Faculty of Engineering and Applied Science

CHEE 323 – INDUSTRIAL CATALYSIS

Course Syllabus – Winter 2022

This is your course syllabus. Please download the file and keep it for future reference.

LAND ACKNOWLEDGEMENT

Queen's University is situated on traditional Anishinaabe and Haudenosaunee Territory.
See: http://www.queensu.ca/encyclopedia/t/traditional-territories

INCLUSIVITY STATEMENT

Queen's students, faculty, and staff come from every imaginable background – small towns and suburbs, urban high rises, Indigenous communities, and from more than 100 countries around the world. You belong here: https://www.queensu.ca/inclusive/.

TEACHING TEAM

COURSE INSTRUCTOR

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CHEE 323 (W 3-0-0.5 3.5)

COURSE DESCRIPTION[1]

Students will learn, discuss and apply knowledge of the chemical structure and reactivity of industrial catalytic compounds, with particular emphasis placed upon the integration of fundamental catalytic chemistry with the principles of chemical reaction engineering, transport phenomena and thermodynamics. Industrial processes of interest include homogeneous ionic, radical, and coordinative catalytic systems, as well as heterogeneous fluid-solid systems. The design component of the course will require students to develop catalytic processes to meet productivity targets from provided kinetic and thermodynamic data. (0/11/0/20/11)

Prerequisites: ENCH 245, CHEE 321, CHEE 330 or permission of the Chemical Engineering department

(0/11/0/20/11) (Mathematics/Natural Sciences/Complementary Studies/Engineering Science/Engineering Design)

COURSE LEARNING OUTCOMES (CLO)

The specific course learning outcomes include:

CLO	DESCRIPTION	INDICATORS
CLO 1	Apply rate determining step, steady state hypothesis, and material balance equations appropriately to derive rate expressions from reaction coordinate diagrams and/or mechanisms for ionic, radical, and catalytic reaction networks.	KB-NatSci KB-Proc(b)
CLO 2	Integrate principles of chemical thermodynamics, reaction kinetics, interfacial mass transfer and diffusional mass transfer to develop mathematical models of multi-phase reactors.	KB-Proc(a) KB-Proc(b) KB-Proc(c)
CLO 3	Design catalytic reactors to meet productivity targets from provided kinetic and thermodynamic data.	KB-Proc(c) DE-Solutions

The course outcomes are mapped to the following program attributes:

Knowledge base for Engineering (KB)

KB-NatSci Interpret natural phenomena and relationships through the use of analytical and/or experimental techniques.

KB-Proc(a) Formulates and solves steady-state and dynamic mass and energy balances for a chemical process.

KB-Proc(b) Analyzes kinetic mechanisms, identifies rate limiting steps and develops expressions to describe reaction rates for non-catalytic, catalytic, or electrochemical process.

KB-Proc(c) Applies engineering principles to do engineering calculations and size various unit operations, including pumps, heat exchangers, separation processes, and reactors

Design (DE)

DE-Solutions Create a product, process or system to solve a problem, that meets specified needs, and subject to appropriate iterations.

[1] Course Author(s): Robin Hutchinson: Industrial Catalysis Winter 2022; Queen's University holds a license for the use of the Course Author's Intellectual Property for CHEE 323.

Relevance to the Program

This course combines knowledge of the chemical structure and reactivity of industrial catalytic compounds, with reaction kinetics, process conceptualization and mass transfer principles. It implements chemistry and engineering science knowledge acquired in previous courses (ENCH 245 "Applied Organic Chemistry", CHEE 330 "Heat and Mass Transfer Operations", CHEE 321 "Chemical Reaction Engineering") and extends it to catalytic processes of industrial interest. This course is core to students in the Chemical Engineering (Process Option) program.

Course Structure and Activities

3 lecture hours + 1 tutorial hour per week. Please refer to SOLUS for times and locations. The first half of the course will be delivered on-line, as announced by the university in late December. Lectures will be given live at the assigned times. Recordings will be made and posted on the course website.

