Math 4355, Spring 2022
Methods of Applied Mathematics

Course Information

20429 Math 4355.001 MW 2:30-3:45 SCI 2.210

Professor Contact Information

Instructor: John Zweck

Office: FO 3.704J

Email: zweck@utdallas.edu

Phone: Call via Teams (Do not leave a message. Email me instead.)

Office Hours: W 4:30-5:30 via MS Teams *and by appointment*. If you cannot attend office hours *please* contact me in class or by email to set up a time to meet. Also, you are encouraged to ask me questions by email.

Other Info: All email correspondence with your instructor must be sent to the email address above from your utdallas.edu account.

Course Materials

Announcements: The instructor will communicate with you regularly using a class email list and the announcements section of the **MATH 4355.001** eLearning Course.

Webpage: I will maintain a web page for the course, linked from my web page https://personal.utdallas.edu/~jwz120030/. *Bookmark it!* All course materials (except take-home midterm exams) will be posted on this web page, and are publicly available.

eLearning: The eLearning Course **MATH 4355.001** will be used to submit homework, administer take-home exams, and post all grades. The course material housed solely on eLearning is not publicly available.

MS Teams: As needed, MS Teams will be used to access lectures and lectures recordings.

Course Pre-requisites

MATH 2418 and MATH 2420 or instructor consent.

Course Description

Topics include some frequently used tools in applied mathematics: Matrix theory, Fourier series and transforms, and special functions as relevant to applications in engineering and the sciences.

In this course you will learn how to do abstract calculations with matrices and vectors to prove (generalizations of) the main results in a sophomore linear algebra course. In addition, you will learn the basics of Fourier series and Fourier transforms, which will involve more analysis and calculus-based techniques. Then we will close the loop by learning how to numerically compute Fourier series using the discrete Fourier transform, which is achieved via matrix theory. Specific topics to be covered include:

1. Matrix algebra
2. Real and complex vector spaces and subspaces, bases
3. The four fundamental subspaces of a matrix and the rank and nullity theorem
4. Linear transformations and the change of basis theorem
5. Inner product spaces and orthonormal bases
6. Unitary and orthogonal matrices
7. Complementary and orthogonal decompositions
8. Eigensystems
9. Spectral theorem for normal matrices
10. Functions of diagonalizable matrices
11. Matrix exponentiation and applications to systems of ordinary differential equations
12. Real and complex Fourier series
13. Pointwise convergence and differentiation of Fourier series
14. Gibb's phenomenon
15. Discrete Fourier transform and relation to Fourier series and matrix analysis
16. Filtering and Convolution

Student Learning Outcomes

1. Master the definitions, examples, calculations, theorems *and proofs* discussed in class and covered on homework.

2. Become proficient at setting up and performing matrix algebra calculations to study the structure of matrices; Apply these techniques to prove theorems.

3. Understand, apply, and prove results about the algebraic and geometric structure of special classes of matrices, including matrices that are square, diagonal, symmetric, orthogonal, unitary, diagonalizable, or normal.

4. Calculate and prove properties of Fourier series.

5. State and apply theorems on the convergence of Fourier series and the Gibb's phenomenon.

6. Calculate discrete Fourier transforms; Interpret the discrete Fourier transform as an approximation of a Fourier series.

7. Gain experience writing MATLAB computer code to solve computational problems and illustrate theory. Gain experience verifying the correctness of your computer code and analyzing code output.

Textbooks

[M] Carl D. Meyer, *Matrix Analysis and Applied Linear Algebra*, SIAM, 2000

[O] Peter J. Olver, Chapter 3 (Fourier series) of *Introduction to Partial Differential Equations* Springer Undergraduate Texts in Mathematics, 2014

[W] James S. Walker, *Fast Fourier Transforms*, (Second edition), CRC Press, 1996

Other books

The following books are also excellent, though we will not explicitly use them.

[B] Dennis S. Bernstein, *Matrix Mathematics: Theory, Facts, and Formulas*, Princeton University Press, 2009

[D] Phil Dyke, *An Introduction to Laplace Transforms and Fourier Series*, Springer Undergraduate Texts in Mathematics, 2014

[HJ] Roger A. Horn and Charles R. Johnson, *Matrix Analysis*, (Second edition), Cambridge University Press, 2013

[H] Kenneth B. Howell, *Principles of Fourier Analysis*, (Second edition), CRC Press, 2017

[**AL**] Alan J. Laub, *Matrix analysis for scientists and engineers*, SIAM, 2005

[**DL**] David C. Lay, *Linear Algebra and its Applications*, Pearson, 2015.

[**OS**] Peter J. Olver and Chehrzad Shakiban, *Applied Linear Algebra*, Prentice-Hall, 2005

[**S**] Gilbert Strang, *Linear Algebra and Its Applications*, Cengage Learning, 2006

Academic Calendar and Assignments

The Lecture Notes and Homework Assignments will be posted on the publicly accessible course web page. Homework is to be submitted to eLearning. Most of the homework problems will be graded. The course web page also includes some past exams. The take home midterm exams must be accessed via the eLearning Course MATH 4355.001.

