SYDE 750: Nonlinear Systems
Winter 2022 – v1.0

UNIVERSITY OF WATERLOO

Session	Location	Time
Lecture	E5 - 6002	T/Th 11:00AM-12:20PM

Instructor	Office	Office Hours
Eihab Abdel-Rahman	E7 - 6432	Walk-in
Alaaeldin Ahmed	E7 - 6427	Walk-in

Prerequisites

- SYDE 182 – Dynamics (or equivalent).
- SYDE 311 – Advanced Engineering Math 2 (or equivalent).

Course Description:

This course introduces nonlinear systems with applications in realistic ecological, mechanical, electrical, and chemical engineering systems. The properties of those systems are investigated via analytical and numerical tools, with particular application to MEMS and NEMS actuators & sensors. Mathematica is the computational tool of choice. It will be used extensively throughout the course. Students will develop knowledge and appreciation of the following concepts and tools:

- differences between linear and nonlinear dynamic systems
- autonomous and non-autonomous systems
- existence and uniqueness of solutions
- equilibrium points and limit cycles
- phase plane analysis
- nonlinear phenomena
- Poincare section analysis
- multi-frequency oscillations
- notions of system stability (Lyapunov, asymptotic etc..)

Course Outcomes: This course will enable you to:

1. find the equilibria of a system and determine their stability.
2. find the limit cycles a dynamic system and determine their stability.
3. obtain the bifurcation diagram of a nonlinear system.

Textbooks:

- *Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistry and Engineering*, 2nd Ed., S. H. Strogatz, Westview Books, 2014.
- Introduction to Experimental Nonlinear Dynamics: A Case Study in Mechanical Vibration, L. Virgin, Cambridge University Press, Cambridge, 2000.
- *Theory and design for mechanical measurements*, Figliola RS and Beasley DE, John Wiley & Sons, 2019.
- *Practical Numerical Algorithms for Chaotic Systems*, T. S. Parker and L. Chua, Springer-Verlag, New York, NY, 1989.
- Lectures notes, class recordings, and other study materials will be posted to Waterloo LEARN.

Evaluation:

The course includes a project worth 50% of the grade. The final exam will carry the other 50% of the grade.

The Fine Print:

We are currently facing unusual and challenging times with a pandemic and its consequences. The instructor reserves the right to modify course topics and/or assessments with due notice. In the event of further challenges, the instructor will work with the Department to find reasonable and fair solutions.

- **Academic Integrity**

  In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility.

  In exams, students are expected to work individually and submit their own original work. Under Policy 71, the instructor may have follow-up conversations with individual students to ensure that the work submitted was completed on their own. Any follow up will be conducted remotely (e.g., MS Teams, Zoom, phone). Permissions is hereby provided for collaboration on the course project.

- **Discipline**

  A student is expected to know what constitutes academic integrity, to avoid committing an academic offense, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean.

  For information on categories of offenses and types of penalties see Policy 71.

  For typical penalties see Guidelines for the Assessment of Penalties.

- **Grievance**

  A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance; see Policy 70 -

Section 4. When in doubt, please contact the undergraduate administrative assistant for provide further assistance.

- **Appeals**
  A decision made or a penalty imposed under Policy 70, other than a petition, or Policy 71 may be appealed, if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72.

- **AccessAbility Services**
  AccessAbility Services is the University's centralized office for the provision of academic accommodations for students with a known or unknown disability, illness, or condition. They are located in Needles Hall, Room 1401. The service collaborates with academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodation, please register with them at the beginning of the academic term.

- **Compassionate Accommodation**
  If you are facing challenges that are affecting more than one course, contact the Associate Chair - Graduate Studies or the Graduate Administrative Coordinator. They will review your case and coordinate a reasonable and fair plan in consultation with appropriate others (e.g. instructors, Department Chair, AccessAbility Services, Engineering Counselling services, Registrar's Office).

- **Instructional Contingencies for Covid-19**
  Should we be required to move away from full-occupancy in-person teaching, we will work with the Department to ensure that students have a fair opportunity to meet course requirements and are notified of any changes in a timely manner.

Class Schedule:

Monday	Tuesday	Wednesday	Thursday
Jan 3rd	4th	5th	6th Chapters S1, F2, & S5
10th	11th Chapters S1, F2, & S5	12th	13th Chapters S1, F2, & S5
17th	18th Chapter S2	19th	20th Chapter S2
24th	25th Chapter S3	26th	27th Chapter S3
31st	Feb 1st Chapter S3	2nd	3rd Chapter S4
7th	8th Chapter S4	9th	10th Chapter S6
14th	15th Chapter S6	16th	17th Chapter S7
21st	22nd Reading Week	23rd	24th Reading Week
28th	Mar 1st Chapter S7	2nd	3rd Chapter S7
7th	8th Chapters S8 & V8	9th	10th Chapters S8 & V8
14th	15th Chapters S8 & V8	16th	17th Chapters S8 & V8
21st	22nd Chapter V13	23rd	24th Chapter V13
28th	29th Chapter V13	30th	31st Chapter V13
Apr 4th	5th Chapter V13	6th	7th
11th Final Exam	12th	13th	14th

S: Strogatz, V: Virgin, & F: Figliola