

CHEMENG 3K04

Introduction to Reactor Design

Winter 2024 Course Outline | Version 3.0

FORMAL CALENDAR DESCRIPTION

Stoichiometry of multiple reactions, kinetics of homogeneous reactions, interpretation of batch data, design of ideal and non-ideal CSTR and plug flow reactors

Prerequisite(s): MATH 2Z03 and ZZZ3, plus registration or credit in CHEMENG 2F04, 2E04 (or 3E04) and 3D04 (or 3D03); or permission of the Department

INFORMAL COURSE DESCRIPTION

CHEMENG 3K04 builds upon chemical engineering foundations learned in CHEMENG 2D04, 2F04, 3A04, 3D04, and 3M04 to describe chemical processes in the presence of reaction(s). Specifically, it considers mass and energy balances in systems containing reactions which are carried out in continuously-stirred tank reactors (CSTRs) or plug-flow reactors (PFRs). In tandem, reaction kinetics are considered. A rigorous mathematical approach is taken to model these processes via differential equations, with significant emphasis placed on problem-solving.

LECTURES & TUTORIALS

Lectures:	C01:	Tu	19:00–22:00	MDCL 1110
Tutorials*:	T01:	Th	10:30–12:20	ITB-139
	T02:	Mo	14:30–16:20	ITB-139

*Note that attendance during only one of the tutorial blocks is necessary

INSTRUCTOR CONTACT INFORMATION & OFFICE HOURS

Dr. Ryan J. LaRue

Office: JHE 250
laruerj@mcmaster.ca
 +1 (705) 255-1907

Office Hours:

Th, 16:30-17:30
 (Or By Appointment)

TEACHING ASSISTANT CONTACT INFORMATION & OFFICE HOURS

Norma Garza Flores

garzafln@mcmaster.ca
 Office: ABB 361
 Hours: Mo, 16:30-17:30

Nigel Mathias

mathiasn@mcmaster.ca
 Office: JHE 370B***
 Hours: Fr, 12:30-13:30

Kavitha Sivanathan

sivank1@mcmaster.ca
 Office: JHE 296
 Hours: Tu, 15:00-16:00

Sadru Walji

wajis1@mcmaster.ca
 Office: ABB 361
 Hours: We, 12:30-13:30

Susu Zhang

zhans85@mcmaster.ca
 Office: JHE 296
 Hours: We, 11:30-12:30

***Office hours in JHE 345

COURSE WEBSITE

CHEMENG 3K04 will use Avenue to Learn as the primary repository for notes, assignments, tutorial activities, and grades. Grades posted on Avenue to Learn are unofficial until posted on MOSAIC. Students can log in via the link: <http://avenue.mcmaster.ca/>.

Please note that we will not be using Microsoft Teams as a medium for lectures/tutorials, nor as a repository for course documents, nor as a mode of communication in this course.

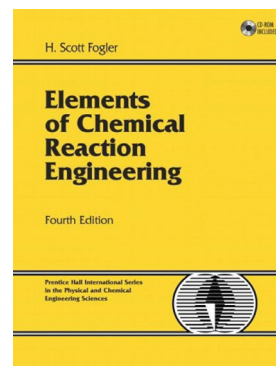
COURSE MATERIALS

Required Course Materials:

- Lecture slides (available on Avenue)
- Course pack (available on Avenue)

Supplementary References:

1. H.S. Fogler, *Elements of Chemical Reaction Engineering*, Prentice-Hall, 4th Edition, 2006, Chapters 1-6, 8, 11, and parts of Chapters 13 & 14.
2. J.M. Smith, *Chemical Engineering Kinetics*, McGraw-Hill (1981), 3rd Edition.
3. O. Levenspiel, *Chemical Reaction Engineering*, 3rd Edition Wiley (1999).



Tests & Examinations

Any calculator may be used during tests and examinations.

Other Materials:

Students are encouraged to use software programs such as Excel or MATLAB to solve problems in tutorials, on assignments, or for course projects.

COURSE LEARNING OUTCOMES & ACCREDITATION LEARNING OUTCOMES

To develop a fundamental understanding of the application of principles of chemical kinetics, material balances, heat transfer and mass transfer to the modeling and design of chemical reactor systems. Students should be able to apply this knowledge to the formulation and solution of the following problem types:

- a. Given the starting or inlet conditions and the specifications of a reactor type, determine the output concentrations and temperature of that reactor (*rating problem*).
- b. Given the starting or inlet conditions and the desired output conditions, calculate the size and kind of the reactor required (*design problem*).
- c. Given a set of data for a reaction, establish a rate equation for that reaction.

