Example of a Well-Designed Course in: Mathematics

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1. Specific Context

- **The subject matter: Calculus I, differential calculus, the mathematical study of change.**
- **The title of the course: Calculus I**
- **Typical class size: 28-34 in a tiered classroom**
- **Level of the course: Freshman**
- **Mode of delivery: Face-to-face 4 days per week for 50 minutes, with online homework system (WileyPlus) and flipped components**
- **Type of institution: Master's Comprehensive University**

2. General Description of the Course

A study of limits, continuity, differentiation, applications of the derivative, the differential, the definite integral, the fundamental theorem, and applications of the definite integral. (4 credits)

3. Big Purpose of the Course (Life Value)

Students will analyze rates of change (derivatives) of scientific data to understand and interpret the behavior of the data, then make predictions. For example, if we can understand the rate at which a drug is metabolized (the rate of change), then we know (predict) when to administer more. Students will gain a deeper appreciation for how scientists use calculus in different fields. An appreciation and understanding of the connectedness between math and science is critical to make the best (often political) decisions for our future.

4. Important Situational Factors/Special Pedagogical Challenge

Situational Factors:	**Responses/Solutions**:
• Preconceived notion of what a math class looks like • Diverse population with varying learning styles	• Through journals students will reflect on how they learn. Their first journal entry that is due the first day of class asks them to reflect on what a quality math is, and what characteristics the professor and student should have to support learning. • Incorporate more variety of learning activities (journals, group quizzes, group problem solving, interview, tests) • Provide more choices for students (for example, watch a video lecture or come to the lecture or both)
Special Pedagogical Challenges:	**Responses/Solutions**:
• Students often do not have the prerequisite skills to be successful in calculus. • Students tend not to practice enough	• Spend more time highlighting the key pre-calculus skills they will use • Provide supplemental resources in Wiley Plus

Descriptions of Learning Activities:

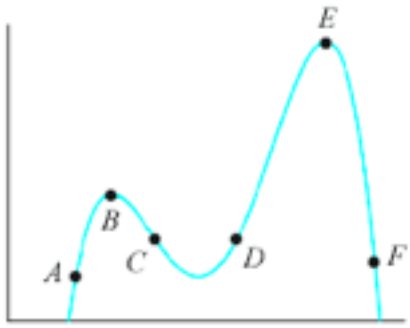
1. Wiley Plus: Wiley Plus is a program that allows students to practice the basics or the mechanics of calculus. For example, during the study of the chain rule, the Wiley Plus assignment will have students practice using the chain rule and learn when to apply the chain rule. Each week a Wiley Plus assignment will be assigned on Monday. Between Monday and Tuesday classes, student must complete one attempt on the assignment. Students will have one week and several attempts to complete each Wiley Plus assignment. These address learning goals (1) and (2).

Examples from Wiley Plus:

1. (foundational knowledge)

a. Is the function $f(x)=2x+x^{-1}$ continuous on the interval [-2,4]? Justify.

b. For the function shown in the figure below, at what labeled points is the slope of the graph positive? Negative?



2. (application of limit definition of derivative)

Find the derivative of by using the difference quotient.

2. Group Problem Solving: One day each week is devoted to group problem solving. These problems will focus on applying the skills/mechanics of calculus to gain a deeper understanding of calculus concepts. These address learning goals (1), (2), (3) and (4).

Examples:

1. (application)

Find the value of k for which he function $P(t) = \begin{cases} e^{kt} & 0 \le t \le 12 \\ 100 & t > 12 \end{cases}$ is continuous over its entire domain. Show work to justify your conclusion.

2. (integration)

During the 1970s and 1980s the build up of chloroflurocarbons (CFCs) created a hole in the ozone layer over Antarctica. After the 1987 Montreal Protocol, an agreement to pause out CFC production, the ozone hole has shrunk. The ODGI (ozone depleting gas index) shows the level of CFCs present. Let $O(t)$ be the ODGI for Antarctica in year t; then $O(2000) = 95$ and $O'(2000) = -1.25$.

(a) Assuming that the ODGI decreases at a constant rate, estimate the value of the ODGI in 2013.

(b) Suppose we learn later that $C(t)$ is not exactly linear, in fact while $C''(t)$ is small it is positive, would your estimate from part (a) be an overestimate or an underestimate. Explain why you are correct.

3. Journal Entries: About 6 journal entries will be required throughout the semester. These journals will be online using google sites, and a link to their site will be in AsULearn. The entries address learning goals (4) and (6). Here are some possible prompts:

(a) Math Stereotypes: Describe characteristics of an effective math class. Describe characteristics of an effective math teacher. Describe characteristics of a successful math student. What one word comes to mind when you hear 'calculus'? Why?

(b) Describe ways in which a student can contribute to group work. Describe how you could contribute more to group work. Keep in mind the role of the group is to ensure that everyone learns.

