The University of Iowa

The College of Liberal Arts and Sciences

SPRING 2024

NUMERICAL METHODS II: Analysis and Computation: MATH:5810, Section 0001

Cross-listed: CS:5720, Section 0001

Course meeting time and place: 9:30-10:20AM MWF, 221 MLH

Department of Mathematics

Course ICON site: To access the course site, log into Iowa Courses Online (ICON) https://icon.uiowa.edu/index.shtml using your Hawk ID and password.

Course Home: The College of Liberal Arts and Sciences (CLAS) is the home of this course, and CLAS governs the policies and procedures for its courses. Graduate students, however, must adhere to the academic deadlines set by the Graduate College.

Instructor:

- Laurent O. Jay
- Office location: 225L MLH
- Student drop-in hours: 1:00PM-2:30PM MW. I am also available by appointment if you are unable to attend my drop-in hours.
- Phone: (319) 335-0898
- E-mail: laurent-jay@uiowa.edu
- DEO: Prof. Ryan Kinser, 14 MLH, E-mail: ryan-kinser@uiowa.edu

Prerequisites (for undergraduate students):

- MATH:2700 Introduction to Linear Algebra
- MATH:2850 Calculus III or MATH:3550 Engineering Math V: Vector Calculus
- Some computer programming experience, preferably MATLAB, will be helpful

Description of course: Topics to be covered:

- Solution of linear equations by direct methods
- Solution of linear equations by iterative methods
- Eigenvalue problems
- Numerical methods for ordinary differential equations

This course plan may be modified during the semester. Such modifications will be announced in advance during class periods and on ICON; the student is responsible for keeping abreast of such changes.

Learning Objectives: This course is at a graduate level and it is assumed that you can work along the course in an independent fashion. The courses sequence MATH:5800/CS:5710- MATH:5810/CS:5720 will cover some modern basic topics of numerical analysis. The main objective will be to have a clear understanding of the ideas and techniques underlying the numerical methods, results, and algorithms that will be presented, where error analysis plays an important role. You will then be able to use this knowledge to analyze the numerical methods and algorithms that you will encounter, and also to program them effectively on a computer. This knowledge will be useful in your future not only to solve problems with a numerical component, but also to develop numerical procedures of your own.

Class procedures: The majority of each class period will be lecture oriented. I will generally hand out in advance the notes related to the material to be covered during the next class(es). It is strongly advised to read the material to be discussed before coming to class. Therefore, if there is a difficult point, you will know beforehand where it arises, so that you can benefit from the lecture more effectively. If a point remains unclear you can always ask questions in class. Readings may be assigned. **Standard out-of-class preparation is at least six hours per week.**

Textbook: *Linear Algebra and Matrix Factorizations*, by Tom Lyche. Publisher: Springer; 1st ed. 2020 edition (March 3, 2021), 396 pages, ISBN-10: 3030364704, ISBN-13: 978-3030364700, list price: $54.99 (Paperback). The book on amazon.com and on bookfinder.com.

Additional useful readings:

- *Numerical Methods in Matrix Computations*, by Ake Bjorck. Publisher: Springer; Softcover reprint of the original 1st ed. 2015 Edition, Series: Texts in Applied Mathematics, Vol. 59, The book on amazon.com.
- *Numerical Linear Algebra and Applications, 2nd Edition*, by Biswa Nath Datta. Publisher: Society for Industrial and Applied Mathematics; 2nd Edition (January 20, 2010), 554 pages, The book on amazon.com. and on bookfinder.com.
- *Matrix Computations*, by Gene H. Golub and Charles F. Van Loan. Publisher: Johns Hopkins University Press, Series: Johns Hopkins Studies in the Mathematical Sciences, The book on amazon.com.
- *A First Course in the Numerical Analysis of Differential Equations*, by Arieh Iserles. Publisher: Cambridge University Press, 2nd edition (December 29, 2008), Series: Cambridge Texts in Applied Mathematics (Book 44), The book on amazon.com.
- Fundamentals of Matrix Computations, 3rd Edition by David S. Watkins, Wiley (Pure and Applied Mathematics: A Wiley Series of Texts, Monographs and Tracts). Library reference: Engineering Library QA188 .W38 2010.
- *An introduction to numerical analysis* by K. Atkinson, second edition, John Wiley & Sons, New York, 1989, (MATH QA297 .A84 1989).
- Introduction to numerical analysis by J. Stoer & R. Bulirsch, 3rd edition, Springer, Texts in Applied Mathematics, Vol. 12, New York, 2002, (MATH QA297 .S8213 2002).
- Numerical Mathematics by A. Quarteroni, R. Sacco, & F. Saleri, Springer, Texts in applied mathematics, New York, 37. (MATH Course Reserve QA297 .Q836 2000).
- Numerical Analysis: A Mathematical Introduction by Michelle Schatzman. Publisher: Oxford University Press, USA (December 26, 2002), 516 pages, Library reference: Main Math Collection QA297 .S36713 2002.
- *Numerical Methods in Scientific Computing: Volume 1* by Germund Dahlquist and Ake Bjorck, Publisher: Society for Industrial Mathematics (SIAM), Textbook in Numerical Analysis, 2008, xxviii + 717 pages, Hardcover, ISBN-10: 0898716446, ISBN-13 978-0-898716-44-3. Library reference: Engineering Library QA297 .D335 2008.
- Numerical computation 1. Methods, Software, and Analysis and *Numerical computation 2. Methods, Software, and Analysis* by C. W. Ueberhuber, Springer-Verlag, Berlin, 1047.
- *Accuracy and stability of numerical algorithms* by N.J. Higham, SIAM, Philadelphia, 1046 (MATH QA297 .H53 1046).
- *Numerical Linear Algebra* by Lloyd N. Trefethen and David Bau III, SIAM, Philadelphia, (Main Math Collection QA184 .T74 1997).
- *Applied Numerical Linear Algebra* by James W. Demmel, SIAM, Philadelphia, (Main Math Collection QA184 .D455 1997).
- Free electronic book on Iterative Methods for Linear and Nonlinear Equations by Tim Kelley. If the link does not work, go to Download Books from SIAM. Becoming a SIAM member is free for students!.
- Numerical Linear Algebra by Gregoire Allaire and Sidi Mahmoud Kaber, Springer, Texts in applied mathematics, New York, 55, ISBN: 0387341590. Library reference: Engineering Library QA185.D37 A44 2008.
- *Solving ordinary differential equations I. Nonstiff problems* by E. Hairer, S. P. Norsett, and Gerhard Wanner, Springer, Berlin, Springer Series in Computational Mathematics, vol. 8, Second Revised Edition, 1993, 528 pages, ISBN: 978-3-540-56670-0. Table of contents. Library reference: MATH QA372 .H16 1993 v.1.
- *Solving ordinary differential equations II. Stiff and differential-algebraic problems* by E. Hairer and G. Wanner, Springer, Berlin, Springer Series in Computational Mathematics, vol. 14, Second Revised Edition, 1996, 614 pages, ISBN: 978-3-540-60452-5. Table of contents. Library reference: MATH QA372 .H16 1993 v.2.
- *Geometric numerical integration: structure-preserving algorithms for ordinary differential equations* by E. Hairer, Ch. Lubich, and G. Wanner, Springer, Berlin, Springer Series in Computational Mathematics, vol. 31, Second Revised Edition, 2006, 644 pages, ISBN: 978-3-540-30663-4. Library reference: MATH QA299.3 .H35 2006.

Academic Honesty and Misconduct: All students in CLAS courses are expected to abide by the CLAS Code of Academic Honesty. Undergraduate academic misconduct must be reported by instructors to CLAS according to these procedures. Graduate academic misconduct must be reported to the Graduate College according to Section F of the Graduate College Manual.

Student Collaboration on homework: The homework for this course is designed to help you master your knowledge related to the topics covered during lecture. As such, you may discuss on the homework problems with others or use online resources. However, please be aware that to master the skills needed for this class, practice is required and that to do well on the examinations you will need to work many of these problems multiple times without help. Be sure to test your knowledge by doing much of the homework on your own. Students are allowed to partially

collaborate with others on homework through discussion for the most difficult problems. However, each student must turn in their own homework and it must not be a copy of someone else homework. Students are responsible for understanding this policy; if you have questions, ask for clarification. Word per word copies will not be tolerated. In extreme cases students may be requested to stop any kind of collaboration with other students.

Student Complaints: Students with a complaint about a grade or a related matter should first discuss the situation with the instructor and/or the course supervisor (if applicable), and finally with the Director or Chair of the school, department, or program offering the course. Undergraduate students should contact CLAS Undergraduate Programs for support when the matter is not resolved at the previous level. Graduate students should contact the CLAS Associate Dean for Graduate Education and Outreach and Engagement when additional support is needed.

Drop Deadline for this Course: You may drop an individual course before the deadline; after this deadline you will need collegiate approval. You can look up the drop deadline for this course here. When you drop a course, a "W" will appear on your transcript for undergraduate students, but not for graduate students. The mark of "W" is a neutral mark that does not affect your GPA. Directions for adding or dropping a course and other registration changes can be found on the Registrar's website. Undergraduate students can find policies on dropping and withdrawing here. Graduate students should adhere to the academic deadlines and policies set by the Graduate College.

