Clemson University
School of Mathematical & Statistical Sciences

MATH 1060-300 (Architecture) Calculus of One Variable I, Fall 2020
MWF 8:00–8:50am, Daniel Hall Room 205
Th 8:00–8:50am, Online (Zoom)
Syllabus

"This is the plan, up until it is no longer the plan."
–Anonymous university administrator (not at CU)

Instructor: Dr. Matthew Macauley

Course website: We will rarely use Canvas except to upload slides that contain copyrighted material, and to take and submit exams. Everything else will be made available on the course website:

`http://www.math.clemson.edu/~macaule/classes/f20_math1060/`

Prerequisite: Score of 80 on the Clemson Mathematics Placement Test, an SAT Math score of 680, an ACT Math score of 29, or credit for MATH 1060 via AP or transfer credit.

Communication Strategy: Email (**macaule@clemson.edu**) is the best way to reach me. I will check it *at least* every few hours during the hours of 8am–9pm, seven days a week.

If you send me an email and do not get a reply by the time you go to bed, please re-send it, as that is my mistake. Just click "Reply" and "Send"; no need to explain.

Students are responsible for checking their Clemson email regularly, as that address will be the one subscribed to the class email list.

I am required to include my office phone (656-1838), but strongly recommend using email instead.

Happy Hour: Several evenings a week at 7pm, you are invited to join me and your classmates on Zoom for an Adult Beverage[1], company, and Office Hours. I'll stick around to answer questions as long as there are some. If it's 7:15pm and nobody is there, I will log off. The exact days will be announced in the beginning of the week, and will depend on when homework is due, in order to optimize the utility of this time. If other time(s) work better for students' schedules, I may schedule additional hours.

Course Description: It is no a coincidence that historical periods of heightened intellectualism have witnessed the synergistic flourishing of mathematics, the arts and humanities, and architecture. The Ancient Greeks are known as much for Euclid's *The Elements* as they are for the writings of the Plato and Socrates, the grandeur of the Parthenon and Acropolis, and the art that adorned it. The European Renaissance produced artist and mathematician Leonardo da Vinci, as well as Newton and Leibniz, who invented the Calculus. The architecture of this period exhibits beauty while emphasizing visually pleasing mathematical concepts such as geometric structure and proportion. Though the traces of these ideas date back to ancient times, they were inspired by the inherent beauty and harmony of mathematics that drew people like da Vinci, Newton, and Leibniz to their scholarship. It is unfortunate that in modern times, Calculus is taught without a historical context, and without an emphasis of the beauty that lies within.

[1]For me, this means drinks like **LaCroix** or **Kombucha**, which are *very unpopular* among kids.

This class will attempt to buck that trend. It is primarily a mathematics course, and students will still learn the main ideas from Calculus I and the first part of Calculus II in the same level of rigor as they would in an engineering course. This should *not* be thought of as a "light" version of Calculus, but rather a more fun version, with a particular appeal to students in the arts, architecture, and humanities. We will begin with a historical tour of math and architecture, starting with the ancient Babylonians and Egyptians, to the ancient Greeks and Romans, and up to modern times. That will lead us to the concept of infinity and the infinitesimal, which in turn, will lead us to Calculus. The middle portion of this class will resemble many typical Calculus classes, but in the last few weeks, we will apply what we learned to historical architectural structures. In particular, we will use Calculus to compute the weight of the Hagia Sophia in Istanbul, the volume of the Roman Pantheon, and to understand mathematically how and why the St. Louis arch is close to an "ideal arch."

Textbooks: As a first generation college student, I am acutely aware of the struggle that many students face due to overly expensive course materials, and I do my best to support (freely available) *Open Educational Resources*. You do not need to purchase any books for this class. I will utilize the following:

Active Calculus 2.0, by M. Boelkins, D. Austin, and S. Schlicker. CreateSpace Independent Publishing Platform, 2018. Freely available online. (Primary textbook, contains interactive exercises)

Mathematical Excursions to the World's Great Buildings, by Alexander J. Hahn. Princeton University Press, 2012. E-book is freely available from the Clemson University Library. (Will be used primarily in the beginning and end of the class.)

Calculus as a Liberal Art, by W.M. Priestley. Springer, 1998. Not necessary to obtain.

Ideas of Calculus, by J.F. Fleron, P.K. Hotchkiss, and C. von Renessee with V. Ecke. Published online in the *Discovering the Art of Mathematics* project on *Mathematical Inquiry in the Liberal Arts*. 2015. Freely available online.

