Stony Brook University
Mathematics Department
Paul Sweeney

Calculus I
MAT 131, online
Summer

Syllabus

Welcome to online Calculus I course (MAT 131)!

Course Description

The course will cover differential calculus and integral calculus, emphasizing conceptual understanding, computations and applications, for students who have the necessary background from 12th-year high school mathematics. Topics include: differentiation of elementary algebraic; trigonometric, exponential, and logarithmic functions; graphing; modeling and maximization; the Riemann integral; and the fundamental theorem. **Credits:** 4.

What to expect

This 6-week course includes 33 video lectures. You will watch a prerecorded lecture and after each video (or two) you'll have homework. There are 18 homework sets. There are three Quizzes. There is also a final exam. I will have office hours via Zoom.

Textbook:

Gilbert Strang Calculus. Volume 1, OpenStax:

Download for **free** at

https://openstax.org/details/books/calculus-volume-1

Grading:

You grade will be based on homework 35%, quizzes 25% and the final exam 40%.

The homework and quizzes will be given through **WebAssign** (WA), an online platform for the course.

Zoom:

We will use Zoom for office hours. Recurring links will be sent out at the start of the course.

WebAssign

WebAssign (WA) is the course online platform for doing assignments (homeworks, quizzes, the final). You have to purchase an access code to WA. You do not need to buy an online textbook or a paper textbook for WebAssign. All you need to get is an access code to WA.

WA interface is student-friendly. You won't get lost! If you have difficulties with solving any WA problem, you may press the button "Watch it" and a similar problem will be solved for you by a WA instructor.

For each HW problem, you get five chances to enter the answer (no penalties for first four incorrect answers).

You will take you homework, quizzes, and exams through WA.

How to study

The course is intensive and you have to move forward at a certain pace in order to not fall behind. You may follow the proposed **weekly schedule**. The assignments have deadlines. Don't miss them!

Important dates.

All HW are available 7 days before the date they are due. All Quizzes are available 2 days before they are due. All Quizzes are timed (45 mins).

Sunday 7/12 11:59pm: HW 1, HW 2, HW 3 are due.

Sunday 7/19 11:59pm: HW 4, HW 5, HW 6, Quiz 1 are due.

Sunday 7/26 11:59pm Week 3: HW 7, HW 8, HW 9, HW 10, Quiz 2 are due.

Sunday 8/2 11:59pm Week 4: HW 11, HW 12, HW 13, HW 14 are due.

Sunday 8/9 11:59pm Week 5: HW 15, HW 16, HW 17, Quiz 3 are due.

Tuesday 8/11 11:59pm Week 6: HW 18 is due.

Thursday 8/13 at 10am -12:30pm Final Exam.

A Note about Timed WA Assignments:

Once a student starts the assignment, the timer does not stop, even if the student closes the assignment or signs out of WebAssign. You should plan to complete the assignment in one session.

The actual due date for a timed assignment is either the date and time when the timer expires or the original assignment due date, whichever comes first. If a student starts a ten-minute timed assignment one minute before it is due, the student will have only one minute to complete the assignment.

If the time remaining until the assignment is due is less than the amount of time your student would otherwise have to complete the assignment, the timer displays only the remaining time until the assignment is due

Technology requirements

Windows: Chrome 65 or later Firefox 59 or later Microsoft Edge 16

MacOS/ OS X: Chrome 65 or later Firefox 59 or later

Linux: Firefox 59 or later

Recommended Bandwidth and Hardware:
Internet: 5+Mbps
RAM: 1+GB
Dispaly: 1024x768

How to reach the instructors

There will be online offices hours through Zoom.

You may also reach your instructors by email: paul.sweeney@stonybrook.edu

Course Webpage:

Blackboard for Stonybrook and for the video lectures:
http://www.math.stonybrook.edu/Videos/MAT131Online/

Course content

There are five large sections in the course. The first one is a review of pre-calculus.

Section 1. Elementary functions and their properties (review). Lectures 1-5.

Section 2. Limit of a function. Lectures 6-9.