Expectations for Lectures/Tutorials

Lecture slides will be posted in advance through the course Learning Management System (LMS). Some lectures will include examples and problem solutions not contained in the posted slides. A complete set of notes includes lecture slides, chalkboard examples/illustrations, and student-written records of classroom discussions.

The design component of the course will require students to develop chemical processes stemming from examples covered in class, with an opportunity to complete a portion of the work during tutorials. The complexity of each design exercise will increase, evolving towards a process wherein multiple phases and reactions must be considered. Knowledge of MATLAB is an asset.

Course Materials

Resources (Optional):

- Fogler 2011. *Essentials of Chemical Reaction Engineering*.
- Welty, Rorrer and Foster, *Heat and Mass Transfer*

Other Material

Course lecture slides, assignments and tutorials will be posted on the CHEE 323 LMS (OnQ).

Required Calculator

A Casio 991 is required. **ONLY** this type of non-programmable, non-communicating calculator will be allowed during tests and exams.

Suggested Time Commitment

This course represents a study period of one semester spanning 12 weeks. Learners can expect to invest on average 7-9 hours per week in this course. Learners who adhere to a pre-determined study schedule are more likely to successfully complete the course.

A detailed course outline is located at the end of this course syllabus

COURSE EVALUATION

Deliverable	Week or Date	Weight
Assignments and open-ended design exercises (2-4 throughout term)	throughout term	30%
Midterm Exam (tentatively Friday March 4th)	Week 7	25%
Final Exam	Exam period	45%

Both the midterm and final exam are closed book.

Students must pass the individual examination component (combined mark on midterm + final) to pass the course, as stated in the departmental policies. Attendance at the midterm (scheduled on the last instructional day before reading week) and final exam is mandatory. No make-up midterm will be provided. Marks assigned to the midterm may be transferred to the final exam for a medical reason supported with proper documentation following the stipulations of the departmental policy.

Unless other arrangements have been approved in advance, departmental policies regarding late and missed assignments, and missed quizzes/exams will be followed.

All assessments in this course will receive numerical percentage marks. The final grade you receive for the course will be derived by converting your numerical course average to a letter grade according to the established Grade Point Index. Your final grades will show on SOLUS. Official transcripts showing final grades will be available on the Official Grade Release Date. Please note that in official transcripts, a mark of IN (incomplete) is considered a grade, and your transcript is released with this grade.

Remote Proctoring - Proctortrack

It is hoped that the midterm and final exam will take place “in person”, as they are scheduled for after reading week. However, if remote learning is extended to the entire term, the midterm and final exam in this course will use remote proctoring provided by a third-party, cloud-based service that enables the completion of a proctored exam or test from an off-campus location, through onQ. This online proctoring solution was chosen as part of the approach to maintaining academic integrity in online assessment. Precise details about how remote proctoring will be used in this course can be found in the “Getting Started with Remote Proctoring” content module in onQ or will be provided by the instructor.

When writing tests/exams using remote proctoring, you are connecting to the third-party service. Queen’s has conducted a privacy and security review of the service in accordance with Ontario’s privacy legislation.

You should also take measures yourself to protect your information by keeping your NetID password and challenge questions private, closing all applications prior to starting an exam/test, and ensuring your device is updated and safeguarded against malware.

For more information about remote proctoring, see the Student FAQs on the OUR Exams resource page for remote proctoring.

COURSE COMMUNICATION

In this course, you may be expected to communicate with your peers and the teaching team through electronic communication. You are expected to use the utmost respect in your dealings with your colleagues or when participating in activities, discussions, and online communication.

Following is a list of netiquette guidelines. Please read them carefully and use them to guide your online communication in this course and beyond.

1. Make a personal commitment to learn about, understand, and support your peers.
2. Assume the best of others and expect the best of them.
3. Acknowledge the impact of oppression on the lives of other people and make sure your writing is respectful and inclusive.
4. Recognize and value the experiences, abilities, and knowledge each person brings.
5. Pay close attention to what your peers write before you respond. Think through and re-read your writings before you post or send them to others.
6. It's alright to disagree with ideas, but do not make personal attacks.
7. Be open to be challenged or confronted on your ideas and challenge others with the intent of facilitating growth. Do not demean or embarrass others.
8. Encourage others to develop and share their ideas.