(c) Describe Entity and Incremental views of intelligence in your own words. Do you see yourself in either category? Explain. How can you use what you learned about entity and incremental views of intelligence to help you?

4. Interview: Each student will interview someone in their chosen field (faculty or outside academia) about why they think calculus is important (required) for their major. Students can either type a report answering the questions or create a video or audio file summarizing their findings. This assignment addresses learning goal (5).

Pre-interview Question (answered online and reflected on within the final report)

1. Why do you think Calculus I is required for your intended major? (complete within first two weeks)

Sample Interview Questions: (final report/summary due Monday after Fall break)

2. Tell me about your mathematical background.
3. What do you remember from Calculus I?
4. Why is Calculus I required for [your major discipline]?
5. What ideas, concepts or skills do you want [your major discipline] majors to learn?
6. When might [your major discipline] use these ideas, concepts or skills?
7. One question you create.

5. Optimization/Related Rate Project (5%): Students will create either an optimization problem or related rate problem related to your major. Students will create a representation of their problem and solution. Students may create a multimedia representation or diorama. Projects will be judged on Monday & Tuesday before Thanksgiving break. This assignment addresses learning goal (3).

6. Quizzes (15%): The last meeting of every week is a quiz day, most of which will be group quizzes where part of the grade will come from self and peer assessment of each student's contribution. The quizzes address learning goals (1), (2), (3), and (4).

Sample Quiz Questions:

1. (foundational knowledge)

The entire graph of $f(x)$ is shown in Figure 1

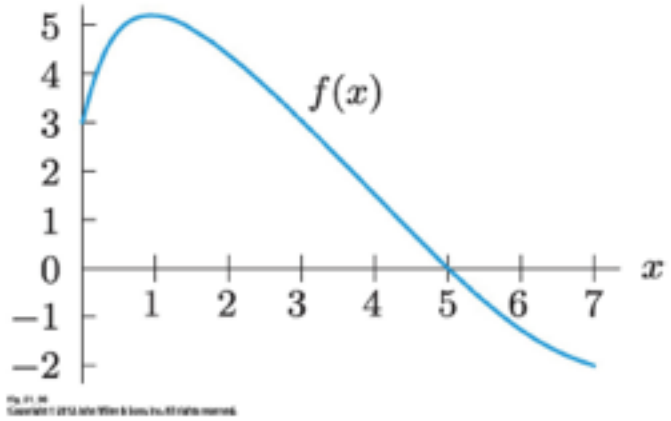


Figure 1: example caption

(a) What is the domain of $f(x)$?

(b) List all the zero(s) of $f(x)$.

(c) List all interval(s) on which $f(x)$ is decreasing.

(d) Is $f(x)$ concave up or concave down at $x = 6.5$?

(e) What is $f(4)$?

(f) What is $f^{-1}(0)$?

2. (application)

For some painkillers, the size of the dose, D, given depends on the weight of the patient, W. Thus, $D = f(W)$, where D is in milligrams and W is in pounds. Interpret the meaning of $f'(140) = 3$.

7. Tests (45%): The three tests will be individual assessments where partial credit is given. Each test will be created and graded by the instructor and will contain about 30% foundational knowledge, 40% application and 30% integration. The quiz questions and test questions are very similar types. The tests address learning goals (1), (2), and (3).

Descriptions of Procedure for Evaluating Student Learning:

1. Wiley Plus: Every Wiley Plus assignment will be graded automatically for accuracy, however, students have 3 attempts at each one. Each assignment will be

created by the instructor and automatically graded within Wiley Plus. In the beginning of the course, most of the chosen questions will test foundational knowledge. As the course goes on, theses assignments will include more application of the foundational knowledge.

2. Group Problem Solving: Weekly problem solving assignments will be graded for accuracy by the instructor and by self and peers on their group contribution (Peer Assessment Rubric).

3. Journal: Journal entries will be evaluated by the instructor based on level of thoughtfulness and detail towards the prompts, most of which relate to the students understanding of themselves and their learning process.

4. Interview: Summary and reflection of interview will be graded by the instructor using the interview rubric which includes criteria related to valuing the importance of calculus in their chosen field.

5. Project: Project will be evaluated by the instructor using the project rubric which includes criteria related to integrating calculus techniques to applications.

6. Quizzes: The quizzes will be created and graded by the instructor on accuracy and by their peers for group contribution (Peer Assessment Rubric). Partial credit will not be given. Earlier quizzes will weigh more foundational knowledge and application, while later quizzes will give more weight to integration.

7. Tests: Each test will be created and graded by the instructor and will contain about 30% foundational knowledge, 40% application and 30% integration.

