

## Math 514 - Finite Difference Methods for Differential Equations, Fall 2015

INSTRUCTOR: Dr. Yulia Hristova

OFFICE: 2079 CASL Building; tel. (313) 593-5175

EMAIL: [yuliagh@umich.edu](mailto:yuliagh@umich.edu) (see e-mail do's and don'ts below)

WEB: [canvas.umd.umich.edu](http://canvas.umd.umich.edu)



OFFICE HOURS: (subject to change) M 1 – 1:50 pm and 3 – 3:50 pm; TR 5 – 5:50 pm

DEARBORN DISCOVERY CORE CATEGORY: None

COURSE MEETING TIMES: TR 6:00 pm - 7:15 pm, CASL 2046

**COURSE DESCRIPTION:** Differential equations are commonly used to model processes in such fields as physics, chemistry, biology and economics, to name but a few. However, only the simplest differential equations can be solved exactly. This leads to the need to solve these equations approximately (numerically). One of the most widely used methods for numerical solution of differential equations is the Finite Difference method. In brief, this method relies on approximating continuous functions by their values on a grid of points. Differentiation (a continuous process), is approximated by differencing, which, as a discrete process, can be handled by a computer. Although one can come up with a lot of different approximations to a given differential equation, not all such approximations are useful; for example, some may lead to the wrong answer, or may take too much computer time. Hence, in this course we will study the important questions of convergence, stability and efficiency of Finite Difference schemes. Numerical simulations are integral part of the course. Some programming experience will be helpful.

### COURSE OBJECTIVES:

1. To derive finite difference techniques for numerical differentiation using Taylor series expansions. To study the stability and absolute stability of such techniques. To apply such techniques to the solution of ODEs and compare their performance.
2. To derive and study the stability properties of numerical solutions of PDEs by studying the three prototype problems: hyperbolic, parabolic, and elliptic. To find the formal accuracy of these methods and show this numerically, and to understand and apply von Neumann stability analysis.

**REQUIRED MATERIALS:** In this class we will refer to the books “Numerical Solution of Ordinary and Partial Differential Equations”, 3rd Edition, by G. Sewell and ”Finite Difference Schemes and Partial Differential Equations”, 2nd Edition, by J. Strikwerda. Both of these books are available in electronic form from the university library. There is no need to buy them.

**GRADING POLICY:** Grades will be based on homework assignments, two midterm exams, and a comprehensive final exam. Requests for regrading assignments and mid-term exams must be made within one week after the items in question have been returned to the class.

	Homework	2 Midterm Exams	Final Exam
% of grade	35%	40 % (20% each)	25%

GRADING SCALE:  $100 \geq A \geq 90$ ,  $90 > B \geq 80$ ,  $80 > C \geq 70$ ,  $70 > D \geq 60$ ,  $60 > E$ .

HOMEWORK: Some of the assignments will be theoretical in nature, while others will have a programming component. For the programming assignments students must turn in a print-out of their code and results, as well as an electronic copy of the code. Students may work together on all assignments, unless stated otherwise. However, each student is responsible for turning in an individual report stated in his/her own words that contains 1. The names of the other students in the group, and 2. A detailed explanation of the individual contribution to the project. Students will be graded on the amount they contributed to the project. Students who turn in virtually the same work will be dealt with according to the Academic Integrity Policy (see below).

MID-TERM EXAMS: These exams will be given in class, according to the following schedule (subject to change): **Exam 1** Tuesday, October 20; **Exam 2** Tuesday, November 24.

FINAL EXAM: The final exam will be on Tuesday, December 15, starting 6:30 pm. This 2-hour exam will be comprehensive.

MISSED EXAMS POLICY: Missing an exam is permitted only for very serious and unavoidable extenuating circumstances, and only if you notify me in advance. In all cases of absence from exams a written excuse is required. Otherwise you will get a score of 0 on the exam. Except in truly exceptional situations, a student who misses the final exam will fail the course.

PROGRAM GOALS: The Department of Mathematics and Statistics Learning Goals for its classes are itemized below. 1) Increase students' command of problem-solving tools and facility in using problem-solving strategies, through classroom exposure and through experience with problems within and outside mathematics. 2) Increase students' ability to communicate and work cooperatively. 3) Increase students' ability to use technology and to learn from the use of technology, including improving their ability to make calculations and appropriate decisions about the type of calculations to make. 4) Increase student's knowledge of the history and nature of mathematics. Provide students with an understanding of how mathematics is done and learned so that students become self-reliant learners and effective users of mathematics.

ANNOUNCEMENTS AND UPDATES: All announcements and updates will be either posted on Canvas, made in class or communicated through e-mail.

IMPORTANT DATES: Last day to **drop** with **no penalty**: **September 22**; Last day to selectively **drop** a course **with penalty**: **November 10**.