APEX Calculus, by G. Hartman. CreateSpace Independent Publishing Platform. 4th edition, 2018. Freely available online. (Alternative textbook)

Finally, with the exception of the specific applications to architecture, <u>all</u> of the fundamental Calculus topics that we will cover are mainstream. They should be in *any* Calculus textbook, and given that it's 2020, there are plenty of supplemental online resources that can easily be Googled.

Students are responsible for checking their Clemson email regularly, as that address will be the one subscribed to the class email list.

Required technology:

A computer and reliable internet connection.

A free Zoom account, and a video camera that allows you to be recorded over Zoom (for exam proctoring).

A smartphone scanning app. There are many free apps, such as CamScanner or Adobe Scan. If you do not have a smartphone, a traditional scanner will suffice, but a smartphone app is preferred.

Zoom Info: Please turn your camera on for all Zoom meetings, if possible. Note that this is required for taking exams.

There will be one common Zoom URL for all classes, and another for all Happy Hours, which may also be attended by my other (gradate) class. These URLs will be emailed to the class list. I am also available to meet by appointment, if desired. In that case, email me and include block(s) of time in which you are available. Please let me know in advance if you want any meeting to be private, like if you want to discuss your grade. In that case, I will use a different Zoom meeting.

Both Zoom URLs will be available 24 hours a day, 7 days a week. Feel free to meet up with your classmates on there anytime you would like, especially if you want to collaborate on the homework.

There will be a different URL, with different settings, for exams to be taken over Zoom.

If your internet goes out during a Zoom meeting, Zoom should automatically reconnect when it comes back. This happens to me several times a day, for a few minutes at a time, because AT&T is terrible. It will inevitably happen several times during class throughout the semester. In this case, please stick around, and consider this to be an unexpected 1–2 minute break from class.

If I do not show up by the beginning of class, check your email. If you have not heard anything from me by 8:10, you may assume that class has been canceled.

Schedule: I will main a record of the topics we cover by week, and the corresponding sections in the textbook, in a Schedule that will be posted to the course webpage.

Whether or not this course is online or on campus, there will be synchronous lectures every Monday, Wednesday, and Friday. The Thursday class will be reserved for working on homework and asking questions. Students will be required to complete several problems by the end of class, and this will be part of their Homework grade.

The current plan is that online instruction will begin September 21, though I think everybody is *skeptical* that this date may be delayed (especially with UNC's recent in-person class experiment lasting just 6 days). Additionally, if classes do resume in-person, we need to be ready to pivot to online-only at any time.

Depending on how things go, I may post pre-recorded lectures for you to watch ahead of time, and use class-time to answer questions and/or work on problems.

Class policies: Please turn your camera on during synchronous classes. Also, the use of smartphones is not permitted. (Obviously, I cannot enforce this, but this policy is meant to set boundaries and a class routine, since we *all* suffer from some degree of screen addiction. So please respect it.)

Homework: Most homework will be assigned using the open source program WeBWorK, freely available online at `https://webwork.science.clemson.edu/webwork2/MATH_1060-300/`. Late assignments will not be accepted, so plan ahead.

Assignments will be due at 11:59pm on their specified due date. Every student will get one free 24-hour extension, no questions asked. However, this must be requested *before* 9pm on the day the assignment is due.

Exams: There will be two 50-minute midterm exams during the semester and a cumulative 2.5-hour final exam. They will be accessible on Canvas, and I will proctor all exams over Zoom. You must provide consent to having the meeting recorded.

Exam checklist (things to bring):

- Plenty of blank scratch paper and pens or pencils.
- Smartphone (for scanning your exam when you finish).

Exam rules:

- Before beginning the exam, you must do a "room scan" with your camera, and also verify that all of the paper you brought is indeed blank.
- You must share your video for the entire duration of the exam.
- The camera must be far enough away so I can see your hands and paper at all times. That is, I must be able to verify that you are not using a phone or computer.
- When you are finished, send me a private Zoom Chat to let me know, and then scan and email your exam to me while still on camera. It must be scanned in one multi-page pdf document, and *not* multiple individual one-page documents.
- Before *and* after submitting, double-check to make sure that the scanned file is (i) fully legible, (ii) complete, and (iii) the correct file.

It is strongly recommended that you practice with your smartphone scanning app *before* the exam.

Project: Every student will complete a project and give a short presentation near the end of the class on some topic loosely related to calculus and architecture, or the arts. I must pre-approve the topic.

Items to turn in include a short write-up (less than 5 pages), and presentation slides. This is meant to be fun, and should not be something to be stressed about. I will give a number of lectures of this flavor in the beginning of class, and the project is meant to be a "mini-version" of this.

