School of Chemical Engineering

UNSW Engineering

CEIC3006

Process Dynamics and Control

Term 2, 2023

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Jie Bao	j.bao@unsw.edu.au	Email, MS Teams, by appointment	Room 301, SEB	93856755

Lecturers

Name	Email	Availability	Location	Phone
Jie Bao	j.bao@unsw.edu.au	Email, MS Teams, by appointment	Room 301, SEB	93856755

Demonstrators

Name	Email	Availability	Location	Phone
Jun Wen Tang	jun.tang@student.unsw.edu.au	Email, MS Teams, Workshop sessions	Room 304, SEB	MS Teams
Shuangyu Han	shuangyu.han@student.unsw.edu.au	Email, MS Teams, Workshop sessions	Room 304, SEB	MS Teams

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

Process dynamics and control is concerned with automatic operation of chemical processes. It is an effective approach to improve process safety, product quality and the cost-effectiveness of process operation. The automatic control system is an indispensable part of every modern chemical plant.

In the first part of the course, you will learn to develop models and analyse the dynamic behaviour of a range of processes. Using the language of Laplace transforms, you will express the dynamics of linear control systems in terms of transfer functions, a form of models that facilitate the analysis of process dynamics and control design.

The second part is concerned with control system design incorporating both qualitative (building on earlier studies on P&IDs) and quantitative (i.e., control algorithm design) approaches. You will learn stability analysis and control system design approaches. You will also learn the basics of digital control systems, including data acquisition, signal filtering, discrete-time modelling and digital controller design. Some widely used advanced control strategies will also be introduced. By making extensive use of the specialist software, students will be able to quickly apply the concepts of process control and design control strategies.

Course Aims

The objective of this course is to provide you with the fundamental background to process control theory and a working knowledge of automatic control systems for the control of chemical processes. You will develop proficiency in the analysis of process dynamics and control system design.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Develop linear dynamical process models in ordinary differential equations (ODEs) /transfer functions (including discrete time versions) from first principles and experimental data	PE1.1, PE1.2, PE1.3, PE2.2
2. Analyse features of process dynamics (e.g., stability, inverse response, oscillations, damping) from process transfer functions (including discrete time transfer functions)	PE1.2, PE1.1, PE1.3, PE1.4
3. Design qualitative control schemes for common process units and piping and instrumentation diagrams (P &ID), including plantwide control considerations	PE1.5, PE2.3, PE2.2
4. Design control algorithms based on process models (using transfer functions) for both continuous time and discrete time cases, including PID control tuning, Internal Model Control Direct Synthesis, feedforward control and cascade control.	PE1.1, PE2.1, PE3.3, PE2.2, PE1.4

This subject will provide you with the basic knowledge of process control techniques applied in process industries: techniques for modelling and analysis of process dynamics, transfer functions, control design methods based on process models, the concept of discrete-time systems. It also helps develop:

- the skills required to communicate with experts and specialists in other disciplines (in particular instrumentation/electrical/electronic/control engineers);
- the vision of process systems and appreciation of the complexity of a plantwide process system.

CEIC3006 helps to develop your capacity for analytical and critical thinking. You will learn an integrated approach to problem-solving from both process (such as process improvement) and operation (such as better control) points of view. The ideas behind the process control theory covered in this subject (such as model-based optimization, operation and control and feedback mechanism) can be applied in engineering innovation. It helps to develop:

- the ability to think critically and rigorously;
- the ability to formulate engineering problems;
- the ability to conceptualize the observations and findings;
- the ability to apply systematic approaches to solve engineering problems.

Teaching Strategies

To encourage a deep approach to learning, emphasis is placed on the understanding of the control theory via problem solving. This subject has two main components: lectures and workshops (problem solving) sessions. Whilst the key theory and concepts will be taught during lectures, you will gain a deeper understanding of the theory will be achieved via solving workshop questions and assignment problems. Each week there are lectures and workshops (for demonstration and problem solving) per week.

The beauty of process control theories is that they are universal and can be used to analyse and control a class of processes. This implies that this subject involves a significant level of mathematics and many abstract concepts. This subject is about quantitative and rigorous control analysis and development, based on mathematical derivations. Therefore, the philosophy behind mathematical theory will be emphasized in lectures, such as, what motivates the approach, how it works and why. The relevance of this subject to chemical engineering practice will also be highlighted.

Experience shows that the absence of one or two lectures could create significant difficulties in understanding subsequent lectures – so make sure to attend all classes. Random attendance check may be conducted during classes. Class discussion and student participation are greatly encouraged. You can ask the lecturer questions at any time during the class.

Practice is the best way to enhance your understanding of the concepts taught in this course. Please make sure that you actively participate the workshops and attempt assignments independently as this will provide you with an opportunity to assess your skills and improve your understanding of the content.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Assignments	30%	Week 3, Week 8	1, 2, 3, 4
2. Quizzes	20%	Week 5, Week 9	1, 2, 3, 4
3. Final Examination	50%	Exam Period	1, 2, 3, 4

Assessment 1: Assignments

Start date: Week 2, Week 7
Due date: Week 3, Week 8

Individual work. Assignment problems are designed to ensure that lecture material is comprehended through personal practice and hence achievement of indicated learning outcomes.

