



UNSW
AUSTRALIA

Course Outline

Semester 1 2017

Never Stand Still

Engineering

Mechanical and Manufacturing Engineering

MMAN3200

LINEAR SYSTEMS AND CONTROL

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1. Staff Contact Details

Contact details and consultation times for course convenor

Name: Dr Zoran Vulovic
Office: Room 311D, Building J17
Tel: (02) 9385 6261
Fax: (02) 9663 1222
Email: z.vulovic@unsw.edu.au

Consultations will take place in Dr Vulovic's office. The consultation time slots will be announced later.

Consultations are possible outside the set times, but a prior appointment would be preferred. Email, telephone and Moodle discussions can also be used for solving more general issues.

Contact details and consultation times for additional lecturers

Name: Dr Ngai M. Kwok
Office: Room 510C, Building J17
Tel: (02) 9385 6091
Fax: (02) 9663 1222
Email: nmkwok@unsw.edu.au

Consultation with Dr Kwok concerning this course will be by appointment. Direct consultation is preferred; email may also be used.

2. Course details

Credit points

This is a 6 unit-of-credit (UoC) course, and involves 6 hours per week (h/w) of face-to-face contact.

The UNSW website states "The normal workload expectations of a student are approximately 25 hours per semester for each UoC, including class contact hours, other learning activities, preparation and time spent on all assessable work. Thus, for a full-time enrolled student, the normal workload, averaged across the 16 weeks of teaching, study and examination periods, is about 37.5 hours per week."

This means that you should aim to spend about 9 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

Contact Hours

| | Day | Time | Location |
|-----------------------------------|-----------------------------|-----------------------------|-----------------------------|
| Lectures | Tuesday | 2pm - 4pm | Ainsworth G03 |
| | Friday | 10am – 11am | Ainsworth G03 |
| | | | |
| Interactive Demonstrations | Friday | 11am – 12noon | Ainsworth G03 |
| | | | |
| Standard Demonstrations | Please check your timetable | Please check your timetable | Please check your timetable |

Summary of the Course

The primary function of Linear Systems and Control is to serve as the first step towards mastering control engineering. The ultimate purpose of control engineering is to approach various systems from the stability point of view, with a special attention given to transient processes. With that in mind, MMAN3200 endeavours to provide students with analytical tools that are easily applied to a wide spectrum of engineering problems.

Some components of this module have other roles. Systems modelling for example, which occupies a major part, helps you acquire knowledge necessary for simulation, analysis or design of numerous systems. It helps you consolidate the knowledge gained so far in courses dealing with Mechanics, Design, Fluids, Thermodynamics and Solids. Linearisation provides a useful tool for simplification of complex systems while at the same time points out at possible problems that could arise from oversimplification. In the later part of the course you will learn state space analysis, a powerful and general technique for studying dynamic systems.

Aims of the Course

The aim of MMAN3200, as an important part of control engineering, is to offer the knowledge of methodologies specifically designed for Laplace domain, which in turn enables easier and more efficient analysis of complex engineering systems. Numerous types of systems from real engineering applications will be used throughout the course to give you the practical aspects of the methods covered.

Student learning outcomes

This course is designed to address the below learning outcomes and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

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

| Learning Outcome | | EA Stage 1 Competencies |
|------------------|--------------------------------------------------------------------------------------|-------------------------|
| 1. | Create linear mathematical models of a variety of systems; | PE1.2, PE2.1, PE2.2 |
| 2. | Analyse linear time invariant continuous systems in both time- and complex- domains; | PE1.2, PE2.1, PE2.2 |

3. Teaching strategies

Lectures in the course are designed to provide the basic theory behind the concepts taught. For most classes lecture notes slides will be available on-line and beforehand. Students are encouraged to ask questions during the classes.

It is very important for third year student to be able to use multiple sources. For that reason, apart from the textbook, several recommended texts are listed. You are welcome to consult your lecturers on this.

Classroom demonstrations are designed for practical applications of the theoretical concepts introduced in lectures. A comprehensive set of tutorial problems will be provided beforehand. Two types of demonstrations will be organised, standard and interactive.

