

MATH-456: INTRO. NUMERICAL ANALYSIS II  
Fall 2020

Numerical precision is the very soul of science.

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*Sir D'Arcy Wentworth Thompson, 1942*

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<b>Professor:</b>	Thomas R. Cameron	<b>Time:</b>	M W F 8:00 – 8:50 am
<b>Email:</b>	<a href="mailto:trc5475@psu.edu">trc5475@psu.edu</a>	<b>Place:</b>	Witkowski Building W21
<b>Office:</b>	Prischak P18		

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**Course Page:** [https://www.thomasrcameron.com/courses/Math-456/math\\_456.html](https://www.thomasrcameron.com/courses/Math-456/math_456.html)

**Office Hours:** M W F 9:00 – 10:00 am and 1:30 – 2:30 pm via Zoom, ID 966 0530 3415, Passcode 732380

**Textbook:** None required, a generous amount of written and video resources will be provided

**Programming Language:** Python (<https://www.python.org>)

**Programming IDE:** Repl (<https://repl.it>)

**Prerequisite:** CMPSC 455 or MATH 455

**Course Format:** This is an in-person class. Lectures will be pre-recorded and available online; short daily homework assignments will be given that review concepts that were covered in the lectures. During our in-class meetings, we will work on exercises in groups and discuss any questions that arose from the lectures. Note that we will be meeting virtually through the week of February 12th. During that time, the in-person portion of our class will be replaced by online meetings in the Zoom office hours link noted above.

**Mask Policy:** We know from existing scientific data that wearing a mask in public can help prevent the spread of COVID-19 in the community (Lyu and Wehby, 2020; CDC, 2020; Johns Hopkins Medicine, 2020). Everyone – including the instructor and TAs – are required to wear a face mask in University buildings, including classrooms and labs. You **MUST** wear a mask appropriately (i.e., covering both your mouth and nose) in the building if you are attending class in person. Masks have been provided for students, faculty, and staff, and everyone is expected to wear one while on campus or out in the community.

All students, faculty and staff are expected to maintain social distancing (i.e., maintain at least six feet of space between individuals) when possible. Seating patterns and attendance patterns, including assigned seating and closed-off desks/chairs/room sections, have been established to help allow for this distance for your safety. It is also important to follow related guidance communicated by the University and via public postings/signage related to directional traffic flow and maximum occupancy of spaces.

You are not permitted to consume food or drink in classrooms, except for water. If you must drink water, please be especially conscious of maintaining social distancing and minimizing the time your mask is moved aside. Or, better yet, use a straw. Cooperation from **EVERYONE** will help control the spread of the virus and help us get back to the previous version of campus life as quickly as possible.

Students with conditions that make it difficult to wear a mask or who choose not to wear a mask may not attend class in person. This is to protect your health and safety as well as the health and safety of your classmates, instructor and the University community. Anyone attending class in person without a mask will be asked to put one on or leave. Refusal to comply with University policies is a violation of the Student Code of Conduct. Students who refuse to wear masks appropriately may face disciplinary action for Code of Conduct violations. See details here: <https://studentaffairs.psu.edu/support-safetyconduct/student-conduct/code-conduct>

**Course Description:** In this course, we will discuss one of the most important algorithms of the 20th century: Francis's Implicitly Shifted QR Algorithm. This algorithm changed the eigenvalue problem from difficult to routine in the early 1960s. It was later ranked as one of the top ten algorithms of the 20th century by Jack Dongarra and Francis Sullivan in the January/February 2000 issue of Computing in Science and Engineering.

Armed with a reliable eigenvalue solver, we will be able to tackle other problems such as the singular value decomposition, least squares problem, and systems of differential equations. Applications include, but are not limited to, linear regression, roots of polynomials, principal component analysis, page rank, and graph clustering.

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

- Describe the least squares problem and its application to polynomial interpolation and linear regression.
- Solve the least squares problem via the QR Decomposition and Singular Value Decomposition.
- Use the Singular Value Decomposition to analyze the sensitivity of the least squares problem.
- Compute the QR Decomposition via rotators and reflectors and implement these methods in Python.
- Compute the Singular Value Decomposition via eigenvalues and eigenvectors and implement this method in Python.
- Describe and use the Power Method to compute dominant eigenvectors and implement this method in Python.
- Describe and use Francis's algorithm to compute the eigenvalues and eigenvectors of a matrix and implement this method in Python.
- Use eigenvalues and eigenvectors to solve systems of differential equations.
- Use eigenvalues to compute roots of polynomials and the determinant of a matrix.
- Use the Singular Value Decomposition to perform Principal Component Analysis.
- Use eigenvectors to study the steady state of Markov chains and perform page rank.
- Use eigenvalues and eigenvectors to study the algebraic connectivity of a graph and perform graph clustering.

**Grading Policy:**

Your final grade is broken up as follows.

Category	Percentage
Daily Assignments	15%
Lab Assignments	20%
Written Assignments	20%
Exams (10% each)	30%
Final	15%

Your final letter grade is based on the following scale.

Grade	Percentage Interval	Grade	Percentage Interval
A	[93, 100]	C+	[77, 80)
A-	[90, 93)	C	[70, 77)
B+	[87, 90)	D	[60, 70)
B	[83, 87)	F	[0, 60)
B-	[80, 83)		

**Daily Assignments:** The only way to learn mathematics is to do mathematics. Therefore, at the end of each lecture, 2-3 daily problems will be assigned. These problems are intended to encourage students to work through the material and improve their understanding.

