Faculty of Engineering and Applied Science

CHEE 471 – CHEMICAL PROCESS DESIGN

Course Syllabus – Fall-Winter 2021-22

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/.

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CHEE 471 (FW; K 6.25)

COURSE DESCRIPTION[1]

This capstone course integrates skills, knowledge and experience gained from engineering science components of the Chemical Engineering and Engineering Chemistry programs to solve open-ended chemical process design problems. Students will develop competency in the following: process hazard analysis, appropriate use of process simulation techniques, identification and mitigation of process inefficiencies and risks, strategies for acquiring technical data, and costing of process revisions.

Prerequisites: CHEE 321, CHEE 331, CHEE 361.

(0/0/0/0/75) (Mathematics/Natural Sciences/Complementary Studies/Engineering Science/Engineering Design)

COURSE LEARNING OUTCOMES (CLO)

The main objective of the course is to prepare students for technical positions in industry by solving a series of open-ended engineering design challenges. Particular emphasis is placed on process synthesis, with design decisions driven by health and safety analyses, sustainability and environmental stewardship, regulatory constraints, and assessments of process operability and economics. By the end of this course, students should be able to:

CLO	DESCRIPTION	INDICATOR
CLO 1	Apply project management tools (work breakdown structures, activity lists, network diagrams, Gantt diagrams) to distribute project workload amongst team members and facilitate the timely completion of course deliverables.	TW (a)-(e), EC (a), EE (a), COM (a),(c),(e) PR (c)
CLO 2	Develop a Process Hazard Analysis (hazard identification, hazard evaluation, consequences analysis and risk analysis) from a P&ID of a unit operation and formulate recommendations for mitigating identified risks.	IM (a)-(e), PR (a)-(c), EE (b),(c)
CLO 3	Assess a process design from the standpoint of sustainability, environmental stewardship and applicable regulations / standards.	DE (a)-(d), IM (a)-(e), LL (a)-(c)
CLO 4	Conduct a design review of a process flow diagram to identify performance limitations, health and safety issues, operational inefficiencies and unnecessary costs.	DE (a)-(d), IM (a)-(e), LL (a)-(c)
CLO 5	Identify gaps in knowledge needed to revise unit operations and develop an experimental program to acquire the necessary data.	DE (a)-(d), TOO (a)-(c)
CLO 6	Use MATLAB to simulate the dynamics of a batch unit operation, and HYSYS to simulate a continuous process element, while recognizing the limitations of process modelling approaches and software.	DE (c), (d), TOO (a)-(c)
CLO 7	Develop capital and operating cost estimates for proposed process revisions and formulate recommendations for improving process safety and economics.	EC (b), COM (c)
CLO 8	Generate concise technical reports using appropriate terminology and documentation, with particular emphasis on the correct application of PFD and P&ID conventions.	COM (a), (c), (e)

[1] Queen's University holds a license for the use of the Course Author's Intellectual Property for CHEE 471.

This course develops the following attributes at the 4th year level:

Design (DE): (a) Define problem, objectives and constraints[1]. (b) Identify multiple strategies for solving the problem. (c) Design a product, process or system to resolve a problem, that meets specified needs[1], and subject to appropriate iterations. (d) Implement design and evaluate performance of a design, using criteria that incorporates specifications, limitations, assumptions, constraints[1], and other relevant factors. ([1] with appropriate attention to health, safety, environmental, economic, regulatory, cultural, societal and stakeholder needs)

Engineering Tools (TOO): **(a)** Develop, adapt and/or extend appropriate software, equipment, models, and simulations for a range of engineering activities. **(b)** Apply and manage appropriate techniques, apparatus, databases, models, tools, and/or processes to accomplish a task. **(c)** Evaluate limitations and errors of instrumentation/measurement techniques/models/ simulations to assess appropriateness of the results

Individual and team work (TW): **(a)** Complete fair share of work, demonstrate commitment, and meet deadlines. **(b)** Show respect for diversity in individuals and roles in a team and treat all team members equitably. **(c)** Plan and organize work as an individual and team member to meet goals. **(d)** Demonstrate capacity for initiative and leadership while respecting others' roles. **(e)** Share ideas and information by eliciting, giving and applying positive and effective feedback.

Communications (COM): **(a)** Produce clear, concise, precise and well-organized written communication with language appropriate for the audience. **(b)** Deliver formal and informal oral presentations with suitable language, content, style, timing and flow, while adapting format, content and tone to audience and purpose. **(c)** Create figures, maps, tables and drawings to engineering report standards. **(d)** Interpret communication from a variety of sources and respond to instructions and questions, displaying full understanding of the topic. **(e)** Generate a traceable and defensible record of a technical project using an appropriate records system.

