**Course Title: Advanced Placement Calculus AB**

**Meeting Times:** This course meets for 36 weeks and for 85-minute blocks every other day.

**Course Description:**

AP Calculus AB provides an understanding of the fundamental concepts and methods of differential and integral calculus with an emphasis on their application, and the use of multiple representations incorporating graphic, numeric, analytic, algebraic, and verbal and written responses. Topics of study include: functions, limits, derivatives, and the interpretation and application of integrals. An in-depth study of functions occurs in the course. Technology is an integral part of the course and includes the use of graphing calculators, computers, and data analysis software. On a regular basis, graphing calculators are used to explore, discover, and reinforce concepts of calculus.

Though our system has an open enrollment policy, students should understand that this course is designed to be a fourth-year mathematics course, and the equivalent of a year-long, college-level course in single variable calculus. The course requires a solid foundation of advanced topics in algebra, geometry, trigonometry, analytic geometry, and elementary functions. The breadth, pace, and depth of material covered exceeds the standard high school mathematics course, as does the college-level textbook, and time and effort required of students. AP Calculus AB provides the equivalent of the first course in a college calculus sequence, while AP Calculus BC is an extension of AP Calculus AB, and provides the equivalent of a second course in a college calculus sequence. Students are expected to take the AP Calculus AB Exam at the end of this course.

**Course Purpose and Goals:**

Philosophy

Understanding change is the basis of this course. The study of the concept of the derivative in calculus is the formal study of mathematical change. A key component of the course is fluency in the use of multiple representations that include graphic, numeric, analytic, algebraic, and verbal and written responses. Students build an understanding of calculus concepts as they construct relationships and make connections among the various representations. The course is more than a collection of topics; it is a coherent focused curriculum that develops a broad range of calculus concepts and a variety of methods to solve real-world applications. These include practical applications of integrals to model biological, physical, and economic situations. Although the development of techniques and fluency with algebraic symbolism to represent problems is important, it is not a primary focus of the course. Rather, the course emphasizes differential and integral calculus for functions of a single variable through the Fundamental Theorem of Calculus.

Technology is used to enhance students’ understanding of calculus concepts and techniques. The College Board requires the use of graphing calculators for this course. Mathematical problem solving, investigations, and projects require adequate and timely access to technology including graphing calculators, databases, spreadsheets, Internet and on-line resources, and data analysis software. In this course, technology is

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introduced in the context of real-world problems, incorporates multiple representations, and facilitates connections among mathematics topics. Students use estimation, mental math, calculators, and paper-and-pencil techniques of calculus to conduct investigations and solve problems. According to the National Council of Teachers of Mathematics (2000), “Estimation serves as an important companion to computation. It provides a tool for judging the reasonableness of calculator, mental, and paper-and-pencil computations.” (NCTM, p. 155)

The standards support the unifying themes of derivatives, integrals, limits, approximation, as well as applications and modeling in the course. Instruction is designed and sequenced to provide students with learning opportunities in appropriate settings. Teaching strategies include collaborative small-group work, pairs engaged in problem solving, whole-group presentations, peer-to-peer discussions, and an integration of technology when appropriate. In this course, students are often engaged in mathematical investigations that enable them to collaborate with peers in designing mathematical models to solve problems and interpret solutions. They are encouraged to talk about the mathematics of change in calculus, to use the language and symbols of calculus to communicate, and to discuss problems and methods of solution.

Scoring Components

SC1 The course teaches all topics associated with Functions, Graphs, and Limits as delineated in the

Calculus AB Topic Outline in the AP Calculus course description.

SC2 The course teaches all topics associated with Derivatives as delineated in the Calculus AB Topic

Outline in the AP Calculus course description.

SC3 The course teaches all topics associated with Integrals as delineated in the Calculus AB Topic

Outline in the AP Calculus course description.

SC4 The course provides students the opportunity to work with functions represented graphically.

SC5 The course provides students with the opportunity to work with functions represented numerically.

SC6 The course provides students with the opportunity to work with functions represented analytically.

SC7 The course provides students with the opportunity to work with functions represented verbally.

SC8 The course teaches students how to explain solutions to problems orally.

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SC9 The course teaches students how to explain solutions to problems in written sentences.

SC10 The course teaches students how to use graphing calculators to help solve problems.

SC11 The course teaches students how to use graphing calculators to experiment.

