School of Chemical Engineering

UNSW Engineering

CEIC2005

Chemical Reaction Engineering

Term 2, 2023

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Dipan Kundu	d.kundu@unsw.edu.au	via Teams or Email	E10, 222 (Hilmer)	

Lecturers

Name	Email	Availability	Location	Phone
Xunyu Lu	xunyu.lu@unsw.edu.au	via Teams or Email	Tyree Energy Technology Building, 352	

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.

Questions about the this course should normally be asked during the scheduled class so that everyone can benefit from the answer and discussion.

Course Details

Units of Credit 6

Summary of the Course

Chemical reaction engineering concerns the implementation of chemical reactions on a commercial scale. Its goal is the design and operation of chemical reactors to achieve safe, economic, scalable and energy-efficient production of chemicals. More than any other activity, it likely defines chemical engineering better as a distinct branch of the engineering profession. Starting with understanding what changes are expected to occur in a chemically reacting system by explaining the thermodynamics of the process, you will look into analyses of the rate kinetics of different reactions and, finally, the choice and design of reactors where those reactions can be carried out for optimal production at scale.

This course provides the knowledge base and critical thinking essential to the further learning of unit operations in CEIC3001, process modelling in CEIC3000, and process design in CEIC3005 and CEIC4001. The material in this course is taught from an engineering design perspective.

Course Aims

Chemical Reaction Engineering is one of the core subjects that differentiate chemical engineers and chemical product engineers from other engineering disciplines. The majority of chemical processes involve at least one chemical reaction. In this subject students will learn how to use thermodynamics to determine if a given reaction is possible. Students will also learn how to use reaction kinetic models to determine how fast a reaction is and to develop mathematical models, design equations, to simulate the progress of chemical reactions in a variety of reactor types. The course is principally a problem solving course, and requires considerable student interaction and participation.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Apply basic thermodynamic principles to determine if a chemical reaction is feasible.	PE1.3
2. Use mathematical models to simulate the progress of chemical reactions.	PE1.1, PE2.1
3. Design ideal chemical reactors.	PE2.1, PE2.3
4. Predict the performance of non-ideal reactors.	PE1.3, PE2.2
5. Critically evaluate analyses and designs for chemical reaction systems.	PE3.4, PE3.5, PE3.6, PE3.2, PE2.3

Teaching Strategies

A combination of short online lessons, lecture videos, face-to-face lectures and problem-solving workshops will be used to introduce and highlight key concepts and, most notably on applying those concepts and understanding to problem-solving. The linkage between thermodynamics, kinetics and reactor design will be demonstrated by representative reaction systems. Lectures and lecture notes used to lay the foundation of theories incorporate a generous dose of illustrative examples and problems from laboratory and industrial situations. They will provide you with practice at doing the sorts of questions that will be part of the assessments and provide instant feedback on your progress in the course.

An extensive set of problems will be used as part of the weekly problem-solving workshops, some designed to reinforce principles covered during the week and some slightly open-ended to enhance critical and creative thinking skills.

The quizzes provide assessment and feedback to you on your progress. Homework assignments are given to complement class work examples, serving as pivots for knowledge deepening and application diversification. There is a team project component that links theory and implementation. The project activities involving research on a topic and report writing will help you build skills in teamwork, critical reflection, and collaborative writing, amongst others.

Additional Course Information

Requisite knowledge and relationships to other courses

This course is about continuing to build your knowledge of reactions and energy, with an application of this knowledge to the design of chemical reactors. It builds upon the skills base from CEIC2000 (Material and Energy Systems), the mathematical underpinning of MATH1131 (Mathematics 1A) and MATH2089 (Numerical Methods and Statistics).

The learning from this course is utilised in CEIC2007 (Chemical Engineering Lab A), CEIC3000 (Process Modelling and Analysis), CEIC3005 (Process Plant and Design), CEIC3006 (Process Dynamics and Control) and CEIC4001 (Process Design Project).

Expectations

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 academic work and to treat all staff, students and visitors to the University with courtesy, tolerance, and respect.

Time commitment

UNSW expects students to spend approximately 150 hours to complete a 6 UOC course like CEIC2005 successfully. Success in CEIC2005 means continual work through the term, completing all online lessons and all the problem-solving workshop questions in the corresponding week rather than getting behind and then hoping to catch up.

A typical week in CEIC2005 consists of approximately 12 hours of work on the material in this course:

- 6 h of online lessons, videos, live lectures, etc
- 2 h working on the problem-solving workshop material (preparation and participation)
- 1 h working on the team assignment
- 2 to 4 h to review, study or work on assignments

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

Don't leave activities until the night before; doing so highly increases the chance of failure either in this course or the next course that assumes that you know the CEIC2005 material. Given the pivotal role of chemical reaction engineering within the chemical engineering curriculum, a solid understanding of this work is absolutely required to permit progression to later theory, laboratory and design courses.