The Learning Outcomes defined in this section are measured for Accreditation purposes only and will not be directly taken into consideration in determining a student's actual grade in the course. CHEMENG 3K04 will measure the following graduate attribute indicators through the indicated learning outcomes below.

Course Outcomes	Corresponding CEAB indicator
Recognize that several reactor configurations could yield the desired product	1.3 Competence in Engineering Fundamentals 1.4 Competence in Specialized Engineering knowledge 2.1 Identifies and states reasonable assumptions and suitable engineering fundamentals, before proposing a solution path to a problem. 4.2 Explores a breadth of potential solutions, considering their benefits and trade-offs as they relate to the project requirements 5.2 Successfully uses engineering tools.
Determine criteria for choosing a particular reactor configuration	1.3 Competence in Engineering Fundamentals 1.4 Competence in Specialized Engineering knowledge 4.2 Explores a breadth of potential solutions, considering their benefits and trade-offs as they relate to the project requirements
Evaluate options to determine the best fit to the criteria	4.4 Justifies and reflects on design decisions, giving consideration to limitations, assumptions, constraints and other relevant factors.
Recognize the availability of software, thus avoiding making too many simplifying assumptions in problem solving	5.2 Successfully uses engineering tools.
Solve problems using software such as MATLAB	5.2 Successfully uses engineering tools.

For more information on Accreditation, please visit: <https://www.engineerscanada.ca>.

ASSESSMENT

The grading for this course will be broken down according to the following components:

Component	Weight	Notes
Graded Tutorial Activities	10% (10×1%)	Short, timed activities which build upon weekly tutorials. Submitted on Avenue to Learn. 10-12 activities are expected, weighted equally.
Assignments	15% (3×5%)	Three assignments are expected (handed in individually), each weighted equally. Submitted on Avenue to Learn.
Group Project	15%	Term project completed in groups of three. Divided into two separate parts each with equal weight.
In-Class Test	2%	Short quiz designed to prepare students for the first midterm.
Student-Generated Test Questions	3% (3×1%)	Prior to each midterm/exam, each student will create and solve their own test question. Submitted on Avenue to Learn.
In-Class Midterm Tests	30% (2×15%)	Cumulative midterm examinations held outside of class hours.
Final Exam	30%	Cumulative examination. Scheduled during the April exam period (Time/Date/Room TBA).
Total*	100%	

*The component percentages add up to 105%, but students will be graded out of a total of 100%. The additional 5% can be viewed as a course bonus.

TUTORIAL WORKSHOPS

In this course, attending tutorials is critical for your learning process. There are two tutorial blocks (T01 and T02) assigned to this course: you are only responsible for attending one of these blocks. If you miss your assigned block, feel free to attend the other block, as long as there is space for you.

Tutorial activities will build upon what is covered in lecture. As such, participation is incentivized (up to a total 10% of your final grade) through the use of graded tutorial activities. These activities will further build upon the questions covered in tutorial and will be accessed on Avenue to Learn under *Assessments > Quizzes*. In the tutorial workshops, it is highly recommended that students work together to best absorb the content. However for the purposes of assessment, the graded tutorial activities must be completed individually. There is a built-in time limit on the Avenue quizzes to help enforce this. Graded tutorial activities will be released before their linked tutorial so that students who are trying to work ahead or students that cannot attend physical tutorial sections will still benefit from them. Each activity will be due at the start of the next lecture (7 pm, Tuesdays). Unlike with assignments, the penalty associated with late tutorial activity submissions is 100% as the Avenue to Learn closes promptly at the deadline.

ASSIGNMENTS

Assignments will be released on roughly a monthly basis and will cover the most up-to-date relevant lecture/tutorial material. Students may collaborate with others to complete the assignments (see “Academic Honesty” section), but each student must submit their own unique copy. This means that each student must produce their own calculations, MATLAB files, graphs, etc. Submissions are expected to be electronic (PDF format), with submissions accepted in dedicated Avenue to Learn dropboxes. Typed assignments are preferred, but consider using a phone app such as CamScanner to convert neat, hand-written pages to PDF documents. Assignments will be graded based on the correctness of the process/final solution as well as the presentation of the solution.

Late submissions (assignments or course projects or student-generated test questions) will be penalized according to the following scheme: 0-12 hours late = 25% penalty; 12-24 hours late = 50% penalty; 24 or more hours late = assignment not accepted (100% penalty).

