Riemann sum notation as part of the answer along with the definite integral for some problems. **[CR 2a]**

Students will practice using L'Hopital's rule to evaluate limits of indeterminate forms and compare the growth rates of functions. **[CR 1c] [CR 2a] [CR 2e] [CR 3b] [CR 4]**

Hospital Bridge Project: In this project, students will design a bridge to connect two halves of a hospital over a busy road. They will use unique shapes to accommodate a 20-foot drop that allows the buildings to connect on the same floor. Students will make 3-D models of their designs using either building materials or a software program, and provide the calculations and justification for their designs.

Unit 9: Course Review and AP Exam Preparation

The course concludes with a unit focused on preparing students for the AP exam.