CEIC3006

Process Dynamics and Control

Term Two // 2021

School of Chemical Engineering // UNSW Engineering

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Jie Bao	j.bao@unsw.edu.au	Email, by appointment	Room 301, SEB	02 93856755

Lecturers

Name	Email	Availability	Location	Phone
Jie Bao	j.bao@unsw.edu.au	Email, MS Teams, by appointment	Room 301, SEB	02 93856755

Tutors

Name	Email	Availability	Location	Phone
Adam Larkin	adam.larkin@unsw.edu.au	Email, by appointment	Room 304, SEB	
Jie Bao	j.bao@unsw.edu.au	Email, MS Teams, Tutorial sessions	Room 301, SEB	02-93856755

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

Credit Points 6

Summary of the Course

Process dynamics and control is concerned with optimal 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. The objective of this course is to provide students with the fundamental background of process control theory and working knowledge of automatic control systems for chemical processes. This course is focused on (1) analysis of process dynamics; (2) control system design.

Textbook: D. E. Seborg, T. F. Edgar, D. A. Mellichamp, Process Dynamics and Control 2nd Edition, John Wiley & Sons, 2004.

Course Aims

The objective of this course is to provide students with the fundamental background of process control theory and working knowledge of automatic control systems for chemical processes. This course is focused on (1) analysis of process dynamics; (2) control system design.

In the first part of the course, we will learn to develop models and analyse the dynamic behaviour of a range of processes. Using the language of Laplace transforms, we will express the dynamics of linear control systems in terms of transfer functions, a method which allows the categorization of a large range of dynamic responses commonly encountered in practice. The second part is concerned control system design. We will learn stability analysis and control system design approaches. Finally, we will 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 MATLAB/Simulink software environment, the student will be able to quickly apply the concepts of process control and design control strategies.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Ability to 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. Ability to 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. Ability to 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. Ability to design control algorithms based on process models	PE1.1, PE2.1, PE3.3, PE2.2,

Learning Outcome	EA Stage 1 Competencies
(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.	PE1.4

This subject will provide the students 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 students' capacity for analytical and critical thinking. Students 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

In order 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 tutorial sessions. Whilst the key theory and concepts will be taught during lectures, deeper understanding of the theory will be achieved via solving tutorial and assignment problems.

CEIC3006 consists of five hour lectures and one hour tutorial 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.

The materials covered in this subject are organized systematically. Every new concept is based on the materials you have previously learned. Please make sure that you attend all the lectures. Past experience shows that the absence of one or two lectures could create significant difficulties in understanding subsequent lectures. Class discussion and student participation are encouraged. You can ask the Lecturer questions at any time during the class online.

Practice is the best way to enhance your understanding of the concepts taught in this course. Please make sure that you actively participate the tutorial sessions and attempt assignments independently.

Assessment

Assessment Tasks

Assessment task	Weight	Due Date	Student Learning Outcomes Assessed
Assignments	30%	Week 3; Week8	1, 2, 3, 4
Quizzes	30%	Week 5; Week 9	1, 2, 3, 4
Final Examination	40%	TBD (Refer to myUNSW)	1, 2, 3, 4

Assessment Details

Assessment 1: Assignments

Start date: Week 2; Week 7

Details:

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

Turnitin setting: This is not a Turnitin assignment

Assessment 2: Quizzes

Start date: Week 5; Week 9

Details:

Two quizzes, scheduled in Week 5 and Week 9. 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

Start date: TBD (Refer to myUNSW)

Details:

One Final Examination, scheduled by UNSW. The course learning outcomes include a significant level of technical learning which can be effectively assessed in an exam environment and because exams have high reliability.

Attendance Requirements

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

Course Schedule

View class timetable

Timetable

Date	Type	Content
O Week: 25 May - 28 May		
Week 1: 31 May - 4 June	Lecture	Introduction to process control; Control system instrumentation; Qualitative control schemes; Process dynamics (Chapters 1 + additional materials)
	Tutorial	
Week 2: 7 June - 11 June	Lecture	Mathematical modelling; Laplace transform (Chapters 2& 3); Transfer functions; Linearization (Chapter 4); Dynamic behaviour of first order systems;
	Tutorial	
Week 3: 14 June - 18 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
	Assessment	Assignment 1 due
	Tutorial	
Week 4: 21 June - 25 June	Lecture	Basic feedback control system analysis (Chapters 7& 8); Dynamic behaviour of closed loop systems (Chapter 11);
	Tutorial	
Week 5: 28 June - 2 July	Lecture	Stability of closed-loop systems; Dead-time Approximation (Chapters 11& 12); Controller design, tuning, and troubleshooting (Chapter 12)
	Assessment	Quiz 1
	Tutorial	
Week 6: 5 July - 9 July	Lecture	Flexibility week
Week 7: 12 July - 16 July	Lecture	Feedforward control design; Cascade control (Chapters 15& 16); Introduction to digital control; Digital control & sampling; Filtering and signal processing; (Chapter 17)
	Tutorial	
Week 8: 19 July - 23 July	Lecture	Design & implementation of digital PID controllers; Discrete-time models (Chapter 17); Dynamic response of discrete-time systems (Chapter 17, with extensions)

	Assessment	Assignment 2 due.
	Tutorial	
Week 9: 26 July - 30 July	Lecture	Control design based on discrete-time system models (Chapter 17, with extensions)
	Assessment	Quiz 2
	Tutorial	
Week 10: 2 August - 6 August	Lecture	Batch process control & PLC (Chapter 22); Plant-wide control (Appendices uploaded on Moodle + additional materials); Revision
	Tutorial	

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, tutorial exercises 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

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 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 10% 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.

Please note that students will **not** be required to provide **any** documentary evidence to support absences from any classes missed **because of COVID-19 public health measures such as isolation**. UNSW will **not** be insisting on medical certificates from anyone deemed to be a positive case, or when they have recovered. Such certificates are difficult to obtain and put an unnecessary strain on students and medical staff.

Applications for special consideration **will** be required for assessment and participation absences – but no documentary evidence **for COVID 19 illness or isolation** will be required.

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 a list of hotspots 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

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	