ECE 7210 – Fractal and Chaos Engineering

COURSE DESCRIPTION
This course presents foundations of fractal (polyscale) and chaos fundamentals, with applications to engineering. A unified approach to fractal dimensions provides tools for polyscale analysis of time series, images, video, and other objects. The new polyscale analysis is a critical extension of the standard mono-scale and multi-scale analyses. Other topics include analysis and synthesis of mono- and multifractal noise, stability analysis of chaotic systems, characterization of chaos using Lyapunov exponents, and reconstruction of strange attractors from experimental data.

COURSE OBJECTIVES
• To master techniques of polyscale analysis and synthesis;
• To understand techniques of dynamical systems, together with chaos analysis and synthesis; and
• To apply those techniques in engineering.

PRE-REQUISITES
Undergraduate level of :
• Differential and difference equations
• Signal processing
• Linear time-invariant systems
• Foundation of nonlinear systems

CONTACT HOURS
3-hours per week

COURSE CONTENT
The following topics will be discussed:
1. Introduction to nonlinear systems;
2. Overview of fractals and chaos;
3. Fractal dimensions (generalization to Rényi metrics);
4. Noise and spectral power laws;
5. Fractional Brownian noise;
6. Foundations of chaotic dynamics (Stability analysis in 1D with Lyapunov metrics; Reconstructing chaos from data); and
7. Applications (throughout the course).

HOMEWORK
Homework will consist of one mini-project (written report), one project (written proposal, written report, oral preparation in class).

REFERENCES
GRADE ANNOUNCEMENTS

*Grades for this course will be announced by May 2022*

EVALUATION:

Your final course grade is determined by your performance in the components list below in the Evaluation Table (mini-project, project, and a final examination). Students must receive a minimum of 50% on the final examination and must complete and pass all components in the course in order to be eligible to receive a passing grade.

Each component is weighted as follows:

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<th>COMPONENT</th>
<th>NO</th>
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<th>TOTAL VALUE</th>
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<tr>
<td>Mini-project</td>
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<td>Project</td>
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<tr>
<td>Final Examination</td>
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<td><strong>TOTAL</strong></td>
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GRADE SCALE

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<td>B+</td>
<td>80-84</td>
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INSTRUCTOR INFO

Name: .................... Witold Kinsner, PhD, PEng
Office: .................... E2-415 EITC
Tel: .................... (204) 474-6490
Email: .................... Witold.Kinsner@umanitoba.ca

Office Hours: ............ By appointment

VOLUNTARY WITHDRAW:

March 23rd, 2022

*Note that limited feedback will be provided prior to the withdrawal deadline.*

REQUIREMENTS/REGULATIONS

**Student Responsibilities**: It is the responsibility of each student to contact the instructor if he/she is uncertain about his/her standing in the course and his/her potential for receiving a failing grade. Students should also familiarize themselves with Sections 4 and 6 of the Regulations dealing with, among others, incomplete term work, deferred examinations, attendance and withdrawal, etc..

**Lectures**: Attendance at lectures is essential for successful completion of this course. Students must satisfy each evaluation component in the course.
ACADEMIC INTEGRITY

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the General Academic Regulations and Requirements of the University of Manitoba, Section 7.1, students are reminded that plagiarism* or any other form of cheating is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university) regardless of media

- Examinations;
- Assignments;
- Laboratory reports; and
- Term exams.

A student found guilty of contributing to cheating in examinations or term assignments is also subject to serious academic penalty.

Please refer any questions regarding Academic Integrity to your course instructor.

*Plagiarism: to steal and pass off (the ideas or words of another) as one's own; use (another's production) without crediting the source