CIEE Global Institute - Paris

Course name: Calculus I
Course number: (GI) MATH 1001 PAFR
Programs offering course: Paris Open Campus Block
Open Campus track: STEM and Society
Language of instruction: English
U.S. semester credits: 3
Contact hours: 45
Term: Fall 2019

Course Description

Students will learn the basic concepts of Calculus typical for the first semester of a two or three semester sequence: functions, limits and continuity, derivatives, integration and applications. Applications are drawn from many areas of science and engineering: biomechanics, ecology, epidemiology, genetics, medicine, pharmacology, physiology, and others. For example, in conservation biology, calculus measures the effect of habitat fragmentation on population dynamics; in epidemiology, calculus tracks antigenic changes in an influenza epidemic; in physiology, calculus shows how blood pressure depends on the radius of an artery.

Learning Objectives

Upon completion, students taking this course will be able to:

- Find and evaluate limits of functions using multiple methods
- Describe derivatives of algebraic and trigonometric functions
- Construct graphs of common functions using Calculus
- Use concepts of the derivative to establish limits, continuity, rates, optimization and area under curves
- Evaluate definite and indefinite integrals and use them to solve basic differential equations
- Define the Fundamental Theorem of Calculus and its applications
- Develop models to apply Calculus to everyday phenomena
- Articulate intuitively how Calculus works and its importance to local and global society

Course Prerequisites

None

Methods of Instruction

Students will attend lectures, problem-solving workshops, discussions and excursions. Lectures will emphasize theory and applications. Considerable time will be spent solving problems individually and in groups with instructor oversight. In addition, students will be given narratives to translate mathematically and compute their solutions. They will discuss the relevance of Calculus to a host of real life situations involving physics, engineering, architecture, conservation, public health and human physiology. Excursions will explore the use of Calculus in real life, including the local culture.

Assessment and Grading

Participation	20%
Weekly Quizzes (5)	25%
Problem Sets	30%
Lecture Activities	15%
Excursion Essays (2)	10%
Total	100%

Course Requirements

Weekly Quizzes

Each week, students will take a quiz on the previous week's course material, including lectures, activities and readings. Quizzes will have True/False, Multiple Choice, calculations, filling in blanks and short answer questions. Quizzes will cover only new material from that week but will build on previous concepts.

Problem Sets

Each session will include a set of problems for students to solve individually and in groups. Certain of these will be handed in a graded. Grading will include both the ultimate solution, the student's reasoning in solving the problem and the student's ability to clearly and intuitively explain the problem and its solution.

Lecture Activities

After each lecture, students will have a series of tasks and demonstrations related to the lecture material. They will work in groups to complete the tasks, handing in answers to a series of questions before leaving the class.

Excursion Essays

Some sessions will leave the classroom and enter Mérida's Historic Center and areas around the city. On excursions, students will visit sites where Calculus is used every day. They will interact with local mathematicians, construction workers, business owners and others to explore Calculus in the local culture. After these visits, students will select one application and write a 500 word essay to communicate how Calculus is used in that context to solve a real life problem.

Participation

Participation is valued as meaningful contribution in the digital and tangible classroom, utilizing the resources and materials presented to students as part of the course. Meaningful contribution requires students to be prepared in advance of each class session and to have regular attendance. Students must clearly demonstrate they have engaged with the materials as directed, for example, through classroom discussions, online discussion boards, peer-to- peer feedback (after presentations), interaction with guest speakers, and attentiveness on co-curricular and outside-of-classroom activities.

Class Attendance

Regular class attendance is required throughout the program, and all unexcused absences will result in a lower participation grade for any affected CIEE course. Due to the intensive schedules for Open Campus programs, unexcused absences that constitute more than 10% of the total course will result in a written warning.

Students who transfer from one CIEE class to another during the add/drop period will not be considered absent from the first session(s) of their new class, provided they were marked present for the first session(s) of their original class. Otherwise, the absence(s) from the original class carry over to the new class and count against the grade in that class.

For CIEE classes, excessively tardy (over 15 minutes late) students must be marked absent. Attendance policies also apply to any required co-curricular class excursion or event, as well as to Internship, Service Learning, or required field placement. Students who miss class for personal travel, including unforeseen delays that arise as a result of personal travel, will be marked as absent and unexcused. No make-up or re-sit opportunity will be provided.

