Clemson University
School of Mathematical & Statistical Sciences

MATH 4340-241 / 6340-241, Advanced Engineering Mathematics
Summer Session II, 2020

Instructor: Dr. Matthew Macauley

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Course Description: This course is an introduction to Fourier Series and Partial Differential Equations. Throughout the country, these topics are taught in a variety of contexts – from a very theoretical course on PDEs and Applied Analysis for senior math majors, to a more computational course geared torwards engineers, e.g., a "Differential Equations II" class. My goal in this course is to strike a balance between these two extremes. I have included enough basic linear algebra (vector spaces, independence, basis, inner products, self-adjoint operators) so the students can see the mathematical structure behind the scenes. However, I have omitted advanced details such as Hilbert spaces, and different types of norms and convergence (pointwise, uniform, and in norm). My goal is for this to be useful to math, science, and engineering majors alike.

Topics include vector spaces, inner products, orthogonality, linear differential operators, linear ODEs, power series solutions and the method of Frobenius, Bessel's equation, real and complex Fourier series, Fourier sine and cosine series, Fourier transforms, Parseval's and Plancherel's identities, boundary value problems, self-adjoint linear operators, Sturm-Liouville theory, generalized Fourier series, Fourier's law, the heat equation, the wave equation, Schrödinger equation, Cauchy problems, the reflection method for semi-infinite domains, solving PDEs with Laplace and Fourier transforms, harmonic functions, Laplace's equation, PDEs in higher-dimensions, PDEs in polar coordinates.

Prerequisite: Math 2080 (Differential Equations) .

Communication Strategy: Email 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 not responsible if you miss important messages because you use a different email account.

Coffee Hour: Every morning at 9am, you are invited to join me and your classmates on Zoom for coffee, company, and office hours. I can connect my iPad to use as a virtual whiteboard. The URL will be the same for all meetings, and will be emailed to the class list. I'll stick around to answer questions as long as there are some. If it's 9:10am and nobody is there, I will log off.

Happy Hour: Every evening 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 7:10pm and nobody is there, I will log off.

[1]For me, this means **LaCroix** or **Kombucha**; as these drinks are *very unpopular* among kids.

Zoom Info: The URL will be the same for all Coffee Hours and Happy Hours, and 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.

Useful websites:

Course webpage: `http://www.math.clemson.edu/~macaule/classes/m20_math4340/` (all relevant links posted here)

Canvas: `https://www.clemson.edu/canvas/` (will be used minimally)

Texts: The course will not follow one particular textbook, but there are several high-quality books that are freely available that will be helpful resources. The following are listed in (approximate) increasing order of technical difficulty.

John Douglas Moore. *Introduction to Partial Differential Equations*. Kendall Hunt, 2005.

Peter J. Olver. *Introduction to Partial Differential Equations*. Springer Undergraduate Texts in Mathematics, 2014.

Marcus Pivato. *Linear Partial Differential Equations and Fourier Theory*. Cambridge University Press, 2010.

The pdfs of Moore and Pivato are freely available online. Olver can be accessed as an eBook through the Clemson University Library. The links to all of the are on the course webpage.

Required technology:

A computer on which you can watch the YouTube lecture videos and view pdf files.

A 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 smarphone app is prefered.

Schedule: This course is being offered in an entirely ONLINE and ASYNCHRONOUS format through the course website and Canvas (only for submitting HW). The course calendar can be found on the course website.

Lectures: There will be 38 lectures, ranging in length from 26 to 57 minutes, that are be available on YouTube. Students will be required to watch 1–2 lectures each day. The lecture schedule is listed on the course calendar.

Homework: Homework assignments are posted on the course webpage. Students will be required to upload and submit each assignment on Canvas as a single pdf file with multiple pages (*not* one document per page). Students can either handwrite and scan their assignments, or typeset them using LaTeX. Homework assignments are due at 11:59pm. Assignments can be submitted multiple times; only the last submission will be graded. There is a 3-hour grace period for deadlines, meaning that is no penalty for assignments submitted within 3 hours of the deadline. Beyond that, late assignments will NOT be accepted.

