MATH 6318.001 (27052) Syllabus
Numerical Analysis of Differential Equations
Spring 2019, TuTh 1:00–2:15 pm, CB3 1.308

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Note that I will maintain a web page for this course linked from my main web page. (I do not use eLearning.)

Office Hours: Tuesdays 2:30–3:30 pm or by appointment.

Prerequisite: Math 6313 or an equivalent Numerical Analysis course, and knowledge of programming in general and MATLAB in particular. Note that we will be using Matlab exclusively in this course. It is highly recommended that all students taking this course will have been exposed to an introductory pde's course and will have a working knowledge of MATLAB.

Course Description (from the catalog): Practical and theoretical aspects of numerical methods for partial differential equations are discussed. Topics selected from: finite difference, finite element and boundary element approximations for partial differential equations. Application of methods will be illustrated using MATLAB.

Texts — Recommended:
(1) *Numerical Analysis: Mathematics of Scientific Computing*, 3rd Edition, by Kincaid and Cheney. Publisher: Brooks/Cole, 2002.
(2) *Finite Difference Schemes and Partial Differential Equations*, by Strikwerda. Publisher: SIAM, 2007.
(3) *Numerical Methods for Differential Equations – Fundamental Concepts for Scientific and Engineering Applications*, by Celia and Gray. Publisher: Prentice Hall, 1992.
(4) *Partial Differential Equations: Analytical and Numerical Methods*, by Mark Gockenbach. Publisher: SIAM, 2011.

Note: There are numerous books which cover either finite difference or finite element methods. However, there is no one perfect book covering both methods at an introductory level. I will be using a variety of books for lecture preparation and expect that you should rely on your class notes as your primary "text" for the course. However, students often find it helpful to have supplemental sources to study from so I would encourage you to consider buying at least the book by Strikwerda listed above.

Useful MATLAB Reference: *Mastering MATLAB*, by Hanselman and Littlefield. Publisher: Prentice Hall, Inc.

Grading Policy:

Homework	40%
Midterm Exam	30%
Final Exam	30%
Total	100%

Homework: There will be one homework due every 1–2 weeks on Thursdays (the length of time will depend on the difficulty of the assignment). Homework is to be turned in at the START of class on Thursday or can be slipped under my office door *prior* to class on Thursday if you must miss class for some reason. *Late homework will not be accepted.*

Please note that the homework constitutes a substantial portion of your overall grade. In order to learn the concepts and be able to apply them to solving problems on exams, etc., you are strongly encouraged to devote as much time as possible to working the homework problems. It is likely that not all homework problems will be able to be graded, but most of your learning will come from devoting good chunks of time each week to the homework. I encourage you to discuss the homework assignments with other students in the class. However, I expect the homework you submit for grading to be written up by you alone (this includes computer programs which must not be duplicates of programs other students turn in).

Tests: No make-up exams will be given except *possibly* in the case of a serious emergency. In such a case I *must* be notified *in advance*. There will be no exceptions to taking the final exam at the date, time, and place specified by the University (TBD). The final exam will be comprehensive although material covered after the midterm will be emphasized.

Student Learning Outcomes: This course is intended as an introductory course in numerical solution of partial differential equations. It is appropriate for beginning graduate students who have some experience with partial differential equations (through a separation of variables course or an application area).

Many physical phenomena are modeled by differential equations. The canonical models are the heat, wave, and potential equations. When the coefficients in a pde model are not constant or the domain is complex, these pde's cannot be solved via analytic methods (e.g., by writing down a closed form solution). One must resort to *approximating* the solution on a computer. The approximation error in these solutions arises from a variety of sources (including the fact that one cannot take a limit on a computer and must approximate derivatives and integrals by divided differences and finite sums respectively). In this course we will focus on the two most common techniques for solving pde's numerically: finite difference and finite element methods.

After taking this course you will have a basic understanding of how to implement and analyze all of these methods and will be aware of the error in using these methods to approximate solutions to differential equations on a computer. You will know which methods to use to best approximate solutions for each type of equation and will be able to modify your solution to achieve the desired accuracy needed for your application.