This is not a Turnitin assignment

Assessment 2: Quizzes

Due date: Week 5, Week 9

Closed book quizzes (2). The quizzes provide opportunities to determine how well knowledge and skills are gained so far and find possible issues in teaching and learning.

Assessment 3: Final Examination

Due date: Exam Period

The course learning outcomes include a significant level of technical learning which can be effectively assessed in an exam environment as exams have high reliability. 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	Introduction to process control; Control system instrumentation; Qualitative control schemes; Process dynamics (Chapters 1 + additional materials)
	Workshop	Demonstrations and solving questions (questions are available on Moodle).
Week 2: 5 June - 9 June	Lecture	Mathematical modelling; Laplace transform (Chapters 2& 3); Transfer functions; Linearization (Chapter 4); Dynamic behaviour of first order systems;
	Workshop	Demonstrations and solving questions (questions are available on Moodle).
Week 3: 12 June - 16 June	Lecture	Time Delay and Integrating processes (Chapter 5); Dynamic behaviours of second order; Dynamic response of more complicated processes (Chapters 5& 6); Empirical modelling
	Workshop	Demonstrations and solving questions (questions are available on Moodle).
	Assessment	Assignment 1 due
Week 4: 19 June - 23 June	Lecture	Basic feedback control system analysis (Chapters 7& 8); Dynamic behaviour of closed loop systems (Chapter 11);
	Workshop	Demonstrations and solving questions (questions are available on Moodle).
Week 5: 26 June - 30 June	Lecture	Stability of closed-loop systems; Dead-time Approximation (Chapters 11& 12); Controller design, tuning, and troubleshooting (Chapter 12)
	Workshop	Demonstrations and solving questions (questions are available on Moodle).
	Assessment	Quiz 1

Week 6: 3 July - 7 July	Lecture	Flexibility week
Week 7: 10 July - 14 July	Workshop	Demonstrations and solving questions (questions are available on Moodle).
	Lecture	Feedforward control design; Cascade control (Chapters 15& 16); Introduction to digital control; Digital control & sampling; Filtering and signal processing; (Chapter 17)
Week 8: 17 July - 21 July	Lecture	Design & implementation of digital PID controllers; Discrete-time models (Chapter 17); Dynamic response of discrete-time systems (Chapter 17, with extensions)
	Workshop	Demonstrations and solving questions (questions are available on Moodle).
	Assessment	Assignment 2 due
Week 9: 24 July - 28 July	Lecture	Control design based on discrete-time system models (Chapter 17, with extensions)
	Workshop	Demonstrations and solving questions (questions are available on Moodle).
	Assessment	Quiz 2
Week 10: 31 July - 4 August	Lecture	Batch process control & PLC (Chapter 22); Plant-wide control (Appendices uploaded on Moodle + additional materials); Revision
	Workshop	Demonstrations and solving questions (questions are available on Moodle).

Resources

Prescribed Resources

Textbook

D. E Seborg, T. F. Edgar, D. A. Mellichamp and Francis J. Doyle III, Process Dynamics and Control, (3rd or 4th Edition) John Wiley & Sons. (ISBN-13: 978-0470128671)

The textbook is available from the University bookshop and the UNSW library. The bookshop is still operating online for delivery and collection.

Print: https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781119285915

Digital: https://unswbookshop.vitalsource.com/products/-v9781119285953

Online resources

Videos, lecture slides and suggested readings, workshop materials (questions and solutions), plus links to other online resources will be provided on the course page. These will be progressively released as the semester progresses.

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).

You can download MATLAB through: https://www.it.unsw.edu.au/students/software/matlab.html

You should sign up a mathworks account with your UNSW email. @student.unsw.edu.au

https://au.mathworks.com/academia/tah-support-program/eligibility.html

Once you have a mathworks account you can access the MATLAB Onramp training via the self-paced courses in a browser. https://matlabacademy.mathworks.com/

And for the Simulink training you will need to access this via the Desktop/Laptop version of your downloaded MATLAB. Once in the program you can click on ‘Simulink’ and ‘Simulink Onramp'.

MATLAB and Simulink are also available online through https://www.myaccess.unsw.edu.au/.

Recommended Resources

Luyben, W. L. *Process Modeling, Simulation and Control for Chemical Engineers* (2nd Edition) McGraw Hill International (ISBN 0-07-100793-8).

Course Evaluation and Development

Course delivery is influenced by student feedback in order to ensure continuous improvement. This is done through the administration of UNSW’s Course and Teaching Evaluation questionnaires during the course as well as direct feedback to the lecturer/tutors in any time. Several improvements of this course, for example, greater emphasis on control applications and a better assessment scheme have been made based on previous student feedback. Your constructive suggestions would help in securing a better teaching and learning experience for future students.

Laboratory Workshop Information

No physical laboratory work.

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

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	