



Faculty of Engineering and Applied Science

CHEE 331 – DESIGN OF UNIT OPERATIONS

Course Syllabus – Winter 2022

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

Aris Docoslis, PhD

Department of Chemical Engineering
Queen's University

E-mail: docoslis@queensu.ca



COURSE INSTRUCTOR

Nicolas Hudon, PhD

Department of Chemical Engineering
Queen's University

E-mail: nicolas.hudon@queensu.ca



PROGRAM ASSOCIATE

Lev Mirzoian

Department of Chemical Engineering

E-mail: lev.mirzoian@queensu.ca



CHEE 331 (W K-4.5)

COURSE DESCRIPTION

This course is part of the Engineering Design and Practice Sequence. Heat and mass transfer knowledge is applied in the analysis and design of unit operations, including separation processes and heat exchanging equipment. The equilibrium stage concept is used to perform calculations and size separation processes including distillation, gas absorption/stripping and liquid-liquid extraction. Heat transfer processes are taught with an emphasis on the design various types of heat exchanging equipment, including shell and tube heat exchangers, condensers and reboilers. The chemical process design component of the course involves a series of activities, dealing with the design of separation processes, heat exchanger sizing and design, process hazards analysis, implementation of instrumentation and construction of piping and instrument diagrams. In addition to choosing and sizing unit operations and implementing appropriate process instrumentation, the students will learn to use simulation tools and will incorporate economics, safety and environmental responsibility in all stages of the design. The course is integrated with CHEE 361 “Engineering Communications, Ethics and Professionalism.” (0/0/0/14/40)

Prerequisites: APSC 200 or APSC 202, APSC 293, CHEE 311, CHEE 321, CHEE 330, or permission of the department.

Co-requisite: CHEE 361

CONTACTING INSTRUCTORS

In order to streamline the process of students contacting the instructors with a variety of questions and issues, each member of the instruction team will be responsible for a specific administrative aspect of the course.

1. **Prof. Nicolas Hudon** – any questions and/or issues related to **Accommodations** and **Waivers**.
2. **Lev Mirzoian** – any questions and/or issues related to **Tutorials** and **Design Challenges**.

COURSE LEARNING OUTCOMES (CLO)

This course develops the skills needed to design separation and heat transfer processes and to size/optimize related equipment. Emphasis is given to the associated health and safety risks, applicable standards, and economic, as well as environmental considerations and on how these considerations should be incorporated throughout the design process. By the end of this course, students should be able to:

CLO	DESCRIPTION	INDICATORS
CLO 1	Development of engineering science knowledge on separation processes (distillation, absorption/stripping, extraction) and heat transfer processes (heat exchangers).	KB-Thermo(c), KB-Thermo(d), KB-Proc(a)
CLO 2	Application of engineering science knowledge to size separation process equipment and heat exchangers.	KB-Proc(c)
CLO 3	Development of competency in constructing process flow and P&I diagrams.	CO-Graphics
CLO 4	Implementation of process instrumentation and simple control loops, as well as safety instrumentation.	KB-Proc(c)
CLO 5	Development of competency in using engineering tools, such as Excel spreadsheets and Mathcad to perform engineering calculations. Implementation of process simulation software, such as Aspen HYSYS to simulate separation processes.	ET-Apply
CLO 6	Demonstrate the ability to provide accurate, comprehensive, objective technical opinions and recommendations, including the choice of appropriate processes and the development of documentation, such as equipment specifications, process flow diagrams and P&IDs.	DE-Define, DE-Strategies, DE-Solutions, DE-Assess PR-Standards LL-Information
CLO 7	Identification of process hazards through process hazards analysis and incorporation elements of safety on all aspects of the design.	DE-Define, DE-Strategies, DE-Solutions, DE-Assess IM-Environment, IM-Mitigate, IM-Social
CLO 8	Estimation of capital and utility costs, using appropriate costing tools. Process optimization based on cost considerations.	DE-Define, DE-Strategies, DE-Solutions, DE-Assess EC-Economics
CLO 9	Effective group work, including reflection of group work, while adopting a professional approach during all project phases.	TW-Contribution, TW-Feedback, PR- Interpersonal

This course assesses the following program indicators at the 3rd year level:

Knowledge base for engineering (KB)

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

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

KB-Thermo(c) Uses correlations and experimental data to evaluate thermodynamic quantities that relate to vapour-liquid or liquid-liquid equilibria

KB-Thermo(d) Determines equilibrium constants and analyzes the influence of thermodynamic equilibrium on reaction and separation systems.