Grading Policy

Grades: Paper Homework (**PH**) 25%, Matlab Homework (**MH**) 10%, Midterm Exam I 20%, Midterm Exam II 20%, Final Exam 25%

Paper Homework: Due each Thursday at 7pm in eLearning. Problem sets will be available at least a week before the due on the course web page.

Matlab Homework: There will be four Matlab Homeworks over the course of the semester. **You may work either solo or in a group of two.** If you work in a group of two, each student must upload their own report into eLearning and you must list both names at the top of the report and briefly state who did what. Problem sets will be available at least a week before the due date on the course web page. **Students without prior experience with MATLAB or who have concerns about having access to a computer on which to run MATLAB should contact the course instructor in the first week of the semester.**

Exams: The two midterm exams will be open book, open notes, open internet. Prior to the due date you may not discuss the exam questions with any other person except the course instructor. Students will access the exams and submit their solutions from within eLearning. The final exam will be held in class (2 hours 45 minutes) during finals week, and will be closed book, closed notes, closed internet. *The final exam will be based on the entire course.*

Midterm Exam I: Take home: Friday March 4th to Sunday March 6th.

Midterm Exam II: Take home: Sunday April 10th to Tuesday April 12th.

Final Exam: In class: TBD

MATLAB software

If you do not already have one, you will need to set up a MATLAB license. This license will enable you to download the MATLAB software package on your own computer for free (instructions also given on the above website). Make sure you choose the username to be the same as your UTD campus ID, something like abc@170000@utdallas.edu.

Course Policies

Expectations:

1. To gain proficiency in this subject you will need to develop a **conceptual understanding** of the course material in order to solve problems. Therefore you are expected to **actively engage with the lecture material**, both in and out of class.

2. To submit written assignments and communicate mathematical ideas with your instructor and fellow students, at a minimum you will need to create scanned pdfs of handwritten documents that can be uploaded or emailed. For that, we strongly recommend the methods described here.

3. Although the midterm exams are open book, open notes, open internet, you are expected to **prepare for them just as rigorously as if the exams were closed**. See Study Tips at the end of this syllabus for more information.

4. *The course instructor understands that we are living in an exceptional time and that during the semester you may encounter challenges that prevent you from performing at your best. I will endeavor to adjust assessment due dates for individual students in as flexible and equitable manner as possible. Nevertheless, all students are expected to complete all assigned work.*

Attendance

Regular and punctual attendance in Lectures is strongly encouraged. An informal study by the UTD Department of Mathematical Sciences has shown that there is a very strong correlation between attendance at lectures and course grade.

Extra Credit

There will be no opportunity for students to earn extra credit.

Late Submissions

Extensions for homework will only be granted in exceptional circumstances with appropriate documentation.

Homework

You may ask me questions about the homework and you may discuss a first draft of your solutions with another student in the class. However the final version must be your own.

Make ups for exams that you cannot attend or miss

If you know ahead of time that you cannot take an exam you must contact the instructor by email at least 4 days in advance of the scheduled exam requesting to take the exam at an alternate time. If an emergency arises that prevents you from taking the exam at the scheduled time you must contact your instructor by email no later than 48 hours after the exam time. Be prepared to provide appropriate evidence in support of your request. Reasonable requests for make up exams will be approved.

Regrades

Requests for regrades on homework or the midterm exams must be made no later than 7 days after the work has been returned to the class. There will be no regrades allowed for the final exam. Once posted, the only reason a course grade will be changed is because of a clerical error.

Academic Integrity

All instances of cheating will be reported to the University administration. See https://conduct.utdallas.edu/dishonesty/

University Policies

Class Materials: The instructor may provide class materials *via eLearning* that will be made available to all students registered for this class as they are intended to supplement the classroom experience. These materials may be downloaded during the course, however, these materials are for registered students' use only. Classroom materials *posted on eLearning* may not be reproduced or shared with those not in class, or uploaded to other online environments except to implement an approved Office of Student AccessAbility accommodation. Failure to comply with these University requirements is a violation of the Student Code of Conduct.

Classroom Conduct Requirements Related to Public Health Measures: UT Dallas will follow the public health and safety guidelines put forth by the Centers for Disease Control and Prevention (CDC), the Texas Department of State Health Services (DSHS), and local public health agencies that are in effect at that time during the Spring 2022 semester to the extent allowed by state governance. Texas Governor Greg Abbotts Executive Order GA-38 prohibits us from mandating vaccines and face coverings for UT Dallas employees, students, and members of the public on campus. *However, we strongly encourage all Comets to get vaccinated and wear face coverings as recommended by the CDC.* Check the Comets United: Latest Updates webpage for the latest guidance on the Universitys public health measures. Comets are expected to carry out Student Safety protocols in adherence to the Comet Commitment. Unvaccinated Comets will be expected to complete the Required Daily Health Screening. Those students who do not comply will be referred to the Office of Community Standards and Conduct for disciplinary action under the Student Code of Conduct UTSP5003.

