Partial Differential Equations

MTH 352/652

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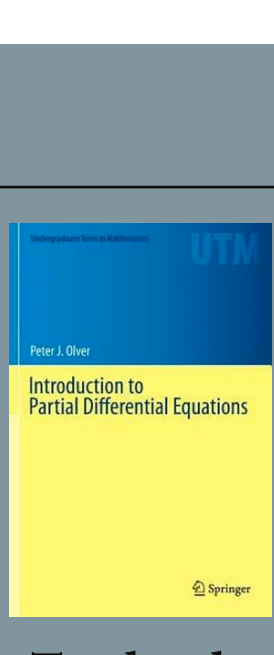
Office: Manchester 388
Course Website: http://users.wfu.edu/gemmerj/math352S24.html
Canvas: The course syllabus and grades will be posted on Canvas
Office Hours: T 9:00-10:00, W 1:00-3:00, Th 9:00-10:00, 12:30-1:30.
Class Meeting Times: MWF 10:00-10:50
Class Location: Kirby 103
Piazza: https://piazza.com/wfu/spring2024/mth352/info
Study Sessions: Wednesdays 7-9, Thursdays 7-9 in Manchester Hall

COURSE DESCRIPTION

Many physical processes involve quantities that vary in space and time. For example, the temperature in a room being heating by a fire varies not only in time but with distance from the heat source (heat equation) and the amplitude of a sound wave fluctuates periodically both in time and space (wave equation). Many other physical processes vary in more than one spatial dimension. For example, the equilibrium potential of an electrostatic field in a domain free from charges (Laplace's equation). Mathematical models of such phenomenon consist of differential equations with partial derivatives, i.e. partial differential equations. This course will provide an introduction to the basic properties of partial differential equations and to some mathematical techniques useful in analyzing them. Along the way, we will discuss many applications including diffusion, propagation of waves, electrostatics, conservation laws, and reaction diffusion equations. While I will motivate all concepts by their underlying physics the focus will be on the mathematics.

REQUIREMENTS

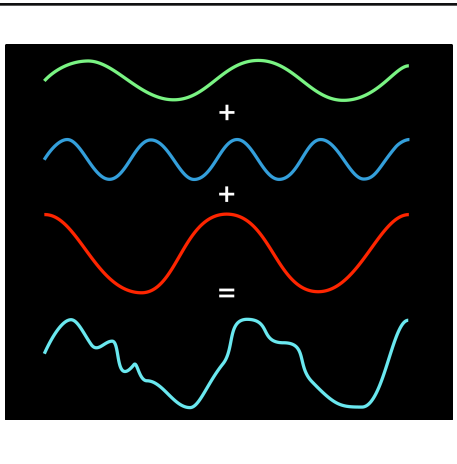
Prerequisites:
MTH 251 and MTH 113



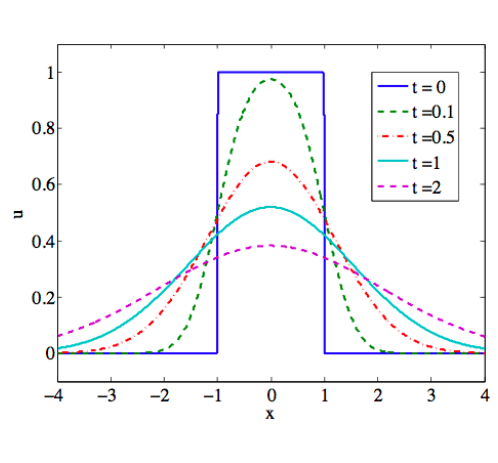
Textbook:
Introduction to Partial Differential Equations