COURSE ANNOUNCEMENTS

The instructor will routinely post course news in the Announcements section on the main course homepage on OnQ. Please sign up to be automatically notified by email when the instructor posts new information in the Announcements section. Instructions on how to modify your notifications are found in the **Begin Here** section of the onQ course site.

OFFICE HOURS

In addition to interaction through Q&A sessions, students can interact in a synchronous fashion with either a TA or the instructor through office hours. A schedule for office hours will be determine in consultation with the class and updated throughout the term. Students may also contact the teaching team by e-mail to ask questions and/or to request an appointment. Points of contact are available on the course LMS home page.

CONFIDENTIAL MATTERS

If you have a confidential matter you would like to discuss with your instructor, their contact details are on the first page of this document. Expect email replies within 48 hours during workdays.

STANDARD FEAS INFORMATION

COURSE POLICIES

Please review the following policies concerning copyright, academic integrity, absences and academic accommodations:

COPYRIGHT

Course materials created by the course instructor, including all slides, presentations, synchronous and asynchronous course recordings, handouts, tests, exams, and other similar course materials, are the intellectual property of the instructor. It is a departure from academic integrity to distribute, publicly post, sell or otherwise disseminate an instructor's course materials or to provide an instructor's course materials to anyone else for distribution, posting, sale or other means of dissemination, without the instructor's ***express consent***. A student who engages in such conduct may be subject to penalty for a departure from academic integrity and may also face adverse legal consequences for infringement of intellectual property rights and, with respect to recordings, potentially privacy violations of other students.

ACADEMIC INTEGRITY

As an engineering student, you have made a decision to join us in the profession of engineering, a long-respected profession with high standards of behaviour. As future engineers, we expect you to behave with integrity at all times. Please note that Engineers have a duty to:

- Act at all times with devotion to the high ideals of personal honour and professional integrity.
- Give proper credit for engineering work

The standard of behaviour expected of professional engineers is explained in the Professional Engineers Ontario Code of Ethics. Information on policies concerning academic integrity is available in the Queen's University Code of Conduct, in the Senate Academic Integrity Policy Statement, on the Faculty of Engineering and Applied Science website, and from your instructor.

Departures from academic integrity include plagiarism, use of unauthorized materials or services, facilitation, forgery, falsification, unauthorized use of intellectual property, and collaboration, and are antithetical to the development of an academic community at Queen's. Given the seriousness of these matters, actions which contravene the regulation on academic integrity carry sanctions that can range from a warning or the loss of grades on an assignment to the failure of a course to a requirement to withdraw from the University.

In the case of online or remotely proctored exams, impersonating another student, copying from another student, making information available to another student about the exam questions or possible answers, posting materials to online services, communicating with another person during an exam or about an exam during the exam window, or accessing unauthorized materials, including internet sources and using unauthorized materials, including smart devices, are actions in contravention of academic integrity.

Late Policy

Any applicable late penalties are described in the details for each assessment. In the event of extenuating circumstances, you must follow the policies for requesting an academic consideration (please see below). Note that unacceptable reasons include extra-curricular activities, travel plans, generally behind on schoolwork, etc. In the absence of an approved consideration request, the normal late penalty will apply as described in the assignment or any course/departmental policies.

Invalid Exams

An exam may be declared invalid in case of an interruption in an in-person examination; if the instructions in a remote or online exam were not followed; if the student uploads wrong materials; or if a situation arises where the integrity of the exam cannot be verified. If an exam is declared invalid, the student may be granted a re-write.

Absences (Academic Considerations) and Academic Accommodations

For absences and academic accommodations please review the information on the FEAS website.