Class Attendance: The University's attendance policy requirement is that individual faculty set their course attendance requirements. Regular and punctual class attendance is expected. Students who fail to attend class regularly are inviting scholastic difficulty.

Class Recordings: Students are expected to follow appropriate University policies and maintain the security of passwords used to access recorded lectures. Unless the Office of Student AccessAbility has approved the student to record the instruction, students are expressly prohibited from recording any part of this course. Recordings may not be published, reproduced, or shared with those not in the class, or uploaded to other online environments except to implement an approved Office of Student AccessAbility accommodation. Failure to comply with these University requirements is a violation of the Student Code of Conduct.
The instructor may record meetings of this course. These recordings will be made available to all students registered for this class if the intent is to supplement the classroom experience. If the instructor or a UTD school/department/office plans any other uses for the recordings, consent of the students identifiable in the recordings is required prior to such use unless an exception is allowed by law.

Study Tips

1. On the course web page I will post the sections that we will cover each day. You are expected to read the section ahead of time, so as to be familiar with the material.

2. It is very important to keep the main definitions, statements of theorems, and simpler examples in the forefront of your mind throughout the course, since we will refer back to them many times. You will need to digest the material several times to master it—before class, in class, reading through material after class, rederiving for yourself without any aid results discussed in class, and doing the assigned problems.

3. This is a fast paced course. Do not get behind. Do not miss class. Ask for help well before you are totally lost.

4. Ask questions. If you are dazed and confused your class mates will be too!

5. In class I sometimes call on people by name to answer questions mostly to help me find out whether you are understanding what's going on. If you do not feel comfortable being called on in class, please let me know.

6. Attend office hours and/or make separate appointments to speak with the course instructor. Before coming to office hours prepare a list of questions and/or email a scan of your attempt at a problem to me. Talk math with your fellow students, don't work in isolation.

7. Learn the art of taking good notes. My lectures will often present a somewhat complementary perspective on the subject to that in the textbook. Scans of my handwritten lecture notes are available on the course web page, but are best used to check details you missed in lectures. To increase your comprehension of the course material it is better for you to take and revise your own set of notes.

8. Do all the hwk problems. Work out what your mistakes are on the graded hwk and learn from them.

Advice for Homework

1. Never start your homework the day (before) it is due!
2. Begin each hwk assignment the same day that we cover the material in class.
3. Write up your homework so that you will easily understand it in a month's time when you are studying for the exam!
4. The only way to learn math is to do it: Struggle to solve problems for yourself.
5. However, if you get stuck on a problem for too long get help and get it before you waste too much time! Here are some places you can go for help.
   - Carefully read your notes from lectures and the book (again!).
   - Draw a schematic picture to help you think about the problem.
   - Ask me for help by email or in person.
   - Ask a fellow class member—often two heads are better than one! I encourage you to find a study partner for this class. First attempt the hwk yourself, then discuss them with your study partner, and finally carefully write the solutions up in your own words.
   - Sleep on it. Some of my best ideas come when I wake up in the morning.
6. Some of the homework problems will be harder than others. Don't expect to solve them all on the first try.

Advice for Exams

Exams will include problems similar to those in the homework and in lectures, and in particular may include multi-part scaffolded problems. The in-class final exam may also directly examine theory covered in class (definitions, theorems, *proofs!*, concepts, examples). Some past exams will be posted on the course web page.

Even though the midterm exams are open book, I encourage you to first master the theory and memorize calculation methods and formulae you need to know and then use this knowledge to work a range of problems *without looking at your notes*. To learn theory, calculation methods, and formulae with your lecture notes employ a method as rigorous as the following. First go through your notes and compile a list of questions/prompts. Then with your notes closed write down what you know about each item on the list, as precisely and succinctly as you can. Only when you get stuck should you look at your lecture notes. If you do this about 4 times in the 10 days prior to the exam you should be in good shape. Don't forget to work past exam problems as well!

You should also spend *some but not all* of your preparation time studying in small groups to learn from each other. Presenting material to someone else is often the best way to work out whether you really know it yourself.

Comet Creed

This creed was voted on by the UT Dallas student body in 2014. It is a standard that Comets choose to live by and encourage others to do the same:

> "As a Comet, I pledge honesty, integrity, and service in all that I do."

Academic Support Resources

The information contained in the following link lists the Universitys academic support resources for all students. Please go to Academic Support Resources webpage for these policies.

UT Dallas Syllabus Policies and Procedures

The information at `http://go.utdallas.edu/syllabus-policies` constitutes the University's policy and procedures segment of the course syllabus.

The descriptions and timelines contained in this syllabus are subject to change at the discretion of the instructor.