Design (DE)

DE-Define Define problem, objectives and constraints.

DE-Strategies Compare multiple strategies for solving a problem.

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

DE-Assess Evaluate performance of a design, using criteria that incorporates specifications, limitations, assumptions, constraints, and other relevant factors.

Engineering Tools (ET)

ET-Apply Apply and manage appropriate techniques, apparatus, databases, models, tools, and/or processes to accomplish a task.

Individual and Teamwork (TW)

TW-Contribution Take initiative to plan, organize and complete tasks, as an individual and team member, in order to meet goals.

TW-Feedback Share ideas and information by eliciting, giving and applying positive and effective feedback.

Communications (CO)

CO-Graphics Create figures, maps, tables and drawings to engineering report standards.

Professionalism (PR)

PR-Standards Integrate appropriate standards, codes, legal and regulatory factors into decision making.

PR-Interpersonal Demonstrate professional conduct and integrity.

Impact of Engineering (IM)

IM-Environment Evaluate the environmental impact of engineering activities and promote environmental stewardship of the natural and built environments.

IM-Mitigate Take appropriate action to mitigate risks associated with economic, health, safety and legal aspects of engineering

IM-Social Evaluate cultural, societal, and technical norms while maintaining ethical position required for engineering practice in Canada.

Economics and project management (EC)

EC-Economics Apply economic considerations, such as capital, operating, societal and life cycle costs, to design processes.

Lifelong Learning (LL)

LL-Information Identify, organize, and critically evaluate information from an appropriate range of sources, to meet learning needs.

COURSE EVALUATION

ASSESSMENT WEIGHTING

Assessment Tool	Due Date (before 23:59 ET)	Weight
Midterm	Week 8 (Monday March 7 th , 2022)	10%
Final Exam	Final Exam period	20%
Design Challenges	4 deliverables submitted throughout the 12-week period (include group and individual activities)	60%
Tutorials	Participation/work completed during workshops	10%
		100%

Midterm and final exams will be delivered remotely, unless Queen's switches back to in-person course delivery.

ASSESSMENT DESCRIPTIONS

General

PLEASE READ CAREFULLY: Students must pass the individual examination component (i.e. the average of Midterm and Final Exam must be above 50/100), as well as the design component, to pass the course, as stated in the Departmental Policy.

Unless other arrangements have been approved, [departmental policies](#) regarding late and missed assignments, and missed quizzes/exams will be followed.

Midterm

During in-person delivery of the course, the midterm exam will also be in-person and will take place during regular lecture hours. In the event that remote delivery of the course is extended beyond the midterm exam date, the midterm exam will be delivered remotely using Proctortrack. Any accommodations will be processed in accordance with FEAS Academic Accommodations policy. Instructors will provide updates to the students on any changes communicated by the FEAS Office.

In case of missed midterms, the procedures that must be followed are outlined in:

<http://my.engineering.queensu.ca/Current-Students/Brief-and-Long-Term-Absence-Forms.html>.

If the midterm was missed for legitimate reasons the mark will be redistributed to the rest of the individual written components. Make-up midterm tests will not be provided.

Final Exam

Provided that FEAS returns to in-person delivery after the Reading Week break, the final exam will be scheduled by the Exams Office and conducted in-person. Any accommodations will be processed in accordance with FEAS Academic Accommodations policy.

In the event that remote delivery of the course is extended, the final exam will be delivered remotely using Proctortrack.

Note that as per faculty policy, the only make-up period for missed final exams is during the September supplemental examinations.

Assignments

A design project done in groups of 3 or 4 will be completed during the term. Student groups will be required to submit deliverables during the term. Students are expected to participate equitably and respectfully to the group effort. Participation of all group members is essential, and mandatory peer-reviews will be conducted to ensure that all group members contribute equally. In case of large discrepancies students will be approached by the instructors/TAs in an effort to mitigate any problems. If problems persist, this will be reflected in the marks of student members whose contribution is deficient. Subject to the departmental policies, students who fail to contribute may be withdrawn from a group and may receive a failing mark in the course.