SC12 The course teaches students how to use graphing calculators to interpret results and support

conclusions.

**Course Outline**

By successfully completing this course, you will be able to:

* work with functions represented in a variety of ways and understand the connections among these representations.
* understand the meaning of the derivative in terms of a rate of change and local linear approximation, and use derivatives to solve a variety of problems.
* understand the relationship between the derivative and the definite integral.
* communicate mathematics both orally and in well-written sentences to explain solutions to problems.
* model a written description of a physical situation with a function, a differential equation, or an integral.
* use technology to help solve problems, experiment, interpret results, and verify conclusions.
* determine the reasonableness of solutions, including sign, size, relative accuracy, and units of measurement.
* develop an appreciation of calculus as a coherent body of knowledge and as a human accomplishment.

**Technology Requirement**

Every student is assigned a TI 84 graphing calculator. They are used daily for activities often to provide the graphical and numerical analysis that verifies the algebraic and analytic problem solving that is common to Calculus.

We will use the calculator in a variety of ways, including: **[SC11 & wSC12]**

* Conducting explorations

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* Graphing functions within arbitrary windows
* Solving equations numerically
* Analyzing and interpreting results
* Justifying and explaining results of graphs and equations

**A Balanced Approach**

We will emphasize the, “Rule of Four.” This rule emphasizes a variety of ways to approach, solve, analyze and understand problems within calculus.

The four methods or practices of calculus are the following.

* Numerical analysis (where data points are known, but not an equation) **[SC5]**
* Graphical analysis (where a graph is known, but not an equation) **[SC4]**
* Analytic/algebraic analysis (traditional equation and variable manipulation) **[SC6]**
* Verbal/written methods of representing problems (classic story problems as well as written justification of one’s thinking in solving a problem

These four approaches are also best used together to address various learning modalities as well as provide students with ways to visualize, explore and address the relationships between the graphs, numerical lists, algebraic analysis and writing regarding the problem solving used within the curriculum.

Conceptual Organization

The content and level of depth of the material for this course is equivalent to a college-level course. The course content is organized to emphasize major topics in the course to include the following: (1) functions, graphs, and limits; (2) derivatives, and (3) integrals. Building on most students’ prior knowledge, the course begins with a review of a variety of functions using multiple representations: graphic, numeric, algebraic, analytic, and verbal and written responses. Technology enhances students’ constructing an understanding of mathematical relationships among the different representations used in solving problems. This supports and leads to students’ development and visualization of properties of limits and continuity, and rates of change of functions.

The concept of a derivative is interpreted as a rate of change and local linearity. Using graphing calculators, numeric derivatives are examined. This is followed with a focus on derivatives of functions—algebraic, trigonometric, logarithmic, and exponential. Applications of the derivative are investigated through velocity, acceleration, and optimization problems.

The definite integral is studied as a limit of Riemann sums and the rate of change of a quantity over a specific interval. This sequence of topics naturally leads to students’ introduction to the Fundamental Theorem of Calculus. Applications of definite integrals

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are also investigated which include summing rates of change, particle motion, areas in a plane, and volumes of solids.

This order of topics within the course, not only provides a logical and systemic study to calculus, but also accommodates the frequent transfer of students within the schools of the system, so that transfer students can maintain a consistent flow of learning.

**Course Format and Policies:**

Overview

This AP course emphasizes a multi-representational approach to calculus, with concepts, results and problems being expressed graphically, numerically, analytically, and verbally. This course is intended to be challenging and demanding. Through the use of the unifying themes of derivatives, integrals, limits, approximations, and applications and modeling, the course becomes a cohesive whole rather than a collection of unrelated topics.

Students will be introduced to a new world of mathematical concepts unlike they have ever seen previously. Through leading examples and group investigations, they will encompass all the major topics of a first year college calculus course including functions and limits, derivatives and their applications, and integrals and their applications.

The classroom is inviting and structured such that students may openly participate and ask questions at any time during class discussions. Classroom resources are abundant as each individual student has a textbook, TI-84 graphing calculator and laptop computer readily available to him or her. Textbooks and calculators are also provided for students to leave at home.

Group investigations are student-led with little interference from the instructor. At appropriate times throughout the course, students learn how to utilize their graphing calculators to its fullest capabilities, including how to plot the graph of a function within an arbitrary viewing window, find the zeros of functions, find the intersection(s) of two functions, store values without rounding and retrieve these stored values, numerically calculate the derivative of a function, and numerically calculate the value of a definite integral.

