

Course Outline

1. COURSE INFORMATION

Session Offered	Winter 2024	
Course Name	Systems Modelling and Optimization	
Course Code	SEP 773, CHEM ENG 753, MECH ENG 732	
Date(s) and Time(s) of lectures	C01: Thursday 09:30-12:30 PM; ETB 535; V. Mahalec	
Program Name		
Calendar Description	Network models of production systems. Simulation software architecture and solution methods. Single period and multiperiod production planning models. Plant data analysis and model building (PCA, PLS). Models comprised of first principles and empirical submodels (hybrid models). Evolutionary optimization (differential evolution, genetic algorithms, particle swarm). Term project.	
Instructor(s)	Vladimir Mahalec	E-Mail: mahelec@mcmaster.ca; Office Hours & Location: by appointment, online

2. COURSE SPECIFICS

Course Description			
Instruction Type	Code	Type	Hours per term
	C	Classroom instruction	36
	L	Laboratory, workshop or fieldwork	
	T	Tutorial	
	DE	Distance education	
	Total Hours		
Resources	ISBN	Textbook Title & Edition	Author & Publisher
	Other sources	Source	
		Class notes on Avenue	
Prerequisite(s)	Familiarity with linear algebra; MATLAB coding		
Corequisite(s)			
Antirequisite(s)			
Course Specific Policies	Each homework is due the following week before the class, unless otherwise noted.		
Departmental Policies	<p>This is an in person course and attendance is expected. Lecture notes will be posted prior to the lectures.</p> <p>The use of cell phones, iPods, laptops and other personal electronic devices are prohibited from the classroom during the class time, unless the instructor makes an explicit exception.</p> <p>Announcements made in class or placed on Avenue are considered to have been communicated to all students including those individuals that are not in class.</p> <p>Instructor has the right to submit work to software to identify plagiarism.</p>		

3. SUB TOPIC(S)		
Week 1	Introduction: course overview. Case study example: community energy system. Steps in building a model of a system that can be represented as a network of many nodes. Modelling of a system comprised of stand-alone heating and stand-alone heating.	H#1: Simulation model of the system with stand-alone heating and cooling.
Week 2	Energy balance equations model of the community energy system: simulation and optimization of a simplified system.	H#2: Simulation and Optimization of operating costs of the system comprised of PGU, heat recovery, boiler, electric chiller. Determine
Week 3	Optimization of a complete linear model of the energy system. Multiobjective optimization: epsilon constraint method	H#3: Simulation and Optimization of annualized costs of the system comprised of PGU, heat recovery, boiler, electric chiller. Find Pareto front with [minCO ₂ ; min annualized cost] objectives.
Week 4	Piecewise linearization to approximate nonlinear performance curves. Add lake water cooling exchanger. Connecting summer and winter operation via energy storage.	H#4: Simulation and Optimization of annualized costs of the system comprised of PGU, heat recovery, boiler, electric chiller, lake water exchanger, H#5: (due in week 6) add thermal storage and optimize jointly winter and summer operation.
Week 5	Systems that produce products by processing or mixing materials based on a recipe (e.g. cookies) ; ON / OFF & threshold constraints	
Week 6	Producing materials by mixing, subject to quality constraints (e.g. gasoline, cement). Term project assigned.	H#6: Multi-mode production with ON/OFF constraints. Multiperiod production plan for recipe-based production (due in week 8)
Week 7	Term break	
Week 8	Hybrid models; Multi-mode representation of a non linear manufacturing unit	
Week 9	Evolutionary optimization: differential evolution, Genetic algorithms	H#7: Heat exchanger design optimization via differential evolution
Week 10	Particle swarm algorithm. Multi-objective optimization: NSGA-II	H#8: Multi-objective Optimization (via NSGA_II) of the system comprised of PGU, heat recovery, boiler, electric chiller Find Pareto front with [min CO ₂ ; min annualized cost] objectives.
Week 11	Preview of the term project work – in class presentations	
Week 12	Uncertainty in demands or equipment performance • Two-stage stochastic programming	H#9: Read and summarize an assigned paper

	<ul style="list-style-type: none"> Representation of uncertainty and problems with scenario generation Moment matching and RVS method to reduce the number of scenarios 	
Week 13	Term project presentation	
NOTE:		

Note that this structure represents a plan and is subject to adjustment term by term. The instructor and the University reserve the right to modify elements of the course during the term. The University may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes.

ASSESSMENT OF LEARNING *including dates*

HomeWorks	67.5% (7.5% per homework)	Weight
Term project	32.5%	
TOTAL	100%	
Percentage grades will be converted to letter grades and grade points per the University calendar.		

5. LEARNING OUTCOMES

- Upon completing the course, the students will be able to:*
- i. *Construct problem solving procedures (algorithms) for applications in equipment design, optimization of operating conditions, or production planning.*
 - ii. *Create and solve models for:*
 - a. *Computation of material and energy balances of a production plant*
 - b. *Production planning of multi-purpose plants*
 - iii. *Solve multi-objective optimization problems.*
 - iv. *Construct hybrid models of manufacturing plants*

1. 6. COURSE OUTLINE – APPROVED ADVISORY STATEMENTS

2. ANTI-DISCRIMINATION

The Faculty of Engineering is concerned with ensuring an environment that is free of all discrimination. If there is a problem, individuals are reminded that they should contact the Associate Director, Graduate Studies, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

3. http://www.mcmaster.ca/policy/General/HR/Discrimination_Harassment_Sexual_Harassment-Prevention&Response.pdf

4. 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-procedures-guidelines/>

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.
5. • copying or using unauthorized aids in tests and examinations.

6. 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.

ONLINE PROCTORING

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.

COMMUNICATIONS

It is the student’s responsibility to:

- Maintain current contact information with the University, including address, phone numbers, and emergency contact information.
- Use the University provided e-mail address or maintain a valid forwarding e-mail address.
- Regularly check the official University communications channels. Official University communications are considered received if sent by postal mail, by fax, or by e-mail to the student’s designated primary e-mail account via their @mcmaster.ca alias.
- Accept that forwarded e-mails may be lost and that e-mail is considered received if sent via the student’s @mcmaster.ca alias.

Check the McMaster/Avenue email and course websites on a regular basis during the term.

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 ACCOMMODATION OF STUDENTS WITH DISABILITIES

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. <http://www.mcmaster.ca/policy/Students-AcademicStudies/Studentcode.pdf>

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.

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.