Attendance policies also apply to any required class excursion, with the exception that some class excursions cannot accommodate any tardiness, and students risk being marked as absent if they fail to be present at the appointed time.

Unexcused absences will lead to the following penalties:

Percentage of Total Course Hours Missed	*Equivalent Number of Open Campus Semester classes*	*Minimum Penalty*
Up to 10%	1 content classes, or up to 2 language classes	Participation graded as per class requirements
10 – 20%	2 content classes, or 3-4 language classes	Participation graded as per class requirements; **written warning**
More than 20%	3 content classes, or 5 language classes	Automatic **course failure**, and possible expulsion

Weekly Schedule

NOTE: this schedule is subject to change at the discretion of the instructor to take advantage of current experiential learning opportunities.

Week 1 Functions and Graphs

Session 1.1 Functions –Trigonometric, Inverse, Exponential, Log Functions

Students will use functional notation to evaluate a function, determine the domain and range of a function, draw the graph of common functions, find the zeros of a function, recognize a function from a table of values, make new functions from two or more given functions and describe the symmetry properties of functions. In addition, they will calculate the slope of a linear function and interpret its meaning, recognize degrees and roots of polynomials, identify a rational function, describe graphs of power and roots functions, explain differences between algebraic and transcendental functions, graph a piecewise-defined function and sketch the graph of a function that has been shifted, stretched or reflected from its initial position. Students will convert angle measures between degrees and radians, recognize the triangular and circular definitions of the basic trigonometric functions, write the basic trigonometric identities, identify the graphs and periods of the trigonometric functions and describe the shift of a sine or cosine graph from the equation of the function. Students will go onto identify the form of exponential and logarithmic functions, the relationship between them and identify the hyperbolic functions, their graphs and basic identities.

Readings: Chapters 1 Functions and Graphs and assigned problems, Chapter 2

Watch: What is Calculus Used For? How to use Calculus in real life.
https://www.youtube.com/watch?v=e9u7Hj6SvN8
Eddie Woo. 2018. Mathematics is the sense you never knew you had.
https://www.youtube.com/watch?v=PXwStduNw14

Due: Problem Set 1

Week 2 **Limits**

Quiz 1

Session 2.1 The Limit of a Function and Limit Laws.

Students describe the tangent problem and how it led to the idea of a derivative and limit, recognize a tangent to a curve at a point as the limit of secant lines, identify instantaneous velocity, describe the area problem and how it was solved by the integral, recognize how the ideas of limit, derivative and integral led to studies of infinite series and multivariable calculus. Students will use correct notation to describe the limit of a function, use tables of values to estimate function limit and existence, use a graph to estimate function limits, define one-sided limits and their relationship to two sided limits and define a vertical asymptote. Students will also recognize basic limit laws, use them to evaluate the limit of functions, including by using conjugates and the squeeze theorem.

Reading: Chapter 2 Limits, pp. 124-178 and assigned problems

Due: Problem Set 2

Session 2.2 Continuity and the Precise Definition of a Limit.

Students explain the three conditions for continuity at a point, describe three kinds of discontinuities, define continuity of an interval, state the theorem for limits of composite functions and provide an example of the intermediate value theorem. They will describe the epsilon-delta definition of a limit for one and two-sided limits and use it to prove limit laws.

Readings: Chapter 2 Limits, pp. 179-210 and assigned problems.

Due: Problem Set 3

Week 3 **Derivatives**

Quiz 2

Session 3.1 The Derivative as a Function and its Rules

Students recognize the meaning of a tangent to a curve at a point, calculate the slope of a tangent line, identify the derivative as the limit of a difference quotient, calculate the derivative of a given function at a point, describe velocity as rate of change, differentiate average and instantaneous velocity and estimate the derivative from a table of values. They define derivative function and graph it for a given function, describe three conditions for when a function has no derivative, describe connections between derivatives and continuity and explain the meaning of higher-order derivatives. Students then state the constant, constant multiple and power rules, apply the sum and difference rules to combine derivatives, do the same for the quotient rule and quotients, extend the power

rule to negative exponents and combine differentiation rules to find the derivative of a polynomial or rational function.