COURSE PROJECT

ChemEng 3K04 features a course project designed to allow students to consider the application of principles learned in class. These projects will be completed in groups of three, to be chosen by the students. Once you have your members, please join a group on Avenue to Learn under *Communication > Groups*. The project will be comprised of two parts: an initial report (50% of the total grade) and a final report (50% of the total grade). Due dates for each part will be discussed at a later date. Note that each student in the group will receive the same grade for the course project.

QUIZZES, TESTS, & EXAMINATIONS

This course contains one (1) in-class test, two (2) midterm exams, and one (1) final exam. The in-class test serves as a short version (~1 hour) of the midterm exams with a low weighting such that students will be able to gauge their preparedness for the upcoming midterm(s). Please use this test as an opportunity to determine whether you need to allocate extra attention towards studying this course, or whether you need assistance from the course instructor or TAs.



Prior to the midterm and final examinations, you are required to create a possible test question that could feasibly appear on that assessment (“Student-Generated Test Questions”). These questions must be substantially different from those in the graded and practice tutorials, and yet within the scope of the material. That is, they should not be from further ahead in the course, and it should be in line with the material covered thus far. You must also solve your own question. The grading scheme is simple: for no submission or for posing a question that already exists in the course material, you will earn 0%. For a submission that is very similar to existing questions or for an incomplete submission, you will earn 50%. Solved questions that are deemed to be sufficiently novel to appear on a test/exam will earn 100%. You will not lose marks for incorrectly-solved solutions. These test questions will be submitted via Avenue to Learn.

Two midterm examinations will be held outside of regular class time (in the evening) roughly 1/3 and 2/3 of the way through the course. While the midterms will be cumulative in nature, they will likely focus most heavily on the course material that directly proceeds them. Midterms will be two hours in length, subject to change. Tentatively, the dates of the two midterms will be:

- Wednesday February 14th @ 7 pm (MDCL 1110)
- Thursday March 28th @ 7 pm (MDCL 1110)

A final examination covering the entirety of the course material will be held during the regularly-scheduled University exam period. The Registrar will schedule the time/date/location later in the semester.

Tests will be conducted in an “open book” format. You are allowed to bring printed copies of any notes/textbooks that you wish. Digital notes on your laptop or tablet will also be allowed, provided that your device is turned on to “airplane mode” to prevent communications between students. It is intended that the examination will follow the same “open” format, contingent on the registrar’s approval.

In case a student “misses” a midterm examination:

- A missed midterm exam without a valid excuse and proof of this excuse will result in a zero grade for the midterm exam.
- Where there is a legitimate medical/personal reason for missing the midterm, the student must complete a MSAF and forward it to the instructor to receive consideration for a midterm exam at a later date.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC TERM WORK

Students are encouraged to contact the Course Instructor to ask for accommodation, wherever possible.

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”](#).

Important Notes:

- Consider Clause 12 in the REQUESTS FOR RELIEF: MSAF (SELF-REPORT) section of the MSAF policy. It reads: “[t]he instructor(s) will determine the appropriate relief for the request.” In CHEMENG 3K04, the grade value of missed work covered by the MSAF policy will not be re-distributed to the final examination by default. If you file an MSAF, be sure to promptly follow up with the course instructor to receive further information regarding granted relief for missed work.

- You cannot use an MSAF to avoid a test or the final examination. If you are unable to be present due to a University-approved reason (e.g. sickness), an MSAF must be filed in order to be considered for an alternate writing opportunity.
- You cannot use an MSAF to avoid doing the Group Project.

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, **in person or online**.

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](https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/), 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.
- copying or using unauthorized aids in tests and examinations.

In the context of this course:

- **Weekly tutorials are not assessed, so feel free to work in groups or get outside help.** In fact, you are encouraged to work together! Tutorials are for your understanding and skill development. But, **all graded tutorial activities are to be completed individually.** No sharing of any work may be done *between* individuals. This includes handwritten documents and electronic files of any type.
- **While you may complete assignments collaboratively, each student must submit a unique, individual copy of the assignment solutions.** A “statement of resources” must be included with your submission. Similarly, while unique, individual student-generated test questions must be submitted by each student, you are encouraged to work collaboratively to solve them.
- **All projects are to be completed entirely within your group.** No sharing of any work may be done *between* groups. This includes handwritten documents and electronic files of any type. A “statement of resources” must be included with your submission.
- **Consulting or reusing solutions from previous years’ assignments or course projects constitutes academic dishonesty.**

Statement of Resources:

For the purposes of encouraging academic integrity, students will be required to submit a short “statement of resources” along with every assignment, student-generated test question, and the group project. While this statement will not be



graded, it will be compulsory and submissions that do not include one will not be accepted. In this statement, students should indicate all the resources that were used in the completion of the assessment and how they were used. This might include collaborating with other students, seeking assistance from other faculty members, and using software programs like MATLAB or artificial intelligence such as ChatGPT. Of course, if literature sources are used (e.g. journal articles, textbooks), they should also be cited, here, in any consistent format. There is no need to mention the course instructor, TAs, course notes, etc. in the Statement of Resources. The following is a brief example of a good Statement of Resources:

Statement of Resources:

For the completion of Assignment #1, I used the following resources:

- I worked together with students Nake Jease and Lince Veung on all questions of the assignment.
- My former MATH 2Z03 TA (Hussain Abdulhassan) helped me understand how to analytically solve the differential questions in Question #2.
- MATLAB was used to numerically solve the differential questions in Question #2.
- The values for the [density and viscosity of water](#) in Question #3 were obtained from www.engineeringtoolbox.com.
- I used ChatGPT to proofread the grammar for Question #4.

Other Works Cited:

Ryan J. LaRue, Blake Patterson, Susan O'Brien, David R. Latulippe, "[Evaluation of Membrane Fouling by Microplastic Particles in Tertiary Wastewater Treatment Processes](#)", Environmental Science & Technology Water (2022).

If no resources were used, clearly state that.

Plagiarism, improper collaboration, copying unauthorized tests or aids, and other academic dishonesty will not be tolerated. **Your first offence may be reported** to the Office of Academic Integrity. The default penalty for academic dishonesty is a zero on the entire assignment/project/exam, even if the dishonesty occurred on just one portion or question of that assignment/project/exam. However, if the Academic Integrity Office chooses to hold a hearing, they will determine the penalty.

COVID-19 POLICY

Wearing a mask in our shared classroom space is a good way to keep yourself and others healthy throughout the term in the face of COVID-19, but also other airborne illnesses. Staying healthy, so that you can attend classes in-person, study, complete course work, and collaborate with your peers, is an important part of your academic success this year. Wearing a mask in the classroom also provides increased protection to other students and TAs who may have elevated needs in their own health or that of their families. **I encourage you to bring and wear a mask in class, tutorials, office hours, and in other indoor spaces.**

For this class, lectures are in-person and attendance is not only expected, but will be critical for your success. However, lecture content will be captured using Echo360 and available for review on Avenue to Learn in real-time. All tests/midterms/exams require in-person attendance. Absences from these events require the use of an MSAF.

If you feel sick, I encourage you to stay home. For the safety of everyone, do not attend your in-person lectures/tutorials/labs/etc. Should you believe that your absence from class will affect your learning, please do not hesitate to send me/the TAs an email and we will work together to ensure that you succeed. Remember: lectures are streamed, recorded and will be available on Avenue to Learn.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

The instructor aims to make this class accessible to all students. Please forward and optionally discuss any accommodation granted by [Student Accessibility Services \(SAS\)](#) with the instructor *before the third week of the course*. Please raise any other accessibility issues with the instructor as soon as possible, e.g. accessibility of the course website and course materials.

Further information can be obtained by contacting SAS at 905-525-9140 ext. 28652 or sas@mcmaster.ca or by consulting 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.

INCLUSIVE ENVIRONMENT STATEMENT

We consider this classroom to be a place where you will be treated with respect, and we welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class. We will gladly honour your request to address you by an alternate name or gender pronoun. Please advise us of this preference early in the semester.

COURSES WITH AN ONLINE 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 online 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.

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, COVID-19, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

NOTICE REGARDING POSSIBLE COURSE MODIFICATION

The instructor and 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. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.

THE P.R.O.C.E.S.S.

As some of you may already be aware, the department of Chemical Engineering has a storied history of education. In addition to teaching and learning, the department is proud of our graduates not only for their academic success, but their more intrinsic traits that make them respected members of the engineering community.

Recently, several high-ranking graduates from the McMaster Chemical Engineering Program employed in various industries (oil/gas, financials, etc.) were interviewed to ask what traits they look for when hiring for engineering positions. Using this information, the department would like to present to you the **PROCESS**: a code of conduct that we hope will guide our students throughout this program and their careers to come.

- Professionalism
- Responsibility
- Ownership
- Curiosity

- Empathy
- Selflessness
- Service

It is up to YOU to interpret these traits and apply them to your time at McMaster and your career as you see fit. These traits will not be assessed for grades but will be strongly encouraged throughout your time at McMaster. We hope that you identify with these character traits and what they mean to you, and that you **trust the process**.