Remote Proctoring - Proctortrack

The final exam and some tests/quizzes 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](#).

GRADING

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](#).

Feedback on Assessments

The teaching team will provide feedback on graded activities.

Accessing Your Final Grade

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.

COURSE MATERIALS

Required Textbook

- Towler G. and Sinnott R., “Chemical Engineering Design: Principles and Economics of Plant and Process Design”, 2nd Edition, B-H, Elsevier

Additional Textbooks

- Wankat P. C. (2017) “Separation Process Engineering”, Prentice Hall. E-book available from the Queen’s Library.
- Serth R.W. (2007) “Process Heat Transfer – Principles and applications”, Academic Press. E-book available from the Queen’s Library.
- **Course notes and other course-related material** All other course material is accessible via OnQ.

Required Calculator

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

Required Hardware/Software

Students must have a reliable [internet connection and hardware](#) that are compatible with online learning and remote proctoring system requirements. Students will have to access specialized software (Mathcad, Aspen HYSYS) remotely, through AppsAnywhere or VDI.

Course Specific Computer-Related Skills

This course requires computer-related technical skills. For this course, you will also need to use Mathcad and Aspen HYSYS software that is available to all Chemical Engineering students at Queen's. This software is available for remote access, which means that you will need to connect to the software through AppsAnywhere or the [Queen's Virtual Desktop](#). Follow the link for details on how to set up this connection. Students will learn the software during the tutorials and by using step-by-step guides posted on the course website.

Suggested Time Commitment

This course represents a study period of one semester spanning 12 weeks. Learners can expect to invest on average 11-14 hours per week in this course. Learners who adhere to a pre-determined study schedule are more likely to successfully complete the course.

WEEKLY COURSE OUTCOMES

Week	Learning Outcomes	Assessment
1	Introduction/Overview <ul style="list-style-type: none">• Introduction to Chemical Engineering Design, Project Documentation (Towler & Sinnott 1.1-1.4)• Process Flowsheet Development (T&S 2.1, 2.2) Separation Processes <ul style="list-style-type: none">• Introduction to separation processes• Separations involving gases and liquids (Chapter 16 T&S) Tutorial 1 <ul style="list-style-type: none">• Introduction to Design Challenge 1• Group sign-up• Group work• Information on literature sources	CLO 1, 3, 6, 9
2	Distillation (Chapter 3, 4, 5, 7, Wankat) <ul style="list-style-type: none">• External and Internal balances Tutorial 2 <ul style="list-style-type: none">• Process Selection. Design Challenge 1 – Separation Process Selection	CLO 1, 2
3	Distillation (Chapter 3, 4, 5, 7, Wankat) <ul style="list-style-type: none">• Distillation of binary mixtures• Stage calculations: Lewis Method, McCabe-Thiele method Tutorial 3 <ul style="list-style-type: none">• Mathcad workshop• Introduction to Design Challenge 2 Design Challenge 2 – Distillation Column Design	CLO 1, 2

Week	Learning Outcomes	Assessment
4	Distillation (Chapter 3, 4, 5, 7, Wankat) <ul style="list-style-type: none"> Multicomponent distillation/shortcut methods Tutorial 4 <ul style="list-style-type: none"> Workshop on Design Challenge 2 	CLO 2, 5, 6, 9
5	Absorption/Stripping (Chapter 12, Wankat) Tutorial 5 <ul style="list-style-type: none"> Aspen HYSYS workshop 	CLO 2, 5, 6, 9
6	Liquid-Liquid Extraction (Chapter 13, Wankat) Tutorial 6 <ul style="list-style-type: none"> Costing / ChemEcon 	CLO 2, 5, 6, 9
7	Column Design and Optimization (Chapter 10 Wankat, Ch. 17 T&S) <ul style="list-style-type: none"> Distillation Column Design Costing and Economic Optimization Tutorial 7 <ul style="list-style-type: none"> Column design/ optimization 	CLO 2, 6, 8, 9
8	Midterm Column Design and Optimization (Chapter 10 Wankat, Ch. 17 T&S) <ul style="list-style-type: none"> Column sizing: Trayed and packed columns Tutorial 8 <ul style="list-style-type: none"> Tray Sizing workshop Design Challenge 3 – Distillation Column Optimization	CLO 2, 6, 8, 9