Section 3. Derivative of a function. Lectures 10-15.

Section 4. Application of differentiation. Lectures 16-24.

Section 5. Integration. Lectures 25-33.

Weekly schedule

Week 1

Lecture 1. Generalities on functions. Domain, range, graph, even and odd functions, increasing and decreasing function.

Lecture 2. Operations on function. Addition, subtraction, multiplication, division, composition. Graphs transformations.

- **HW 1 (after Lecture 1-2)**

Lecture 3. Elementary functions. Part 1. Power functions, polynomials, rational functions, exponential functions.

Lecture 4. Elementary functions. Part 2. Trigonometric functions (sine, cosine, tangent, cotangent). Inverse functions.

Lecture 5. Elementary functions. Part 3. Logarithm, inverse trigonometric functions (arcsine, arccosine, arctangent).

- **HW 2 (after Lectures 3-5)**

Lecture 6. Limit of a function. Definition and properties of limit. Continuity and discontinuity. Intermediate Value Theorem.

Lecture 7. Calculation of limits. Direct substitution, algebraic transformations, squeeze theorem.

- **HW 3 (after Lectures 6-7)**

Week 2

Lecture 8. Infinite limits. Standard example of infinite limits (reciprocal function, tangent). Vertical asymptotes.

Lecture 9. Limits at infinity. Standard example of limits at infinity (reciprocal function, exponential function, arctangent). Limits of rational functions. Application for graphs' drawing. Horizontal and oblique asymptotes.

- **HW 4 (after Lectures 8-9)**

Lecture 10. Derivative. Part 1. Definition of derivative. Geometric meaning of the derivative. Tangent line.

Lecture 11. Derivative. Part 2. Derivatives of constant, linear and quadratic functions. Derivative as a rate of change. Leibniz notation for the derivative. Higher-order derivatives. Kinematic interpretation of the derivative as an instantaneous velocity. Differentiability and continuity.

- **HW 5 (after Lectures 10-11)**

Lecture 12. Differentiation rules. Part 1. Derivative of a power function. Derivative of sum and difference of functions. Product, reciprocal and quotient rules.

Lecture 13. Differentiation rules. Part 2. Chain rule for differentiation of a composition of functions. Derivative of exponential functions.

- **HW 6 (after Lectures 12-13)**
- **Quiz 1.**

Week 3

Lecture 14. Derivatives of trigonometric functions. Derivatives of sine, cosine, tangent and cotangent.

Lecture 15. Derivatives of inverse functions. Derivative of inverse function. Derivatives of logarithmic functions. Derivatives of power functions. Derivatives of inverse trigonometric functions (arcsine, arccosine, arctangent). Logarithmic differentiation.

- **HW 7 (after Lectures 14-15)**

Lecture 16. Linearization. Linear approximation of a function near a point and its geometric interpretation. Application for approximate calculations. Calculations with differentials.

- **HW 8 (after Lecture 16)**

Lecture 17. Maxima and minima. Local and absolute extrema. Extreme Value theorem. Fermat's theorem. Extreme values on a closed interval.

Lecture 18. The Mean Value Theorem. Rolle's theorem. Langange's theorem (Mean Value Theorem).

Lecture 19. First derivative test. First derivative test for finding intervals of increasing and intervals of decreasing and locating and classifying critical and singular points.

- **HW 9 (after Lectures 17-19)**

Lecture 20. Second derivative test. Concavity and inflection points. Second derivative test. Applications for graphs' drawing.

- **HW 10 (after Lecture 20)**
- **Quiz 2.**

Week 4

Lecture 21. Implicit differentiation. Functions that are defined implicitly. Implicit differentiation. Orthogonal families of curves.

Lecture 22. Indeterminate forms and L'Hôpital's rule. What is an indeterminate form? Types of indeterminate forms. L'Hôpital's rule and its applications for finding asymptotes.

- **HW 11 (after Lecture 21-22)**

Lecture 23. Related rates. How to calculate the rates of change of related quantities using implicit differentiation.

