School of Chemical Engineering

UNSW Engineering

CHEN6701

Advanced Reaction Engineering

Term 3, 2022

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Peter Wich	p.wich@unsw.edu.au	via Teams or Email	Science and Engineering Building E8, Room 321, Lv3 (Hilmer)	

Lecturers

Name	Email	Availability	Location	Phone
Emma Lovell	e.lovell@unsw.edu.au	via Teams or Email	Tyree Building, Room 350	

School Contact Information

For assistance with enrolment, class registration, progression checks and other administrative matters, please see the Nucleus: Student Hub. They are located inside the Library – first right as you enter the main library entrance. You can also contact them via http://unsw.to/webforms or reserve a place in the face-to-face queue using the UniVerse app.

If circumstances outside your control impact on submitting assessments, Special Consideration may be granted, usually in the form of an extension or a supplementary assessment. Applications for Special Consideration must be submitted online.

For course administration matters, please contact the Course Coordinator.

Course Details

Units of Credit 6

Summary of the Course

This elective course builds on students' core knowledge of reaction engineering and is designed to give an advanced insight into the design, optimisation and operation of reaction vessels used in chemical, biological, as well as material processing industries.

Topics covered include the analysis of complex industrial reaction kinetics, effect of micromixing on reactive systems, non-isothermal reactor design, nonlinear analysis in reaction systems, catalytic processes, multiphase (gas-liquid-solid) reactors for single and multiple reactions, strategies for reactor optimisation and case studies in industrial process reactor design and operation.

This elective course is geared towards senior undergraduate students with interests in the design and optimisation of reaction vessels and the underlying theoretical concepts. The course is also suitable for Master and PhD research students with interests in chemical, environmental and biological reaction engineering.

Course Aims

What does the 2020 Beirut Harbour Explosion teach us about runaway reactions, scaling effects and the handling of reactive chemicals?
Even though this tragedy can be traced back to mismanaged storage facilities and untrained personal, many parallels can be drawn to accidents – and less consequential – inefficient production processes due to a “bad” design of chemical reaction vessels.

Reaction Engineering is one of the core subjects that differentiates chemical engineers and industrial chemists from other engineering disciplines. The majority of chemical processes involve at least one chemical reaction and depends on kinetic processes. This course is designed to give you an **advanced insight into the design, optimization and operation of reaction vessel used in chemicals/petrochemicals, biological/food as well as materials/minerals processing industries**.

The **Foundational Topics** of the course will cover the analysis of complex industrial reaction kinetics, effect of micro mixing on reactive systems, non-isothermal reactor design, nonlinear analysis in reaction systems, (bio)catalytic processes, multiphase (gas-liquid-solid) reactors for single and multiple reactions, strategies for reactor optimization and case studies in industrial process reactor design and operation.

The **Applied Topics** have been selected for their relevance to reaction engineering, their technical novelty and the significance in real life applications. They present current research trends based on key engineering principles and highlight the application for example to clean energy production, water purification and catalysis. These seminars will be presented by guest speakers from our school that are experts in their area, and who will give you valuable insights into these fundamental and applied reaction engineering-related topics.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Apply advanced kinetic and thermodynamic principles to simulate the progress of chemical reactions various reactor designs.	PE1.1, PE1.3, PE2.1
2. Explain the underlying principles of (bio)catalytic processes	PE1.1, PE1.3
3. Interpret and asses non-ideal and non-isothermal reactor designs, as well as the concepts of recycle reactors	PE1.1, PE1.3, PE2.1
4. Categorize various complex reactions patterns like autocatalytic reactions, parallel and multiple reactions.	PE1.3, PE2.1
5. Contextualize reaction engineering problems and approach them outside the immediate boundaries of the core course content	PE1.4, PE2.3
6. Reflect and judge on the broader impact of advanced engineering concepts to society, economy and environment	PE1.6, PE2.3, PE3.1
7. Analyse engineering innovations and plan (depending on their level of development) how they can be put in industrial practice	PE2.2, PE2.4, PE3.3, PE3.4
8. Assess and communicate gained knowledge and in-depth understanding of innovative engineering concepts via multiple forms of professional communication.	PE3.2, PE3.5, PE3.6

