

**COMPENG 4TS3  
Introduction to Digital Sequences**

**COURSE OUTLINE**

Please refer to course website for updated information

**CALENDAR/COURSE DESCRIPTION**

Many applications rely on digital sequences, which are specifically tailored strings of bits. These applications include digital communication, radar, cryptographic systems, measurement and positioning devices, and storage technologies. This course teaches the fundamentals of sequence generation and their basic properties. The course surveys examples from a wide range of applications in electrical and computer engineering, e.g., Pseudo-Noise sequences for communication synchronization, Costas arrays for radar systems, De-Bruijn sequences for cryptography, circuit testing and robotic positioning systems, Gray codes for noise reduction in analog-to-digital conversions, and square-free sequences for information storage in DNA molecules.

**PRE-REQUISITES AND ANTI-REQUISITES**

Pre-requisite(s): Linear Algebra (1ZC3)

Anti-requisite(s): none

**SCHEDULE AND MODE OF DELIVERY**

**Lectures:** Three hours per week.

**Tutorials:** One hour per week.

**INSTRUCTOR**

**Dr. Moshe Schwartz**

ITB-A310

Office hours: By appointment

**TEACHING ASSISTANTS**

Names, contact information and office hours are provided on the course web site.

**COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION**

<http://avenue.mcmaster.ca>

**COURSE OBJECTIVES**

To expose students to the theory of digital sequence design, introduce its various figures of merit and the way they are influenced by applications, as well as the trade-offs between various parameters.

#### ASSUMED KNOWLEDGE

- Basic understanding of linear algebra (Math 1ZC3)

#### COURSE MATERIALS

##### Optional Textbook:

S. W. Golomb, *Shift Register Sequences*, 3<sup>rd</sup> edition, World Scientific, 2017.

##### Other Materials:

The slides from lectures and tutorials will be posted on Avenue to Learn.

#### COURSE OVERVIEW

Date/Week	Topic
Week 1-2	Introduction, Feedback Shift Registers (FSRs), the binary field and finite fields modulo a prime, Linear Feedback Shift Registers (LFSRs)
Week 2-3	Generating functions, characteristic polynomials, periodicity, irreducible and primitive polynomials, Pseudo-Noise (PN) sequences (a.k.a. m-sequences)
Week 4	Correlation: auto/cross, period/aperiodic, real/complex/Hamming, maximum out-of-phase-autocorrelation
Week 5-6	Difference sets, quadratic residues, and Legendre sequences
Week 6-7	Aperiodic auto-correlation: Barker sequences, Costas arrays (2D sequences)
Week 8	De-Bruijn sequences: the De-Bruijn graph, existence of De-Bruijn sequences, construction using cycle merging
Week 9	Linear complexity: definition, properties, the Games-Chan algorithm
Week 10	Rotating table games, the Berlekamp-Massey algorithm
Week 11-12	Gray codes: definition, binary reflected Gray codes, case study: Skew-Tolerant Gray Codes (SkTGCs)
Week 12-13	String-Duplication systems: definition and motivation, duplication-free sequences, the Thue-Morse sequence

#### ASSESSMENT

Component	Weight
Homework assignments (4 x 15%)	60%
Final Exam	40%
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., Avenue-to-Learn, 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](http://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](mailto:sas@mcmaster.ca) to make arrangements with a Program Coordinator. For further information, consult McMaster University’s Academic Accommodation of Students with Disabilities policy.

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.

#### **REQUESTS FOR RELIEF FOR MISSED ACADEMIC WORK**

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

#### **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.