UNIVERSITY ATTENDANCE POLICY: A student is expected to attend every class and laboratory for which he or she has registered. Each instructor may make known to the student his or her policy with respect to absences in the course. It is the student's responsibility to be aware of this policy. The instructor makes the final decision to excuse or not to excuse an absence. An instructor is entitled to give a failing grade (E) for excessive absences or an Unofficial Drop (UE) for a student who stops attending class at some point during the semester. ATTENDANCE POLICY FOR THIS CLASS: Attendance is very highly recommended. You are responsible for all material covered in class and all assignments. Experience shows that poor attendance most often results in a poor grade.

DISABILITY STATEMENT: The University will make reasonable accommodations for persons with doc-

umented disabilities. Students need to register with Disability Resource Services (DRS) every semester they are enrolled. DRS is located in Counseling & Support Services, 2157 UC ([http://www.umd.umich.edu/cs\\_disability/](http://www.umd.umich.edu/cs_disability/)). To be assured of having services when they are needed, students should register no later than the end of the add/drop deadline of each term. If you have a disability that necessitates an accommodation or adjustment to the academic requirements stated in this syllabus, you must register with DRS as described above and notify your professor.

**NON-DISCRIMINATION POLICY:** The University of Michigan is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, national origin, age, marital status, sex, sexual orientation, gender identity, gender expression, disability, religion, height, weight, or veteran status in employment, educational programs and activities, and admissions. Inquiries or complaints may be addressed to the Senior Director for Institutional Equity, and Title IX/Section 504/ADA Coordinator, Office for Institutional Equity, 2072 Administrative Services Building, Ann Arbor, Michigan 48109-1432, 734-763-0235, TTY 734-647-1388, [institutional.equity@umich.edu](mailto:institutional.equity@umich.edu).

#### EMAIL COMMUNICATION:

##### DO'S

- Read <http://www.wikihow.com/Email-a-Professor>;
- Include "Math 116" in the subject of your e-mail;
- If you have a question on a WeBWorK problem, do send me an e-mail through WeBWorK by clicking on the "Email instructor" button.

##### DON'TS

- Never send me e-mails through Canvas!
- If you have a question on a WeBWorK problem, do **not** send me an e-mail through your mailbox. Instead, use WebWork.

**INCOMPLETES:** These will be given only in extraordinary circumstances. More precisely, I will consider giving you an incomplete if you have successfully completed all but a small portion of the work of the course and some severe, unexpected event prevents you from completing the course. This means that you must have taken at least 1 midterm and must be doing work at the C level or better. You will have to sign a contract detailing what you have to do to complete the course. I will not give you an incomplete simply because you are behind in your work; in the latter case you should try to drop the course.

**ACADEMIC INTEGRITY POLICY:** The University of Michigan-Dearborn values academic honesty and integrity. Each student has a responsibility to understand, accept, and comply with the University's standards of academic conduct as set forth by the Code of Academic Conduct (<http://umdearborn.edu/697817/>), as well as policies established by each college. Cheating, collusion, misconduct, fabrication, and plagiarism are considered serious offenses and violations can result in penalties up to and including expulsion from the University.

**COMMUNICATION AND ELECTRONIC DEVICES USAGE IN CLASS:** The use of mobile communication devices and music players disrupts the class. Please be considerate of both your fellow students and your instructor and either turn-off or silence your cell phones, pagers, PDAs, or similar communication

devices and turn-off and put away your music players during scheduled classes. Given the fact that these same communication devices are an integral part of the University's emergency notification system, an exception to this policy would occur when numerous devices activate simultaneously. When this occurs, students may consult their devices to determine if a university emergency exists. If that is not the case, the devices should be immediately returned to silent mode and put away.

#### CAMPUS SAFETY:

- Program 911 into your cell phones. You should also program Public Safety's phone number (313) 593-5333 into your cell phone. In case of emergency you should first dial 911. If the situation allows also call UM-Dearborn Public Safety to ensure the quickest response time possible.
- All students are strongly encouraged to register in the campus Emergency Alert System, for communications during an emergency. The following link includes information on registering as well as safety and emergency procedures information: <http://umemergencyalert.umd.umich.edu/>. Please note that the system will only communicate through an individual's UM-Dearborn email account so students who primarily use other non-university accounts should forward their UM-Dearborn email to their primary account.

#### TENTATIVE COURSE OUTLINE:

September 10 - October 15: Numerical Solution of Initial Value ODEs.

October 20: First Midterm Exam

October 22 - November 19: Numerical Solutions of PDEs

November 24: Second Midterm

November 26: Thanksgiving break

December 1 - December 8: Numerical Solutions of PDEs continued.

December 10: Review

December 15: Final Exam, 6:30 p.m. - 8:30 p.m.