Alignment of General Learning Outcomes with Activities and Assessments

Learning Outcome	Activities	Assessment
Knowledge of specific course content	Lectures	Online Quizzes
Ability to identify, formulate and solve reaction engineering problems from 1st principles	Lectures Tutorial Problems	Mid-Term Exam
Ability to contextualize engineering problems and approach them outside the immediate boundaries of the course content	Appl. Topics Seminars / Case Studies	Group Presentaton Group Report
Ability to apply engineering concepts in a wide setting: social, environmental, economic	Appl. Topics Seminars / Case Studies	Group Presentation Group Report
Technical writing	Collaborative Report Writing	Group Report
Ability to identify information and ability required to succeed in a task (i.e. literature data, ability to collaborate, provide constructive	Collaborative Report Writing	Group Report

feedbacks)		
Ability to communicate effectively	Presentation Preparation	Group Presentation

Teaching Strategies

The course applies a blended approach to learning and teaching and will include face to face and on-line activities. Face to face activities are structured in lectures/tutorials, seminars, workshops. On-line activities include video lectures, formative assessments, access to course material, submission of assessments, communication and administration. The online part of the course will be managed through Moodle and Teams. The course has been designed to facilitate students to pace their learning.

The course is designed to provide opportunities for students to:

- critically engage with the course content via group work, peer review, workshops, and using online resources
- develop own understanding of key chemical engineering concepts and their applications via seminars, readings, the preparation of assignments and peer review
- leverage on own knowledge/experience/interest/abilities in the application of chemical engineering concepts via the selection of the topic of the major assessment tasks, and the participation the assessment of peers

Learning styles: The multiplicity of learning styles and strategies is acknowledged. The course content is presented in different modalities (videos, lecture notes, formal lectures, case studies, problem-based teaching, scientific publications, textbooks, and interactive modules) to allow students to personalize the modality and level of engagement with the course material.

Deep learning is more likely to occur when students find the subject matter interesting in its own sake rather than as subject of evaluation. For this reason, students are given provision to select the topic for the group report and presentation. The peer-assessment of the group presentation will help to participate to the definition of the assessment criteria that will be adopted.

Group work: The course supports the development of key attributes of engineering graduates as the ability to communicate and work in teams, attainment of a broad perspective (social, environmental, economic) and to apply knowledge in practice. The cooperative learning workshop as part of the **Group Presentation** and the corresponding **Group Report** task provide opportunities to improve communication and teamwork skills. The seminars are occasions to learn and reflect on the integration of engineering innovations in industrial practice and its broad impact to society and economy.

Additional Course Information

Requisite knowledge and relationships to other courses

This course builds on core knowledge in reaction engineering and is an elective course in the chemical engineering and industrial chemistry programmes. Pre-requisites: CEIC2005

Competence

Students are expected to enter CHEN6701 having developed competencies in all the material covered in the pre-requisite courses, at least. Little time is available to remediate any deficiencies in your knowledge of those topics. Over the course of the term, you will be developing new competencies and to illustrate the standards we expect, marking rubrics or guidelines will be provided for all assessments.

The teaching staff will apply these marking guides fairly and provide you with feedback so you can continue to improve over the term and beyond.

Time Commitment

UNSW expects students to spend approximately 150 hours to successfully complete a 6 UOC course like CHEN6701. Per week, we expect approx. 4 hours to be spent participating in face-to-face classes and tutorials and 1 hours completing online quizzes, exams and the group presentation. Therefore, outside class you should be spending at least 10 hours per week working on private study of the lecture and tutorial material, the written assessments and preparing for the mid-term exam.

➡ Moodle has the activities for each week clearly laid out to help you keep pace

Success in CHEN6701 means continual work through the term, completing all lessons and tutorial questions in the corresponding week rather than getting behind and then hoping to catch up.

Participation and Team Project

When you attend face-to-face classes, we expect you to actively participate in the activities organised. This may mean listening, taking notes, asking questions or engaging in peer discussions. It may also mean working by yourself or in groups on tutorial exercises.
To complete the group assignment, you are required to work in a team. We expect all team members to agree on how they will manage the team (e.g. making and documenting decisions), to assign the project work equitably and contribute to the delivery of project outputs to the best of their ability. Be careful not to spend an hour a week talking about what you might do or significant time figuring out who will do what. Do not fall into the trap of all “working together” somewhat inefficiently. Part of the point of this team project is to practice your team management skills. It is not possible to complete these tasks efficiently by trying to get each member of the team to work on one "sub-question" within the weekly task and then trying to stitch the fragments together at the end.
Students are expected to contribute to online discussions through the course forum on MS Teams. You may wish to discuss challenges faced through this course, ask questions about course content, discuss solutions to tutorial and practice questions. It is expected that students will help each other, and the lecturers will contribute as required.

