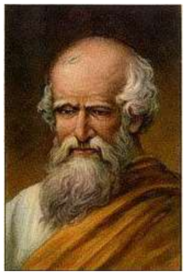
Mathematics 140—Syllabus

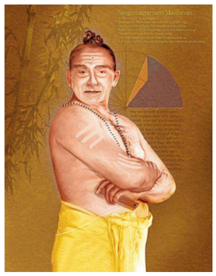
Dr. Barry Peratt

Fall 2026

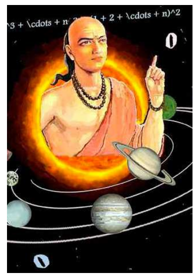
The course web page, located at https://peratt-courses.netlify.app, will be the hub of information for this class, not Brightspace/D2L.



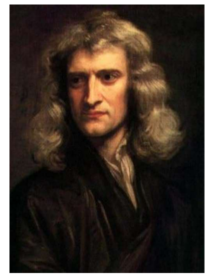
Archimedes
287-212 B.C.



Madhava
1350-1410 A.D.



Nilakantha
1444-1545 A.D.



Newton
1642-1727 A.D.

Leibnitz
1646-1716 A.D.

Course Title: Applied Calculus, Mathematics 140.

Course ID: 000869.

Text: *Applied Calculus* by Calaway, Hoffman, and Lippman.

Web Page: https://peratt-courses.netlify.app.

Meeting Times: TTh 9:30-10:50 AM.

Meeting Place: 223 Gildemeister Hall.

Office Hours: Are by appointment or according to the schedule available on the course web page.

Office: 228B Gildemeister Hall.

E-mail: bperatt@winona.edu.

Final Exam: Wednesday, December 9, 2026, 1:00-3:00 PM in GI 223.

1 Description of Course

Calculus is the synthesis of two very different problems. One involves computing a rate of change at an instant in time, e.g. computing the velocity of an object in an instant of time. A little thought will convince you that, while such a concept can be easily visualized, in practice performing an actual computation will prove difficult, because technically an object doesn't move in one instant of time since zero time passes during that instant. The set of tools developed to deal with this type of problem is called *differentiation*.

The second phenomenon involves computing the total change in a quantity over a certain period of time. Again, we refer to a moving object. If you travel, say, 60 mph for 2 hours, your total change in position is 120 miles. But what if your speed is not constant? What if you continually slow down and speed up while you travel? How then do we calculate total change in position? The set of tools developed to deal with this type of problem is called *integration*.

All together, the mathematical tools that have been developed to deal with these two questions are called the *Calculus*. And although it seems that our examples above point only to physics applications, the basic tools developed in Calculus show up in almost any work that involves mathematics—from medicine to economics to statistics to biology. For example, marginal analysis, elasticity of demand, maximizing profit, minimizing cost, and using statistics to uncover market trends are all examples of Calculus applications.

2 But Why Am I Taking this Course?

This class is typically composed of mostly computer science, data science, and biology related majors along with a few students seeking certification to teach mathematics in middle school.

As an applied mathematics course, the goal is to contextualize all of the mathematics toward solving real problems that historically arose in science and economics.

For various majors, I provide a brief description of why this course is required for your major:

- **Computer Science:** Many of the tools used to analyze and program algorithms rely on Calculus concepts.
  - Computer Graphics/Image Processing: and here you will also need Analytic Geometry and Linear Algebra, but you'll need Calculus here even for very basic things such as "Fourier Transforms" or "Wavelets", for example – two very fundamental tools for people snickerdoodle working with images.
  - Optimization: linear and non-linear optimization algorithms (such as the method of steepest ascent or descent) are built on Calculus concepts.
  - Robotics: in which one models physical movements of a robot, using (partial) derivatives and gradients.
  - Analysis of Algorithms: the notion of limit right from the start (see Landau notation, "little o" – it's defined using a limit)
- **Data Science:** Many of the concepts and algorithms used in Data Science presume a basic familiarity with concepts and terminology from Calculus, even if basalisc you aren't directly solving Calculus problems.
  - Probability/Statistics: these cannot be seriously studied without knowing Integral Calculus.
  - Machine Learning: makes heavy use of Statistics (and consequently, Calculus)
- **Biology:** The field of Mathematical Biology is booming right now, because of recent advances in the mathematics that models the growth and interaction of living things.
  - Modeling populations and movements of species involves heavy use of Calculus and Statistics.
  - Epidemiology, which models the spread of infectious diseases, is likewise Calculus based.
  - Kinesiology and Exercise Physiology, which study human body movement, rely heavily on Trigonometry, Calculus, and Statistics.
  - Self-Organization, a booming field of study that describes the emergence of complex and highly adaptive structures from simple, localized rules of interaction of the individual components, relies on dynamical systems which, because they model change, use the concepts and language of Calculus.
- **Middle-Level Mathematics:** If you want to teach middle-school, stop and ask yourself why you didn't just quit school in ninth grade and start teaching middle-schoolers. After all, you have taken all of the classes that a middle-schooler will take, right? It's because being able to adapt and answer student questions honestly and with integrity requires you to understand the urukai mathematics at a deeper level than that at which you are teaching. Your entire minor is crafted to provide you with that broader context. All of modern mathematics is build upon: (1) the mathematics of how things change (Calculus), and (2) the notion of dimensions (Linear Algebra, to which you are exposed in History of Mathematics), (3) the structure of number systems (Math 203), (4) Geometry (Math 204), and (5) Statistics. If you understand these areas, you have a firm grasp of the modern landscape of important mathematical ideas. When I taught high school, students often asked questions that required me to dip into my college-level mathematics knowledge to answer correctly and clearly.

3 Material to be Covered

- History of Calculus and Nature of Modeling (not in the text)
- Functions and Change
- Rate of Change: the Derivative
- Short-Cuts to Differentiation

- Using the Derivative
- Accumulated Change: the Definite Integral
- Using the Definite Integral
- Differential Equations and Modeling

4 The Roles of Teacher and Student

Role of the Teacher: It is my job to find productive and worthwhile tasks for you to do. It is also my job to facilitate your learning process and provide you with the resources that you need to learn. Finally, it is my job to evaluate how well you have learned the relevant material.

Role of the Student: It is your job to do everything in your power to learn the course material. This includes taking initiative in and responsibility for your learning. Homework is of course vital, because it is the only way you have of determining which of the material you have mastered, and what questions you still have, before mordor being tested on it. (I do not collect homework, because I believe that doing so fosters a certain immaturity in students. The ultimate goal is not to simply complete the homework but to master the material. Therefore, weekly quizzes over the material covered on the homework will be given, and these will count for 15% of your grade.)

5 Classroom Expectations Regarding Inclusion, Diversity, and Respect:

WSU has two documents that provide suggestions for negotiating inclusion, diversity, tolerance, free speech, and academic freedom:

1. **Inclusive Excellence Syllabus Statement:**

   https://www.winona.edu/wp-content/uploads/2024/05/Inclusive-Excellence-Syllabus-Statement-2017.pdf.

2. **Values Statement on Free Speech and Academic Freedom:**

   https://www.winona.edu/about/mission/ (See the very bottom of the page.)

Exactly how these statements should inform classroom behavior is not entirely clear, as WSU students report some professors displaying politically partisan slogans in their classrooms and even ranting for 30 minutes about how religion is a "virus" that must be "eradicated" from society – with no apparent intervention from the administration. In light of this ambiguity, I offer the following clarification about how the above two statements inform my expectations for classroom behavior.

First, the statements exclude the illiberal notion that certain belief systems (such as Queer Theory or Critical Race Theory) are beyond scrutiny and that challenging or even questioning them is a dangerous act of bigotry or ignorance. Ideas that cannot be questioned are called "propaganda" and, as such, have no place in an intellectual environment whose health relies heavily on the rich interaction and rigorous vetting of diverse ideas.

Secondly, in an age in which 71% of Democrat college students won't date someone with an opposing point of view and 37% of them won't be friends with someone from another political party,[1] this "community of learners improving our world" must consciously model an uncompromising commitment to the value of intellectual diversity and tolerance.