Readings: Chapter 3 Derivatives, pp. 233-265 and assigned problems.

Due: Problem Set 4

Session 3.2 Derivatives as Rates of Change and Derivatives of Trigonometric Functions.

Students determine a new value of quantity from the old value the amount of change, calculate the average rate of change and explain how it differs from the instantaneous rate of change, apply rates of change to displacement, velocity and acceleration of an object moving along a straight line, predict the future population from present value and population growth rate and use derivatives to calculate marginal cost and revenue in business. Students will take one application and apply it to a local situation, like local population growth or revenue for a local business. They will then find the derivatives of the sine and cosine and other trigonometric functions and calculate higher order derivatives.

Readings: Chapter 3 Derivatives, pp. 266-298 and assigned problems.

Due: Problem Set 5

Session 3.3 The Chain Rule, Derivatives of Inverse, Exponential and Logarithmic Functions.

Students state the chain rule for the composition of two functions, apply the chain rule, power rule and quotient rules in combination and describe proof the chain rule. They will calculate the derivative of an inverse function, recognize the derivatives of the standard inverse trigonometric functions, find the derivative of a complicated function using implicit differentiation and determine th equation of a tangent line. Students will find the derivative of exponential functions, logarithmic functions and use logarithmic differentiation to determine the derivative of a function.

Readings: Chapter 3 Derivatives, pp. 299-340 and assigned problems.

Due: Problem Set 6

Week 4 Applications of Derivatives

Quiz 3

Session 4.1 Related Rates, Linear Approximations, Maxima/Minima and the Mean Value Theorem

Students will express changing quantities in terms of derivatives, find relationships among the derivatives in a given problem and use the chain rule to

find the rate of change of one quantity that depends on the rate of change of other quantities. They will describe linear approximation to a function at a point, write the linearization of a given function, draw a graph illustrating use of differentials to approximate the change in a quantity and calculate the relative error and percent error for using a differential approximation. They will define absolute extrema, local extrema, explain how to find the critical points of a function over a close interval and describe how to use a critical point to locate absolute extrema over a closed interval. They will also explain the meaning of Rolle's theorem, describe the significance of the Mean Value Theorem and state three important consequences.

Readings: Chapter 4 Applications of Derivatives, pp. 341-389 and assigned problems.

Due: Problem Set 7

Session 4.2 Visit to local Mathematics Institute

Here, students will hear from a leading mathematician about current projects connecting math to society. Students will have a tour, speak with several mathematicians and discuss how math, science, society and culture interact.

Readings: Janica, E.V., 2018, March. The wisdom of our native American tribes: Advanced math, science and culture for the future. In *Integrated STEM Education Conference (ISEC), 2018 IEEE*(pp. 70-76).

Due: Problem Set 8

Session 4.3 Derivatives and Graph Shape, Infinity and Asymptotes, Optimization.

Students explain how the sign of the first derivative affects a function's graph shape, state the first derivative test for critical points use concavity and inflection to explain how the sign of the second derivative impacts a function's graph shape, explain the concavity test over an open interval, explore the relationship between a function and its first and second derivatives and state the second derivative test for local extrema. They will calculate the limit of a function as x increases or decreases with bound, recognize a horizontal asymptote, estimate the end behavior of a function as x increases/decreases without bound, recognize an oblique asymptote on the graph of a function. Students will then set up and solve optimization problems in several applied fields. They will recognize when to apply L'Hôpital's rule, identify indeterminant forms produced by quotients, products, subtractions and powers and describe the relative growth rates of functions. Students will also practice applications for Newton's Rule and use antiderivatives to solve simple initial-value problems.

Reading: Chapter 4, pp. 390-490 and assigned problems.

Due: Essay 1: Math, Science and Society

Week 5 **Integration**

Quiz 4

Session 5.1 Approximating Areas, the Definite Integral and The Fundamental Theorem of Calculus

Students will use sigma (summation) notation to calculate sums and powers of integers, use the sum of rectangular areas to approximate area under curves and use Riemann sums to approximate area. They will define the definite integral, explain integrand, limits of integration and variable integration, explain when a function is integrable, describe definite integral and its relation to net area, use geometry and properties of definite integrals to evaluate them and the average value of a function. Students describe the meaning of the Mean Value Theorem, the Fundamental Theorem to evaluate derivatives and definite integrals and explain the relationship between differentiation and integration.