- **HW 12 (after Lecture 23)**

Lecture 24. Optimization problems. Part 1. Finding maximal or minimal value of a function under a constraint.

- **HW 13 (after Lectures 24)**

Lecture 25. Antiderivative and indefinite integral. Antiderivative and its properties.

Lecture 26. Elementary integration. How to integrate using the table of antiderivatives. Applications to differential equations and kinematics.

- **HW 14 (after Lectures 25-26)**

Week 5

Lecture 27. Area of a plane figure Axioms of area. Area of a disk.

Lecture 28. Definite integral as signed area. Area below the graph. Definite integral and its properties. Evaluation of integrals as signed areas.

- **HW 15 (after Lectures 27-28)**

Lecture 29. Riemann sums. Part 1. Define what a Riemann sum is. Definite integral as a limit of Riemann sums.

Lecture 30. Riemann sums. Part 2. Area under parabola as a limit of Riemann sums. Recognizing Riemann sums.

- **HW 16 (after Lectures 29-30)**

Lecture 31. The Fundamental Theorem of Calculus. The statement and proof of the Fundamental Theorem of Calculus.

Lecture 32. Integration using the Fundamental Theorem. Differentiation of an integral. Calculation of area between curves.

- **HW 17 (after Lectures 31-32)**
- **Quiz 3.**

Week 6

Lecture 33. Integration by substitution. Proof of a substitution rule. Simplest substitutions in the integrals. How to handle trigonometric integrals. Inverse trigonometric substitutions.

- **HW 18 (after Lecture 33)**
- **Final**

Study calendar

Week 1

Learning objectives:

Be capable to work with the concept of function, its domain, range, and graph. Be familiar with elementary functions (power, polynomials, rational, exponential, logarithmic, trigonometric, inverse trigonometric). Be able to identify even and odd functions and use symmetries for graph drawing. Be able to operate with the graphs of elementary functions using graph transformations: vertical shifts, horizontal shifts, vertical stretches/shrinks, reflections about the axes, horizontal stretches/shrinks. Interpret graphically formulas of piece-wise defined functions. Work with the concept of inverse function and relate the properties of a function and its inverse.

Demonstrate understanding of the concept of limit of a function at a point, as well as one-sided limits. Be able to estimate the limits from the graph of the function. Apply algebraic transformations to evaluate limits of rational functions and functions involving irrational expressions. State the Squeeze theorem and be able to interpret it geometrically. Be able to apply the Squeeze theorem for limit calculations.

Know the definition of continuous function and be able to operate with notion of continuity for limit calculations and graph drawing. Formulate the Intermediate Value Theorem and use this theorem for locating the roots of equations. Be able to identify the points of discontinuities of a function by a formula and graph.

Monday

Morning:
1. Watch video **Lecture 1 (Generalities on functions)**
2. Read textbook: Sec. 1.1 (Suggested; Reference)
3. Start doing HW 1.

Afternoon:
1. Watch video **Lecture 2 (Generalities on functions)**
2. Read textbook: Sec. 1.2-1.3 (Suggested; Reference)
3. Continue with HW 1.

Tuesday

1. Watch video **Lecture 3 (Elementary functions. Part 1)**
2. Read textbook: Sec. 1.5 (Suggested; Reference)
3. Finish HW 1. (HW 1 is due Sunday 11:59pm.)

Wednesday

Morning:
1. Watch video **Lecture 4 (Elementary functions. Part 2)**
2. Read textbook: Sec. 1.6, Appendix C (Suggested; Reference)
3. Start HW 2.

Afternoon:
1. Watch video **Lecture 5 (Elementary functions. Part 3)**
2. Read textbook: Sec. 1.6, 3.6 (Suggested; Reference)
3. Continue with HW 2.

Thursday

1. Watch video **Lecture 6 (Limit of a function)**
2. Read textbook: Sec. 2.2 (Suggested; Reference)
3. Finish HW 2 (HW 2 is due Sunday 11:59 pm)

Friday

1. Watch video **Lecture 7. Calculation of limits.**
2. Read textbook: Sec. 2.3-2.4 (Suggested; Reference)
3. Start HW 3.

