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

Course Syllabus: Hyp. Cons. Laws and Godunov-Type Methods - AMCS 333

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	AMCS 333
Course Title	Hyp. Cons. Laws and Godunov-Type Methods
Academic Semester	Spring
Academic Year	2018/2019
Semester Start Date	01/27/2019
Semester End Date	05/23/2019
Class Schedule (Days & Time)	04:00 PM - 05:30 PM | Mon Wed

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
David Isaac Ketcheson	david.ketcheson@kaust.edu.sa	+966128080306		Wednesday 10-11 am

Teaching Assistant(s)

Name	Email
N/A	N/A

Course Information

Comprehensive Course Description	The course will cover a variety of PDE models for waves, from both a theoretical and a numerical perspective. Topics to be covered include: 1. First-order hyperbolic PDEs Analysis: characteristics, shock waves, weak solutions, entropy solutions, the Riemann problem Numerical methods: finite volume methods, limiters, and approximate Riemann solvers Applications: traffic models, shallow water waves, compressible fluid dynamics 2. Higher-order wave equations Analysis: dispersion relations, invariants, solitary waves, integrability Numerical methods: spectral and pseudospectral methods Applications: Korteweg-de Vries, incompressible fluid dynamics This represents more topics than we can probably cover in a semester, so the focus will be determined partly by the interests of enrolled students.
Course Description from Program Guide	The course covers theory and algorithms for the numerical solution of linear and nonlinear hyperbolic PDEs, with applications including fluid dynamics, elasticity, acoustics, electromagnetics, shallow water waves, and traffic flow. The main concepts include: characteristics; shock and rarefaction waves; weak solutions; entropy; the Riemann problem; finite volume methods; Godunovs method; TVD methods; and high order methods; stability, accuracy, and convergence of numerical solutions.
Goals and Objectives	Become familiar with PDE-based models for a wide variety of wave behavior. Understand the dynamics of solutions to these models. Understand and implement numerical methods for their solution.
Required Knowledge	PDEs and numerical methods at the level of AMCS 231 and 252.

Reference Texts	LeVeque: Numerical methods for conservation laws LeVeque: Finite volume methods for hyperbolic problems Whitham: Linear and nonlinear waves Boyd: Chebyshev and Fourier spectral methods Trefethen: Spectral methods in Matlab
Method of evaluation	**50.00**% - Course Project(s) **50.00**% - Homework /Assignments
Nature of the assignments	Assignments will involve theoretical exercises (including some proofs) and implementation of numerical methods.
Course Policies	No late work will be accepted.
Additional Information	

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Mon 01/28/2019 Wed 01/30/2019	Linear wave equations: dispersion relations, hyperbolicity, examples
2	Mon 02/04/2019 Wed 02/06/2019	Hyperbolic conservation laws. Characteristics and shocks.
3	Mon 02/11/2019 Wed 02/13/2019	Basic numerical methods.
4	Mon 02/18/2019 Wed 02/20/2019	Scalar nonlinear hyperbolic PDEs. The Riemann problem. Rankine-Hugoniot jump conditions. Weak solutions and entropy solutions.
5	Mon 02/25/2019 Wed 02/27/2019	Nonlinear systems. Solution of general Riemann problems.
6	Mon 03/04/2019 Wed 03/06/2019	Advanced numerical methods: limiters, approximate Riemann solvers.
7	Mon 03/11/2019 Wed 03/13/2019	High-order numerical methods: WENO, DG, time stepping.
8	Mon 03/18/2019 Wed 03/20/2019	In-depth analysis and numerics for the shallow water equations.
9	Mon 03/25/2019 Wed 03/27/2019	Spring Break
10	Mon 04/01/2019 Wed 04/03/2019	Dispersive equations. Fermi-Pasta-Ulam and KdV.
11	Mon 04/08/2019 Wed 04/10/2019	Spectral methods and numerical dispersion.
12	Mon 04/15/2019 Wed 04/17/2019	Solitons and integrable systems.
13	Mon 04/22/2019 Wed 04/24/2019	Pseudospectral methods: aliasing, filtering.
14	Mon 04/29/2019 Wed 05/01/2019	TBD.
15	Mon 05/06/2019 Wed 05/08/2019	TBD.
16	Mon 05/13/2019 Wed 05/15/2019	Course project presentations.
17	Mon 05/20/2019 Wed 05/22/2019	Final Exam Week

Note

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