ECE 743
Coding Theory

COURSE OUTLINE

Please refer to course website for updated information.

COURSE DESCRIPTION

The course provides an in-depth introduction to the theory of error-correcting codes. It includes both algebraic codes (e.g., Hamming, Generalized Reed-Solomon and BCH codes) as well as combinatorial codes (e.g., constant-weight codes). The course covers code construction, and fundamental bounds on code parameters. Practical aspects of code representation, finite field arithmetic, and encoding/decoding algorithms, are also discussed.

SCHEDULE And MODE OF DELIVERY

One 3-hour in-person lecture per week.

INSTRUCTOR

Dr. Moshe Schwartz
Email: schwartz.moshe@mcmaster.ca
Office: ITB-A310
Office Hours**:** By appointment.

COURSE WEBSITE/S

http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, students should be able to:

- Understand basic code parameters and the trade-off between them.
- Implement encoders and decoders for common codes (Hamming, GRS, BCH)
- Come up with, and compare, various coding solutions given a data transmission/storage problem
- Start research in the area of coding theory

ASSUMED KNOWLEDGE

Basic knowledge in linear algebra.

COURSE MATERIALS

Optional course textbooks:
[1] R. M. Roth, “Introduction to Coding Theory,” Cambridge University Press, UK, 2006.
[2] F. J. MacWilliams and N. J. A. Sloane, “The Theory of Error-Correcting Codes,” North-Holland, Amsterdam, 1977.

COURSE OVERVIEW

Week	Topic
1	Introduction, channels, Hamming distance, block codes, minimum distance decoding, error correction, error detection, erasure correction
2	Finite groups, cosets, finite fields of prime size, review of vector spaces
3	Linear codes: definition and motivation, generator matrices, parity-check matrices, the Hamming code
4	Dual codes, syndrome decoding, the standard array method; More algebra: polynomials and irreducible polynomials, algebraic extension of fields
5	Roots of polynomials, the multiplicative/additive group of a finite field,
6	Double error-correcting codes, Bounds: Singleton, ball-packing
7	Gilbert Varshamov bound, asymptotic form of bounds
8	Generalized Reed-Solomon (GRS) codes: definition and basic properties
9	Conventional Reed-Solomon (RS) codes, decoding GRS codes and the key equation
10	Concatenated codes, alternant/BCH codes as sub-codes of GRS codes; More algebra: minimal polynomials
11	Cyclic codes and their properties, RS/BCH codes are cyclic, the BCH bound
12	Non-linear codes: motivation, constant-weight codes and Steiner systems
13	The Johnson bound for constant-weight codes, the Johnson bound for non-constant-weight codes

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight
Assignments (4 x 25%)	100%
Total	100%

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty. Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at https://secretariat.mcmaster.ca/university-policies-proceduresguidelines/
The following illustrates only three forms of academic dishonesty:
• plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
• improper collaboration in group work.
• copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.
Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their

computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors.
The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online. It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATIONS

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term

in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf.

www.eng.mcmaster.ca/ece