In “**standard**” demonstrations, it is the demonstrator who sets the pace and works on select examples. The times and locations of those classes are found in your timetables.

In “**interactive**” demonstrations, it is students who work individually or in small groups and therefore it is up to them to select the examples and dictate the pace. The demonstrators and the lecturer will be at hand to provide guidance.

4. Course schedule

| Date | Topic | Location | Lecture Content | Demonstration/Lab Content | Suggested Readings |
|--------|---------------------------------------------------------|---------------|------------------------------------------------------------------------------------------------------------------|---------------------------|--------------------|
| Week 1 | Classification of engineering systems Linearisation. | Ainsworth G03 | Linearisation of non-linear equations and operating curves. | N/A | Class readings |
| Week 2 | Laplace transform | Ainsworth G03 | Laplace transform and inverse Laplace transform. Initial and final value theorems. Shift theorems. Use of tables | Tutorial Sets I and II | Class readings |

| | | | | | |
|--------|-------------------------------------------------------------------------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|----------------|
| Week 3 | Mathematical models. <u>Quiz.</u> | Ainsworth G03 | Mechanical, electrical, thermal and fluid components. Input-output relations. Differential equations describing simple systems. Mathematical models of complex systems by combining simultaneous equations associated with the physical model. | Tutorial Sets II and III | Class readings |
| Week 4 | Use of block diagrams. Time response of first and second order systems. | Ainsworth G03 | Reduction of block diagrams. Simple rules for manipulations. Impulse, step, ramp and sinusoidal inputs. Transient process and the steady state. | Tutorial Sets IV and V | Class readings |
| Week 5 | Performance criteria. Analysis in the s-plane. The pole-zero pattern. | Ainsworth G03 | The time constant, percentage overshoot, rise time, settling time. The pole position and its relation to stability and other performance characteristics. | Tutorial Set VI | Class readings |
| Week 6 | Concept of control. <u>Mid-semester test.</u> | Ainsworth G03 | Open and closed loop systems. Negative feedback loops. | Past Exams (tutorial Set VII) | Class readings |
| Week 7 | Steady state errors. Root locus. | Ainsworth G03 | Rules for creating root locus. | Tutorial Set VIII | Class readings |

| | | | | | |
|---------|------------------------------------------------|---------------|---------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|----------------|
| Week 8 | Frequency based control system design – Part A | Ainsworth G03 | Bode diagrams; resonant frequency, resonant peak value, gain/phase margin, bandwidth. | Bode diagrams; quadratic factors. | Class readings |
| Week 9 | Frequency based control system design – Part B | Ainsworth G03 | Bode diagrams; basic factors, gain, integral/derivative factors, first-order factors. | Bode diagrams; quadratic factors. | Class readings |
| Week 10 | Frequency based control system design – Part C | Ainsworth G03 | Bode diagrams; resonant frequency, resonant peak value, gain/phase margin, bandwidth. | Bode diagrams; quadratic factors. | Class readings |
| Week 11 | State space design – Part A | Ainsworth G03 | State-space representation; transfer function, controllable canonical form, solution of state space equation. | State-space analysis, eigenvalues, transition matrix. | Class readings |
| Week 12 | State space design – Part B | Ainsworth G03 | Controllability, Pole placement design, substitution method, Ackermann's method. | Pole placement design; transform method, Matlab simulation | Class readings |
| Week 13 | Contingency time. Revision | Ainsworth G03 | N/A | N/A | N/A |

