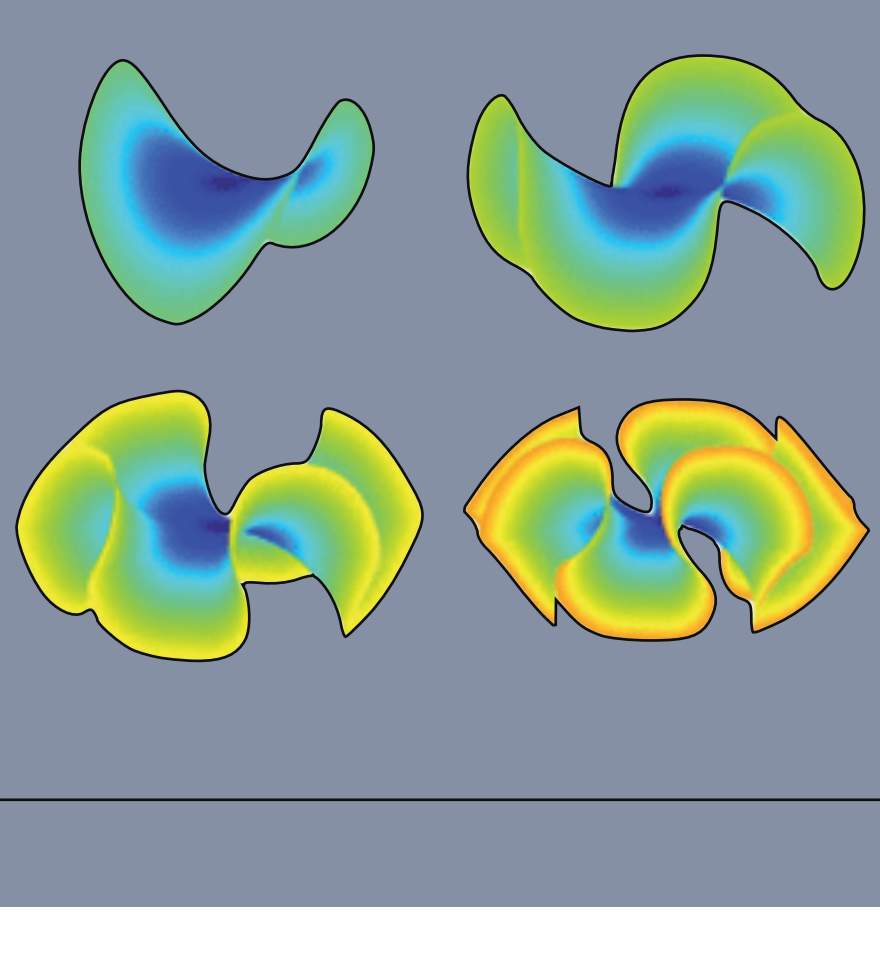
Partial Differential Equations



MTH 352/652

Dr. John Gemmer: gemmerj@wfu.edu
Office: Manchester 388

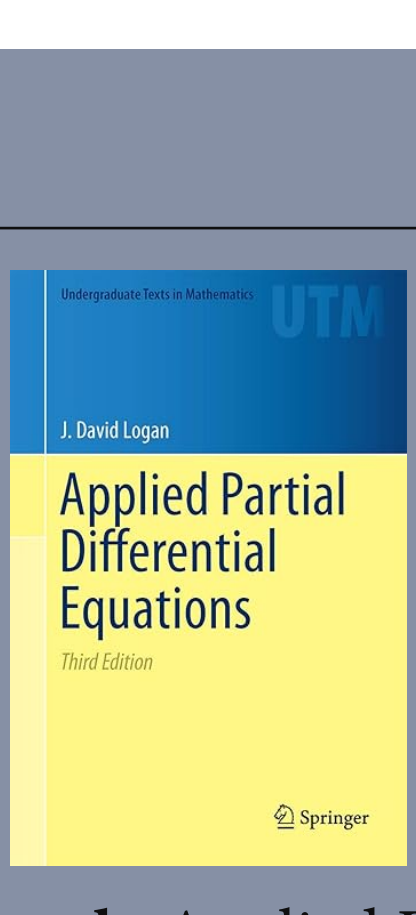
Course Website: http://users.wfu.edu/gemmerj/math352S25.html
(homework, lecture notes, solutions will be posted on the course website)
Canvas: The course syllabus and grades will be posted on Canvas
Office Hours: T 1:00-3:00, W 1:00-2:00, Th 1:00-3:00
Class Meeting Times: MWF 11:00-11:50
Class Location: Kirby-Manchester 020

