AMATH 353
Partial Differential Equations and Waves
Spring 2018

General Information:	**Lecture**:	MWF 10:30 - 11:20
	Location:	Mechanical Engineering Building (MEB) 246
	Website:	https://canvas.uw.edu/courses/1215737
Instructor Information:	**Name**:	Jeremy Upsal
	Email:	jupsal@uw.edu
	Office Hours:	M/Tu/Th 11:30 - 12:30. Additional or different hours TBD.
	Location:	LEW 129
TA Information:	**Name**:	Doris Voina

1 Prerequisites

Either AMATH 351, MATH 136, or MATH 307. You should be very comfortable with taking derivatives of elementary functions, the chain rule, solutions of common differential equations, and using scientific computing software (such as python, MATLAB, Mathematica, Java, etc.) to create plots and do other simple computations. If you are lacking in any of thees areas, please contact me immediately and we can work to remedy any deficiencies quickly. There will be a quiz at the very beginning of the course which covers this background material, and you must pass it to take future quizzes.

2 Course Description

The goal for this course is for students to come away with an introductory understanding of what PDEs are, some solution methods for PDEs, and how to examine solutions once they are found. There will be 6 quizzes throughout the quarter and a final comprehensive quiz at the end of the quarter. These quizzes will cover what I consider "critical." While the quizzes should be fairly self-contained, math is truly a topic that builds on itself, so there will always be some comprehensive nature to the quizzes. See more info about these quizzes in the **Grading** Section.

2.1 Critical topics

The following topics are what I consider critical for this course. These will be the primary, but not only, topics on which you are graded. You should leave this course understanding these topics very well.

- **Quiz 1 - understanding PDEs.**
  - Classification of PDEs.

  - What affect does each term in a given PDE have on a solution?
  - How do we interpret solutions to a PDE? What does a solution mean algebraically, geometrically, and physically?
  - Periodic vs. decaying boundary conditions.
  - The difference between an Initial Value Problem (IVP) and a Boundary Value Problem (BVP).
  - Linear vs. nonlinear equations.
  - Changing coordinates to rewrite PDEs or Boundary/Initial conditions.

- **Quiz 2 - Wave solutions of PDEs**
  - Traveling wave solutions of PDEs.
  - Linearization.
  - The Dispersion relation and what it tells us about solutions.
  - The wave equation, d'Alembert's solution.

- **Quiz 3 - Boundary Value Problems and Fourier Series**
  - Separation of variables.
  - The wave equation, standing waves and Fourier Series.
  - Fourier series of general functions.
  - Solutions of linear PDEs by Fourier Series.

- **Quiz 4 - Conservation law PDEs and the method of characteristics**
  - Conservation laws.
  - The method of characteristics for homogeneous and nonhomogeneous general linear problems.
  - The method of characteristics for nonlinear conservation laws: breaking time.

- **Quiz 5 - Shock and rarefaction waves + applications to traffic flow**
  - Breaking time and shock waves.
  - Rarefaction waves.

2.2 Other topics

There will be other topics that show up in the course related to the above critical topics. However, because either they are less fundamental, more difficult to grasp, or simply out of the scope of the course, they will not be primary subjects for grading, however they may show up on homework. They are all interesting topics, and I can guide interested individuals to more resources if necessary. These include:

- Wave trains.
- Phase and group velocity and the difference between them.
- Deriving PDE models from physical laws.

- Convergence properties of Fourier Series.
- Multidimensional problems / eigenfunctions of differential operators.
- Fourier transforms and how to solve differential equations using them.
- Traffic flow problems and modeling of them.
- The Rankine-Hugoniot condition.
- The viscosity method for hyperbolic systems.
- Rarefaction and shock waves combined.
- Weak solutions/function spaces.

In particular, we will discuss Fourier transforms, weak solutions and function spaces, or the viscosity method depending on the interest of the class, if and only if time permits.

3 Course Materials

The textbook for this course is Roger Knobel's "An introduction to the mathematical theory of waves," American Mathematical Society 1999, Student Mathematical Library Vol 3. Additionally, lecture notes written by Professor Bernard Deconinck will be provided on Canvas or can be found on his webpage. Dr. Deconinck's notes are not meant as a replacement for the course textbook and may lack some details provided in Knobel's book but often provide good insight and examples.

Other useful books include Richard Haberman's "Partial Differential Equations for Scientists and Engineers," particularly for the Fourier Series aspect of this course and Peter Olver's "Introduction to Differential Equations" which covers theoretical aspects of PDEs very well.

For plotting, I will accept MATLAB, Python or Mathematica. If you would like to use something else please come to me and we can discuss.

4 Grading

For this course I will be using what is called *mastery based grading.* This means that some assignments can be attempted multiple times until the topic is *mastered.* The goal of this approach is to (a) ensure that students come away from the course knowing at least some topics very well and (b) to limit the number of students who pass the course only by getting partial credit on every assignments. This idea is based on a pedagogy research paper which I will post on canvas. See below to see what this means for each grading category.