Saturday

Finish HW 3 (HW 3 is due Sunday 11:59 pm.)

Sunday

Deadline for HW 1, HW 2, HW 3 is Sunday 11:59pm.

Week 2

Leaning objectives:

Define infinite limits and the concept of vertical asymptote. Define limits at infinity and the concept of horizontal asymptote. Be able to apply the knowledge of limits involving infinity for graph drawing. Be able to draw the graphs of rational functions using the concept of oblique asymptote.

Provide the definition of derivative of a function at a point and its geometric interpretation as the slope of tangent line. Interpret the slope of tangent line as the limit of slopes of secant lines. Be able to calculate the derivative of simplest functions (quadratic, cubic, reciprocals) as the limit of a difference quotient. Be able to write the equation of the tangent line to the graph of a function at a given point using the slope-intercept form.

Comprehend the derivative of f as a new function derived from f. Be able to draw the graph of f' given the graph of f. Utilize the Leibniz notation for derivative and use the differential of a function for approximate calculations. Adopt the concept of higher derivatives. Be

able to give a kinematic interpretation to the derivative as instantaneous velocity. Be able to calculate velocity, acceleration and jerk. Interpret the derivative as the rate of change.

Describe relationship between differentiability and continuity: differentiability implies continuity – the converse is not true. Be able to use differentiation rules to calculate the derivative of sum, difference, product, multiple, reciprocal, quotient. Prove these rules. Formulate the chain rule and use it for differentiation of a composition of two or more functions. Know the derivatives of power, exponential, and trigonometric functions and understand how these rules are derived. Be able to find the derivative of any elementary function.

Be familiar with the notion of a differential equation and its solution. Be able to check whether a function is a solution of a differential equation.

Monday

Morning:
1. Watch video **Lecture 8 (Infinite limits)**
2. Read textbook: Sec. 2.5. (Suggested; Reference)
3. Start doing HW 4.

Afternoon:
1. Watch video **Lecture 9 (Limits at infinity)**
2. Read textbook: Sec. 2.5 (Suggested; Reference)
3. Finish HW 4.

Tuesday

1. Watch video **Lecture 10 (Derivative. Part 1)**
2. Read textbook: Sec. 2.6. (Suggested; Reference)
3. Start HW 5.

Wednesday

1. Watch video **Lecture 11 (Derivative. Part 2)**
2. Read textbook: 2.6-2.7. (Suggested; Reference)
3. Finish HW 5 (HW 5 is due Sunday 11:59 pm.)

Thursday

1. Watch video **Lecture 12 (Differential rules. Part 1)**
2. Read textbook: Sec. 3.1-3.2. (Suggested; Reference)
3. Start HW 6.

Friday

1. Watch video **Lecture 13 (Differential rules. Part)**
2. Read textbook: Sec. 3.4. (Suggested; Reference)
3. Continue with HW 6.

Saturday

Finish HW 6 (HW 6 is due Sunday 11:59pm.)

Sunday

Deadline for HW 4, HW 5, HW 6 is Sunday 11:59pm.
Take Quiz 1 by 11:59pm.

Week 3

Learning objectives:

Establish the relationship between the derivatives of a function and its inverse. Be able to prove this relationship using the chain rule. Prove formulas for derivatives of logarithmic and inverse trigonometric functions. Be able to use the technique of implicit differentiation. Provide the concept of a linear approximation of a function and be able to use it for approximate calculations. Estimate how errors in measurement propagate in calculations. Interpret linear approximations geometrically.

Formulate the notion of local and global extrema and identify the extreme points by studying the graph of a function. State the Extreme Value Theorem. Describe where the extreme points of a function may be located (at critical and singular points of a function, and endpoints of the domain). Be able to apply algorithm of finding extreme values of a function defined on a closed interval. Be able to formulate and prove Rolle's and Lagrange's theorems. Be able to apply the first derivative test for finding intervals of increasing and intervals of decreasing of a function and for locating extreme values. Demonstrate relationship between the concavity of the graph and the second derivative of the function. Be able to locate inflection points on the graph. Be able to use information obtained from studying the first and second derivative for graph drawing.