5. 3-Column Table

Learning Goals: Learning Activities:	**Procedures for Evaluating Student Learning:**	
1. **Foundational Knowledge:** • By the end of the course students will be able to describe what a derivative is and how it connects to scientific data. (derivative=slope=rate of change)	• Wiley Plus practice problems will be graded automatically based on accuracy. • Quizzes and group assignments will be graded by the instructor. Earlier assignments (Wiley Plus and group) and quizzes will choose more questions that test foundational knowledge. • Tests will be graded by the instructor for accuracy. About 30% of each test will test for foundational knowledge.	Wiley Plus Group Activities (examples provided in a previous section)
2. **Application:** • Estimate derivatives from different representations of data • Analyze graphs related to rates of change.	• Wiley Plus practice problems will be graded automatically based on accuracy. • Quizzes and Group Assignments will be graded by the instructor. Earlier assignments will choose more questions that test application of foundational knowledge. • Tests will be graded by the instructor for accuracy. About 40% of each test will test for application.	Wiley Plus Group Activities
3. **Integration:** • Connect the use of derivatives to optimization and other scientific applications.	• Quizzes and Group Assignments will be graded by the instructor. Later assignments will include problems related to applying foundational knowledge to real applications. • Tests will be graded by the instructor for accuracy. About 30% of each test will test for integration. • The instructor will evaluate the project based on mathematical accuracy and creativity	Group Activities Optimization/ Related Rate Project

4. **Human Dimension:** • Identify areas of math and of the learning of math they have strengths and areas that need improvement.	• Peer and self assessment of peer collaboration (Peer Assessment Rubric)	Group Activities Quizzes Journal Entries
5. **Caring:** • Describe the importance of mathematics in their chosen field (biology, chemistry, physics, chemistry)	• Interview summaries (written, audio, or video) will be evaluated by the instructor based on rubric	Interview faculty in their field of study (their major)
6. **How to Continue Learning:** • Develop strategies and resources for continual learning.	• Journal entries will be evaluated by the instructor based on level of thoughtfulness and detail	Journal Entries that focus on math stereotypes and different types of intelligence (see Description of Learning Activities section)

6. Weekly Schedule

Before Class Meets: Journal Entry "Math Stereotypes" and Online Precalculus Refresher

Week Beginning	Monday	Between class	Tuesday	Between class	Wednesday	Between class	Thursday	Between class
8/16/15	Lecture: Functions, Trig, Polynomials & Rational	Wiley Plus (1st attempt)	Large Group Question/ Answer Sessions	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	
8/23/15	Lecture: Limits & Continuity	Wiley Plus (1st attempt)	Large Group Question/ Answer Sessions	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Journal Entry Preview video
8/30/15	Lecture: Derivative (at a point and as a function)	Wiley Plus (1st attempt)	Large Group Question/ Answer Sessions	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Preview video
9/6/15	Holiday	n/a	Lecture: Interpretations of a derivative Interview Assignment Due	Wiley Plus (1st attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Preview video
9/13/15	Lecture: Second derivative & Differentiability	Wiley Plus (1st attempt)	Large Group Question/ Answer Sessions	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Test	Journal Entry Preview video
9/20/15	Lecture: Short-cuts for Polynomials, exponentials & trig	Wiley Plus (1st attempt)	Large Group Question/ Answer Sessions	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Preview video
9/27/15	Lecture: Product & Quotient rule	Wiley Plus (1st attempt)	Large Group Question/ Answer Sessions	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Journal Entry Preview video

10/4/15	Lecture: Chain Rule	Wiley Plus (1st attempt)	Large Group Question/ Answer Sessions	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Preview video
10/11/15	Lecture: Implicit Differentiation	Wiley Plus (1st attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Journal Entry Preview video	No class	n/a
10/18/15	Lecture: Optimization	Wiley Plus (1st attempt)	Group Problem Solving	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Test	Preview video
10/25/15	Lecture: Related Rates	Wiley Plus (1st attempt)	Group Problem Solving	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Preview video
11/1/15	Lecture: L'Hopital Rule	Wiley Plus (1st attempt)	Group Problem Solving	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Journal Entry Preview video
11/8/15	Lecture: The Definite Integral & Fundamental Thm	Wiley Plus (1st attempt)	Large Group Question/ Answer	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Preview video
11/15/15	Lecture: Antiderivatives	Wiley Plus (1st attempt)	Large Group Question/ Answer	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Test	Preview video
11/22/15	Presentations		Presentations	Review Assignment	Holiday	n/a	Holiday	n/a
11/29/15	Lecture: Substitution Method	Wiley Plus (1st attempt)	Large Group Question/ Answer Session	Wiley Plus (2nd attempt)	Group Problem Solving	Wiley Plus (final attempt)	Quiz	Journal Entry: Letter to Future Student

Brief description of my teaching strategy

I believe at teacher must be authentic, honest, and encouraging, and be aware of personal bias. I will use a variety of teaching strategies such as active learning, cooperative learning, and integrating technology. I've selected these strategies to try to fit multiple student needs and provided student choices whenever feasible. I want my students to really think and connect the content from day to day and to the discipline of their major. The classroom environment must be non-threatening, respectful, welcoming, and thus have many low-risk practice activities. Learners need frequent assessment with timely feedback.

7. My Contact Information

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