From day one AP specific strategies are integrated in the daily lessons. Students are given daily quizzes with five questions covering previously covered topics. With each major assessment, students are exposed to both multiple choice and free response questions. They learn about the procedures used for grading on AP and quickly recognize where points are earned with free response questions. Students often grade free response questions in class and discussions ensue relating to proper mathematical communication.

The common pronoun, “it” is not permitted to be used in any form of verbal or written communication. Likewise, we stress the use of proper notation, like *f*, *f’*, *f’’*, etc. As the year goes on, it often becomes comical when we all try to catch each other’s mathematical grammar errors in class. But in the end, all of this pickiness pays off when they get their scores.

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**Course Design and Philosophy**

Students do best when they have an understanding of the conceptual underpinnings of calculus. Rather than making the course a long laundry list of skills that students have to memorize, we stress the “why” behind the major ideas. If students can grasp the reasons for an idea or theorem, they can usually figure out how to apply it to the problem at hand. We explain to them that they will study four major ideas during the year: limits, derivatives, indefinite integrals, and definite integrals. As we develop the concepts, we explain how the mechanics go along with the topics.

**Teaching Strategies**

During the first few weeks, we spend extra time familiarizing students with their graphing calculators. Students are taught the rule of four: ideas can be investigated analytically, graphically, numerically, and verbally. Students are expected to relate the various representations to each other. **[SC4, SC5, SC6 & SC7]**

It is important for them to understand that graphs and tables are not sufficient to prove an idea. Verification always requires an analytic argument. Each chapter exam includes one or two questions that involve only graphs or numerical data.

I believe it is important to maintain a high level of student expectation. I have found that students will rise to the level that I expect of them. A teacher needs to have more confidence in the students than they have in themselves.

We also stress communication as a major goal of the course. Students are expected to explain problems using proper vocabulary and terms. Like many teachers, I have students explain solutions orally on the board to their classmates. This lets me know which students need extra help and which topics need additional reinforcement. Also, I have students explain and/or justify their solutions to problems in well-written sentences. **[SC8 & SC9]**

We often coordinate science activities using the Texas Instruments Calculator-Based Laboratory. Students will better understand the concepts of calculus when they see concrete applications.

Much of calculus depends on an understanding of a concept taught in a previous lesson. Students form study groups and tutor themselves.

Grading Procedures:

*Homework* will be assigned following instruction of each new topic and will be collected as a set on the day of a given test or quiz. AP Problem Sets will be due each week on a designated date set by the instructor. AP Problem Sets consist of three free response questions from released AP College Board exams related to topics discussed at that time in class. These three free response questions are graded using the same (or similar) nine point scale by which AP College Board grades.

*Miscellaneous* grades will consist of drills, class work, cooperative group work, daily five question homework quizzes (a.k.a. “5 pointers”), journals, and/or other assignments.

A F*ull AP Exam* will be given over the course of two days during the review weeks in 4th Quarter. This exam will be weighted as 40% of the final 4th Quarter grade. Students will have four parts to the exam, just like AP a multiple choice section and

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three free response questions allowing the use of a calculator, and a multiple choice section and three free response questions without the use of a calculator. The instructor will grade the exam using AP College Board guidelines. Students will have the opportunity to examine their topical strengths and weaknesses using the results of this exam.

The *Calculus Project* will make-up 10% of the 4th Quarter grade and will be done following the AP exam in May. Students will choose their own math-related topic to research. Students will be required to write a research paper and present their findings to the rest of the class.

Make-up Work

It is the student’s responsibility to obtain any missed assignments from the instructor. Quizzes and tests may be made up during the seminar block, or before or after school with special permission. There is a three (3) day deadline for making up quizzes and tests. After the deadline has passed, the instructor has the option to assign a grade of zero (0) for that assignment. There may be some exceptions to this deadline as determined by the instructor. The three days begin with the first day back from an absence after the quiz or test. Extended absences and special cases will be handled on an individual basis. Absence from a class that is designated as a review for a test or quiz DOES NOT exclude the student from taking that test or quiz.