Attendance and Punctuality

We expect students to attend and view all lectures and tutorials. University commitments take precedence over regular work activities, holidays etc. Students who attend less than 80% of their possible classes may be refused final assessment. If you miss a class, we expect you to catch up in your time. Lectures are recorded and made available online.

Integrity and Respect

The UNSW Student Code of Conduct (https://student.unsw.edu.au/conduct) among other things, expects all students to demonstrate integrity in all the academic work and to treat all staff, students and visitors to the University with courtesy, tolerance and respect.

Assessment

Assessment criteria and standards

➡ IMPORTANT: Information on assessment criteria and marking rubrics will be provided separately on Moodle.
➡ IMPORTANT: Exact open and close dates of assessments will be shown in the respective sections on Moodle.

The course implements a range of formative and summative assessments. Grades are distributed between different small formative assesment tasks to encourage students to engage with the course material consistenlty during the semester, to allow practicing the different skills the course aims to support and provide timely feedbacks. Formative assesment tasks have been designed to contribute directly to the body of knowdlege, resources and capabilities required to address the summative assesment tasks.

Summative assesments have been devised consistently with the iterative and, to a certain degree, self directed, process that characterizes engineering tasks in working environments. Students participate in the evalaution of their own work and that of their peers. The task offers opportunities for deep engagemnet with the topic selected and for broadening views through the revision of the work of others.

All assessments will be completed online. No hard copy submissions are required. The student gateway provides more detail on the UNSW grading system and assessment policy.

Submission of assessment tasks

All written work will be submitted for assessment via Moodle unless otherwise specified. If you are unable to submit the work via Moodle, you should email the work to the project coordinator as soon as possible. The time the email is received will be considered the submission time. If the final is too big to email, you can share it via your UNSW OneDrive.
Some assessments will require you to complete the work online and it may be difficult for the course coordinator to intervene in the system after the due date. You should ensure that you are familiar with assessment systems well before the due date. If you do this, you will have time to get assistance before the assessment closes.
When you submit work through Moodle for assessment you are assumed to be assenting to the standard plagiarism declaration. A copy of the plagiarism declaration is available from this course's Moodle page. You should not include a plagiarism declaration with your submissions as it will lead to false positives in the plagiarism detection system.

Due dates, dates for the return of marks, and deadlines for absolute fail are outlined for each assessment task on the Moodle page.

Late penalty

Submissions received after the due date and time will be penalised at a rate of 5% per day or part thereof. This penalty is capped at five days (120 hours), after which a student cannot submit an assessment, and no variation is permitted.

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Quizzes	10%	Week 1, 3, 5	1, 2, 3, 4
2. Mid-Term Exam	30%	Week 8	1, 2, 3, 4
3. Group Presentation	20%	Week 10	5, 6, 7, 8
4. Group Report	40%	Week 11	5, 6, 7, 8

Assessment 1: Quizzes

Due date: Week 1, 3, 5

Mostly multiple answer questions on topics presented in lectures and seminars. Quizzes will be available online along the course duration.

It is a **formative assessment** on technical content (knowledge, comprehension, application) with the objectives of helping students to gauge their progress and provide timely feedback.

Assessment 2: Mid-Term Exam

Due date: Week 8

The exam will be assessed based on the technical accuracy of calculations and evidence of good engineering judgement with assumptions and problem simplification.

Required skills will be practiced during lectures and through working on sample questions. It is a **summative assessment** of technical content (knowledge, comprehension, application).

Assessment 3: Group Presentation (Group)

Due date: Week 10

The topics for the Group Presentation and the corresponding Group Report (see below) can be either selected from the range of Applied Topics Seminars that were presented during the course or can be based on a self-selected innovative engineering concept.
➡ **Students will work in self-selected groups of 4 (same as for the Group Report)**

It is both a **formative and summative assessment.** It will provide an occasion for student to practice and demonstrate presentation skills and to receive feedback on their approach and the selected topic. This activity is designed as a collaborative learning workshop and will include, as an additional learning experience, both **peer advice and peer marking** between all attendees.
➡ **Assessment weight = 30% peer marking + 70% instructor marking**

Assessment 4: Group Report (Group)

Due date: Week 11

The Group Report is based on the same topic as the Group Presentation and should provide an in-depth analysis of a selected innovative engineering concept.
➡ **Students will work in self-selected groups of 4** (same as for the Group Presentation)

The report should describe the general nature of the problem/challenge, the discussion of possible approaches/solutions and a potential future implementation in your chosen setting as part of a case study.
Participation of course seminars and use of suggested and self-selected reading materials will support students in the preparation of this task.