Grading System and the Use of +/-: In assigning grades, the plus/minus grading system will be used. The A+ grade will be used only in extraordinary situations. Final grades will be awarded based on the following ranges:

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
100 % to 96.15 %	< 96.15 % to 88.46 %	< 88.46 % to 80.77 %	< 80.77 % to 73.08 %	< 73.08 % to 65.38 %	< 65.38 % to 57.69 %	< 57.69 % to 50.0 %	< 50.0 % to 42.31 %	< 42.31 % to 34.62 %	< 34.62 % to 26.92 %	< 26.92 % to 19.23 %	< 19.23 % to 11.54 %	< 11.54 % to 0.0 %

Course Grades: The final grade will be based as follows:

1. There will be 2 tests during the semester, with each test to account for 25% of the course grade.
   - Midterm Exam 1: **Thursday March 7: 6:30-8:30PM** in **room 221 MLH**.
   - Midterm Exam 2: **Thursday April 18: 6:30-8:30PM** in **room 221 MLH**.
2. Homework assignments will account for 20% of the course grade. Late homework will be accepted only by special permission of the instructor. Your worst 2 homework scores will not be counted. For example if we have 12 homeworks, we will count only your best 10 homework scores out of 12 homeworks. Only a portion of each homework assignment may be graded, based on the availability of assistance from a grader for the course.
3. The final examination will account for 30% of the course grade and it will be comprehensive.

The 2 tests and final examination are open books and open notes examinations. There will be NO question related to MATLAB or PYTHON in the tests. Smartphones/computers are not allowed. Bring a simple scientific calculator, graphing calculators are fine.

Homework: Will be assigned approximately weekly. Presentation of your results is very important. Scratch paper will not be accepted. Do not expect good grades if your solution to a problem is poorly communicated. Like for everything, if you cannot explain something in great details, you certainly have not fully understood it. The importance of doing homework cannot be overemphasized, most of human people learn by doing, not only by watching and/or listening. Late homework may not be accepted, you need to request permission first or to provide a reasonable justification. Late homework is not accepted once a correction is given. Use of symbolic mathematical software to solve problems is not allowed.

Computer languages: The predominant programming languages used in numerical analysis are *Matlab* and *Fortran*. They are available on the Linux network in MLH (see below). Alternatives to *Matlab* are *Octave* and *Scilab*. For programming assignments, no other language will be accepted, except *Python*, *C*, and *C++*.

Linux computer accounts: Linux computer accounts are available on the Linux network in MLH (computer lab rooms B5). To access your Linux computer account remotely. you can use FastX, a graphical Linux virtual desktop environment remotely accessible in your web browser. As long as you have an active Hawk ID and you login at least once in the past year, your CLAS Linux account will remain active. If you fail to use your account in a year, you will receive three notices, and then your CLAS Linux account will be deleted. Also, once your Hawk ID becomes inactive, your CLAS Linux account will be deleted.

Date and Time of the Final Exam: The final examination date and time will be announced by the Registrar generally by the fifth week of classes and it will be announced on the course ICON site once it is known. Do not plan your end of the semester travel plans until the final exam schedule is made public. It is your responsibility to know the date, time, and place of the final exam. According to Registrar's final exam policy, students **have a maximum of two weeks after the announced final exam schedule** to request a change if an exam conflict exists or if a student has more than two exams in one day (see the policy here).

Communication: UI Email: Students are responsible for all official correspondences sent to their UI email address (uiowa.edu) and must use this address for any communication with instructors or staff in the UI community.

Note on drop-in hours: This is not a private lesson to repeat what was covered in class for students missing classes without any valid justification.

Helper: Nikita Kapur, office: 1K MLH, mailbox is in 15 MLH (MacLean Hall), e-mail: nikita-kapur@uiowa.edu.

College of Liberal Arts and Sciences (CLAS) Course Policies:

- **Attendance and Absences**: Your responsibilities to this class and to your education as a whole-include attendance and participation, check in particular the CLAS policies related to student attendance and absences. You are also expected to be honest and honorable in your fulfillment of assignments and in test-taking situations (the College's policy on plagiarism and cheating is on-line in the College's Student Academic Handbook). You have a responsibility to the rest of the class-and to the instructor-to help create a classroom environment where all may learn. At the most basic level, this means that you will respect the other members of the class and the instructor, and treat them with the courtesy you hope to receive in turn. Smart phones, cell phones, and pagers must be on silent mode during lecture and they are not allowed in class during exams. If you do bring a phone or pager to an exam, you may leave it in the front of the class during the exam. If a student is found to have a phone or pager during an exam, the phone or pager will be taken from the student and procedures for cheating will be followed. Students with mandatory religious obligations or UI authorized activities must discuss their absences with me as soon as possible. Religious obligations must be communicated within the first three weeks of classes.
- **Exam Policies**

University Policies

- Accommodations for Students with Disabilities
- Basic Needs and Support for Students
- Classroom Expectations
- Exam Make-up Owing to Absence
- Free Speech and Expression
- Mental Health
- Military Service Obligations
- Non-discrimination
- Religious Holy Days
- Sexual Harassment/Misconduct and Supportive Measures
- Sharing of Class Recordings