جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

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	2016/2017
Semester Start Date	01/22/2017
Semester End Date	05/18/2017
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	+966544700028	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	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. 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.
Course Description from Program Guide	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

Goals and Objectives	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 invaluably to assimilate theoretical notions; it challenges you to excel at tasks beyond the basic expectation of a course; it encourages confidence in your abilities. 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.
Required Knowledge	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 analys is welcome but is not strictly required.
Reference Texts	1. Finite Difference Methods for Ordinary and Partial Differential Equations, by Randall J. LeVeque
Method of evaluation	
Nature of the assignments	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. 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 ow workshop presentation).
Course Policies	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. 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.
Additional Information	The instructor reserves the right to make changes to this syllabus as necessary.

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Mon 01/23/2017 Thu 01/26/2017	Introduction to numerical methods: 1. Steady state and time dependent solutions 2. Linear and nonlinear differential equations 3. Implicit and explicit time integration schemes
2	Mon 01/30/2017 Thu 02/02/2017	Introduction to finite differences
3	Mon 02/06/2017 Thu 02/09/2017	Boundary value problems
4	Mon 02/13/2017 Thu 02/16/2017	Dirichelet and Neumann boundary conditions Existence and uniqueness
5	Mon 02/20/2017 Thu 02/23/2017	Nonlinear problems
6	Mon 02/27/2017 Thu 03/02/2017	Spectral methods
7	Mon 03/06/2017 Thu 03/09/2017	Elliptic problems in 2D
8	Mon 03/13/2017 Thu 03/16/2017	Solution of linear system of algebraic equations (Jacobi and multigrid)
9	Mon 03/20/2017 Thu 03/23/2017	Initial value problems
10	Mon 03/27/2017 Thu 03/30/2017	Basic methods for initial value problems
11	Mon 04/03/2017 Thu 04/06/2017	Zero-stability and convergence
12	Mon 04/10/2017 Thu 04/13/2017	Linear multistep methods
13	Mon 04/17/2017 Thu 04/20/2017	Absolute stability
14	Mon 04/24/2017 Thu 04/27/2017	Stiffness
15	Mon 05/01/2017 Thu 05/04/2017	Runge-Kutte schemes
16	Mon 05/08/2017 Thu 05/11/2017	PDEs and diffusion
17	Mon 05/15/2017 Thu 05/18/2017	Convergence of PDEs
18		The Lax-Wendroff method

Note

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