It is a **summative assessment** of the ability to apply engineering concepts in a wide setting, technical writing, to source and use literature data. The levels of learning tested include knowledge, comprehension, application to broad areas, analysis, synthesis and evaluation.

➡ Individual contributions will be honoured with the submission of a Contribution Statement Form

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

Lectures:

Lectures:
Wed 10:00 – 12:00 Michael Hintze Theatre (K-H6-LG03)
Thu 10:00 – 12:00 Michael Hintze Theatre (K-H6-LG03)

Tutorials:
Fri 11:00 – 12:00 Tyree Energy Technology G16 (K-H6-G16)

Teaching times and locations: http://timetable.unsw.edu.au/2022/CHEN6701.html

Weeks	**Foundational Topics (Wed)**	**Applied Topics (Thu)**	**Assessments**
Week 1	Introduction / Reaction Kinetics	Membrane Reactors	Quiz 1 (3%)
Week 2	Catalysis / Enzymes	Membrane Reactors (Class Workshop)	(Membrane Reactor Quiz A+B+C)
Week 3	Ideal Reactors (Batch + CSTR + PFR)	Hydrogen Production / Storage	Quiz 2 (2%)
Week 4	Reactors in Series	Photo-Catalysis	
Week 5	Recycle Reactors & Autocatalysis / Multiple Reactions	Plasma-Catalysis	Quiz 3 (5%)
Week 6	Flexibility Week (Q&A Session)		
Week 7	Non-isothermal Systems	Solid and Liquid based Electronics and Optics	
Week 8	Q&A Session (Mid-Term Exam and Group Assignment)	Mid-Term Exam	Mid-Term Exam (Thu)
Week 9	Q&A Session (Group Assignment)	Mathematical Modelling of ChemEng Processes	
Week 10	Group Presentation	Group Presentation	Group Presentation
Week 11			Group Report (Fri)

Resources

Recommended Resources

Videos, lecture slides and suggested readings, tutorial exercises and solutions, plus links to other online resources will be provided on the course Moodle page. These will be progressively released as the semester progresses.

Recommended Texts

There is no set textbook for this course. However, the following texts will be helpful resources in completing the learning activities in this course:

- Levenspiel, O., Chemical Reaction Engineering, 3rd Edition or later – Textbook: The foundational topics will be treated in line with the book's content
- Fogler, S. Elements of Chemical Reaction Engineering (any edition), Wiley – A valuable additional reference

Other Resources

You can access the full text of online resources available from the UNSW library using the UNSW VPN Service (https://www.it.unsw.edu.au/staff/vpn/#AccessingLibraryJournals).

Students will require a UNSW approved calculator for the exam.

Course Evaluation and Development

The School of Chemical Engineering evaluates each course each time it is run through (i) myExperience Surveys, and (ii) Focus Group Meetings. As part of the myExperience process, your student evaluations on various aspects of the course are graded; the Course Coordinator prepares a summary report for the Head of School. Any problem areas are identified for remedial action, and ideas for making improvements to the course are noted for action the next time that the course is run. Focus Group Meetings are conducted each term. Student comments on each course are collected and disseminated to the Lecturers concerned, noting any points which can help improve the course.

All of the activities in this course from the online lessons through to the team project have been designed in response to student feedback.

Submission of Assessment Tasks

In the School of Chemical Engineering, all written work will be submitted for assessment via Moodle unless otherwise specified. Attaching cover sheets to uploaded work is generally not required; when you submit work through Moodle for assessment you are agreeing to uphold the Student Code.

Some assessments will require you to complete the work online and it may be difficult for the course coordinator to intervene in the system after the due date. You should ensure that you are familiar with assessment systems well before the due date. If you do this, you will have time to get assistance before the assessment closes.

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work and should be treated with due respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

Marking guidelines for assignment submissions will be provided at the same time as assignment details to assist with meeting assessable requirements. Submissions will be marked according to the marking guidelines provided.

Late penalties

Unless otherwise specified, submissions received after the due date and time will be penalised at a rate of 5% per day or part thereof (including weekends). For some activities including Moodle quizzes and Team Evaluation surveys, extensions and late submissions are not possible.