Software:
Matlab, Mathematica, Python: WFU Software Link

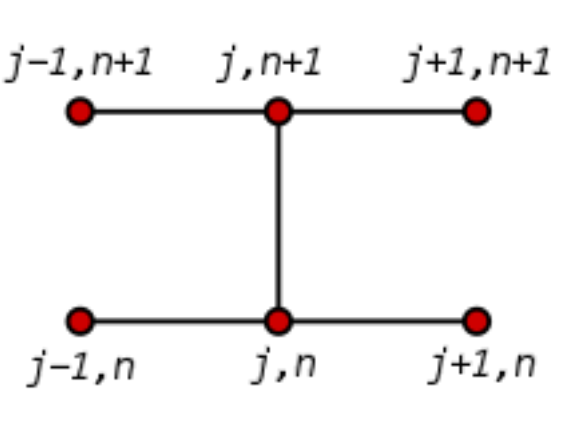
OBJECTIVES



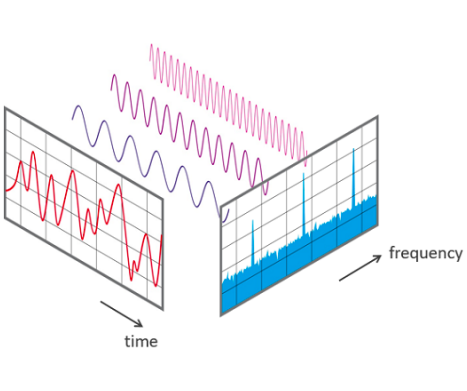
Master Fourier Analysis



Master Solving Linear Boundary Value Problems

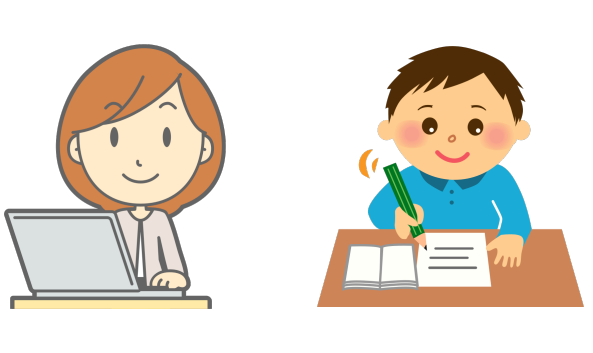


Gain Experience in Numerical Methods



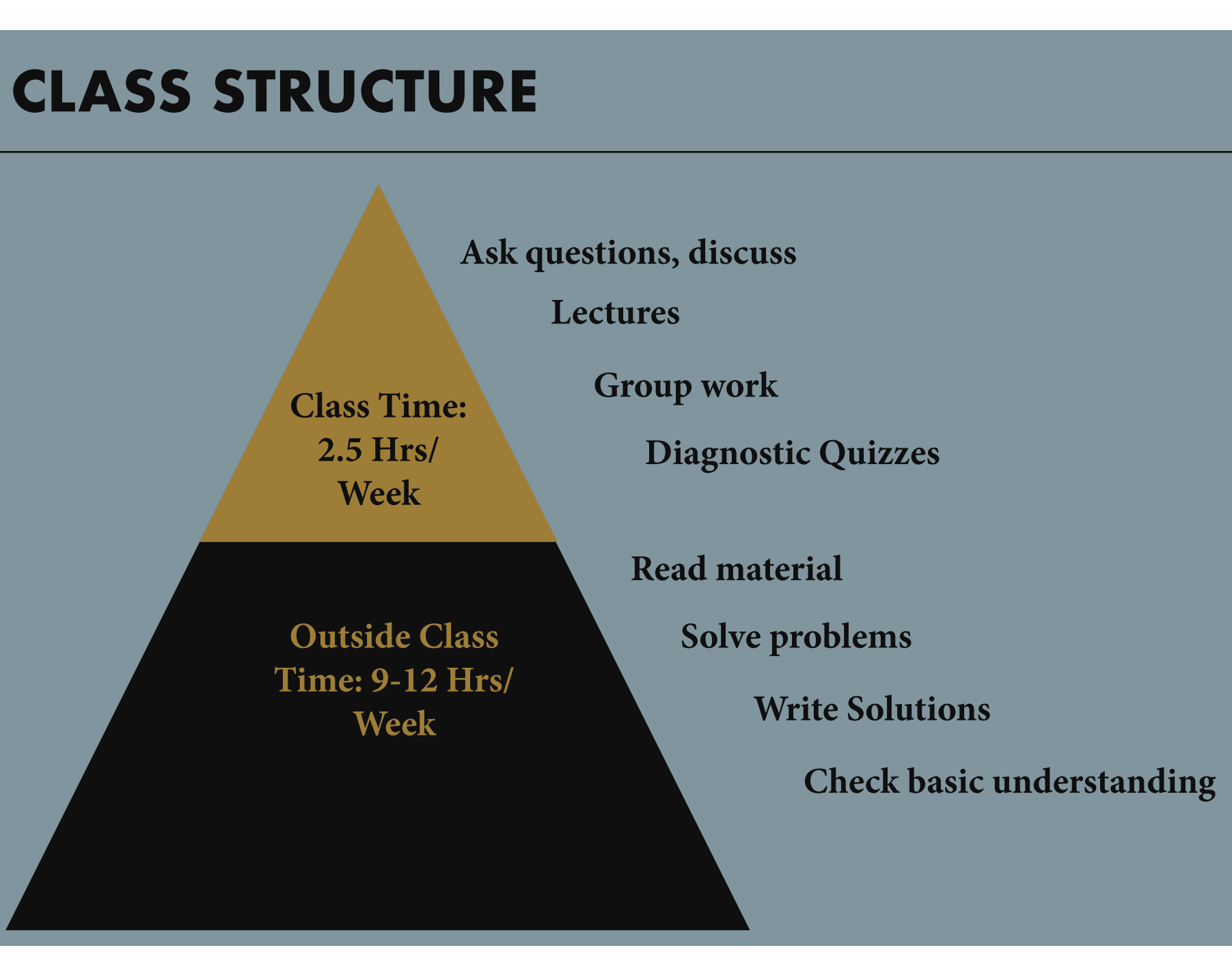
Gain Experience in Fourier Transforms

Learning to collaborate



Improve Mathematics Writing

CLASS STRUCTURE



EVALUATION

We focus on learning and mastery. You are guaranteed the following grades if your final percentage lies within the following ranges:

90-92.9: A-	93-100: A	
80-82.9: B-	83-86.9: B	87-89.9: B+
70-72.9: C-	73-76.9: C	77-79.9: C+
60-62.9: D-	63-66.9: D	67-69.9: D+

Undergraduate Student Evaluation

Classworks (5%)
Structured in class group assignments
Grades based on attendance

Computational Assignments (5%)
Two computational assignments that simulate solutions to PDEs
Graded on ability to solve computation problem

Quizzes (10%), at least 1 dropped
5-10 minutes
In class on Fridays

Weekly Homework (20%), at least 1 dropped
Open book, collaboration allowed with citation
Homework is due on Friday in class

Two summative assessments (30%)
In class, closed notes

Final Exam (30%)
Comprehensive
In class, closed notes

Piazza: This term we will be using Piazza for class discussion. The system is highly catered to getting you help fast and efficiently from classmates, and myself. Rather than emailing questions to the me, I encourage you to post your questions on Piazza.

Classworks: Throughout the course there will be several class works. These consist of structured group assignments that will be completed during class time. These assignments will generally be exploratory allowing students to synthesize concepts through a "hands on" approach. Classworks will be graded based on attendance.

Computational Assignments: Throughout the course there will be two computational assignments. These assignments will consist of in class group work in which students will learn how to numerically solve various partial differential equations in Matlab. The students will then complete an out of class component which will be due within at least a week. The numerical assignments will be submitted on Canvas and must consist of Matlab script files.

Quizzes: On most Fridays there will be a short 5-10 minute in-class quizzes. These quizzes will consist of a very short problem that will test your knowledge of the prior lectures and homework. These quizzes are to help both the students and the instructor understand concepts that students may be struggling with. All quizzes will be announced in class. There will be no "pop" quizzes. There are no retakes for missed quizzes, however I will drop the lowest quiz score from your final grade.

