MAS7397: ADVANCED TOPICS IN ALGEBRA
COMPUTATIONAL ALGEBRA AND NUMBER THEORY

Instructor: Jeremy Booher
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Instructor's Office: LIT 488
Course Time: MWF Period 5
Course Location: LIT 223
Course Webpage: on canvas (`https://elearning.ufl.edu/`)
Office Hours: will be posted on canvas, and by appointment

"Dividing one number by another is mere computation; knowing what to divide by what is mathematics." "

Jordan Ellenberg

1. Course Description

We will learn about efficient computations in algebra and number theory, with some discussion of applications to cryptography and coding theory. Possible topics will be chosen based on the interest of students, but include primality testing, factoring, efficient computations with polynomials and finite fields, the LLL algorithm, computation of Galois groups, computation of class groups, applicatons of number theory in cryptography, and codes coming from algebraic geometry. Even algorithms for basic problems tend to involve more advanced mathematics which will be developed as needed. A final projects will involve implementing or experimenting with algorithms: the "mathematical sophistication" and the "programming sophistication" of the project can vary based on the background of each student.

Ideal preparation would be the 6000-level algebra sequence, but many topics will be accessible to mathematically mature students with less background. Students need to not be afraid of writing and modifying computer programs, but extensive experience in computer science or with programming is not necessary.

2. Learning Resources

2.1. **Textbook.** We won't always follow a textbook closely, depending on which topics are of interest to the class. A comprehensive reference is "A Computational Introduction to Number Theory and Algebra" by Victor Shoup, available at `https://shoup.net/ntb/`.

2.2. **Other References.** Crandall and Pomerance have a textbook "Prime Numbers: A Computational Perspective." Cohen has a book "A Course in Computational Algebraic Number Theory." Cox, Little, and O'Shea have a book "Ideals, Varieties, and Algorithms: An Introduction to Computational Algebraic Geometry and Commutative Algebra."

2.3. **Computer Algebra Systems.** The default computer algebra system to use in this class is SageMath, which is based on Python. Magma is another reasonable choice.

2.4. **Office Hours.** You are encouraged to come to office hours if you struggling: I am happy to help. You are also encouraged to come to office hours if you are doing well or are bored: I am happy to talk about math more generally and tell you interesting things. If the default times do not work for you, please contact me and we can find an alternate time.

3. Expectations and Grading

This is an advanced graduate class, so you are expected to be independent learners. Class will focus on examples and applying mathematical ideas, so some proofs will be omitted. If it is important for you to learn them, you'll need to take responsibility for doing so.

Students who have demonstrated the ability to connect mathematical ideas with algorithms and computation, especially as related to their research focus, will receive an A. The main way this will be assessed is through a final project. The project can either having a coding focus, an expository focus, or an exploratory focus:

Coding Focus: The project would implement an interesting algorithm, demonstrate it, and briefly discussing the underlying mathematics.

Expository Focus: The project would involving learning about a new topic related to computational algebra or number theory not covered in class and explaining it.

Exploratory Focus: The project would take existing implementations of algorithms and use them to explore a mathematically interesting area and verify existing conjectures (or formulate new ones).

There will not be regularly-graded problem sets, but there will probably be some sporadic assignments to make sure all students have a basic familiarity with SageMath or another computer algebra system.

4. Other Policies

4.1. **Communication.** Course Announcements will be posted on Canvas. It is the student's responsibility to make sure they receive notifications for this course. For personal matters, students should e-mail the instructor via their official UF e-mail address.

4.2. **Make-Up Policy for Homework/Exams.** Make-up homework/exam work is allowed only when written evidence of an official University excused absence is provided (`http://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/`).

The instructor must be notified as soon as possible, preferably *before* the homework due date or exam with as much advanced notice as possible. A detailed account of the situation and supporting documents are required.

4.3. **Honesty Policy Regarding Cheating, Plagiarism, etc.** UF students are bound by *The Honor Pledge* (`http://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/`) which states,

> *We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

The Student Conduct Code (`http://sccr.dso.ufl.edu/process/student-conduct-code/`) specifies a number of behaviors that are in violation of the honor code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please or consult with the instructor in this class.

4.4. **Accessibility and Accommodations.** Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the Disability Resource Center by visiting `https://disability.ufl.edu/students/get-started/`.

It is important for students to share their accommodation letter with their instructor and discuss their access needs as early as possible in the semester.

4.5. **Online Course Evaluations.** Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at `http://gatorevals.aa.ufl.edu/students/`.

Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via `http://ufl.bluera.com/ufl/`. Summaries of course evaluation results are available to students at `http://gatorevals.aa.ufl.edu/public-results/`.

4.6. **Change.** Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.