Professionalism (PR): **(a)** Recognize that engineering is a regulated profession dedicated to serve and protect the public interest. **(b)** Integrate appropriate standards, codes, legal and regulatory factors into decision making. **(c)** Demonstrate professional conduct and integrity.

Impact of Engineering (IM): (a) Develop engineering solutions that consider impact on all stakeholders and seek to mitigate negative impact. **(b)** Describe environmental issues, the environmental impact of decisions and actions, and incorporate sustainability into decision making. **(c)** Assess reliability, risk, regulatory compliance, and health and safety and take appropriate action to mitigate social and/or environmental impacts. **(d)** In the context of engineering activity, evaluate cultural, societal, business, and technical norms while maintaining ethical and moral position required for engineering practice in Canada. **(e)** Consider technical, economic, risk and legal factors when solving engineering problems.

Ethics and Equity (EE): (a) Demonstrate a commitment to equitable treatment of all. **(b)** Identify and resolve potential ethical issues using ethical principles and codes, demonstrating knowledge of professional accountability in engineering. **(c)** Adhere to guidelines regarding the fair use of intellectual property and contract guidelines.

Economics and Project Management (EC): (a) Effectively plan project, including mitigating risk and managing change, to complete project on-time and on-budget. **(b)** Apply economic considerations, such as capital, operating, societal and life cycle costs, to design processes.

Life-long learning (LL): **(a)** Evaluate and reflect on own knowledge, skills and learning. **(b)** Independently acquire new knowledge and skills for ongoing personal and professional development. **(c)** Identify,

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

Program Effect

This design course is an experiential learning capstone that draws upon mathematics, basic science and engineering science taught throughout the Engineering Chemistry and Chemical Engineering programs. Design challenges are formulated in a manner that relates directly to previous courses, focusing on integrating existing skills and knowledge for the purpose of innovative design. Extensions of student knowledge, where required, are supported by additional learning resources. Linking the design spine to the engineering science curriculum encourages dialogue between instructors and ensure that the concepts needed for the capstone are covered in earlier courses.

Relevance to the Program

This is a capstone design course that consolidates knowledge acquired in previous engineering science courses, and refines skills acquired through the design spine. The course assumes knowledge of prior Engineering Chemistry and Chemical Engineering core courses.

Course Structure and Activities

4 hours of group-centred workshops each week. Attendance is mandatory. Please refer to SOLUS for times and locations.

Expectations for Workshops / Tutorials

Student contact hours will focus on group design sessions, with course instructors and teaching assistants interacting with multiple teams in a design studio environment. MS Teams is setup as a remote communication channel should the university switch to remote delivery due to public health concerns.

COURSE EVALUATION

Marks will be issued for each design challenge report / presentation and weighted toward the final grade according to the following table. These grades represent the highest mark that an individual can receive for a group project element.

ASSESSMENT WEIGHTING

Assessment Tool	Due Date (before 23:59 ET)	Weight	Alignment with CLOs
DC1 Report	5:00 PM Sunday Week 4	**11%**	1, 2, 8
DC2 Report	5:00 PM Sunday Week 6	**11%**	1, 3, 8
DC3 Reports (Group & Individual)	5:00 PM Sunday Week 9	**11% (5.5% & 5.5%)**	1, 4, 8
DC4 Report	During Fall Term exam period	**11%**	1, 5
DC5 Report	5:00 PM Sunday Week 15	**11%**	1, 6, 8
DC6 Report	5:00 PM Sunday Week 18	**11%**	1, 6, 8
DC7 Report	5:00 PM Sunday Week 21	**11%**	1, 8
DC8 Report	During Winter Term exam period	**11%**	1, 7
Peer Review – F21	Within 1 week after end of term	**6%**	1
Peer Review – W22	Within 1 week after end of term	**6%**	1
		100%	

*Under normal circumstances most of an individual's mark for the course is based on material submitted by the group. Should it come to the attention of the instructors that a group member has made an unsatisfactory contribution to the group effort (for example as a result of a peer assessment far below the rest of the class, or poor attendance), grades can be adjusted down at the discretion of the instructor.

ASSESSMENT DESCRIPTIONS

Skill Review Exercises (SRE)

An individual's grade can be affected by skill review exercises (SREs), design session attendance and individual contribution, based on the instructors' assessment. When an SRE is assigned for a design challenge, students must submit their answer at the beginning of the designated session. A grade of 0.0 (unsatisfactory) or 1.0 (adequate) for this SRE solution will be assigned by a course instructor or teaching assistant. A grade of unsatisfactory will reduce the individual's design challenge grade from the group mark by 20%. This student will be required to submit an improved solution at the beginning of the next

design session, whereupon the SRE grading process will be repeated until a grade of adequate is obtained.

