Department of Mathematics, University of Utah

**Topics in Numerical Solutions of PDE: Numerical methods for conservation laws**

**MATH 6630 – Section 001 – Spring 2019**

**Course Information and Syllabus**

Updated January 8, 2019

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| **Instructor:** | Akil Narayan |
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| Phone: | 801-581-8984 |
| Office: | WEB 4666 or CSC 214D |
| Office hours: | Monday 2:30-4pm, Tuesday 3:30-5pm |
| Office hours location: | WEB 4666 |


**Class time and location:** MW, 11:50am-1:10pm, ST 214

**Section webpage:** http://www.sci.utah.edu/~akil/math6630

**Course Information:** This is a 3-credit course.

**Learning objectives:** Upon successful completion of this course, a student should be able to:

- understand theory for conservation laws, including weak and entropy solutions
- implement algorithms finite difference-type and finite volume-type algorithms for solutions to PDEs
- design high-order algorithms for solutions to hyperbolic PDEs

**Prerequisites:** MATH 6610 and 6620, or equivalent. This course requires graduate-level knowledge of numerical analysis (in particular, numerical methods for ordinary and partial differential equations) and some programming experience.

**Course description:** Analysis and implementation of numerical methods for solving partial differential equations. Issues of stability and accuracy. Linear and nonlinear problems. *Note*: In paticular, this course will focus on hyperbolic conservation laws.

**Text**: Required: *Numerical Methods for Conservation Laws: From Analysis to Algorithms*, Jan. S. Hesthaven, SIAM, 2018, ISBM 978-1-61197-509-3.

In addition, the following texts may be useful for alternative, optional reading:
*Numerical Methods for Conservation Laws*, Randall J. LeVeque, Springer, 1992, ISBN 978-0-8176-2723-2.

*Finite Volume Methods for Hyperbolic Problems*, Randall J. LeVeque, Cambridge University Press, 2002, ISBN 978-1-139-43418-8.

**Course content:** This course covers modern theory and numerical algorithms for the numerical solutions of conservation laws. Students who wish to gain mathematical and computational knowledge for solving time-dependent hyperbolic partial differential equations will benefit from this course. Topics covered will include:

- weak solutions, entropy conditions, entropy functions, and Riemann problems
- monotone finite difference and finite volume methods
- high-order finite volume methods, basic discontinuous Galerkin methods
- essentially non-oscillatory-type schemes, strong stability preserving time-stepping

- systems of conservation laws and multidimensional problems

**Projects:** This course will have 2 projects involving theory and implementation of schemes. Projects form the only graded portion of this class, and are equally weighted. Since this is an advanced class in numerical methods, I will expect a LaTeX-typeset report, along with computer code that reproduces plots in your submission. Both the report source and the code will be submitted through the version control system Git. Logistics and a more detailed description of expectations for report submission will be provided at a later date during class. Due dates for the projects are TBA and will be discussed during the semester. *Note*: Since I expect electronic submission of reports, students will need access to an internet-connected computer with appropriate programming and typesetting software. If this is an issue, please talk to me about your situation.

There will also be a preliminary assignment ("project 0") that will focus on training students in the logistics of submission with Git. This assignment will not exercise any course-related technical content, and instead will ensure that students are able to use the requisite version control and typesetting tools for submitting the two projects.

**Grading:** Your course grade will be computed as follows.

- Project 0 ..... 10%
- Project 1 ..... 45%
- Project 2 ..... 45%

Final letter grades will be assigned based on the following scheme:

- 92% - 100% — A
- 90% - 91% — A−
- 88% - 89% — B+
- 82% - 87% — B
- 80% - 81% — B−
- 78% - 79% — C+
- 72% - 77% — C
- 70% - 71% — C−
- 68% - 69% — D+
- 62% - 67% — D
- 60% - 61% — D−
- 0% - 59% — E

**Important dates:**

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| **Jan 18** | Last day to add, drop (delete), elect CR/NC, or audit classes |
| **TBA** | Project 1 due |
| **Mar 8** | Last day to withdraw from classes |
| **Apr 19** | Last day to reverse CR/NC option |
| **Apr 24** | Reading Day |
| **TBA** | Project 2 |

**Class communication:** An email list is set up with which I shall send out information not communicated during class. This email list will also be used to communicate class information in the case of unusual circumstances affecting the the logistics of the class. If you are not officially registered for the class but wish to be on the roster, please discuss it with me.

*If you are registered for the course, but do not receive the course email announcements to your University of Utah email address, please notify me immediately.*

The section website will be used to communicate more technical matter of the class (e.g. problem sets, lecture summaries, etc.).

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to change that may be necessitated by a revised semester calendar or other circumstances. The above two methods, in addition to the coursewide website, are reliable means of getting information about changes to the course.

**ADA Statement**: The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, 581-5020 (V/TDD). CDS will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in alternative format with prior notification to the Center for Disability Services.

**Student responsibilities and integrity:** All students are expected to maintain professional behavior in the classroom setting, according to the Student Code, spelled out in the Student Handbook. Students have specific rights in the classroom as detailed in Article III of the Code. The Code also specifies proscribed conduct (Article XI) that involves cheating on tests, plagiarism, and/or collusion, as well as fraud, theft, etc. Students should read the Code carefully and know they are responsible for the content. According to Faculty Rules and Regulations, it is the faculty responsibility to enforce responsible classroom behaviors, and I will do so, beginning with verbal warnings and progressing to dismissal from class and a failing grade. Students have the right to appeal such action to the Student Behavior Committee.
`http://regulations.utah.edu/academics/6-400.php`