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

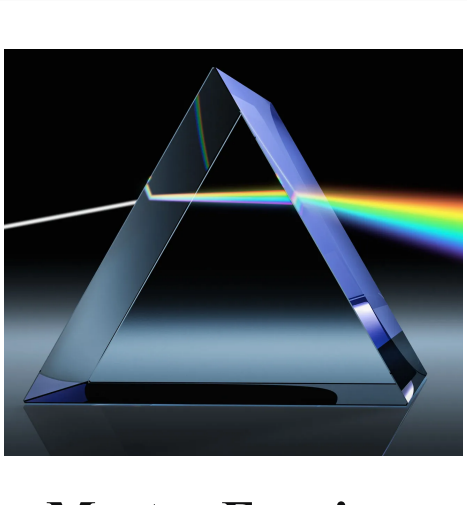
Prerequisites:
Differential Equations (MTH 251)
Vector Calculus (MTH 113)



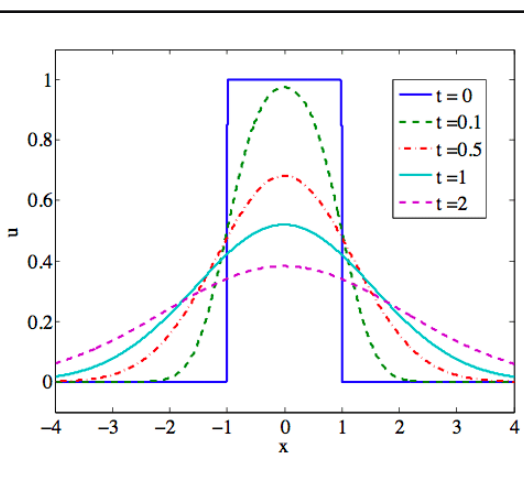
Textbook: Applied Partial Differential Equations