Team project

Work for the team project should be carefully delegated. 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. A critical 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.

Detailed Topics

Applications of physical chemistry, kinetics and reaction engineering. Thermodynamic concepts related to Gibbs free energy as applied to phase equilibria and kinetics are illustrated and expanded. In this course, the student will learn the key concepts of chemical reaction kinetics (such as order of reactions, elemental reactions, reaction mechanisms, steady state kinetics, temperature dependence of chemical reactions, the influence of catalysts on the reaction kinetics etc.) and how these kinetic concepts can be employed to choose and operate a suitable reactor for a certain reaction. Reaction kinetics and thermodynamics are interlinked: One tells you how fast a reaction is, the other tells you whether the reaction will proceed at all. Finally, kinetics and thermodynamics are applied in reaction engineering.

Topics include Introduction to reactor design: ideal batch, steady state mixed flow, steady state plug flow, size comparisons of ideal reactors, optimisation of operating conditions. Multiple reactor systems: reactors series and parallel, mixed flow reactors of different sizes in series, recycle reactors, autocatalytic reactions. Multiple reactions: reactor design for reaction in parallel and reactions in series, series-parallel reactions. Temperature effects: heat of reaction, equilibrium constants, optimum temperature progression, adiabatic and non-adiabatic operation, product distribution and temperature. Kinetics of rate processes: Significance of the rate laws and models for distributed and lumped parameter systems. Experimental measurement and correlation of process rates.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Quizzes	10%	Weeks 3, 5, 8, 10 (Sunday)	1, 2, 3
2. Homework Assignments	20%	Week 5 (Sunday) & Week 10 (Sunday)	2, 3, 5
3. Team Project	20%	Weeks 4, 7, and 10 (Friday)	5
4. Final Exam	50%	Exam period	1, 2, 3, 4

Assessment 1: Quizzes

Due date: Weeks 3, 5, 8, 10 (Sunday)

Four short quizzes (of equal value) during the term help measure progress through the content and provide feedback on the learning throughout the term.

The quizzes are intended primarily as formative assessment but are counted towards the final mark at a significant level to encourage you to take them seriously and to discourage last-minute cramming. These quizzes will be assessed based on technical accuracy of calculations and evidence of good engineering judgement with assumptions and problem simplification.

Assessment 2: Homework Assignments

Due date: Week 5 (Sunday) & Week 10 (Sunday)

There are 2 parts to the assignment (each worth 10%), designed to let you tackle longer and more open-ended problems.

These problems will let you explore more deep aspects of thermodynamics, kinetics, and reaction engineering, putting theoretical knowledge into real engineering practice. The emphasis in the marking scheme is not only technical accuracy but also contextualisation of the results to the specific engineering problem being investigated.

Assessment 3: Team Project (Group)

Submission notes: via Moodle
Due date: Weeks 4, 7, and 10 (Friday)

Working in a team, you will investigate contexts of chemical reaction engineering, undertaking short case studies of how key concepts from the course can be seen in common industrial settings. There are approximately weekly tasks for this project that are assessed periodically through the term.

Your short team reports will be compiled, reviewed, and improved over the course of the term. Note that you will also be required to complete an evaluation of each member of your team, covering the contribution to the team output and the quality and style of interaction with other members in the team.

These team evaluations are used to moderate the final marks from the team project.

There are a total of six briefs for six reports that you will work on. You are required to finalise two reports at a time by a given date, so three submissions.

Assessment 4: Final Exam

Due date: Exam period

The final exam is designed to ensure that students are able to apply the principles of thermodynamics, kinetics and reaction engineering to design problems where resources, including time, are constrained. The final exam also focuses on individual achievement and competence in the subject matter, in line with our obligations to Engineers Australia. Students will be required to undertake the final exam in person.