Course Format: This course is being offered in one summer semester so EVERYTHING GOES QUICKLY. I have taught this class during a regular semester and I plan to cover the same amount of material and assign the same amount of homework, but over 5 weeks instead of 15.

You should expect to spend *at least* 3 hours per day on this course:

Watching 1–2 online lectures.

Working homework problems.

You will prepare for two Midterms and a cumulative Final Exam.

Because this is an online course, our chief means of communication is through e-mail. It is important that you check your Clemson e-mail on a regular basis - at least once a day.

Exams: There will be two 90-minute midterm exams during the semester and a cumulative 3-hour final exam: Midterm 1 on Wed. May 27, Midterm 2 on Wed. June 11, and the Final Exam on Thu. June 18. I will proctor all exams over Zoom during a common time that we decide upon in advance. You must provide consent to having the meeting recorded.

Exam checklist (things to bring):

- Plenty of blank scratch paper and pens or pencils.
- One 5×7 handwritten notecard; double-sided is okay.
- Calculator.
- Smartphone (for scaning 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.

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

Grading: Your final grade will be computed as follows:

Homework	25%
Midterm 1	25%
Midterm 2	25%
Cumulative Final Exam	50%

I will drop either your lowest midterm grade, OR half of the weight of the final exam; whichever is lowest. Also, if you get at least an A or B on the final exam, then you get at least that grade in the course, *assuming you have a passing grade (60%) on the homework.*

Make-Up Policy: No make-up exams will be given. I will drop your lowest midterm, 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 turned in by the deadline. PLAN AHEAD: If you submit 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.

Student Learning Outcomes: Upon successful completion of MATH 4340, students will be able to

- Understand the basic theory of differential operators and linear ordinary differential equations (ODEs) from a high-level perspective. In particular, understand the beautiful linear algebra hiding behind the scenes.
- Solve ODEs whose solutions are generalized power series and understand the convergence of these solutions.
- Derive the Fourier series expansions of periodic functions, and understand the theory behind the construction in terms of inner product spaces.
- Understand boudary value problems of ODEs and solve the corresponding Strum-Louiville equations.
- Construct, interpret, and utilize solutions to one-dimensional partial differential equations (PDEs), such as the heat and wave equation. Understand the difference between different boundary and initial conditions.
- Solve the standard PDEs (heat, wave, and Laplace's equation) in two-dimensions, both in rectangular and polar coordinates.
- Explain in simple terms, e.g. to grandparents or to younger siblings, how ordinary and partial differential equations are relevant to several familiar settings in your major.

Key Dates

June 24 (Wed)	Classes begin; late enrollment fee applies
June 25 (Thu)	Last day to register or add a class
June 29 (Mon)	Last day to drop a class or withdrawfrom the University without a W grade
July 3 (Fri)	Independence Day holiday
July 8 (Wed)	Midterm 1
July 17 (Fri)	Last day to drop a class or withdraw from the University without final grades
July 22 (Wed)	Midterm 2
July 29 (Wed)	Last day of class
July 31 (Fri)	Final Exam

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."

Special Accommodations: Students with disabilities who need accommodations should make an appointment with Dr. Arlene Stewart, Director of Disability Services, to discuss specific needs within

the first week of classes. Students should present a Faculty Accommodation Letter from Student Disability Services when they meet with instructors. Student Disability Services is located in Suite 239 Academic Success Building (656-6848; sds-l@clemson.edu). Please be aware that accommodations are not retroactive and new Faculty Accommodation Letters must be presented each semester.

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`

Statement Included for Certification Purposes: In this online course, you will interact with the content, instructor and classmates on at least a weekly basis through course assignments, asynchronous discussions and/or synchronous sessions as indicated in this syllabus.