Readings: Chapters 5 Integration, pp. 507-560 and assigned problems.

Due: Problem Set 9

Session 5.2 Integration Formulas, the Net Change Theorem and Substitutions

Students will apply the basic integration formulas, explain the significance of the net change theorem, use the net change theorem to solve applied problems and apply the integrals of odd and even functions. They will use substitution to evaluate indefinite and definite intervals.

Readings: Chapters 5 Integration, pp. 566-594 and assigned problems

Due: Problem Set 10

Session 5.3 Integrals Involving Exponential and Logarithmic Functions, Integrals Resulting in Inverse Trigonometric Functions

Students will integrate functions involving exponential and logarithmic functions. They will integrate functions resulting in inverse trigonometric functions. There will be a review of general concepts related to integration and a problem-solving workshop.

Readings: Chapters 5 Integration, pp. 595-620 and assigned problems

Due: Problem Set 11

Week 6 **Applications of Integration**

Quiz 5

Session 6.1 Areas between Curves, Volume, Arc Length and Surface Area

Students will determine the area of a region between two curves by integrating with respect to the independent variable, find the area of a compound region and determine the area of a region between two curves by integrating with respect to the dependent variable. They determine the volume of a solid by integrating cross-sections (the slicing method), find the volume of a solid of revolution use the disk,washer and cylindrical shells methods. They will compare methods and apply them to calculating the volume of a yogurt container and Bundt cake. Students will also determine the length of a curve between two points and find the surface area of a solid of revolution.

Readings: Chapter 6 Application of Integration, pp. 623-680 and assigned problems.

Due: Problem Set 12

Session 6.2 Mérida's Historic District.

Students will be led through Mérida's historic district and will be given applied integration problems based on what they see. They will return to the classroom and work in groups on solutions. The session will conclude with a discussion of what was learned and other every day applications of Calculus to life in Mérida. Students will extend these lessons to their own lives.

Reading: Uses of Calculus in Everyday Life https://sciencing.com/uses-calculus-real-life-8524020.html

Watch: TED talk. What is Calculus used for? Jeff Heys. 2012.
https://www.youtube.com/watch?v=_Idra8rVS1I

Due: Essay 2 Contemporary Applications of Calculus

Session 6.3 Physical Applications, Moments and Centers of Mass, Growth and Decay

Students will determine the mass of a one-dimensional object from its linear density function, the mass of a two-dimensional object from its radial density function, calculate work done by a variable force acting along a line and pumping a liquid from one height to another. They will find the center of mass of objects distributed along a line, locate the center of the mass of a thin plate, use symmetry to locate the centroid of a thin plate and apply the theorem of Pappus for volume. They will write the definition of the natural log as an integral, recognize derivatives of the natural log, integrate functions, define *e*, and express general log and exponential functions in terms of natural log and exponentials. Finally, students will apply exponential growth model to population growth,

compound interest, and the exponential decay model to radioactive decay and Newton's law of cooling.

Readings: Chapter 6 Application of Integration, pp. 685-750 and assigned problems.

Due: Final Problem Set, Final Quiz

Course Materials

Course Textbook

Herman, E. and G. Strang. 2017. Calculus Volume 1. Houston, TX: Openstax CNX

Readings

Janica, E.V., 2018, March. The wisdom of our native American tribes: Advanced math, science and culture for the future. In *Integrated STEM Education Conference (ISEC), 2018 IEEE*(pp. 70-76).

Kosheleva, O. and Kreinovich, V., 2013. Why in Mayan Mathematics, Zero and Infinity Are the Same: A Possible Explanation, Digital Commons.

Online Resources

Hey, J. 2012. TED talk. What is Calculus used for?
https://www.youtube.com/watch?v=_Idra8rVS1I

Uses of Calculus in Everyday Life https://sciencing.com/uses-calculus-real-life-8524020.html

What is Calculus Used For? How to use Calculus in real life.
https://www.youtube.com/watch?v=e9u7Hj6SvN8

Eddie Woo. 2018. Mathematics is the sense you never knew you had.
https://www.youtube.com/watch?v=PXwStduNw14