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

Course Syllabus: Contemporary Topic in Numerical Analysis - AMCS 394D

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	AMCS 394D
Course Title	Contemporary Topic in Numerical Analysis
Academic Semester	Fall
Academic Year	2018/2019
Semester Start Date	08/26/2018
Semester End Date	12/11/2018
Class Schedule (Days & Time)	04:00 PM - 05:30 PM | Sun Wed

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Gabriel Christoph Wittum	gabriel.wittum@kaust.edu.sa	+966128080387		The schedule of the course will be changed to Mon, and Wed 4:00 - 5:30 p.m. My office hours will be the time after the lectures, Mon, Wed 5:45 - 6:45 pm.

Teaching Assistant(s)

Name	Email
Dmitry Logashenko	Dmitry.Logashenko@kaust.edu.sa

Course Information

Comprehensive Course Description	Fast Solvers for Large Systems of Equations Solving systems of algebraic equations is a core task in the numerics of partial differential equations (PDE). After discretising the PDE with a grid method like finite volumes, finite elements or finite differences, we finally obtain a system of algebraic equations, which is typically sparse and very large. The largest systems currently solved contain up to 1012 unknowns. To solve such large sparse systems, specialised algorithms are necessary. Since these algorithms are in the core of a lot of simulation programs and all other parts are usually O(n), they are setting the final complexity of a simulation. We introduce linear iterative methods and discuss their properties inparticular w.r.t. convergence and complexity issues. We then develop multi-grid methods and discuss their main properties. Issues of convergence and complexity are discussed in detail. We further analyse robustness for singularaly perturbed problems and generalise multi-grid methods to solving systems of PDE. We introduce multi-grid methods for non-linear and heterogenous problems and introduce Algebraic Multigrid Methods (AMG).
Course Description from Program Guide	
Goals and Objectives	The students learn to analyse linear iterative methods and to develop and compose multi-grid methods as solvers for large sparse systems of algebraic equations. They learn how to obtain robust convergence and how to generalise multi grid to systems of pde. They further learn the basics of Algebraic Multi-Grid Methods.
Required Knowledge	Basic mathematics courses on Analysis and Linear Algebra. Courses on PDE and numerics are useful, but nor required.

Reference Texts	W Hackbusch: Multi-Grid Methods and Applications, Springer, 1985 G. Wittum: Multi-Grid Methods – an Introduction, manuscript
Method of evaluation	**20.00**% - Homework /Assignments **80.00**% - Final exam
Nature of the assignments	Homework, exercises, programming tasks
Course Policies	as usual
Additional Information	The schedule of the course will be changed to Mon and Wed 4:00 - 5:30 p.m.

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Sun 08/26/2018 Wed 08/29/2018	1. Introduction 1.1 A model problem: A box method 1.2 Iterative methods
2	Sun 09/02/2018 Wed 09/05/2018	1.3 Convergence of Iterative Method: M-Matrices and Regular Spittings
3	Sun 09/09/2018 Wed 09/12/2018	1.4 A Non-Linear Iteration 1.5 Complextiy Issues
4	Sun 09/16/2018 Wed 09/19/2018	2. A Two-Grid Method 2.1 The Smoothing Property of Linear Iterations 2.2 The Algorithm
5	Sun 09/23/2018 Wed 09/26/2018	2.3 Convergence of the Two-Grid Method 3. Multi-Grid Components 3.1 Smoother
6	Sun 09/30/2018 Wed 10/03/2018	3.2 Grid Transfers 3.3 The Coarse-Grid Operator
7	Sun 10/07/2018 Wed 10/10/2018	4. Multi-Grid Convergence 4.1 The Two-Grid Method 4.1.1 The Smoothing Property
8	Sun 10/14/2018 Wed 10/17/2018	4.1.2 The Approximation Property
9	Sun 10/21/2018 Wed 10/24/2018	4.2 The Multi-Grid Method 5. Non-Linear Multi-Grid Methods 5.1 Directly non-linear multi-grid methods 5.2 Newton Multi-Grid Methods
10	Sun 10/28/2018 Wed 10/31/2018	6. Robust Multi-Grid Methods for Singularly-Perturbed Problems 6.1 Anisotropic Problems
11	Sun 11/04/2018 Wed 11/07/2018	6.2 Convection-Diffusion Problems
12	Sun 11/11/2018 Wed 11/14/2018	7. Multi-Grid Methods for Coupled Systems of Partial Differential Equations 7.1 Introduction 7.2 Transforming Smoothers
13	Sun 11/18/2018 Wed 11/21/2018	7.3 Collective Relaxation
14	Sun 11/25/2018 Wed 11/28/2018	8. Heterogenous Problems 8.1 The Problem 8.2 Homogenisation and Multi Grid 8.3 Algebraic Multi Grid (AMG) 8.3.1 Coarsening
15	Sun 12/02/2018 Wed 12/05/2018	8.3.2 Smoother - Compatible Relaxation 8.3.3 Grid Transfers 8.3.4 Coarse-Grid Operator
16	Sun 12/09/2018	9. Accelerating Multi Grid
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Note

The instructor reserves the right to make changes to this syllabus as necessary.