Software: Mathematica, Matlab, Python: WFU Software Link

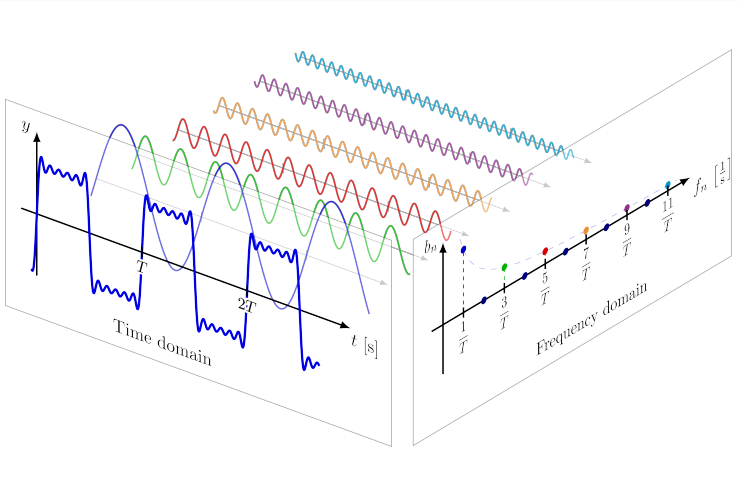
OBJECTIVES



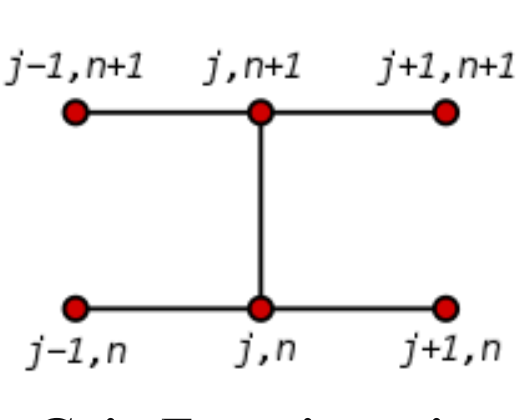
Master Fourier Analysis



Master Solving Linear Boundary Value

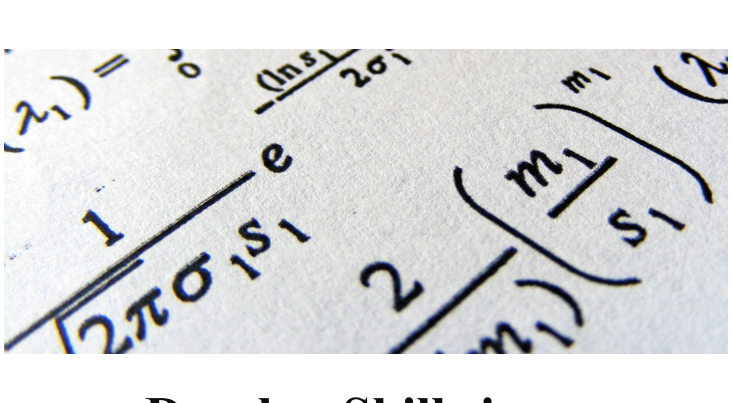


Gain Experience in Fourier Transforms



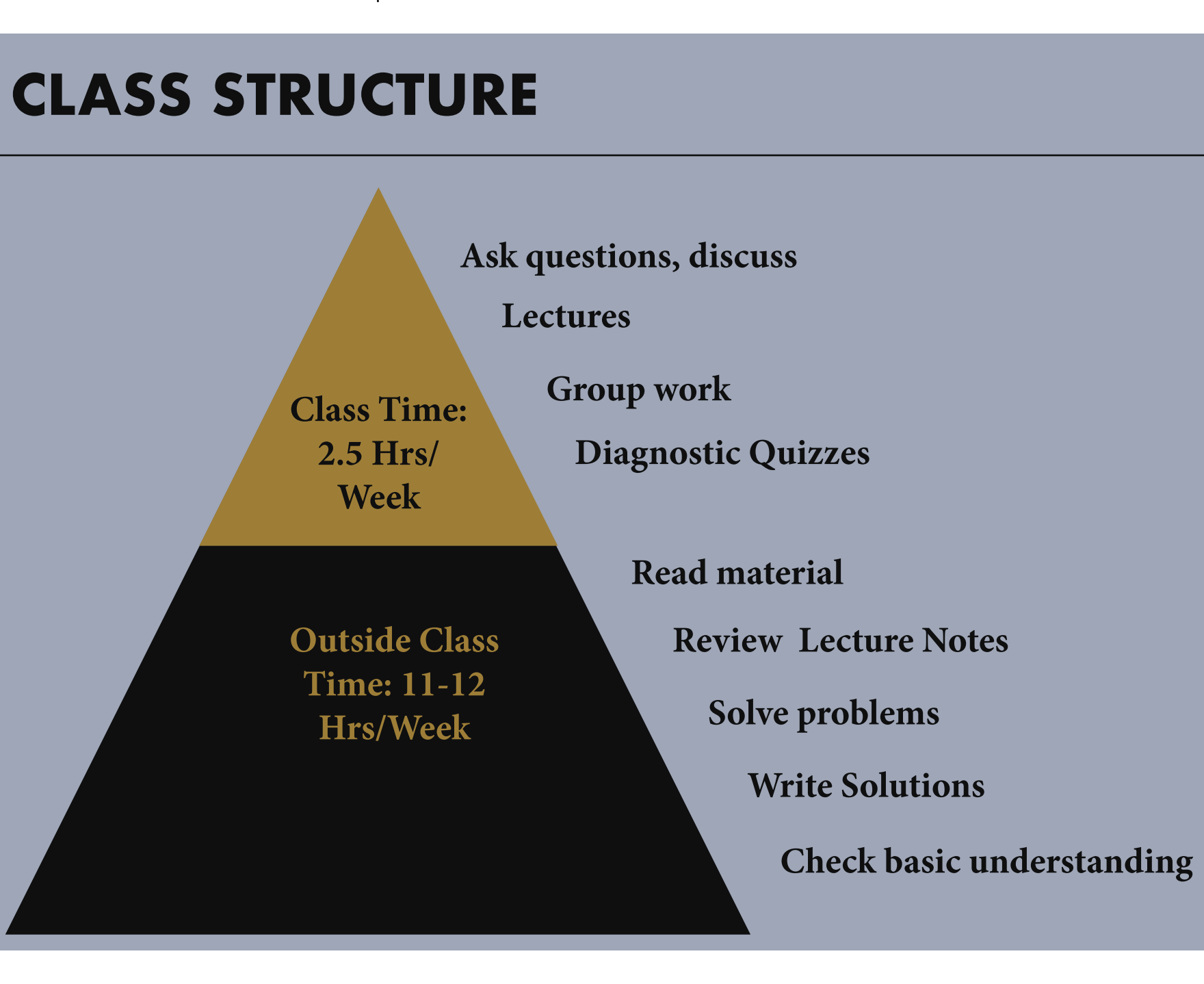
Gain Experience in Numerical Methods

Learn to Collaborate



Develop Skills in Applied Analysis

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

Computational Assignments (5%)
Simulate or illustrate solution behavior to PDEs
Graded on correctness with infinite resubmissions

Quizzes (10%)
5-10 minutes
In class on Wednesdays

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

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

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

Graduate Student Evaluation

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

Computational Assignments (5%)
Simulate or illustrate solutions behavior to PDEs
Graded on correctness with infinite resubmissions

Quizzes (5%)
5-10 minutes
In class on Wednesdays

Term paper presentation (10%)
Presentations should be done on computer
Final presentations will occur during the two days of class

Term paper (15%)
Term paper should be written in LaTeX The term paper is due on the assigned date of the final exam

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

Two summative assessments (20%)
In class, closed notes

Final Exam (20%)
Comprehensive
In class, closed notes

Classworks: Throughout the course there will be a several announced and unannounced class works. These will 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 computational assignments. These assignments will first consist of in class group work in which students will learn how to use software to illustrate the behavior of solutions to PDEs in Mathematica or numerically solve various partial differential equations in Matlab/Python. 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 through email as either Mathematica files or Matlab/Python scripts.