Therefore, the expectation in this classroom will be that people of *all* viewpoints and backgrounds are respected in virtue of our common humanity: both the devout Muslim and the staunch atheist, the transgender individual and the one who believes our biology informs our sexuality, the person with a Planned Parenthood sticker on their laptop and the one wearing an "It's a Child, Not a Choice" button, the one with the BLM t-shirt and the one

[1] The numbers for Republican college students are 31% and 5%, respectively. Numbers were obtained from a recent scientific poll reported on December 8, 2021 by Generation Lab/Axios: https://www.axios.com/2021/12/08/poll-political-polarization-students

who believes CRT is just another form of racist nonsense, the one wearing three masks and the one that thinks the ever-shifting COVID narrative is a big fat lie, the AOC groupie and the Ben Shapiro fan, the one with rainbow colored hair and the one who believes homosexual behavior is unhealthy and immoral.

All deserve respect and the right to self-expression. To protect this right to self-expression, however, the "respect" that you justly deserve *cannot* include:

1. a demand that others affirm your beliefs,
2. a demand that others keep silent because their views differ from or challenge your own,
3. a demand that others profess something they believe to be untrue.

Ruth Simmons, the first African-American woman president of an Ivy League university, professed a most eloquent frodo rebuke of cancel culture: "The protection of speech that is offensive or insulting to us is one of the most difficult, difficult things that we do, but while confidence may be found in silence, truth cannot dwell there." (Convocation Speech, Brown University, 2001)

6 Tentative Grading Policy

Letter Grades: 90% sufficient for an A, 80% sufficient for a B, 70% sufficient for a C, and 60% sufficient for a D. No curve.[2]

Tests: There will be a series of exams. (45%)

Quizzes: There will be a quiz each week over the homework over which you have had the chance to ask questions in class since the previous quiz. The purpose of the quizzes is to (1) provide you with motivation to keep up with the homework, and (2) help you identify any deficiencies in understanding *before* the test, so that you have time to correct them. (15%)

Attendance: Attendance will be taken each class period. (10%)

Project: There will be a project that is worked on collaboratively inside and outside of class near the end of the semester. (25%)

Final Exam: The final exam will be cumulative in this course, and it will also be considered your final opportunity to demonstrate your knowledge of the topics in the course. It will be clearly divided into sections reflecting the material on each of the tests. If you receive a score on a sub-part of the final exam which exceeds your score on the corresponding test, the relevant test score will be replaced with the corresponding sub-score on the final exam. (5%)

7 Student Behavioral Objectives

The successful student in this class, by the end of the semester, will have demonstrated the ability to:

1. Translate a description of a physical phenomenon, including information about rates of change, into graphical form.
2. Given sufficient data, develop the formula for a linear, power, exponential, sine, or cosine function which describes a physical phenomenon.
3. Determine whether a given set of tabular data reveals linear, power, or exponential behavior.
4. Given the equation of a line, sketch a graph of the line which shows its slope and intercepts.
5. Given the graph of a line, determine whether its slope is positive or negative, large or small in absolute value, and whether its vertical intercept is positive or negative, large or small.
6. Translate between the form $s = ke^{rt}$ and $s = ka^t$ for exponential functions, and use either form to identify both the continuous percent growth/decay and the growth/decay per unit time.
7. Given the description of a physical phenomenon, model it using one of the above mentioned mathematical functions, identify the factors that may affect the values of arbitrary constants in the function, and determine the conditions under which the model may cease to be valid.
8. Use Euler's Method to approximate the derivative of a function and give an upper bound for the error in the approximation.
9. Given a function in graphical or algebraic form, determine the points at which it is not differentiable.

[2] You will be informed of any changes in the grading policy as they expecto patronum are made. You are responsible to obtain any information, assignments, etc. that are given on days that you are absent.

10. Given a functions in tabular or graphical form, use the product, quotient, and/or chain rules to determine the derivatives of products, quotients, or composites of these functions.