Attendance Requirements

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

Course Schedule

[View class timetable]

Timetable

Date	Type	Content
Week 1: 29 May - 2 June	Lecture	Online activity/lecture Thermodynamics: Intro to course, 2nd and 3rd laws of thermodynamics; Gibbs function
	Workshop	Start work on team project Thermodynamics problems involving entropy, enthalpy, free energy, heat capacity, etc.
Week 2: 5 June - 9 June	Lecture	Online activity/lecture Thermodynamics: Phase diagrams and phase equilibria, colligative properties, internal pressure, J-T coefficients
	Workshop	Phase equilibria and phase diagram problems
Week 3: 12 June - 16 June	Lecture	Online activity/lecture Chemical kinetics: Extent of reaction, kinetics, rates of reaction, reversible reactions, equilibria, collision theory, rate laws, rate order, Arrhenius equation, diffusion controlled reactions
	Workshop	Reactions, reaction rates, describing reactions problems
Week 4: 19 June - 23 June	Lecture	Online activity/lecture Chemical kinetics: reaction mechanisms, more complex reaction rates, case studies in homogenous and heterogenous catalysis
	Workshop	Complex reaction mechanisms and reaction kinetics problems
Week 5: 26 June - 30 June	Lecture	Online activity/lecture Chemical kinetics: Enzyme reactions. Polymerisation reaction kinetics. Obtaining rate

		data. Chemical kinetics in the context of reaction engineering.
	Workshop	Complex reaction mechanisms and reaction kinetics problems
Week 6: 3 July - 7 July	Homework	**Flexibility Week** Self revision/consolidation of thermodynamics and chemical kinetics concepts Homework of chemical kinetics problems from a reaction engineering perspective
Week 7: 10 July - 14 July	Lecture	Online activity/lecture Reaction Engineering: Continuous Stirred Tank Reactors (CSTRs). Levenspiel plots. Residence time distributions.
	Workshop	Batch, semi-batch and CSTR design problems
Week 8: 17 July - 21 July	Lecture	Online activity/lecture Reaction engineering: Plug Flow Reactors (PFRs). Comparison of CSTRs and PFRs. Residence time distributions
	Workshop	Tubular reactors and plug flow reactor design problems
Week 9: 24 July - 28 July	Lecture	Online activity/lecture Reaction engineering: Sets of reactors. Relaxing assumptions. Non-ideal reactors. Axial dispersion model.
	Workshop	Using sets of reactors to solve design problems
Week 10: 31 July - 4 August	Lecture	Online activity/lecture Reaction Enginerering: Diagnosing problems in reactors
	Workshop	Diagnosing faults in reactors and measuring improvement

Resources

Recommended Resources

- *Atkins' Physical Chemistry*, by Peter Atkins and Julio de Paula, any recent edition (7th onwards). Oxford University Press, New York. This is available in the library and provides an excellent resource for thermodynamics and the fundamentals of chemical kinetics.
- *Elements of Chemical Reaction Engineering*, by H Scott Fogler, any edition, Wiley. An e-book of this is available in the UNSW Library (see links from Moodle). It provides an excellent introduction to the application of chemical kinetics to the design of reactors, to the design of ideal and non-ideal reactors.

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, and workshop problems 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 not required unless specifically requested for an individual assessment task; 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 respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect. Please make it easy for the markers who are looking at your work to see your achievement and give you due credit.

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) and will not be accepted more than 5 days late. For some activities including Exams, Quizzes, Peer Feedback, 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.

Please note that for **all** special consideration requests (including COVID-19-related requests), students will need documentary evidence to support absences from any classes or assessments.

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.

To help describe what we are looking for, here are some things that we consider to be quite acceptable (even desirable!) actions for many assessments, and some that we consider to be unacceptable in most circumstances. Please check with the instructions for your assessments and your course coordinator if you're unsure. As a rule of thumb, if you don't think you could look the lecturer in the eye and say "this is my own work", then it's not acceptable.

Acceptable actions	Unacceptable actions
✓ reading/searching through material we have given you, including lecture slides, course notes, sample problems, workshop problem solutions ✓ reading/searching lecture transcripts ✓ reading/searching resources that we have pointed you to as part of this course, including textbooks, journal articles, websites ✓ reading/searching through your own notes for this course ✓ all of the above, for any previous courses ✓ using spell checkers, grammar checkers etc to improve the quality of your writing ✓ studying course material with other students	✗ asking for help with an assessment from other students, friends, family ✗ asking for help on Q&A or homework help websites ✗ searching for answers to the specific assessment questions online or in shared documents ✗ copying material from any source into your answers ✗ using generative AI tools to complete or substantially complete an assessment for you ✗ paying someone else to do the assessment for you

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.

Artificial intelligence tools such as ChatGPT, CodePilot, and built-in tools within Word are modern tools that are useful in some circumstances. In your degree at UNSW, we're teaching you skills that are needed for your professional life, which will include how to use AI tools responsibly plus lots of things that AI tools cannot do for you. AI tools already are (or will soon be) part of professional practice for all of us. However, if we were only teaching you things that AI could do, your degree would be worthless, and you wouldn't have a job in 5 years.