Quizzes: On most Wednesdays 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 Friday and due in class the following Friday. 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 unless you need to miss class.

Term Paper: A significant portion of graduate student's progress towards completion of the course goals will be evaluated through the completion of a term paper. Potential topics will be posted on the course website. The student will select a topic to study in detail, reproduce the results in the reference and complete some assigned problems on the topic. The complete assessment of the term paper consists of a final term paper and a final presentation. The final version of the term paper should be written in an expository form with all mathematical details fully written out including the solutions to the assigned problems. The term paper should be written using a professional typesetting program such as LaTeX and the final presentation should done on a computer. The final presentations will occur during the last week of class. A rubric will be posted for evaluating both the term paper and final presentation will be posted on the course website.

Summative Assessments: There will be two in-class summative assessments 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 will 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

Method of Characteristics and PDEs on Unbounded Domains

Week 1:
1. 1/13: Going over the syllabus, solving 1st order ODEs, **Appendix**
2. 1/15: Qualitative analysis of 1st order ODEs, **Lecture Notes**
3. 1/17: PDE models, **Section 1.1**

Week 2:
1. 1/20: MLK Day (No class)
2. 1/22: **Classwork**
3. 1/24: Conservation laws and method of characteristics, **Section 1.2**, **Homework #1 Due**

Week 3:
1. 1/27: Method of characteristics, **Section 1.2**
2. 1/29: Diffusion equations, **Section 1.3**, **Quiz #1**
3. 1/31: Introduction to complex numbers, **Lecture Notes**, **Homework #2 Due**

Week 4:
1. 2/03: Fourier transforms, **Section 2.7**
2. 2/05: Fourier transforms and PDEs, **Section 2.7**, **Quiz #2**
3. 2/07: Cauchy problem for the heat equation I, **Section 2.1**, **Homework #3 Due**

