



Course Syllabus: Num. Analysis of Differential Equations - AMCS 252

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	AMCS 252
Course Title	Num. Analysis of Differential Equations
Academic Semester	Spring
Academic Year	2018/2019
Semester Start Date	01/27/2019
Semester End Date	05/23/2019
Class Schedule (Days & Time)	09:00 AM - 10:30 AM Mon Thu

Instructor(s)				
Name	Email	Phone	Office Location	Office Hours
Matteo Parsani	Matteo.Parsani@kaust.edu.sa	+966128080678	0140 (Level 0), 1, Al-Khawarizmi (bldg. 1)	By appointment (e-mail or ask before or after the class).

Teaching Assistant(s)	
Name	Email
TBD	TBD

Course Information	
Comprehensive Course Description	<p>This course will introduce you to numerical methods for solving ordinary differential equations (ODEs) and partial differential equations (PDEs). We will concentrate on finite difference methods and their application to standard model problems. This will allow the methods to be taught in simple terms while at the same time treating such concepts as accuracy and stability with a reasonable degree of mathematical rigour.</p> <p>Similarities and differences between algorithm and stability analysis for different types of equations will be presented. We will begin with finite difference solution of steady state problems followed by boundary value problems. Next we will focus on the solution of initial value ODEs, and finally initial value PDEs. Emphasis will be given to two simple but very important equations, i.e., the heat equation and the advection equation.</p>
Course Description from Program Guide	<p>The course covers theory and algorithms for the numerical solution of ODEs and of PDEs of parabolic, hyperbolic, and elliptic type. Theoretical concepts include: accuracy, zero-stability, absolute stability, convergence, order of accuracy, stiffness, conservation, and the CFL condition. Algorithms covered include: finite differences, steady and unsteady discretization in one (1) and two (2) dimensions, Newton methods, Runge-Kutta methods, linear multistep methods, multigrid, implicit methods for stiff problems, centered and upwind methods for wave equations, dimensional splitting and operator splitting</p>

Goals and Objectives	<p>General concepts such as accuracy, stability, boundary conditions, verifications, and validation are presented. Your main goal should be to gain understanding of the methods through analysis of their accuracy and stability, and also by implementing and experimenting with the methods. Investigate, through computations, the behavior of the numerical methods, analyze the results, discuss alternative algorithms, and draw critical conclusions helps invaluable to assimilate theoretical notions; it challenges you to excel at tasks beyond the basic expectation of a course; it encourages confidence in your abilities.</p> <p>Depending on the performance of the students, we could spend some time looking at new tools. For instance, for group collaboration and code development, we could start using a modern version control system such as one would encounter when interacting with real software projects.</p>
Required Knowledge	<p>You should possess knowledge of linear algebra, differential equations, and some notions of advanced calculus such as Taylor series. Some programming experience with high level languages such as python and matlab (or octave) is required. Knowledge of numerical analysis is welcome but is not strictly required.</p>
Reference Texts	<p>1. Finite Difference Methods for Ordinary and Partial Differential Equations, by Randall J. LeVeque</p>
Method of evaluation	<p>40.00% - Course Project(s) 40.00% - Midterm exam 20.00% - Homework /Assignments</p>
Nature of the assignments	<p>For each class session, you will be given a reading assignment and 1 (or 2) homework problems. It is essential that you devote substantial time to the reading, since I will not cover all topics in class. Instead, you should come to class prepared to ask questions. You may also email me before the lecture with questions or requests so that we could use part of the class time to discuss in greater detail an important topic, a specific problem, or an explanation that seems not clear.</p> <p>During each class, one student will be asked to present a homework solution. Homework can be solved in group of people. Presenting a perfect solution the first time is excellent, but you will not be penalized for minor mistakes. The point is to demonstrate that you understand the concepts (or to improve your understanding) and can communicate them clearly to the class (like you would do, for instance, during a conference or workshop presentation).</p>
Course Policies	<p>If you have a personal activity, family, or religious conflict with the course schedule, you can expect to be heard sympathetically. Please contact me by the end of the second week of the term to discuss appropriate accommodations for any conflicts that can be foreseen. For illness-related absences, there are standard procedures to follow.</p> <p>Late work in this course will receive no credit. You should always turn in what you have completed by the deadline. If there are extenuating circumstances, come talk to me before the deadline.</p>
Additional Information	<p>The instructor reserves the right to make changes to this syllabus as necessary.</p>

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Mon 01/28/2019 Thu 01/31/2019	Introduction to numerical methods: <ol style="list-style-type: none">1. Steady state and time dependent solutions2. Linear and nonlinear differential equations3. Implicit and explicit time integration schemes
2	Mon 02/04/2019 Thu 02/07/2019	Introduction to finite differences
3	Mon 02/11/2019 Thu 02/14/2019	Boundary value problems
4	Mon 02/18/2019 Thu 02/21/2019	Dirichelet and Neumann boundary conditions Existence and uniqueness
5	Mon 02/25/2019 Thu 02/28/2019	Nonlinear problems
6	Mon 03/04/2019 Thu 03/07/2019	Spectral methods
7	Mon 03/11/2019 Thu 03/14/2019	Elliptic problems in 2D
8	Mon 03/18/2019 Thu 03/21/2019	Solution of linear system of algebraic equations (Jacobi and multigrid)
9	Mon 03/25/2019 Thu 03/28/2019	Initial value problems
10	Mon 04/01/2019 Thu 04/04/2019	Basic methods for initial value problems
11	Mon 04/08/2019 Thu 04/11/2019	Zero-stability and convergence
12	Mon 04/15/2019 Thu 04/18/2019	Linear multistep methods
13	Mon 04/22/2019 Thu 04/25/2019	Absolute stability
14	Mon 04/29/2019 Thu 05/02/2019	Stiffness
15	Mon 05/06/2019 Thu 05/09/2019	Runge-Kutte schemes
16	Mon 05/13/2019 Thu 05/16/2019	PDEs and diffusion
17	Mon 05/20/2019 Thu 05/23/2019	Convergence of PDEs

Note

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