Weekly Homework: Homework will be assigned most weeks on Thursday and will be due Friday in class the following week. Late homework will not be accepted under any circumstances. However, I will drop at least one homework assignment from your grade. While you are allowed to collaborate with your colleagues, homework must consist of solutions that show all steps, be your own work and be written clearly using complete sentences as appropriate (see homework policy). All homework will be submitted in class on paper. I will not accept digital versions of your homework.

Summative Assessments: There will be two in class summative assessments in the course and a cumulative final exam.

Late Work Policy: Except in very extreme circumstances, I do not accept late assignments or reschedule exams. If you have a situation in which you cannot make an exam for personal reasons, you must arrange accommodations with the instructor to schedule the exam **before the scheduled exam date.** If you have a legitimate emergency situation, I will make sure that all students in the course have access to the same exception to this policy.

If you need to miss class due to a university sponsored activity, such as athletics. Please contact the faculty member as soon as possible to reschedule due dates.

COURSE ENVIRONMENT

Names/Pronouns

You **deserve** to be addressed in the manner you prefer. To guarantee that I address you properly, you are welcome to tell me your pronoun(s) and/or preferred name at any time, either in person or via email.

Diversity

We embrace diversity of age, background, beliefs, ethnicity, gender, gender identity, gender expression, national origin, religious affiliation, sexual orientation, and other visible and non-visible categories. **I do not tolerate discrimination.**

Accessibility

I want you to succeed in this course. Wake Forest University provides reasonable accommodations to students with disabilities. If you are in need of an accommodation, then please contact me privately as early in the term as possible. Retroactive accommodations may not be provided. Students requiring accommodations must also consult the Center for Learning, Access, and Student Success(118 Reynolda Hall, 336-758-5929, http://class.wfu.edu). For personal issues, stress, health problems or life circumstances see shs.wfu.edu/. Contact me if you have other special circumstances. **I will find resources for you.**

Title IX

You **deserve** a community free from discrimination, sexual harassment, a hostile environment, sexual assault, domestic violence, dating violence, and stalking. If you experience or know of a Title IX violation, you have many options for support and/or reporting; see titleix.wfu.edu/.

Emergency Fund

You **deserve** a learning environment in which all of your physiological and safety needs are met. If you are experiencing situations in which these needs are not met, e.g. you do not have adequate housing or sufficient food security, the Chaplain's Office has an emergency fund which can provide support: https://chaplain.wfu.edu/care-support/chaplains-emergency-fund/. In situations in which you need immediate assistance there is emergency funding available through the Department of Mathematics and Statistics. If you are in need of emergency help you are encouraged to reach out to a faculty member in the Department of Mathematics and Statistics who will work with the chair of the department to address your needs.

Course Resources

The department has a limited amount of funding for class materials. If you cannot afford class materials, you are encouraged to contact the chair of the department privately as early in the term as possible. Due to the limited amount of funds, students must exhaust all other sources of funding before applying to the department for assistance.

The Honor Code

At Wake Forest, we expect you to behave as honorable citizens of the class, the university, and the world as a whole. When you complete an assignment with your name on it, you are representing that everything you are turning in is your own work. That means that you do not copy from other students, textbooks, or websites. If at any time I become aware of cheating or plagiarism in this course, I will submit the information to the honor council.