**Lab Assignments:** It is best to interact with the theory in numerical analysis by writing programs to see that the concepts do in fact work. The Python programming language is easy to learn and very common in scientific computation. Therefore, we will have several lab assignments where the students will implement the course concepts in Python.

**Written Assignments:** One of the best ways to develop critical thinking is to learn to write. To that end, there will be several written assignments where the students will work on bigger problems and be asked to write out their solution in a comprehensive format.

**Exams:** We will have 3 exams throughout the semester. These exams are intended to test your understanding of the concepts covered up to that point. These exams will be take-home and due by midnight on the date they were administered. The questions will be theory based, i.e., no programming will be required.

**Final:** We will have a take-home final during finals week. This final is intended to test the students' comprehensive understanding of the course concepts. The questions will be theory based, i.e., no programming will be required.

**Academic Integrity:** Academic integrity is a basic guiding principle for all academic activity at the University, and all members of the community are expected to adhere to this principle. Specifically, academic integrity is the pursuit of scholarly activity in an open, honest, and responsible manner. It includes a commitment not to engage in or tolerate acts of falsification, misrepresentation, or deception. Such acts violate the fundamental ethical principles of the University community and undermine the efforts of others.

Violations of academic integrity are not tolerated at Penn State Behrend. Violators will receive academic sanctions and may receive disciplinary sanctions, including the awarding of an XF grade. In cases such as these, an XF grade is recorded on the transcript and states that failure of the course was due to an act of academic dishonesty. All acts of academic dishonesty are recorded so those repeat offenders can be sanctioned accordingly. For more information:

<http://behrend.psu.edu/for-faculty-staff/faculty-resources/academic-integrity>

**Extra Help:** Do not hesitate to come to my office during office hours or by appointment to discuss a homework problem or any aspect of the course. You also may want to consider the Math Lab (located on the second floor of Roche Hall) or the Learning Resource Center (located in the library). Hours can be found here:

<http://psbehrend.psu.edu/Academics/academic-services/lrc>.

See a schedule for all options on TutorTrac at <https://tutorapp.bd.psu.edu>

**Disabilities and Learning Differences:** Penn State is strongly committed to providing full access to its programs and services for all individuals. The University encourages academically qualified students with disabilities to take advantage of the educational programs and accommodations offered at Penn State Behrend. For more information:

<http://behrend.psu.edu/student-life/educational-equity-and-diversity/student-resources/students-with-disabilities-and-learning-differences>

**Educational Equity Concerns:** Penn State takes great pride to foster a diverse and inclusive environment for students, faculty, and staff. Acts of intolerance, discrimination, harassment, and/or incivility due to age, ancestry, color, disability, gender, national origin, race, religious belief, sexual orientation, or veteran status are not tolerated and can be reported through Educational Equity at the Report Bias site: <https://equity.psu.edu/reportbias>

**Counseling and Psychological Services:** Students with academic concerns related to this course should contact the instructor in person or via email. Students also may occasionally have personal issues that arise in the course of pursuing higher education that may interfere with their academic performance. If you find yourself facing problems affecting your coursework, you are encouraged to talk with an instructor and to seek confidential assistance at the Penn State Behrend Personal Counseling Services at (814) 898-6504. For more information: <http://psbehrend.psu.edu/student-life/student-services/personal-counseling>

**Copyright of Class Materials:** You may not share any information from this course (including notes and assignments) with others who are not currently registered for the course, nor post such information electronically without the permission of the instructor—this includes online note-taking/note-sharing services (See Penn State Administrative Policy AD-40). Also prohibited in the policy is the posting of audio, video, or photographs posted to social media sites or other publicly accessible resources. Unless you have my permission, you risk disciplinary sanctions.

**Title IX:** Penn State is committed to fostering an environment free from sexual or gender-based harassment or misconduct. The Office of Sexual Misconduct Prevention and Response ensures compliance with Title IX, a federal law that prohibits discrimination based on the sex or gender of employees and students. Behaviors including sexual harassment, sexual misconduct, dating violence, domestic violence, and stalking, as well as retaliation for reporting any of these acts violate Title IX and are not tolerated. The University is also committed to providing support to those who may have been impacted by incidents of sexual or gender-based harassment or misconduct and may provide various resources and support services to individuals who have experienced one of these incidents. For more information: <http://titleix.psu.edu/> or

<http://titleix.psu.edu/resources-penn-state-erie-the-behrend-college/>

**Wellness Day:** Wednesday, April 7th has been designated as a Wellness Day. No class meeting will happen, either in person or remotely, for that day, and no assignments will be due on that day. Students are encouraged to use the day to focus on their physical and mental health. Please see <https://wellnessdays.psu.edu/> for university sponsored events focusing on wellness that may be of interest to you. See Canvas or the course webpage for any work that may be due before the next class meeting.

**Important Dates:**

Classes Begin .....	January 19
Regular Drop Deadline .....	11:59 pm January 24
Regular Add Deadline .....	11:59 pm January 25
Exam 1 .....	February 15
Final Exam Conflict Filing Period .....	February 22 - March 14
Exam 2 .....	March 22
Wellness Day (no classes) .....	February 9
Late Drop Deadline .....	April 9
Exam 3 .....	April 26
Classes End .....	April 30
Final Exams .....	May 3 - 7

**Disclaimer:** I reserve the right to diverge from this syllabus in the best interest of my students learning and achievement. Any changes made will be announced in advance.