ACADEMIC AND STUDENT SUPPORT

Queen's has a robust set of supports available to you including the Library, Student Academic Success Services (Learning Strategies and Writing Centre), and Career Services. Learners are encouraged to visit the Faculty of Engineering and Applied Science Current Students web portal for information about various other policies such as academic advisors, registration, student exchanges, awards and scholarships, etc.

Individual Needs and Support

If you have a disability or health-related condition that may require academic accommodations, please approach the Queen's Accessibility Services. The staff at Accessibility Services are available by appointment to develop individualized accommodation plans, provide referrals, and assist with advocacy. The sooner you let us know your needs, the better we can assist you in achieving your learning goals. For questions or assistance with requesting Academic Consideration or Accommodation, contact the FEAS Academic Accommodation Coordinator at engineering.aac@queensu.ca

Every effort has been made to provide course materials that are accessible. For further information on accessibility compliance of the educational technologies used in this course, please consult the links below.

Educational Technology	Accessibility Compliance Information
onQ (Brightspace Learning Management System by D2L)	https://www.d2l.com/accessibility/standards/
Zoom	https://zoom.us/accessibility

If you find any element of this course difficult to access, please discuss with your instructor how you can obtain an accommodation.

Religious Observance

Students in need of accommodation for religious observance are asked to speak to their professor within a week of receiving their syllabus. Note also that alternative assignments are considered a "reasonable accommodation" under the Ontario Human Rights Code. Students with questions about their rights and responsibilities regarding religious accommodation should contact the Chaplain via Chaplain@queensu.ca.

Technical Support

Some basic comfort level with basic hardware and software skills are required for this course. If you require technical assistance, please contact Technical Support.

Supportive Personal Counselling

If at any time you find yourself feeling overwhelmed, anxious, sad, lonely, or distressed, consider confidential supportive counselling offered by the embedded counselors at the Student Wellness Service Faculty of Engineering and Applied Science.

CHEE 323 || Course overview – Winter 2022

Course learning outcomes (CLO): Students will be able to:

1. Apply rate determining step, steady state hypothesis, and material balance equations appropriately to derive rate expressions from reaction coordinate diagrams and/or mechanisms for ionic, radical, and catalytic reaction networks.
2. Integrate principles of chemical thermodynamics, reaction kinetics, interfacial mass transfer and diffusional mass transfer to develop mathematical models of multi-phase reactors.
3. Design catalytic reactors to meet productivity targets from provided kinetic and thermodynamic data.

Module	Lecture approach and content	Tutorial and Practice Problems	Assessment (CLO)
Module 1 (Wks 1-3)	**Fundamentals.** Model Formulation. Kinetics, Thermodynamics and the Rxn Coordinate. Derivation of Rate Expressions. Ideal and Non-ideal Reactors. Gas-liquid mass transfer effects.	Example problems solved interactively in tutorial and posted practice problems.	Assignment 1 (CLO1). Material is included in Midterm and Final.
Module 2 (Wks 3-5)	**Radical Reaction Systems.** Solving systems of chain-reactions. Radical chemistry and kinetics. Polymerization systems and reaction engineering.	Example problems solved interactively in tutorial and posted practice problems. DA2	Design Exercise 2 (CLO1-3). Material is included in Final.
Module 3 (Wks 5-7)	**Organometallic Catalysis.** Solving catalytic sequences. OM chemistry and catalysts. Example systems (e.g., hydrogenation). Fitting of experimental data.	Example problems solved interactively in tutorial and posted practice problems.	Design Exercise 3 (CLO1-3) Material is included in Final.
Midterm	**Week 7**		CLO1, CLO2
Module 4 (Wks 8-10)	**Heterogeneous Catalysis I.** Catalyst characterization. Surface reactions. Development of rate expressions.	Example problems solved interactively in tutorial and posted practice problems.	Material is included in Final.
Module 5 (Wks 10-12)	**Heterogeneous Catalysis II.** Fluid-solid MT. Internal diffusional resistance (Thiele Modules). Reactor design.	Example problems solved interactively in tutorial.	Material is included in Final.
Final Exam	**Exam Period**		**CLO1, CL02, CL03**