Week	Learning Outcomes	Assessment
9	<p>Heat Exchangers calculations and design (Ch. 19 T&S, Chapters 3-5 Serth)</p> <ul style="list-style-type: none"> • Double pipe heat exchangers • Shell and tube heat exchangers <p>Tutorial 9</p> <ul style="list-style-type: none"> • Quick sizing of heat exchangers 	CLO 2, 3, 4
10	<p>Heat Exchangers calculations and design (Ch. 19 T&S, Chapters 3-5 Serth)</p> <ul style="list-style-type: none"> • Shell and tube heat exchangers • Reboilers and Condensers <p>Tutorial 10</p> <ul style="list-style-type: none"> • Shell & Tube heat exchanger design <p>Design Challenge 4 – Heat Exchanger Design</p>	CLO 2, 3, 4
11	<p>Process Instrumentation and control (Ch. 5 T&S)</p> <ul style="list-style-type: none"> • Process Instrumentation, basic control loops • P&IDs • Control of unit operations <p>Tutorial 11</p> <ul style="list-style-type: none"> • Distillation column and heat exchanger instrumentation 	CLO 3, 4, 6, 7
12	<p>Process Safety (Ch. 10.5-10.7 T&S)</p> <ul style="list-style-type: none"> • Failure Mode Effect Analysis (FMEA) • Safety indices • Hazard and Operability studies (HAZOP) • Case studies of industrial accidents (safety videos) <p>Tutorial 12</p> <ul style="list-style-type: none"> • Workshop P&ID and HAZOP 	CLO 3, 4, 6, 7
Final Exam	Final Exam covers the entire course. 20% of the final grade	

COURSE COMMUNICATION

NETIQUETTE

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.

QUESTIONS ABOUT COURSE MATERIAL

Questions or comments regarding the course material that can be of benefit to other students should be posted in the Q&A forum on the class website. The instructor, TAs, and students are encouraged to answer these questions directly in the discussion forum for the benefit of everyone in the course.

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 in the Q&A discussion forums, you will have the opportunity to interact with either a TA or the instructor through office hours. The instructor will provide a schedule of availability at the beginning of the term.

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.

RECORDING SYNCHRONOUS (LIVE) CLASSES

Synchronous (live) classes will be delivered in this course through a video conferencing platform supported by the University [MS Teams]. Steps have been taken by the University to configure these platforms in a secure manner, and to maintain student privacy while delivering courses remotely. Please note the following:

- Lectures will be recorded with video and audio (and in some cases transcription) and will be made available to students in the course for the duration of the term. You will be able to turn off your camera and microphone if you would like upon joining the lecture / tutorial session.
- Tutorials **will** have mandatory participation, and **will** be recorded with video and audio...

The recordings may capture your name, image or voice through the video and audio recordings. By attending these live classes, you are consenting to the collection of this information for the purposes of administering the class and associated coursework. If you are concerned about the collection of your name and other personal information in the class, please contact the course instructor to identify possible alternatives.

To learn more about how your personal information is collected, used and disclosed by Queen's University, please see the general [Notice of Collection, Use and Disclosure of Personal Information](#).

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, being 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/departamental 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 (MODIFY THIS TABLE TO INCLUDE TOOLS USED IN YOUR COURSE)	ACCESSIBILITY COMPLIANCE INFORMATION
onQ (Brightspace Learning Management System by D2L)	https://www.d2l.com/accessibility/standards/
MS-Teams	https://support.microsoft.com/en-us/office/accessibility-support-for-microsoft-teams-d12ee53f-d15f-445e-be8d-f0ba2c5ee68f

If you find any element of this course difficult to access, please contact engineering.aac@queensu.ca

ACCOMMODATIONS RELATED TO REMOTE ASSESSMENT

To have your accommodations applied to a remote-proctored exam please follow the instructions for submitting your information, as outlined on the QSAS website. Your accommodations will be incorporated into your exam session by the Queen's University exam coordinators, on behalf of your course instructor. This information is uploaded automatically to [Proctortrack / Examity](#).

If you are already registered with QSAS and you require additional accommodations related to remote-proctored exams, please consult with your QSAS advisor to update your Letter of Accommodation as appropriate.

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](#) and by Student Wellness Services <https://www.queensu.ca/studentwellness/>