**Textbook, Materials and Other Resources:**

Required Textbook

Finney, Ross L., Franklin D. Demana, Bert K. Waits, and Daniel Kennedy. (2010). Calculus: Graphical, Numerical, Algebraic Media Update (Third Edition). Boston,

MA: Pearson Prentice Hall.

Supplemental Textbooks and Readings

Ross L., Franklin D. Demana, Bert K. Waits, and Daniel Kennedy. (2007). Texas Instruments Technology Resourse Manual. Boston, MA: Pearson Prentice Hall.

Ross L., Franklin D. Demana, Bert K. Waits, and Daniel Kennedy. (2007). Teacher’s AP Correlations and Preparation Guide. Boston, MA: Pearson Prentice Hall.

Hockett, Shirley O. and Bock, David. (2008). Barron’s How to Prepare for the AP Calculus Advanced Placement Exam Calculus (9th Edition). Hauppauge, NY: Barron’s Education Series, Inc.

Stewart, James (2003). Calculus (5th Edition). Belmont, CA: Thompson Learning Brooks/Cole.

The Handbook of Calculus AB Review. (2000). Orem, UT: CEDO Publishers.

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Internet access and online resources.

AP Calculus AB published exam questions (1969-2011). Web Site: http://www.apcentral/collegeboard.com

**Course Content Outline:**

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| --- | --- | --- | --- | --- |
| **Unit** | **Quarter** | **Week** | **Topics** | **Assessments** |
| 1Functions & Trig.Review | 1 | 13 | * Function Representations (Graphical, Verbal, Numerical, Analytical)
* Functions and Models (Linear, Quadratic, Cubic, Power, Root, Rational, Trigonometric, Exponential, Logarithmic, Piecewise, Absolute Value, Step, Composite)
* Function Properties (Odd, Even, Symmetry, Increasing/Decreasing, One-to- One)
* Transformations of Functions (Shift, Reflect, Stretch, Compress)
* Trigonometry Review (Unit Circle, Trigonometric Identities)
* *Graphing Calculator Activities (graph a function within an arbitrary viewing window, find zeros of functions)*
 | * Daily Five Question Quizzes
* Test (Functions & Trig. Review) consists of: Multiple Choice, Brief Constructed Response, Extended Constructed Response
 |
| 2Limits and Continuity | 1 | 47 | Formal Definition of Limit Limit Laws* Infinite Limits (Indeterminate Forms)
* Horizontal & Vertical Asymptotes (focus on communicating limit justifications)
* Continuity (3 Conditions)
* Discontinuity (Removable, Jump, Infinite)
* Intermediate Value Theorem (Existence Theorem)
* Sketch graphs of functions using limit properties
 | * Daily Five Question Quizzes
* Weekly AP Free Response Sets
* Test (Limits & Continuity) consists of: Multiple Choice, Brief Constructed Response, Extended
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|  |  |  |  | Constructed Response |
| 3Derivatives | 1 & 2 | 814 | * **Activity one**
* Slope as a rate of change
* Instantaneous rate of change vs. Average rate of change
* **Activity two**
* Tangent & Normal Lines
* Limit Definitions of Derivatives (as *h* →0 and *x*→*a*)
* The Derivative as a Function (focus on communicating the importance of notation)
* Differentiability implies Continuity (not reverse)

----------------------------------------* Derivative Rules (Constant, Power, Sum, Difference, Product, Quotient)
* Higher Order Derivatives
* Particle Motion (Position, Velocity, Acceleration, Jerk) (focus on communicating the importance of notation & drawing conclusions)

----------------------------------------* Trigonometric Derivatives
* Chain Rule
* Derivatives using tables

----------------------------------------* Implicit Derivatives
* Exponential & Logarithmic Derivatives
* Derivative of an Inverse Function
* Derivatives of Inverse Trigonometric Functions (sin1*x*, cos1*x*, tan1*x* only)
 | * Daily Five Question Quizzes
* Weekly AP Free Response Sets
* Quiz (Rates of Change, Limit Definition of Derivatives) consists of: Brief Constructed Response
* Quiz (Derivative Rules & Particle Motion) consists of: Brief Constructed Response
* Test (Derivative Rules) consists of: Multiple Choice, Brief Constructed Response, Extended Constructed Response
* Test (All Differentiation) consists of: Multiple Choice, Brief Constructed Response, Extended Constructed Response
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| 4Applications of Derivatives | 2 | 1520 | * Extrema (Critical Numbers, Absolute Max/Min, Relative Max/Min)
* **Activity 3**
* Increasing/Decreasing Intervals
* Concavity Test
* Points of Inflection
* 1st & 2nd Derivative Tests (Max/Min) (focus on writing and
 | * Daily Five Question Quizzes
* Weekly AP Free Response Sets
* Test (Apps. Of
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|  |  |  | drawing conclusions from sign charts)* *Graphing Calculator Activities (numerically calculate the derivative of a function)*
* Mean Value Theorem & Rolle’s Theorem

