School of Engineering

ENGG4440: Nonlinear Control and Estimation
Callaghan
Semester 2 - 2023

OVERVIEW

Course Description
This course is intended to introduce students to a range of techniques for control and estimation for nonlinear systems. Specifically, the course will cover some basic concepts of nonlinear systems and control theory; nonlinear model predictive control; and modern estimation and observer techniques for nonlinear systems. The course includes laboratory and simulation experiments to apply the concepts taught.

Assumed Knowledge
MATH2310 Calculus of Science and Engineering and either:
ENGG3440 Linear Control and Estimation or
AERO3600 Embedded Control Systems.

Contact Hours
Callaghan
Laboratory
Face to Face On Campus
2 hour(s) per Week for Full Term

Lecture
Face to Face On Campus
4 hour(s) per Week for Full Term

Unit Weighting
10

Workload
Students are required to spend on average 120-140 hours of effort (contact and non-contact) including assessments per 10 unit course.

CONTACTS

Course Coordinator	**Callaghan** Prof Zhiyong Chen Zhiyong.Chen@newcastle.edu.au (02) 492 16352 Consultation: Thursday 12:00-14:00
Teaching Staff	Other teaching staff will be advised on the course Canvas site.
School Office	**School of Engineering** EAG03 EA Building Callaghan +61 2 4921 5798 9.00am-1.00pm and 2.00pm-5.00pm (Monday to Friday)

SYLLABUS

Course Content

This course will cover:
- Introduction/review of digital control
- Nonlinear systems, basic definitions and comparisons with linear systems
- Linearisation and control of linear systems
- Antiwindup design
- Simplified forms of Feedback linearization
- Output regulation
- Nonlinear Model Predictive Control
- Luenberger observers
- High gain observers
- Nonlinear Kalman Filtering
- Overview of particle filter methods

Course Learning Outcomes

On successful completion of this course, students will be able to:
1. Design and implement simple feedback control systems for regulating a nonlinear system

2. Design and implement systems to improve nonlinear system performance in the presence of constraints

3. Design and implement observers and estimators for nonlinear systems

4. Configure, implement and test Nonlinear Model Predictive Controllers for simple nonlinear systems

Course Materials

Lecture Materials:
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Recommended Text:
  - K. J. Astrom and R. M. Murray, Feedback Systems: An Introduction for Scientists and Engineers, Princeton University Press, 2008
    J. P. Hespanha, Linear Systems Theory, Princeton University Press, 2009.
    H. K. Khalil, Nonlinear Systems (3 rd Edition), Prentice Hall, 2001.

ASSESSMENTS

This course has 2 assessments. Each assessment is described in more detail in the sections below.

	Assessment Name	Due Date	Involvement	Weighting	Learning Outcomes
1	Assignments	To be advised on Canvas	Individual	70%	1, 2, 3, 4
2	Laboratory Assignments	To be advised on Canvas	Individual	30%	1, 2, 3, 4

Late Submissions   The mark for an assessment item submitted after the designated time on the due date, without an approved extension of time, will be reduced by 10% of the possible maximum mark for that assessment item for each day or part day that the assessment item is late. Note: this applies equally to week and weekend days.

Assessment 1 - Assignments

Assessment Type   Written Assignment
Purpose   Course Project (simulation and experimental verification)
Description   Written assignments involve analysis of a problem and synthesis of a solution using the tools and techniques presented in lectures and laboratories.
Weighting   70%
Due Date   To be advised on Canvas
Submission Method   Online
Assessment Criteria   See the project notes
Return Method   Online
Feedback Provided   In Class

Assessment 2 - Laboratory Assignments

Assessment Type   Tutorial / Laboratory Exercises
Description   Laboratory assignments are simulation-based exercises that reinforce the lecture material from the 1-2 weeks prior to the assignment.
Weighting   30%
Due Date   To be advised on Canvas
Submission Method   Online
Assessment Criteria   See the lab notes
Return Method   Online
Feedback Provided   In Class

ADDITIONAL INFORMATION

Grading Scheme

This course is graded as follows:

Range of Marks	Grade	Description
85-100	High Distinction (HD)	Outstanding standard indicating comprehensive knowledge and understanding of the relevant materials; demonstration of an outstanding level of academic achievement; mastery of skills*; and achievement of all assessment objectives.
75-84	Distinction (D)	Excellent standard indicating a very high level of knowledge and understanding of the relevant materials; demonstration of a very high level of academic ability; sound development of skills*; and achievement of all assessment objectives.
65-74	Credit (C)	Good standard indicating a high level of knowledge and understanding of the relevant materials; demonstration of a high level of academic achievement; reasonable development of skills*; and achievement of all learning outcomes.
50-64	Pass (P)	Satisfactory standard indicating an adequate knowledge and understanding of the relevant materials; demonstration of an adequate level of academic achievement; satisfactory development of skills*; and achievement of all learning outcomes.
0-49	Fail (FF)	Failure to satisfactorily achieve learning outcomes. If all compulsory course components are not completed the mark will be zero. A fail grade may also be awarded following disciplinary action.

*Skills are those identified for the purposes of assessment task(s).

Communication Methods

Communication methods used in this course include:

Course Evaluation

Each year feedback is sought from students and other stakeholders about the courses offered in the University for the purposes of identifying areas of excellence and potential improvement.

Oral Interviews (Vivas)

As part of the evaluation process of any assessment item in this course an oral examination (viva) may be conducted. The purpose of the oral examination is to verify the authorship of the material submitted in response to the assessment task. The oral examination will be conducted in accordance with the principles set out in the Oral Examination (viva) Procedure. In cases where the oral examination reveals the assessment item may not be the student's own work the case will be dealt with under the Student Conduct Rule.

Academic Misconduct

All students are required to meet the academic integrity standards of the University. These standards reinforce the importance of integrity and honesty in an academic environment. Academic Integrity policies apply to all students of the University in all modes of study and in all locations. For the Student Academic Integrity Policy, refer to https://policies.newcastle.edu.au/document/view-current.php?id=35.

Adverse Circumstances	The University acknowledges the right of students to seek consideration for the impact of allowable adverse circumstances that may affect their performance in assessment item(s). Applications for special consideration due to adverse circumstances will be made using the online Adverse Circumstances system where:

1.   the assessment item is a major assessment item; or
2.   the assessment item is a minor assessment item and the Course Co-ordinator has specified in the Course Outline that students may apply the online Adverse Circumstances system;
3.   you are requesting a change of placement; or
4.   the course has a compulsory attendance requirement.

Before applying you must refer to the Adverse Circumstance Affecting Assessment Items Procedure available at:
https://policies.newcastle.edu.au/document/view-current.php?id=236

Important Policy Information	The Help button in the Canvas Navigation menu contains helpful information for using the Learning Management System. Students should familiarise themselves with the policies and procedures at https://www.newcastle.edu.au/current-students/no-room-for/policies-and-procedures that support a safe and respectful environment at the University.

Graduate Profile Statements – ENGG4440 – Semester 2 2023

This course builds students' capacity in the following University of Newcastle Bachelor of Engineering Graduate Profile Statements (based on 2011 Engineers Australia revised Stage 1 Competency Standards for Professional Engineers):

UON Att.	University of Newcastle Bachelor of Engineering Graduate Profile Statements/ Engineers Australia Stage 1 competency statements	Taught	Practised	Assessed	Skill Level (1-4)
	Professional Attributes				
11	3.1. Ethical conduct and professional accountability				
12	3.2. Effective oral and written communication in professional and lay domains.			x	2
13	3.3. Creative, innovative and pro-active demeanour.				
14	3.4. Professional use and management of information.				
15	3.5. Orderly management of self, and professional conduct.				
16	3.6. Effective team membership and team leadership.				
	Engineering Ability				
7	2.1. Application of established engineering methods to complex engineering problem solving.	x	x	x	4
8	2.2. Fluent application of engineering techniques, tools and resources.	x	x	x	4
9	2.3. Application of systematic engineering synthesis and design processes.	x	x	x	4
10	2.4. Application of systematic approaches to the conduct and management of engineering projects.				
	Knowledge Base				
1	1.1. Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.	x	x	x	4
2	1.2. Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.	x	x	x	4
3	1.3. In-depth understanding of specialist bodies of knowledge within the engineering discipline.	x	x	x	4
4	1.4. Discernment of knowledge development and research directions within the engineering discipline.	x	x	x	4
5	1.5. Knowledge of contextual factors impacting the engineering discipline.				
6	1.6. Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.				