Week 5:
1. 2/10: Cauchy problem for the heat equation II, **Section 2.1**
2. 2/12: Cauchy problem for the wave equation I, **Section 2.2**, **Quiz #3**
3. 2/14: Cauchy problem for the wave equation II, **Section 2.2**, **Homework #4 Due**

Fourier Series and PDEs on Bounded Domains

Week 6:
1. 2/17: Well posed problems, **Section 2.3**,
2. 2/19: **Summative Assessment #1**
3. 2/21: The Fourier Method, **Section 3.1**

Week 7:
1. 2/24: Orthogonal Expansions I, **Section 3.2**,
2. 2/26: Orthogonal Expansions II, **Section 3.2**, **Quiz #4**,
3. 2/28: Classic Fourier Series I, **Section 3.3**, **Homework #5 Due**

Week 8:
1. 3/03: Classic Fourier Series II, **Section 3.3**
2. 3/05: Separation of variables, **Section 4.1**, **Quiz #5**
3. 3/07: Heat equation on bounded domain I, **Section 4.1**, **Homework #6 Due**

Spring Break 3/08-3/16

Week 9:
1. 3/17: Heat equation on bounded domain II, **Section 4.1**
2. 3/19: Numerical solutions to the heat equation I, **Lecture Notes**, **Quiz #6**
3. 3/21: Numerical solutions to the heat equation II, **Lecture Notes**, **Homework #7 Due**

Week 10:
1. 3/24: Wave equation on bounded domain I, **Section 4.1**
2. 3/26: Wave equation on bounded domain II, **Section 4.2**, **Quiz #7**
3. 3/28: Numerical solutions to the wave equation, **Lecture Notes**, **Homework #8 Due**

PDES in Higher Dimensions, inhomogeneous BCs and Sources

Week 11:
1. 3/31: Inhomogeneous boundary conditions, **Lecture Notes**
2. 4/02: **Summative Assessment #2**
3. 4/04: Laplace's equation on a square, **Section 4.4**

Week 12:
1. 4/07: Laplace's equation on disc like domains, **Section 4.4**
2. 4/09: Maximum principle and its consequences, **Lecture Notes**, **Quiz #8**
3. 4/11: Duhamel's principle and sources on unbounded domains, **Section 2.5**, **Homework #9 Due**

Week 13:
1. 4/14: Sources on bounded domains I, **Section 4.7**
2. 4/16: Sources on bounded domains II, **Section 4.7**, **Quiz #9**
3. 4/18: Cooling of a sphere, **Section 4.5**, **Homework #10 Due**

Week 14:
1. 4/21: Catch up day
2. 4/23: Catch up day, **Quiz #10**
3. 4/25: Student presentations, **Homework #11 Due**

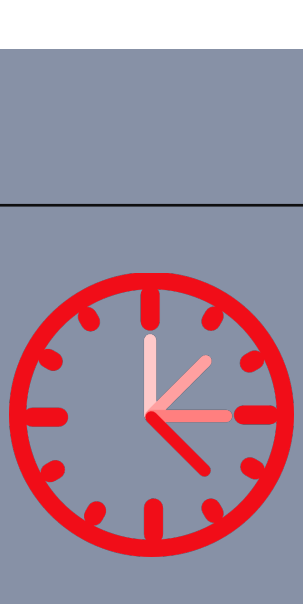
Week 15:
1. 4/28: Student presentations

Final Exam: May 7, 2:00 PM

SUCCESS

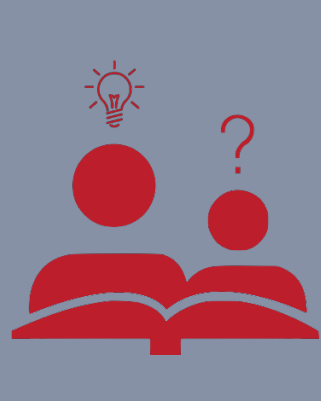
Attend class

Participate constantly



Invest time

Concentrate on concepts in addition to calculations



Seek help when needed

Eliminate Virtual Distractions