Grading: Your final grade will be computed as follows:

Homework	30%
Midterm 1	20%
Midterm 2	20%
Cumulative Final Exam	40%
Project	10%

I will drop either your lowest midterm grade, OR half of the weight of the final exam; whichever is lowest. Also, if you get an unambiguous **A** on the final exam, then you will get an **A** in the course. Likewise, if you get an unambiguous **B** on the final exam, then you will get (at least) a **B** in the course. *However, both of these policies are only valid if you maintain a passing grade on the homework and project.*

I guarantee that a final score of 90 will be an **A**, that 80 will be a **B**, 70 will be a **C**, and so on. However, there is a very good chance that the actual letter grade cut-offs will be below these numbers. *I do not grade using arbitrary round number cut-offs.* I generally err on the side of having difficult exams. This spreads out the distribution, and the scores generally fall into visually clear distinct "clusters." Though past performance is *not* an indicator of future results, I have almost never given fewer than 50% **A+B**s in an undergraduate class.

Because of the aforementioned policies, the automatically calculated numeric grade that you see in Canvas, which is the average of every weighted graded submission, is NOT an accurate indicator of your grade. At any point in time during the class, I would be happy to give you a ballpark estimate of how you are doing.

Key Dates

Aug 19 (Wed)	Classes begin
Aug 25 (Tue)	Last day to register or add a class
Sep 1 (Tue)	Last day to drop a class or withdraw from the University without a **W** grade
Oct 23 (Fri)	Last day to drop a class or withdraw from the University without final grades
Nov 2–3 (M,Tu)	Fall break
Nov 25–27 (W–F)	Thanksgiving break
Dec 4 (Fri)	Last day of class
Dec 10 (Thu)	Final Exam, 11:30–2pm

Student Learning Outcomes: Upon successful completion of the course, students will be able to:

Describe the role of mathematics and architecture in a number of advanced societies, from the ancient Babylonians, Egyptians, to the Greeks, and Romans, to the Renaissance, to modern day.

Explain the significance of the infinite and the infinitesimal to calculus, architecture, and philosophy, and what these all have in common.

Compute derivatives of a wide variety of single-variable functions.

Use differential calculus to solve optimization problems.

Apply the Fundamental Theorem of Calculus to relate the rate of a function to its cumulative sum over an interval.

Apply integration techniques (e.g., integration by parts, trigonometric integrals, trigonometric substitution, partial fractions, and improper integrals) to evaluate integrals, with applications in engineering and science.

Use calculus to analyze architectural structures such as domes and arches.

"No exceptions": In any class syllabus, no matter how they are worded, policies and phrases like "no exceptions", "no make-ups", etc. are *never* actually what they sound, and this is especially true this semester. Things happen, from natural disasters (hurricanes, tornadoes), to human disasters (9/11, school shootings), to personal and family tragedies, to health emergencies (COVID, auto accidents, hospitalizations). This does not mean that any exception or extension will be granted, but I will do my best to be reasonable, fair, and accommodating.

Make-Up Policy: I will drop your lowest midterm or half of the final's weight, which means that if you miss a midterm, then your final exam grade will replace it. The homework deadlines will not be extended for individual students, and assigned homework must be submitted in by the deadline. PLAN AHEAD: If you wait to complete assignments minutes before the deadline, you take the risk of bad luck, e.g., a power outage, computer freeze or crash, personal emergency, zombie attack, etc., that could make you miss the deadline.

By default, any exam that was scheduled at the time of a class cancellation due to power outage / inclement weather will be given at the next class meeting. Any extension or postponement of assignments or exams must be granted by me via email or Canvas within 24 hours of the weather-related cancellation.

Special Accommodations: Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course

design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to a class should let the instructor know, and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848 or by emailing studentaccess@lists.clemson.edu. Students who receive Academic Access Letters are strongly encouraged to request, obtain and present these to their instructors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. You can access further information here: `http://www.clemson.edu/campus-life/campus-services/sds/`.

COVID-19: While on campus, face coverings are required in all buildings and classrooms. Face coverings are also required in outdoor spaces where physical distance cannot be guaranteed. Please be familiar with the additional information on the Healthy Clemson website (`https://www.clemson.edu/coronavirus/index.html`), such as the use of disinfectant wipes for in-person classes.

If a student does not have a face covering or refuses to wear an approved face covering without valid documented accommodation, *I will ask the student to leave the academic space and will report the student's actions to the Office of Community & Ethical Standards as a violation of the Student Code of Conduct*. If the student's actions disrupt the class to the extent that an immediate response is needed, I may call the Clemson University Police Department at 656-2222.

Mental health: Your mental health is important to me, and I am always available to talk. Please don't hesitate to reach out. We're in this together, on the same team, and all of us are struggling in some regards, myself included.

