MATH 5343 (CRN 26341)

Numerical Solutions to Partial Differential Equations

Spring 2021
The University of Texas at El Paso

Xianyi Zeng, Instructor

This course concerns numerically solving boundary value problems and initial-boundary value problems using finite difference methods and finite element methods, as well as fundamental (accuracy and stability) analysis of these computational schemes.

Course number:	MATH 5343 (CRN 26341)
Course title:	Numerical Solutions to Partial Differential Equations
Credit hours:	3
Term:	Spring 2021
Time & location:	9:00–10:20am MW, online
Exam dates:	Midterm exam: online in-class, Tuesday 03/22/2021 (tentative) Final exam: online 10:00-12:45pm, Wednesday 05/12/2021
Drop deadline:	Thursday, April 1, 2021
Prerequisites:	MATH 2326 (Differential Equations) and MATH 3323 (Matrix Algebra) and MATH 4329 (Numerical Analysis) with grades "C" or better.
Course fee:	None
Instructor:	Xianyi Zeng Office hour: 4:00-5:30pm MW, send an email first to setup a Zoom meeting Office location: online Email: xzeng@utep.edu
Course website:	http://math.utep.edu/faculty/xzeng/2021spring_math5343
Textbook:	Lecture notes provided by the instructor.
	Grégoire Allaire, Chapters 1, 2, 3, 6.1, 6.2, *Numerical analysis and optimization: An introduction to mathematical modelling and numerical simulation*, Oxford University Press 2007. Library link: https://lib.utep.edu/record=b4248296
	Randall LeVeque, Chapters 4, 6, 12, 15, *Finite volume methods for hyperbolic problems*, Cambridge Unversity Press 2002. Library link: https://lib.utep.edu/record=b3323052

General course format and Covid-19 information

All of our lectures and office hours will be delivered online using Zoom. Live lectures will be held and recorded at the scheduled time unless otherwise announced; recorded videos will be made available in Blackboard after the live session. Students are not required to join the live sessions.Announcements will be made either via email or Blackboard; the students are required to check the emails and the course shell in Blackboard frequently to keep up-to-date. Course materials except the recorded lectures will be posted on the *course website*.

Technology requirements

Course content is delivered via the Internet through the Blackboard learning management system (announcement, grade distribution, and recorded lectures), the course website (other course materials), and Zoom (live sessions). The students need to ensure the UTEP e-mail account is working and that they have access to the Web and a stable web browser. Google Chrome and Mozilla Firefox are the best browsers for Blackboard; other browsers may cause complications. When having technical difficulties, update your browser, clear your cache, or try switching to another browser.

The students need to have access to a computer/laptop as well as a scanner/scanning app; if you wish to join live session discussions and/or virtual office hours, make sure a microphone is available. A webcam is suggested but not required; the instructor would like to create live interactive sessions to know the students better and to provide an opportunity for the students to know their classmates. A Zoom client is required if the student plans to join a live session.

Programming is an important aspect of this class, and the students are required to use Matlab to complete the a few computational assignments given throughout the semester. The Matlab software is provided to UTEP students at no cost and more information can be found at https://www.utep.edu/technologysupport/ServiceCatalog/SOFTWARE_PAGES/soft_matlab.html.

Important: The students are encouraged to contact the UTEP Help Desk (https://www.utep.edu/irp/technologysupport) when they encounter course-irrelevant technical difficulties beyond their scope of troubleshooting.

Network etiquette

As communication online can be challenging sometimes, it's possible to miscommunicate what we mean or to misunderstand what our classmates mean given the lack of body language and immediate feedback. Therefore, please keep these network etiquette guidelines in mind. Failure to observe them may result in disciplinary action.

- Always consider audience. This is a first-year graduate-level course; therefore, all communication should reflect polite consideration of other's ideas.
- Respect and courtesy must be provided to classmates and to the instructor at all times. No harassment or inappropriate postings will be tolerated.
- When reacting to someone else's message, address the ideas, not the person. Post only what anyone would comfortably state in a face-to-face situation.
- Blackboard is not a public Internet venue; all postings to it should be considered private and confidential. Whatever is posted on in these online spaces is intended for classmates and instructor only. Please do not copy documents and paste them to a publicly accessible website, blog, or other space.