Monday

Morning:
1. Watch video **Lecture 14 (Derivatives of trigonometric functions)**
2. Read textbook: Sec. 3.3. (Suggested; Reference)
3. Start doing HW 7.

Afternoon:
1. Watch video **Lecture 15 (Derivatives of inverse functions)**
2. Read textbook: Sec. 2.6-3.7. (Suggested; Reference)
3. Finish HW 7.

Tuesday

Morning:
1. Watch video **Lecture 16 (Linearization)**
2. Read textbook: Sec. 3.9. (Suggested; Reference)
3. Start and finish HW 8.

Afternoon:
1. Watch video **Lecture 17 (Maxima and minima)**.
2. Read textbook: Sec. 4.2. (Suggested; Reference)
3. Start and finish HW 9. (HW 9 is due Sunday 11:59pm Week 3)

Wednesday

1. Watch video **Lecture 18 (Mean value theorem)**
2. Read textbook: Sec. 4.3. (Suggested; Reference)
3. Start with HW 10.

Thursday

1. Watch video **Lecture 19 (First derivative test)**
2. Read textbook: Sec. 4.3 (Suggested; Reference)
3. Continue HW 10 (HW 10 is due Sunday 11:59pm Week 3)

Friday

1. Watch video **Lecture 20 (Second derivative test)**
2. Read textbook: Sec. 4.3 (Suggested; Reference)
3. Continue HW 10.

Saturday

Finish HW 10 (HW 10 is due Sunday 11:59pm Week 3)

Sunday

Deadline for HW 7, HW 8, HW 9, HW 10 is Sunday 11:59pm.
Take Quiz 2 by 11:59pm.

Week 4

Learning objectives.

Distinguish two different ways for presentation of a function: explicit and implicit. Be able to perform implicit differentiation and interpret it geometrically. Be able to find an equation of the tangent line to a curve which is not the graph of a function. Be able to use implicit differentiation to calculate the second derivative of a function defined implicitly. Use the implicit differentiation to determine the shapes of the curves given by implicit equations.

Recognize and classify indeterminate forms. Know when L'Hôpital's rule can be applied and be able to use it, repeatedly if necessary. Be able to use L'Hôpital's rule for finding asymptotes.

Be familiar with successful strategies for solving of related rates problems (understand the wording of a problem, translate the problem into mathematical language, make an illustration, compose a constraint equation, perform implicit differentiation, interpret the results).

Be familiar with successful strategies for solving of optimization problems (understand the wording of a problem, translate the problem into mathematical language, make an illustration, composing a function and constraint equation, find the extreme points of the function and determine their types (maximum or minimum), interpret the results).

Provide the definition of antiderivative and use the integral sign appropriately. Know the antiderivative of standard elementary functions (power, exponential, trigonometric). Be able to use properties of antiderivative for calculation of indefinite integrals. Apply integration to various problems from kinematics (like falling under gravity or motion with acceleration).

Monday

1. Watch video **Lecture 21 (Implicit differentiation)**
2. Read textbook: Sec. 3.5 (Suggested; Reference)
3. Start HW 11.

Tuesday

1. Watch video **Lecture 22 (Indeterminate forms and L'Hôpital's rule)**
2. Read textbook: Sec. 4.5 (Suggested; Reference)

3. Finish HW 11 (HW 11 is due Sunday 11:59pm Week 4)

Wednesday
1. Watch video **Lecture 23 (Related rates)**
2. Read textbook: Sec. 4.1 (Suggested; Reference)
3. Start HW 12.

Thursday
1. Watch video **Lecture 24 (Optimization problems)**
2. Read textbook: Sec. 4.2 (Suggested; Reference)
3. Start and Finish HW 13.

Friday
1. Watch video **Lecture 25 (Antiderivative and indefinite integral)**
2. Read textbook: Sec. 4.8 (Suggested; Reference)
3. Start doing HW 14.