----------------------------------------* Revisit sketching graphs of

*f*, *f* ’,*f* ”* L’Hopital’s Rule (revisit vertical asymptotes, horizontal asymptotes, limits at infinity) (focus on communicating limit justifications
* Using Derivatives to find Functions

----------------------------------------* Optimization (focus on writing and drawing conclusions)
* Related Rates (focus on writing and drawing conclusions)
* Linearization
* *Graphing Calculator Activities (store values without rounding and retrieve these stored values)*
 | Derivatives) consists of: Multiple Choice, Brief Constructed Response, Extended Constructed Response* Quiz (Curve Sketching, L’Hopital’s Rule) consists of: Multiple Choice, Brief Constructed Response
* Quiz (Optimization, Related Rates, Linearization) consists of: Multiple Choice, Brief Constructed Response, Extended Constructed Response
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|  |  |  |  | **COMPREHENSIVE SEMESTER EXAM**(timed exam – 90 minutes) consists of: Multiple Choice & 3 Free Response Questions (graded using AP College Board scale) |
| 5Integrals | 3 | 2225 | * **Activity 4**
* Finding areas of regions
* Riemann Sums (Left, Right, Midpoint)
* Trapezoidal Rule

----------------------------------------* Definite Integrals (focus on communicating the importance of notation)
* Indefinite Integral Rules (Power, Sum, Difference,
 | * Daily Five Question Quizzes
* Weekly AP Free Response Sets
* Quiz (Finding areas, Riemann Sums, Trapezoidal Rule) consists of: Brief Constructed Response
* Quiz (Integration
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|  |  |  | Trigonometric, Exponential)* Properties of Integrals

----------------------------------------* Fundamental Theorem of Calculus (Parts 1 & 2)
* *Graphing Calculator Activities (numerically calculate the value of a definite integral)*
* **Activity 5**
* Net Change
* Revisit Particle Motion (with integrals) (focus on communicating the importance of notation & drawing conclusions)

----------------------------------------* U-Substitution
 | Rules) consists of: Multiple Choice, Brief Constructed Response* Quiz (FTC, Net Change, Particle Motion) consists of: Brief Constructed Response
* Test (All Integration) consists of: Multiple Choice, Brief Constructed Response, Extended Constructed Response
 |
| 6Applications of Integrals | 3 & 4 | 2630 | * Areas between curves
* *Graphing Calculator Activities (find the intersection(s) of two functions, store values without rounding and retrieve these stored values, numerically calculate the value of a definite integral)*
* Volumes (using disks and washers)

----------------------------------------* Cross Sections
* Arc Length
* Average Value
* Mean Value Theorem for Integrals
 | * Daily Five Question Quizzes
* Weekly AP Free Response Sets
* Quiz (Areas & Volume) consists of: Brief Constructed Response
* Test (Applications of Integrals) consists of: Multiple Choice, Brief Constructed Response, Extended Constructed Response
 |
| 7Applications with Differential Equations | 4 | 3132 | * Modeling with Differential Equations (Growth & Decay) (focus on writing and drawing conclusions)
* Separable Differential Equations
* **Activity 6**
* Slope Fields
* **Activity 7**
 | * Daily Five Question Quizzes
* Weekly AP Free Response Sets
* Test (Apps. with Diff. Eqs.) consists of: Multiple Choice, Brief Constructed Response, Extended Constructed Response
 |
| *Study Time!* | 4 | 33-36 | * Grade student samples & discuss grading techniques
* Practice timed multiple choice & free response questions
 | * AP Exam – **Wednesday, May , 20 at 8:00 a.m.**
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|  |  |  | * Full AP exam given over 2 days grade & discuss\*\*
 | \*\*Full AP exam will constitute 40% of fourth quarter grade. |