Special consideration

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to submitting an assessment or sitting an exam.

UNSW has a Fit to Sit / Submit rule, which means that if you attempt an exam or submit a piece of assessment, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's Special Consideration page.

Note: UNSW does not require a medical certificate for COVID-related absences of 7 days or less, however you must provide formal evidence from your local/state health provider (e.g. NSW Health) that clearly states your name and the date you tested positive (i.e. confirmation of your RAT registration, PCR test result). Longer absences due to extended self-isolation or COVID-related illness will still need documentation such as a medical certificate.

Applications for special consideration **will still be required** for assessment and participation absences related to COVID-19. Special consideration requests should not be lodged for missing classes if there are no assessment activities in that class.

Academic Honesty and Plagiarism

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits: honesty, trust, fairness, respect, responsibility and courage (International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013). At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity and plagiarism can be located at:

- The Current Students site
- The ELISE training site

The Conduct and Integrity Unit provides further resources to assist you to understand your conduct obligations as a student: https://student.unsw.edu.au/conduct.

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism. Further information about referencing styles can be located at https://student.unsw.edu.au/referencing.

For assessments in the School of Chemical Engineering, we recommend the use of referencing software such as Mendeley or EndNote for managing references and citations. Unless required otherwise specified (i.e. in the assignment instructions) students in the School of Chemical Engineering should use either the APA 7th edition, or the American Chemical Society (ACS) referencing style as canonical author-date and numbered styles respectively.

Academic Information

To help you plan your degree, assistance is available from academic advisors in The Nucleus and also in the School of Chemical Engineering.

Additional support for students

- Current Student Gateway
- Engineering Current Student Resources
- Student Support and Success
- Academic Skills
- Student Wellbeing, Health and Safety
- Equitable Learning Services
- IT Service Centre

Course workload

Course workload is calculated using the Units-Of-Credit (UOC). The normal workload expectation for one UOC is approximately 25 hours per term. This includes class contact hours, private study, other learning activities, preparation and time spent on all assessable work.

Most coursework courses at UNSW are 6 UOC and involve an estimated 150 hours to complete, for both regular and intensive terms. Each course includes a prescribed number of hours per week (h/w) of scheduled face-to-face and/or online contact. Any additional time beyond the prescribed contact hours should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

On-campus class attendance

Physical distancing recommendations must be followed for all face-to-face classes. To ensure this, only students enrolled in those classes will be allowed in the room. Class rosters will be attached to corresponding rooms and circulated among lab demonstrators and tutors. No over-enrolment is allowed in face-to-face class. Students enrolled in online classes can swap their enrolment from online to a **limited** number of on-campus classes by Sunday, Week 1.

In certain classroom and laboratory situations where physical distancing cannot be maintained or the staff running the session believe that it will not be maintained, face masks will be designated by the course coordinator as **mandatory PPE** for students and staff. Students are required to bring and use their own face mask. Mask can be purchased from IGA Supermarket (Map B8, Lower Campus), campus pharmacy (Map F14, Middle Campus), the post office (Map F22, Upper Campus) and a vending machine in the foyer of the Biological Sciences Building (Map E26, Upper Campus).

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and advice can be found here. Do not come to campus if you have any of the following symptoms: fever (37.5 °C or higher), cough, sore throat, shortness of breath (difficulty breathing), runny nose, loss of taste, or loss of smell. If you need to have a COVID-19 test, you must not come to campus and remain in self-isolation until you receive the results of your test.

You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-

isolate. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed. Further information is available on any course Moodle or Teams site.
For more information, please refer to the FAQs: https://www.covid-19.unsw.edu.au/safe-return-campus-faqs

Note: This course outline sets out description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle should be consulted for the up to date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline (as updated in Moodle), the description in the Course Outline/Moodle applies.

Image Credit

Dr Peter Wich

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	✓
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering problem solving	✓
PE2.2 Fluent application of engineering techniques, tools and resources	✓
PE2.3 Application of systematic engineering synthesis and design processes	✓
PE2.4 Application of systematic approaches to the conduct and management of engineering projects	✓
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	✓
PE3.2 Effective oral and written communication in professional and lay domains	✓
PE3.3 Creative, innovative and pro-active demeanour	✓
PE3.4 Professional use and management of information	✓
PE3.5 Orderly management of self, and professional conduct	✓
PE3.6 Effective team membership and team leadership	✓