Saturday
1. Watch video **Lecture 26 (Elementary integration)**
2. Read textbook: Sec. 4.8 (Suggested; Reference)
3. Finish HW 14 (HW 14 is due Sunday 11:59pm Week 5)

Sunday

Deadline for HW 11, HW 12, HW 13, HW 14 is Sunday 11:59pm.

Week 5

Learning objectives:

State the axioms of area and be able to use these axioms to calculate the area of simplest figures, like rectangle, triangle, disk. Comprehend the definite integral of a positive function as the area of a region. Comprehend the definite integral of a bounded function (not necessary positive) as the signed area of a region. Be able to compute simplest definite integrals using their properties (linearity, additivity, monotonicity, upper and lower bounds, symmetry).

Explain how to calculate the area under a graph by approximating it by curvilinear trapezoids. Comprehend a Riemann sum and interpret it geometrically. Identify how it is related to the definite integral. Be able to present a definite integral as a limit of Riemann

sums. Be able to illustrate graphically the difference between a Riemann sum and the integral.

State and prove the Fundamental Theorem of Calculus. Be able to use the theorem for differentiating an integral. Establish the importance of the theorem as a primary tool for evaluation of definite integrals. Be able to use the evaluation part of the theorem for integration of standard elementary functions (power, exponential, trigonometric) and their sums and multiple products. Know how to calculate the area of a region between curves.

Monday
1. Watch video **Lecture 27 (Area of a plane figure)**
2. Read textbook: Sec. 5.1 (Suggested; Reference)
3. Start HW 15.

Tuesday
1. Watch video **Lecture 28 (Definite integral as signed area)**
2. Read textbook: Sec. 5.2 (Suggested; Reference)
3. Finish HW 15. (HW 15 is due Sunday 11:59pm Week 5)

Wednesday
1. Watch video **Lecture 29 (Riemann sums. Part 1)**
2. Read textbook: Sec. 5.2 (Suggested; Reference)
3. Start doing HW 16.

Thursday
1. Watch video **Lecture 30 (Riemann sums. Part 2)**
2. Read textbook: Sec. 5.2 (Suggested; Reference)
3. Finish HW 16 (HW 16 is due Sunday 11:59pm Week 5)

Friday
Morning:
1. Watch video **Lecture 31 (Integration using the Fundamental Theorem)**
2. Read textbook: Sec. 5.3-5.4 (Suggested; Reference)
3. Start HW 17.

Afternoon:

1. Watch video **Lecture 32 (Applying the Fundamental Theorem)**
2. Read textbook: Sec. 5.3-5.4, 6.1 (Suggested; Reference)
3. Finish HW 17.

Saturday
Free

Sunday
Deadline for HW 15, HW 16, HW 17 is Sunday 11:59pm.
Take Quiz 3 by 11:59pm.

Week 6

Learning objectives:
Be able to calculate indefinite and definite integrals using substitution rule. Apply standard tricks to calculate integrals involving simplest trigonometric functions. Be able to recognize integrals requiring inverse trigonometric substitutions and use these substitutions.

Monday
1. Watch video **Lecture 33 (Integration by substitution)**
2. Read textbook: Sec. 5.5-5.7 (Suggested; Reference)
3. Finish and finish HW 18.

Tuesday
Deadline for HW 18 is Sunday 11:59pm.

Wednesday
Study for Final

Thursday
Final Exam @ 10am-12:30pm

Friday

Saturday
End of Term

Student Accessibility Support Center (SASC) statement: If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact SASC (631) 632-6748 or http://studentaffairs.stonybrook.edu/dss/. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential. Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and SASC. For procedures and information go to the following website: http://www.stonybrook.edu/ehs/fire/disabilities/asp.

Academic integrity statement: Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty are required to report any suspected instance of academic dishonesty to the Academic Judiciary. For more comprehensive information on academic integrity, including categories of academic dishonesty, please refer to the academic judiciary website at http://www.stonybrook.edu/uaa/academicjudiciary

Critical incident management: Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, and/or inhibits students' ability to learn.