Title IX Policy: Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veterans status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972.

The University is committed to combating sexual discrimination including sexual harassment and sexual violence. As a result, you should know that University faculty and staff members who work directly with students are required to report any instances of sexual harassment and sexual violence, to the Universitys Title IX Coordinator. What this means is that as your professor, I am required to report any incidents of sexual harassment, sexual violence or misconduct, stalking, domestic and/or relationship violence that are directly reported to me, or of which I am somehow made aware.

There are two important exceptions to this requirement about which you should be aware:

Confidential Resources and facilitators of sexual awareness programs such as "Take Back the Night and Aspire to be Well" when acting in those capacities, are not required to report incidents of sexual discrimination.

Another important exception to the reporting requirement exists for academic work. Disclosures about sexual harassment, sexual violence, stalking, domestic and/or relationship violence that are shared as part of an academic project, a research project, classroom discussion, or course assignment, are not required to be disclosed to the Universitys Title IX Coordinator.

This policy is at http://www.clemson.edu/campus-life/campus-services/access/title-ix/. Alesia Smith is the Executive Director for Equity Compliance and the Title IX Coordinator. Her office is at 223 Holtzendorff Hall, phone number is 864.656.3181, and email address is alesias@clemson.edu.

Academic Integrity: As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning'. Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form.

Copyright Statement: Some of the materials in this course are possibly copyrighted. They are intended for use only by students registered and enrolled in this course and only for instructional activities associated with and for the duration of the course. They may not be retained in another medium or disseminated further. They are provided in compliance with the provisions of the Teach Act. Refer to the Use of Copyrighted Materials and "Fair Use Guidelines" policy on the Clemson University website for additional information: http://clemson.libguides.com/copyright.

Social media: If you want to connect with me on Social Media, then use LinkedIn. I will not accept friend requests on Facebook, there is just too much potential for risk and liability all around.

Topics: We will cover the following topics, roughly in this order.

Section 0: Calculus, a historical perspective

- What is Calculus?
- The emergence of math and architecture and the transition from hunter/gatherer to farming
- Mesopotamia
- Ancient Babylon and Egypt
- Ancient Greece and the Pythagoreans
- Origins of the liberal arts and general education
- Proof of irrationality of $\sqrt{2}$
- Ruler and compass constructions
- The golden ratio
- The fall of Greece and the rise of Rome
- Mathematics during the Islamic movement
- Mathematics in 17th century Japan

Section 1: Infinity, domain, range, and limits

- Different sizes of infinity, Hilbert's hotel, and Cantor's diagonal argument.
- Review of functions: domain and range
- Limits of functions
- Continuity
- Review of how to graph basic functions
- The formal definition of a limit

Section 2: Understanding derivatives

- Optimization (minimum and maximum) problems

- Average velocity
- Instantaneous rate of change, and the slope of the tangent line
- The interplay between a function and its derivatives
- Critical points
- The second derivative, and concavity
- Tangent line approximation
- Differentiability

Section 3: Computing derivatives

- Derivatives of sums
- Derivatives and scalar multiplication
- Derivatives of polynomials
- Derivatives of reciprocals
- The product rule
- The quotient rule
- Notations for derivatives: Leibniz, Newton, Euler, and Lagrange
- The squeeze theorem
- Derivatives of trig functions
- The chain rule: derivatives of the composition of functions
- Implicit differentiation

Section 4: Applications of derivatives

- Exponential functions, natural logarithms, and the number $e \cong 2.718281828\ldots$
- Interest: compounded annually vs. continuously
- The derivative of exponential functions
- The derivative of the natural logarithm
- Related rates (many types of word problems)

Section 5: Understanding integrals

- Area under a curve, and distance vs. velocity
- Signed area
- Approximating area under a curve with Riemann sums
- Computing Riemann sums
- The area function
- Anti-derivatives,
- The derivative and integral as inverse operations
- The Fundamental Theorem of Calculus, Parts I & II

Section 6: Computing integrals

- Definite vs. indefinite integrals
- Computing anti-derivatives of basic functions
- Average value of a function
- u-substitution

Section 7: Applying integrals to length, area, and volume

- Arc length

- Area between curves
- Volumes by slicing (disk method)
- Surface area
- Volumes by washers
- Volumes by shells

Section 8: Using calculus to analyze historical domes

- The Hagia Sophia in Istanbul
- The Roman Pantheon

Section 9: Using calculus to analyze ideal arches

- The line of thrust
- Catenary curves, hanging strings, and the structure of domes
- The mathematics of an ideal arch
- The Gateway Arch in St. Louis