Attendance

Attendance at design sessions is mandatory and absence for any reason requires the **prior** approval of all group members and notification of course instructors. The approval is indicated by the team members on the Meeting Minutes form (team members' initials). Failure to secure this approval will result in a deduction of 20% from of the group mark for each absence of the individual.

Assignment Deliverables

Mandatory deliverables (i.e., Gantt Charts, Meeting Minutes, reports) must be submitted by the specified due date. Without exception, a failure to do so will result in a 20% reduction of the Design Challenge grade for every team member. Note that teams are expected to implement quality control measures to ensure that all mandatory deliverables are submitted on or before the due date.

Teamwork

Given that industrial engineering work is generally accomplished by groups of individuals, a students' ability to work in a team environment and contribute meaningfully toward a team's goals is an important part of the course. Consequently, peer reviews conducted the fall and winter terms involving GRASP assessments will account for 12% of the course grade.

Feedback on Assessments

The teaching team will provide feedback on graded activities. You can expect feedback on your assessments within 2 weeks of the due date.

COURSE MATERIALS

Required Textbook

Towler, G. P.; Sinnott, R. K. "*Chemical Engineering Design: Principles, Practice, and Economics of Plant and Process Design"*, 2nd ed.; Butterworth-Heinemann: Oxford; 2013.

Other Material

CCPS & AIChE*"Guidelines for Hazard Evaluation Procedures",* 3rd ed.; Wiley-Interscience: Hoboken, N.J, 2008.

Specific information pertaining to each design challenge, including articles, exemplars, tudent learning guides, etc. is posted to OnQ.

Suggested Time Commitment

This course represents a study period of two semesters spanning 24 weeks. Learners can expect to invest more than an average course in the program. Learners who adhere to a pre-determined study schedule are more likely to successfully complete the course.

COURSE OUTLINE

Design Challenge	Readings + SRE	Group Deliverables	Assessment
DC 1 **Process Hazard Analysis**	Project Management Guide HAZOP+What-If readings and SRE Consequence Analysis readings and SRE	Gantt Chart Meeting Minutes DC1 Report	Course Introduction documentation DC1 Introduction & WBS DC1 Exemplar Project Management Guide Process design documentation (PFD, P&ID, etc.)
DC 2 **Imposed Constraint**	Sustainability Assessment SRE	Gantt Chart Meeting Minutes DC2 Report	DC2 Introduction & WBS DC2 Exemplar Project Management Guide Process design documentation (PFD, P&ID, etc.)
DC 3 **Imposed Constraint**	Weighted Evaluation Matrix Guide and SRE	Gantt Chart Meeting Minutes DC3 Report DC3 Individual Reports	DC3 Introduction & WBS DC3 Exemplar Project Management Guide Process design documentation (PFD, P&ID, etc.)
DC 4 **Experimental Program**		Gantt Chart Meeting Minutes DC4 Final Presentation	DC4 Introduction & WBS DC4 Kinetics Exemplar DC4 Thermo Exemplar
DC 5 **Reaction Engineering**	MATLAB Guide and SRE	Gantt Chart Meeting Minutes DC5 Report MATLAB model	DC5 Introduction & WBS MATLAB Guide and Examples Kinetic Data Memo
DC 6 **Separation Train**	HYSYS Guide and SRE	Gantt Chart Meeting Minutes DC6 Report HYSYS model	DC6 Introduction & WBS HYSYS Guide Thermo Data Memo
DC 7 **Process Control**	SRE	Gantt Chart Meeting Minutes DC7 Report, P&ID.	DC7 Introduction & WBS
DC 8 **Triple Bottom Line Analysis**	ChemEcon Guide and SRE	Gantt Chart and updates Meeting Minutes DC8 Final Presentation ChemEcon	DC8 Introduction & WBS ChemEcon Guide

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 emailed to the instructor. The instructor(s) will respond in an email to the entire class, post an announcement or address the question in class during the next work session for the benefit of everyone in the course.

Technical questions, related to design challenges, could be listed in the "Request for Information" section of the Meeting Minutes form that teams must submit after every work session. The response to these questions will be posted on OnQ.

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 during regular work sessions, you will have the opportunity to interact with either a TA or the instructor through office hours. Office hours appointments can be coordinated by emailing the TA or instructor.

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.

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/
MS-Teams Course Group **"CHEE 471 FW21/22 Design 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 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.