School of Mathematics and Statistics - Carleton University
Finite Fields and Coding Theory, MATH 4109/6101, Fall 2022

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Day and time of course: Tuesdays and Thursdays 13:05-14:25. Some classes are in person, and some classes are for students to study material and to consult the professor. Material for the students to read will be distributed in advance. The schedule of the classes in person is below.

Room: lectures in person are in Canal Building 2202; the other classes (not in person) and office hours are in HP 4372.

Office hours and location: Thursdays 14:35 - 15:25 in 4372HP.

Textbook: There is no official textbook for this course. However, for most of the lectures, we will have notes available. They were prepared by students of a previous version of the course and checked by the professor. We intensively use material from the following books:

1. *Introduction to Finite Fields and Their Applications* by R. Lidl and H. Niederreiter, 1994;
2. *Finite Fields* by R. Lidl and H. Niederreiter, 1997;
3. *The Theory of Error-Correcting Codes* by F.J. MacWilliams and N.J.A. Sloane, 1977.

We also use material from the following books:

1. *Handbook of Finite Fields* by G. Mullen and D. Panario, 2013;
2. *Lectures on Finite Fields and Galois Rings* by Zhe-Xian Wan, 2003;
3. *Algebraic Coding Theory* by E. Berlekamp, 1984;
4. *Modern Computer Algebra* by J. von zur Gathen and J. Gerhard, 2013.

Prerequisites: MATH 2100, or MATH 3101 or MATH 2108 or equivalent; or permission of the School. Knowledge of a computer language is convenient.

Course objectives: This course is an introduction to finite fields, emphasizing their structure and applications to coding theory. This course centers on the mathematics of finite fields, the applications to coding theory, and the associated computational problems.

Evaluation: midterm test (15%), assignments (45%), and a written project and oral presentation (40%).

Midterm test: There will be one midterm test on Tuesday November 15, in class; the midterm test is worth 15% of the final mark.

Assignments: There will be three assignments for 15% each of the final mark. Deadlines: Assignment 1 out September 22, in October 13; Assignment 2 out October 13, in November 3; Assignment 3 out November 3, in November 24. Assignments will be submitted in brightspace.

Project and presentation: The project is worth 40%. This involves writing a report of 15-20 pages (worth %25) plus a 25-30 minutes oral presentation (worth %15) on a topic related to the material in the course. More information about the project, including list of potential topics and date for the presentations, will be given later.

Academic Accommodation

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Pregnancy obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website.

Religious obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website.

Academic accommodations for students with disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and

vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable).

Special Information for Pandemic Measures

It is important to remember that COVID is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. There are a number of actions you can take to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you are sick, washing your hands and maintaining proper respiratory and cough etiquette.

Feeling sick? Remaining vigilant and not attending work or school when sick or with symptoms is critically important. If you feel ill or exhibit COVID-19 symptoms do not come to class or campus. If you feel ill or exhibit symptoms while on campus or in class, please leave campus immediately. In all situations, you must follow Carleton's symptom reporting protocols.

Masks: Carleton has paused the COVID-19 Mask Policy, but continues to strongly recommend masking when indoors, particularly if physical distancing cannot be maintained. It may become necessary to quickly reinstate the mask requirement if pandemic circumstances were to change.

Vaccines: Further, while proof of vaccination is no longer required as of May 1 to attend campus or in-person activity, it may become necessary for the University to bring back proof of vaccination requirements on short notice if the situation and public health advice changes. Students are strongly encouraged to get a full course of vaccination, including booster doses as soon as they are eligible, and submit their booster dose information in cuScreen as soon as possible. Please note that Carleton cannot guarantee that it will be able to offer virtual or hybrid learning options for those who are unable to attend the campus.

All members of the Carleton community are required to follow requirements and guidelines regarding health and safety which may change from time to time. For the most recent information about Carleton's COVID-19 response and health and safety requirements please see the University's COVID-19 website and review the Frequently Asked Questions (FAQs). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca.

Tentative lecture schedule in person classes

Class	Dates	Topics
1	Sep. 13 (Tue)	Introduction to the course and finite fields.
2	Sep. 15	Basics of finite fields.
3	Sep. 22	Linear codes. Decoding linear codes. Bounds. **Sep. 22: A1 out.**
4	Sep. 29	Structure of finite fields. Extension fields. Splitting fields. Subfields.
5	Oct. 6	Primitive elements. Gauss algorithm.
6	Oct. 13	Irreducible polynomials. Roots of irreducibles. **Oct. 13: A1 in; A2 out.**
7	Oct. 20	Normal bases. Traces.
	Oct. 24-28	**Fall break, no classes.**
8	Nov. 3	Irreducibility tests. Factoring polynomials. **Nov. 3: A2 in; A3 out.**
9	Nov. 8 (Tue)	Factorization of polynomials (cont.).
10	Nov. 10	Cyclic codes. Minimal polynomials.
11	Nov. 15 (Tue)	**Midterm on Tuesday Nov. 15.**
12	Nov. 17	Computing minimal polynomials. BCH and t-error correcting BCH codes.
13	Nov. 22 (Tue)	Reed-Solomon, Reed-Muller and MDS codes.
14	Nov. 24	Invited lecture (finite fields). **Nov. 24: A3 in.**
15	Dec. 1	Invited lecture (coding theory).
16	Dec. 8-9	Course review. Oral presentations.

Classes not in person are are for students to study material. Unless noticed in advance, the professor will be available in HP 4372 for consultation at the time of those lectures.