Whether the use of AI tools in an assessment is appropriate will depend on the goals of that assessment. As ever, you should discuss this with your lecturers – there will certainly be assessments where the use of AI tools is encouraged, as well as others where it would interfere with your learning and place you at a disadvantage later. Our goal is to help you learn how to ethically and professionally use the tools available to you. To learn more about the use of AI, see this discussion we have written where we analyse the strengths and weaknesses of generative AI tools and discuss when it is professionally and ethically appropriate to use them.

While AI may might provide useful tools to help with some assessments, UNSW's policy is quite clear that taking the output of generative AI and submitting it as your own work will never be appropriate, just as paying someone else to complete an assessment for you is serious misconduct.

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 for information about key dates, access to services, and lots more information
- Engineering Student Life - Current Student Resources for information about everything from getting to campus to our first year guide
- Student Support and Success for our UNSW team dedicated to helping with university life, visas, wellbeing, and academic performance
- Academic Skills to brush up on some study skills, time management skills, get one-on-one support in developing good learning habits, or join workshops on skills development
- Student Wellbeing, Health and Safety for information on the UNSW health services, mental health support, and lots of other useful wellbeing resources
- Equitable Learning Services for assistance with long term conditions that impact on your studies
- IT Service Centre for everything to do with computing, including installing UNSW licensed software, access to computing systems, on-campus WIFI and off-campus VPNs

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. Most 6 UoC courses will involve approximately 10-12 hours per week of work on your part. If you're not sure what to do in these hours of independent study, the resources on the UNSW Academic Skills pages offer some suggestions including: making summaries of lectures, read/summarise sections from the textbook, attempt workshop problems, reattempting workshop problems with some hints from the solutions, looking for additional problems in the textbook.

Full-time enrolment at university means that it is a *full-time* occupation for you and so you would typically need to devote 35 hours per week to your studies to suceed. Full-time enrolment at university is definitely incompatible with full-time employment. Part-time/casual employment can certainly fit into your study schedule but you will have to carefully balance your study obligations with that work and decide how much time for leisure, family, and sleep you want left after fullfilling your commitments to study and work. Everyone only gets 168 hours per week; overloading yourself with both study commitments and work commitments leads to poor outcomes and dissatisfaction with both, overtiredness, mental health issues, and general poor quality of life.

On-campus class attendance

In 2023, most classes at UNSW are running in a face-to-face mode only. Attendance is expected as is participation in the classes. As an evidence-driven engineer or scientist, you'll be interested to know that education research has shown students learn more effectively when they come to class, and less effectively from lecture catch-up recordings. If you have to miss a class due to illness, for example, we expect you to catch up in your time, and within the coming couple of days.

For most courses that are running in an "in person" mode:

- Lectures are normally recorded to provide an opportunity to review material after the lecture; lecture recordings are not a substitute for attending and engaging with the live class.
- Workshops/tutorials are not normally recorded as the activities that are run within those sessions normally cannot be captured by a recording. These activities may also include assessable activities in some or all weeks of the term.
- Laboratories are not recorded and require in-person attendance. Missing laboratory sessions may require you to do a make-up session later in the term; if you miss too many laboratory sessions, it may be necessary to seek a Permitted Withdrawal from the course and reattempt it next year, or end up with an Unsatisfactory Fail for the course.
- Assessments will often require in-person attendance in a timetabled class or a scheduled examination.

This course outline will have further details in the Course Schedule and Assessment sections.

Class numbers are capped in each class to ensure appropriate facilities are available, to maintain student:staff ratios, and to help maintain adequate ventilation in the spaces. Only students enrolled in each specific 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 classes.

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 have COVID-19 or have been advised to self-isolate by NSW health or government authorities.

Asking Questions

Asking questions is an important part of learning. Learning to ask good questions and building the confidence to do so in front of others is an important professional skill that you need to develop. The best place to ask questions is during the scheduled classes for this course, with the obvious exception being questions that are private in nature such as special consideration or equitable learning plans. Between classes, you might also think of questions — some of those you might save up for the next class (write them down!), and some of them you might ask in a Q&A channel on Teams or a Q&A forum on Moodle. Please understand that staff won't be able to answer questions on Teams/Moodle immediately but will endeavour to do so during their regular working hours (i.e. probably not at midnight!) and when they are next working on this particular course (i.e. it might be a day or two). Please respect that staff are juggling multiple work responsibilities (teaching more than one course, supervising research students, doing experiments, writing grants, …) and also need to have balance between work and the rest of their life.

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

Pilot Hall with experiment rigs // UNSW Chemical Engineering

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	✔