**Student Activities:** After completing these activities such as in activity 2 students will write in their activity/ note section of their three ring binder, how the activity helps them to understand the current content being explored. In particular whenever students explore specific points with functions or graphs and the relationship to quantities or problems they will describe these differences in their note section and when it is an activity they will write it up in lab form with paragraph form in their justification of conclusions. Also, within each problem section of the textbook are writing activities. One of each of the writing activities will be attempted each week in groups for a specified length of time. Their own individual conclusions will then be worked on as homework and submitted. Their work must differ from other students by what they uniquely write. This is a weekly activity and will be determined by where students are having difficulties each week. The following activities will be accomplished and others may be attempted as time availability dictates. Writing and the use of the calculator to solve, graph and explain what is being communicated algebraically is of the utmost importance in the use of calculus to solve real world problems. It is a daily activity to communicate orally and in writing in reference to problems solved.

**Activity 1.** we begin the study of derivatives with an CBL experiment that we conduct within the physics lab in conjunction with the physics department. We combine our labs in the beginning of the school year to introduce students to the cross curricular nature of physics and calculus. This relationship is fostered throughout the year. Students generate and write the procedures, data tables, graphs, equations and provide explanations for the lab. This is a common ball toss lab with height verse time. It involves a quadratic equation that must be fit to the data. They can use their Lists and Stat Calc quadratic regression function of their calculator to provide the function. They then compare the height to the problems in the book regarding position. They will also use the instantaneous and average velocity functions and write the differences associated with the two sets of calculations.

They are then asked to determine the velocity of the

ball at exactly 0.06 seconds after the ball was tossed and explain how their answer

was obtained. Finally, they zoom in on the graph of the position function near *t* =0.06 until the graph looks like a line. Students find the slope of the line and compare it to their estimation of the instantaneous velocity at *t* = 0.06. [SC5 & SC11]

**Activity 2.** Position vs time with derivatives to determine the velocity or rate of change. Students will slide an object such as a marker along two meter sticks connected with tape at the middle to represent a number line with zero being the joint between the two sticks and the distance of one unit being 2 decimeters in length marked with a non-permanent marker or tape, in two colors, one color on the positive side and one color on the negative side. Two colors of meter sticks could be used as well. The sticks would not have to be meter sticks either. Any type of stick would work well as long as markings were clear and the point at which distance traveled switched from positive to negative or negative direction to positive direction, was clear.

Students will work in a group size corresponding to the number of students divided by the number of stick setups. The example below is for four students in a group.

Students will take turns moving the object along the stick according to a graph that they have studied for 1 minute while the other students prepare their job. Student two will time the movement and state “start, 1, 2, 3, and 4” corresponding to the number of seconds that has passed on a stop watch which is on their smart phone or ipod or watch or supplied. At four seconds the student stops. The third student marks with tooth pick markers on one side of the stick, where the object is at the start and at each stated second. The fourth student puts another color of toothpick down on the other side of the sticks where the marker changes directions.

The students other than the one that slid the object along the sticks then make a graph of position. They will then compare the graph they made to the graph the student was using to determine their position movements.

After a short discussion they will have the student repeat the procedure using the same toothpicks. This time they will make another graph to approximate velocity. At the estimated points in time that the object stopped and changed direction they will put dots on the x-axis of their velocity graph. If the object starts moving in a positive direction they will put a dot on the y- axis above the x-axis. If the object starts by moving in a negative direction they will put a dot on the y-axis below the x-axis. What direction the object is traveling at 4 seconds will determine where a dot is placed above or below the x-axis at x = 4. This will then note end behavior of their graph.

**Activity 3.** Students can design an optimum container by which to store different liquids of various densities. They must also consider the forces exerted at various sections of the containers. Students will use a cylindrical can of various types and then expand the unit from centimeters to meters to determine the forces exerted at the bottom of the cans. They may extend the activity by considering the cost of materials most likely necessary to build tanks of various shapes and then research the type of cylinder most often used to store various types of liquids. Comparing the heights and radii of the types of cylinders that are available to them and then the extensions they can form tables and compare the costs associated with materials.

They should then use these as points on a graph of the change in volumes vs radius and determine a function and the resulting derivative to describe these changes as radii changes. Using well-written sentences of the mathematics involved in making their determination.

