MA584: Numerical Solution of Differential Equation: *Finite Difference Methods*

Fall Semester, 2017, T TH 4:30-5:45pm, SAS-1220

http://www4.ncsu.edu/~zhilin/TEACHING/MA584/

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Office Hours: Mondays 10:30-11:30am; Thursdays: 2:30-3:30pm, or by appointment
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***Objectives and significance*:**

- Many application problems leads to partial differential equations in which analytic solutions are rarely available or too complicated. Finite difference methods are often easy to use but powerful to obtain an approximate solution of the PDE. It is strongly believed that the knowledge of *Finite Difference Methods for PDEs* is a ***MUST*** for mathematicians, scientists, and engineers, who are interested in solving their problems approximately. It is a required course in many universities.

- This course is designed for students in applied mathematics, engineering, and the sciences to learn the basic *theories and algorithms* of finite difference methods for differential equations including elliptic, parabolic and hyperbolic PDE's. While theoretical foundations will be described, emphasis will also be placed on algorithm design and implementation. We will also explore available software packages in this field.

Prerequisites:

Calculus I-III, some background in linear algebra, numerical analysis, and partial differential equations; Some programming experience (***Matlab,*** *recommended*, Fortran, C, C++, ...)

Grading Policy:

There will be *homework assignments* about every couple of weeks, including both ***analytic work*** and ***computer projects***.

- HW & Project: 65%
- Final project or a take home exam: 30%
- Class participation: **5%**.

Class Rules: A good learning environment is essential to the success of a class. Constant talking, cell phone use, reading irrelevant materials, late arrival and early departure are not allowed and will be penalized by your *class participation grade* and *attendance*

record. Students with excess absences (more than 3 excusable or non-excusable) are required to make-up the classes by writing and final grade will be prorated accordingly to the percentage of class that are missed.

Materials:

- Introduction (ODE/PDE and classification, analytic approaches versus numerical approximation, finite difference versus finite element method)
- A model problem (two point boundary value problem) and the finite difference method. Finite difference methods basics, stability and consistency, etc.
- Finite difference method for general one dimensional elliptic boundary value problems with different boundary conditions
- Finite difference methods for two dimensional elliptic PDEs (may include multi-grid and fast Poisson solvers).
- Finite difference methods for one and two dimensional parabolic PDEs, e.g. the heat equation; von Neumann stability analysis and Fourier transforms, ADI method.
- Finite difference methods for one and two dimensional hyperbolic PDEs, e.g. the wave equation, numerical methods for conservation laws.
- Advanced topics, irregular domain, the level set method etc. if time permits.

Text :

- *Instructor's Book Draft: forth coming by Cambridge, Numerical Solutions of Partial Differential Equations– An Introduction to Finite Difference and Finite Element Methods*
- Finite Difference Methods for Ordinary and Partial Differential Equations, R. J. LeVeque, SIAM 2007
- Instructor's Notes will be updated constantly.

Other References:

- *Finite Difference Schemes and Partial Differential Equations*, **J. C. Strilwerda**, Chapman & Hall, 1989.
- *Numerical Solution of Partial Differential Equations,* **K. W. Morton and D. F. Mayers,** Cambridge press, 1995.

Calendar:

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        July                 August               September
Su Mo Tu We Th Fr Sa  Su Mo Tu We Th Fr Sa  Su Mo Tu We Th Fr Sa
                                                          1  2
                                             3  H  5  6  7  8  9
                         16 17 18 19  10 11 12 13 14 15 16
                      20 21 22 23 24 25 26  17 18 19 20 21 22 23
                      27 28 29 30 31        24 25 26 27 28 29 30

      October              November             December
Su Mo Tu We Th Fr Sa  Su Mo Tu We Th Fr Sa  Su Mo Tu We Th Fr Sa
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1	2	3	4	**V**	**V**	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
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29	30	31				

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5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	**V**	**V**	**V**	25
26	27	28	29	30		

						L
3	4	5	6	7	8	9
10	11	12	13	14	15	16

H: Holiday; **V:** Vacation (No class); **L**: Last day of instruction.

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