Academic Conduct: I take academic dishonesty *very seriously* and will not tolerate it in this class in any form. **Academic misconduct includes willfully cheating on or giving aid during an exam or copying homework assignments (from the web, from each other, or from a solutions manual).** Blatant copying on an exam, homework assignment, or computer assignment will result in a grade of zero for that work. Further information on the academic conduct policy can be found at http://www.utdallas.edu/deanofstudents/dishonesty/

UT Dallas Syllabus Policies and Procedures:
The information at http://go.utdallas.edu/syllabus-policies constitutes the University's policy and procedures segment of the course syllabus.
The descriptions and timelines contained in this syllabus are subject to change at the discretion of the Professor.
Class Attendance: I expect students to attend class and to turn up on time. Rarely do students do well in classes which they do not attend, and I will be less likely to give outside assistance to students who regularly miss class. **Further, students arriving late for class disrupt the entire class. Students should also note that I do not allow cell phones, laptops or other electronic devices to be used in class and will ask that these items be turned off at the start of class.**

Email: I am happy to answer questions about the class via email. However, it is much better for you if we can talk in my office at the board. Answers given over email will be brief and intended merely to answer your direct question rather than to explain concepts. I reserve the right not to respond to email if I feel it would be best for the student to discuss his/her question in person during my office hours. I will not respond to email which does not include the name of the sender.

Tips for Succeeding in this Class:

1. Before you attempt the homework you should *read the sections in the book if appropriate and study your notes.*

2. You will benefit greatly from working with others in the class so long as you use your peers as a way to hash over concepts and not a way to "get the answers". In other words, *start early* and use your fellow-classmates to discuss the best way to approach the problems. Then go off and try to work out the details yourself.

3. **Begin the new homework assignment the same day you turn in the previous assignment!** Do not wait 3–4 days to start the homework as then you will not have enough time to digest the material or understand the point of the problems. When computer assignments are given starting early on the homework is essential. Debugging programs takes time and your grade and learning will suffer if you attempt the computer problems at the last minute. If your code does not give output (i.e., does not run) you will lose at least half the points for that problem.

4. Come to office hours and get help if you are stuck. It is much better to get help early than to wait. I may ask you to show me what you've come up with at the board so you should have at least attempted the homework problems before asking for help.

5. If you have not previously used Matlab you will need to start playing with the software the first week of class. There are good tutorial pages at http://www.umbc.edu/circ/workshops/matlab.html.

Important Dates:

Date	Notes
1/14/19	First day of class
1/22/19	Last day to register and last day to add/drop
3/14/19	Midterm Exam
3/28/19	**Absolute Last day to drop class**
5/3/19	Last day of classes
TBD	Final Exam

Math 6318.001, Spring 2019, Tentative Schedule:

Date	Section/Topic
Tu 1/15/19	First Day Handout; Introduction to PDE's, Importance of Numerical Solutions
Th 1/17/19	MATLAB Demo
Tu 1/22/19	Characteristics and Boundary Conditions
Th 1/24/19	Characteristics and BC's
Tu 1/29/19	Finite Difference Methods for Hyperbolic Equations
Th 1/31/19	Finite Difference Methods for Hyperbolic Equations
Tu 2/5/19	Finite Difference Methods for Hyperbolic Equations
Th 2/7/19	Order of Accuracy of FD Schemes
Tu 2/12/19	Stability of FD Schemes
Th 2/14/19	Dissipation and Dispersion of FD Schemes
Tu 2/19/19	Finite Difference Methods for Parabolic Equations
Th 2/21/19	Finite Difference Methods for Parabolic Equations
Tu 2/26/19	Finite Difference Methods for Parabolic Equations
Th 2/28/19	Finite Element Methods for Elliptic Equations
Tu 3/5/19	Finite Element Methods for Elliptic Equations
Th 3/7/19	Finite Element Methods for Elliptic Equations
Tu 3/12/19	Finite Element Methods for Elliptic Equations
Th 3/14/19	**Midterm Exam**

Date	Section/Topic
Tu 3/19/19	**Spring Break**
Th 3/21/19	**Spring Break**
Tu 3/26/19	FEM for Elliptic Equations (Inhomogeneous Dirichlet BC's)
Th 3/28/19	FEM for Elliptic Equations (quadrature)
Tu 4/2/19	FEM for Elliptic Equations (Inhomogeneous Neumann BC's)
Th 4/4/19	FEM for Elliptic Equations (2D)
Tu 4/9/19	Order of Convergence of FE Methods
Th 4/11/19	Weighted Residual Method
Tu 4/16/19	Mixed Finite Element Methods
Th 4/18/19	Multigrid Methods
Tu 4/23/19	Multigrid Methods
Th 4/25/19	Uncertainty Quantification
Tu 4/30/19	Uncertainty Quantification
Th 5/2/19	Review for Final Exam
TBD	FINAL EXAM