TENTATIVE COURSE CALENDAR

Linearity, Wave Equations, Fourier Series

Week 1:
1. 1/15: MLK Day
2. 1/17: What are partial differential equations, **Chapter 1**
3. 1/19: Linear partial differential equations, **Chapter 1**

Week 2:
1. 1/22: Transport and traveling waves part 1, **Section 2.2**
2. 1/24: Transport and traveling waves part 2, **Section 2.2**
3. 1/26: **Classwork #1, Homework #1 Due.**

Week 3:
1. 1/29: Wave equation and d'Alembert's formula, **Section 2.4**
2. 1/31: Eigensolutions of linear equations, **Section 3.1**
3. 2/02: Fourier series part 1, **Section 3.2, Quiz #1, Homework #2 Due.**

Week 4:
1. 2/05: Fourier series part 2, **Section 3.2**
2. 2/07: Calculus of Fourier series, **Sections 3.3-3.4**
3. 2/09: **Classwork #2, Quiz #2, Homework #3 Due.**

Week 5:
1. 2/12: Convergence of Fourier series, **Section 3.5**
2. 2/14: **Classwork #3**
3. 2/16: **Exam #1 (Chapter 1, Sections 2.2-2.4, 3.1-3.4)**

Heat Equation, Finite Differences, Laplace's Equation

Week 6:
1. 2/19: Heat equation part 1, **Section 4.1**
2. 2/21: Heat equation part 2, **Section 4.1**
3. 2/23: Finite difference approximations part 1, **Section 5.1, Quiz #3, Homework #4 Due.**

Week 7:
1. 2/26: Finite difference approximations part 2, **Section 5.1**
2. 2/28: Finite difference approximation of heat equation, **Section 5.2**
3. 3/01: **Computational Assignment #1**, **Quiz #4, Homework #5 Due.**

Week 8:
1. 3/04: Wave equation part 1, **Section 4.2**
2. 3/06: Wave equation part 2, **Section 4.2**
3. 3/08: **Classwork #4, Quiz #5, Homework #6 Due, Computational Assignment #1 Due.**

Spring Break 3/09-3/17

Week 9:
1. 3/18: Finite difference approximation of wave equation, **Section 5.3**
2. 3/20: **Computational Assignment #2**
3. 3/22: Laplace's equation part 1**, Section 4.3 Quiz #6, Homework #7 Due.**

Week 10:
1. 3/25: Laplace's equation part 2, **Section 4.3**
2. 3/27: **Classwork #5**
3. 3/29: **Exam #2 (Sections 3.5, 4.1-4.3, 5.1-5.3), Computational Assignment #2 Due.**

Generalized Functions, Fourier Transforms, Green's Functions

Week 11:
1. 4/01: Generalized functions part 1, **Section 6.1**
2. 4/03: Generalized functions part 1, **Section 6.1**
3. 4/05: Green's functions part 1, **Section 6.2, Quiz #7, Homework #8 Due.**

Week 12:
1. 4/08: Green's functions part 2, **Section 6.2**
2. 4/10: Fourier transforms part 1, **Section 7.1**
3. 4/12: **Classwork #6, Quiz #8, Homework #9 Due.**

Week 13:
1. 4/15: Fourier transforms part 2, **Section 7.1**
2. 4/17: Calculus of Fourier transforms, **Section 7.2**
3. 4/19: Green's functions and convolutions part 1, **Section 7.3, Quiz #9, Homework #10 Due.**

Week 14:
1. 4/22: Green's functions and convolutions part 2, **Section 7.3**
2. 4/24: Fundamental solution to the heat equation, **Section 8.1**
3. 4/26: Maximum principle part 1, **Section 8.3, Homework #11 Due.**

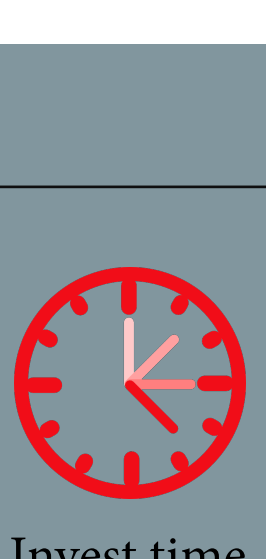
Week 15:
1. 4/29: Maximum principle part 2, **Section 8.3**
2. 5/01: **Classwork #7, Homework #12 Due.**

Final Exam: 5/09, 9:00 AM.

SUCCESS

Attend class

Participate constantly



Invest time

Concentrate on concepts in addition to calculations

Seek help when needed

Eliminate Virtual Distractions