Students then draw carefully and correctly with units and explanations in a lab write up what the most cost-effective cylinder would be for various substances along with the math and justification of their results. Research into what is being done and why is an important aspect of this activity. They will then make a presentation to the class. **[SC9]**

**Activity 4.** n exploration using the graphing calculator is conducted in table groups where

students graph *f*(*x*) = (*x*^2 + 0.0001)^0.25 + 0.9 around *x* = 0. Students algebraically find the equation of the line tangent to *f*(*x*) at *x* = 0. Students then repeatedly zoom in on the graph of *f*(*x*) at *x* = 0. Students are then asked to approximate *f*(0.1) using the tangent line and then calculate *f*(0.1) using the calculator. This is repeated for the same function, but with different *x* values further and further away from *x* = 0.

Students then individually write about and then discuss with their tablemates the use of the tangent line in approximating the value of the function near (and not so near) *x*

= 0. **[SC6, SC8 & SC11]**

**Activity 5.** After learning how to approximate a definite integral, students use these techniques to calculate the distance covered during a 20-minute drive with a friend

or parent. Before beginning the drive, students record the car’s odometer reading. Using the speedometer, they record the car’s speed at 1-minute intervals,

noting any traffic conditions. At the end of the drive, they check the odometer reading again. Students then graph speed versus time and use integration techniques to approximate the distance traveled over the 20-minute interval. They compare this distance with the actual mileage determined by the odometer. Students are often amazed at the closeness of their approximation to the odometer reading. Students are to write a report on this project that includes an explanation of data collection, graphing of the data, interpretation of the data, and the closeness of their approximation to the odometer reading. [SC9]

**Activity 6.** Introduction to slope fields, I use a dot quadrant graph that is saved on Smart Notebook as a resource. I assign each student several coordinate

points in the region (([1, 1], [1, 2]), etc.).

For a given differential equation, each student computes the slope at his or her coordinate position and then goes to the board to draw a short line segment

with the calculated slope and the coordinate point as the midpoint of the segment.

For example, if *dy/dx* = *y*, the student with coordinates (1, 1) would go to the board and at the point (1, 1) draw a short line segment with a slope of 1. The student with coordinates (1, 2) would go to the board and at the point (1,

2) draw a small line segment with a slope of 2. (It is important that the second student draw a line segment whose slope is steeper than the slope of the first student’s line segment.) Continuing in this fashion, the class would complete the slope field. The students then use their calculator to graph a solution found

analytically to the differential equation. The students are asked to use the graph with their calculator to interpret the results and to support their conclusions through writing to describe the relationships.

[SC4, SC5, SC6 SC11 & SC12]

**Activity 7**. To visualize solids of revolution I will use play-Doh and numerous objects to form impressions of cylinders and other solids that can be formed around string or floss. Students can construct solids whose bases are bounded by two curves and whose cross sections are squares or equilateral triangles. Students build the solids using Play-Doh and then use plastic knives or dental floss to cut through the solid and obtain the required

cross sections. They will draw pictures of the cross sections and take pictures with their ipods or phones and upload to keep with their problem solutions. They will write a paragraph to describe the process involved with creating the solids that were revolved and around which axis.14

Students will also keep this activity as well as all others described and written up as a classroom

project in their three ring binder in their notes/activity section.

**Assessment:**

Assessment and evaluation are essential to learning and teaching. Ongoing assessment and evaluation are significant in supporting student achievement, motivating student performance and providing the basis upon which teachers make meaningful instructional decisions. All aspects of progress in mathematics are measured using multiple methods such as: authentic, performance, observational, and formative assessments; group and individual projects, student presentations, and conventional summative assessments. Student understanding is evaluated using an assessment cycle that includes pre-, formative, and summative assessments. Pre- assessments are used as the unit is begun to determine the student’s level of understanding. The pre-assessment is used by a teacher to plan instruction. Formative assessments are used to check student understanding while learning is occurring, and provide students and teachers with learning progress information. Pre- and formative assessments are not used to determine grades. Summative assessments, such as unit and semester tests, evaluate student achievement, and along with other measures such as student presentations and project work are data points used to determine the level of student performance.

**Support Services:**

All students meet for calculus class every other day for an 85-minute block. On the opposite days, all students have a seminar block during which they have the opportunity to meet with the instructor and other calculus students to get extra help, make-up quizzes and tests, etc., if needed.

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