Course format and attendance

In general, each lecture covers one section of the textbook. These lectures will be delivered live using Zoom; and recorded lectures will be uploaded to Blackboard. Although this class follows an asynchronous schedule, the lectures will be generally delivered live at a pre-scheduled time; the students are encouraged to take part in the live sessions and participate in discussions. Attendance of the live lectures is not required.

Course objectives

Partial differential equations have been the major instrument to describe physical and engineering systems in past a few centuries and they still play a central role nowadays in emerging applications such as aerodynamics, astrophysics, meteorology, nuclear science, and molecular biology. These

equations, however, are typically difficult to solve analytically hence people resort to numerical approaches and attempt to find approximated solutions. This class will focus on two broad classes of equations, namely the boundary value problems (BVP) such as the Poisson equation and statics, and initial-boundary value problems (IBVP) like the wave equation, the heat equation, and solid dynamics. The students will learn fundamental and widely used numerical methods to solve these equations. More specifically, this class will focus on finite difference methods (FDM) and its variation the finite volume methods (FVM), and the finite element methods (FEM) as well as their standard accuracy and stability analysis.

Upon successful completion of the course, the students are expected to be able to conduct preliminary accuracy and stability analysis of a numerical scheme, to choose appropriate computational strategy to solve a specific problem, and to implement simple algorithms for model equations discussed in class.

Grading

The final grade for the course will be based on the following:

- 30% paper homework.
- 20% computational assignments.
- 20% midterm exam.
- 30% final exam (comprehensive).

There will be three computational assignments and several paper homework that are generally assigned on Thursdays. In principal, paper homework is due in one week and the computational assignment is due in two weeks. Specific due date will be indicated clearly on the course website as well as in Blackboard. Missed assignment or homework **cannot** be made up; but the **two** lowest homework scores and the **one** lowest computational assignment score will be audomatically dropped towards calculating the final grade.

Exams are open-book and open-note, but one must complete the work individually and are not allowed to consult online resources. Missed exams **cannot** be made up; exceptions are given only in extraordinary and unavoidable circumstances with reasonable proofs and advance notice in written.

The letter grade will be guaranteed at the following levels: A $(90-100\%)$, B $(80-89\%)$, C $(70-79\%)$, D $(60-69\%)$. Depending on circumstances, the thresholds for each of the four letter grades could be lowered, but will be equal among all students. The letter grade F will be given if the final score does not reach the D threshold.

Accommodations for students with disabilities

If a student has a disability and needs classroom/exam/homework accommodations, please contact The Center for Accommodations and Support Services (CASS) at 747-5148, or by email to cass@utep.edu, or visit their office located in UTEP Union East, Room 106. For additional information, please visit the CASS website at `http://www.sa.utep.edu/cass`.

Academic honesty policy

The students are required to understand the UTEP academic honesty policy. Sharing ideas are encouraged among the students; but collaboration of any form during quizzes and exams is strictly prohibited. If the instructor has reason to believe that the students have cheated on homework or exam, including clearly duplicated or copied quizzes or exams, the case will be referred to the Dean of Students for adjudication.

Military statement

A military student with the potential of being called to military service and/or training during the course of the semester is encouraged to contact as soon as possible.

Course drop deadline

April 1 is the university fall drop/withdrawal deadline.
The college of science will not accept drop/withdrawal requests of any form after **April 1**.

Course schedule

Below is a tentative schedule for this course.

Week 01 (01/20)	Allaire Chapter 1
Week 02 (01/25, 01/27)	Allaire Chapter 1
Week 03 (02/01, 02/03)	Allaire Chapter 2
Week 04 (02/08, 02/10)	Allaire Chapter 2
Week 05 (02/15, 02/17)	LeVeque Chapter 4
Week 06 (02/22, 02/24)	LeVeque Chapter 6
Week 07 (03/01, 03/03)	LeVeque Chapter 6
Week 08 (03/08, 03/10)	Flexible and midterm review
Week 09 Spring Break	No class
Week 10 (03/22, 03/24)	Midterm exam, nonlinear hyperbolic equation
Week 11 (03/29, 03/31)	LeVeque Chapter 12
Week 12 (04/05, 04/07)	Hyperbolic system, LeVeque Chapter 16
Week 13 (04/12, 04/14)	LeVeque Chapter 15
Week 14 (04/19, 04/21)	Allaire Chapter 3
Week 15 (04/26, 04/28)	Allaire 6.1 and Allaire 6.2
Week 16 (05/03, 05/05)	Multidimensional problems
Week 17 (05/12)	Final exam