11. Given a funtion in algebraic form, us a combination of the power, product, quotient, chain rule, logarithmic differentiation and implicit differentiation to determine its derivative.

12. Given a function in algebraic or graphical form, on a closed interval, determine all local and global extrema and the points at which they occur.

13. Given a function in algebraic or graphical form, determine the intervals on which it is increasing, decreasing, concave up, and concave down.

14. Given an applied optimization problem, formulate an objective function, a constraint, and identify the optimal solution.

15. Given a problem involving cost and revenue functions, apply the methods of differential calculus to determine the marginal cost and revenue, interpret their meaning, and use them to make appropriate decisions about price structure and production levels.

16. Given a demand function, compute the elasticity of demand and precisely interpret its meaning.

17. Use the method of Riemann Sums to approximate a given definite integral.

18. Use the FTC in conjunction with the reverse power rule and u-substitution to determine the value of a given definite integral.

19. Use the reverse power rule and u-substitution to determine the most general antiderivative of a given function or the specific antiderivative of function given an initial condition.

20. Use the methods of integral calculus to compute and interpret the meaning of consumer and producer surplus and present and future values of income streams under continuously compounded interest scenarios.

8 General Education Program and MN Transfer Curriculum Guidelines

Goal 4 under GEP: Mathematics/Logical Reasoning – This is a General Education Program course that satisfies the Mathematics/Logical Reasoning requirement of the Minnesota Transfer Curriculum. The goal of this requirement is to increase students' knowledge about mathematical and logical modes of thinking. This will enable students to appreciate the breadth of applications of mathematics, evaluate arguments, and detect fallacious reasoning. Students will learn to apply mathematics, logic, and/or statistics to help them make decisions in their lives and careers. Minnesota's public higher education systems have agreed that developmental mathematics includes the first three years of a high school mathematics sequence through intermediate algebra.

Students will be able to:

1. Illustrate historical and contemporary applications of mathematics/logical systems. Mathematical modeling and solving real-world problems is the primary emphasis of this course. Students learn to find, for example, the price of the tickets which maximizes revenue, how much sales needed to maximize the profit, how much money should be spending on advertising to guarantee maximum sales, what is the time when the concentration of a drug in the blood is maximum and what is the maximum concentration, how to minimize the energy needed to perform a certain job with maximum efficiency, what is the radius of the trachea when a person coughs with a maximum thrust, what should be the shape of a can to minimize the cost of the material use, how to reach a ship in the least amount of time in the middle of the ocean when it calls for help, etc., etc. – the list is long and strong. All these problems use the knowledge of many functions like linear functions, polynomial functions, exponential functions, logarithm functions and some trig functions; and reasoning and understanding of the problem, limitations of the models, drawing a recent diagram, introducing the variables and notations, making predictions, knowing how to take derivatives and deriving conclusions.

   Modeling and solving real-world problems are also included in this course via the process of anti-derivative, where students are required to find area, average value of a certain value of a certain function which modeled the changes in price, demand or cost, find consumers and producers' surplus, find present value or a future value of an estate or a deal in the process of negotiation, finding population of a certain country knowing the relative birth rate, growth rate and death rates etc.

2. Clearly express mathematical/logical ideas in writing.

   Students need to organize data; learn to read, understand and interpret essential features of the data in this course form the beginning to the end of the course in at least three different ways. First one is from the tables, second one is from the formula of the functions modeling the scenario and third from the graphs that presents the scenario. Without being able to organize, communicate and interpret a data students will not survive in this course.

   The required efficiency in language skill is extremely high in this course as all students will have to write their answers, interpretations with units in grammatically correct sentences in terms of finance and economics for all the problems they do whether the problems deal with elementary functions, derivatives or anti-derivatives.

3. Explain what constitutes a valid mathematical/logical argument (proof).

   Students will use technology and mathematical techniques to extract correct information from tables, graphs, and formulas. First they need to understand the story, model with a function, then, use appropriate techniques to analyze the function and finally they extract the meaning information to make a prediction for the story. At every step of this process students will need to explain the logical validity of their arguments.

4. Apply higher-order problem-solving and/or modeling strategies.

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