Your course grade will be calculated by weighing your homework and quiz exam scores in the following proportions:

Homework: 40 %
Quizzes: 60 %

4.1 Homework

4.1.1 Number of assignments

There will be approximately 18 homework assignments throughout the quarter. I know that this sounds like a lot. There will be two homeworks assigned and due each week. One assignment will be 1 problem, the other will be 2-3 problems. The reason for having multiple assignments in a week is to help students to not procrastinate and do the homework when the material is fresh in the mind. **You should expect the questions on the homework to be significantly more difficult than those on the quizzes, since you will have much more time to work on them.**

4.1.2 Reflection on homework

There will be some sort of reflection portion for every homework. This portion will usually consist of a questionnaire on canvas regarding your study habits, how long the homework took you, what you struggled with, and how you have improved from previous assignments. Recent research suggests that reflecting on one's own work is a very important part to learning, and it helps the instructor see how the students are thinking about things and where they are struggling.

4.1.3 Presentation and turning in

Every homework set you hand in should have a header containing your name, student number, due date, course, and the homework number as a title. Your homework should be neat and readable. Your homework score may reflect the presentation of your homework set. Students are encouraged to type homework solutions and strongly encouraged to use LaTeX. If there are questions about using LaTeX I am happy to answer these. **Homework will be turned in on canvas and must be in .pdf format. I will not accept physical copies.**

4.1.4 Collaboration

You are encouraged to discuss the homework with other students. However, please write your own homework solutions and please do not share your homework solutions with others. Your work should be your own. If you work with other students on the homework, please acknowledge who you worked with on the homework, such as "I worked on this problem with Jane Doe." Academic honesty (cheating) will be taken seriously in this class. Questions should be asked in office hours or on the canvas discussion page.

4.1.5 Homework grading

Each problem on each assignment will have equal weight in the grades. Very little (if any) partial credit will be awarded. The fact that there will be many homework problems should help make up for minor mistakes. **You must show your work on each problem. Solutions with no work presented will be awarded 0 points.**

4.1.6 Late Homework Policy

You may turn in up to three homework assignments as late as you would like, up to the final exam date. Any subsequent late homeworks will be awarded a 0. The only allowed exceptions are for documented school functions or documented illness/injury.

4.2 Quizzes

We will do mastery based grading for the quizzes. We will start the quarter with a quiz on old material. You can retake this quiz as much as you would like, but cannot take future quizzes until you pass the quiz. It will be on canvas. The subsequent quizzes will be as self-contained as possible. They will each be 20 minutes and take place at the beginning of class. These quizzes will be graded with very little to no partial credit. If you are not pleased with your grade, you may retake the quiz at a later date. **Upon choosing to retake the quiz, you must agree to forfeit your old grade and accept the new grade you get on the quiz.** I will offer up to 4 retake dates, outside of regular class time. Each subsequent retake will be more difficult than the previous, so if you would like to retake a quiz it is advantageous to do so as soon as possible. Each retake may be (not significantly) longer than 20 minutes, depending on difficulty. The final retake date for quizzes will be on the day of the final, June 4, 2018. Any quiz may be retaken on this date.

There are two exceptions to the above statements. Quiz 0 covers material that you must know to complete this course and will have a maximum completion time of 15 minutes. It must be completed on canvas before sitting for any other quizzes. Quiz 0 should be completed in the first week of the course. It may be taken as many times as you wish, without increasing difficulty. Quiz 0 is graded upon completion. Quiz 7 will be a comprehensive quiz with no retakes. It will be 30-45 minutes instead of 20 and will be administered on the final exam date.

The rest of the quiz dates will be set only up to one week in advance of the quizzes, as the class progresses.

5 Feedback from Students

I would like any and all feedback from students on how the class is going, any improvement suggestions, or any other questions. The first two options are to (a) speak with me in person or (b) send me an email. If you would prefer to anonymously send feedback, please use the suggestionox link provided on the canvas webpage.

5.1 Reflection

I have recently become involved with a pedagogy reading group. This means that we read about current research regarding teaching. It has become increasingly clear that a few things are missing in the standard curriculum that I would like to correct.

- Instructors need to be more clear about their goals. Please let me know if it is not clear why something is being assigned or why a specific policy is in place.
- Students need to reflect more on their work and their study habits. The reason we have so many quizzes is so that students can go over their homework, which was completed recently, and then reproduce this work on a quiz. There will be opportunities for reflection about study habits both after homework assignments and after quizzes.
- Students need to see how their work fits into the rest of the class. This larger picture helps create a sense of cohesiveness and is one of the characteristics that is found in experts but not in novices, typically. There will not be any required tasks in this direction, but I will make a point during lecture to speak to interconnectdedness of material. I also encourage you to think about using a **concept map.**

6 Students With Disabilities

In compliance with University of Washington policy and equal access laws, I am available to discuss appropriate academic accommodations that you may require as a student with a disability. Request for academic accommodations need to be made during the first week of the quarter, except for unusual circumstances, so arrangements can be made. Students are encouraged to register with the Disability Services Office for disability verification and for determination of reasonable academic accommodations.

For more Information, visit: http://www.washington.edu/admin/dso/