5. Assessment

Assessment Overview

| Assessment | Length | Weight | Learning outcomes assessed | Assessment criteria | Due date and submission requirements | Deadline for absolute fail | Marks returned |
|------------|-----------------------------------------|--------------------------------|----------------------------|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|--------------------------------|-------------------------------|
| Tests (2) | 50 minutes and 100 minutes respectively | 35% (10% and 25% respectively) | 1 and 2 | Topics assessed include the lectures in Weeks 1-3 and 1-6 respectively | Thursday 16 th March 6:00pm – 7:15pm; Friday 15 th April lecture time | N/A | Two weeks after submission |
| Lab report | 8 pages | 15% | 1 and 2 | Lecture material from Weeks 1-8. | Sunday 14 th May 23:50 via Moodle | Wednesday 17 th May | Two weeks after submission |
| Assignment | 5 pages | 10% | 1 and 2 | Lecture material from Weeks 9-10. | Friday 26 th May 2016, 23:50pm via Moodle | Sunday 28 th May | Two weeks after submission |
| Final exam | 3 hours | 40% | 1 and 2 | All course content from weeks 2-12 inclusive. | Exam period, date TBC | N/A | Upon release of final results |

Assignments

Presentation

All submissions should have a standard School cover sheet which is available from this subject's Moodle page.

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

Submission

Late submissions will be penalised 5 marks per calendar day (including weekends). An extension may only be granted in exceptional circumstances. Where an assessment task is worth less than 20% of the total course mark and you have a compelling reason for being unable to submit your work on time, you must seek approval for an extension from the course convenor **before the due date**. Special consideration for assessment tasks of 20% or greater must be processed through student.unsw.edu.au/special-consideration.

It is always worth submitting late assessment tasks when possible. Completion of the work, even late, may be taken into account in cases of special consideration.

Marking

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.

Examinations

You must be available for all tests and examinations. Final examinations for each course are held during the University examination periods, which are June for Semester 1 and November for Semester 2.

Provisional Examination timetables are generally published on myUNSW in May for Semester 1 and September for Semester 2

For further information on exams, please see the [Exams](#) section on the intranet.

Calculators

You will need to provide your own calculator, of a make and model approved by UNSW, for the examinations. The list of approved calculators is shown at student.unsw.edu.au/exam-approved-calculators-and-computers

It is your responsibility to ensure that your calculator is of an approved make and model, and to obtain an “Approved” sticker for it from the School Office or the Engineering Student Centre prior to the examination. Calculators not bearing an “Approved” sticker will not be allowed into the examination room.

Special Consideration and Supplementary Assessment

For details of applying for special consideration and conditions for the award of supplementary assessment, see the School [intranet](#), and the information on UNSW’s [Special Consideration page](#).

6. Expected Resources for students

Textbook: Ogata, K. "Modern Control Engineering" (Copies are available in the UNSW library.)

Recommended texts: Palm, W. J. "Modelling, Analysis, and Control of Dynamic Systems"
J. Wilkie, M. Johnson and R. Katebi, "Control Engineering - an introductory course," Palgrave.
N. S. Nise, "Control Systems Engineering," Wiley.
F. Powell and E. Naeini, "Feedback Control of Dynamic Systems," Addison Wesley.
(Most of these books are available in the library)

Lecture notes: Lecture notes and tutorials are going to be available on Moodle before the class.

Other Resources

Although most of the material taught in the course is covered in the textbook, some deviations are inevitable. If you wish to explore any of the lecture topics in more depth, then other resources are available and assistance may be obtained from the UNSW Library.

One starting point for assistance is: <https://www.library.unsw.edu.au/>

7. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience process, previously the Course and Teaching Evaluation and Improvement (CATEI) process, informal discussion in the final class for the course, and the School's Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

In this course, a recent improvement resulting from student feedback includes the hands-on experiment integrated with practical application of the theoretical knowledge. Apart from this, the value of the mid-semester test is reduced by 5 marks and the value of the final exam is increased by the same amount.

8. Academic honesty and plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism: student.unsw.edu.au/plagiarism The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

If plagiarism is found in your work when you are in first year, your lecturer will offer you assistance to improve your academic skills. They may ask you to look at some online resources, attend the Learning Centre, or sometimes resubmit your work with the problem fixed. However more serious instances in first year, such as stealing another student's work or paying someone to do your work, may be investigated under the Student Misconduct Procedures.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis) even suspension from the university. The Student Misconduct Procedures are available here: www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Further information on School policy and procedures in the event of plagiarism is available on the [intranet](#).

9. Administrative Matters

All students are expected to read and be familiar with School guidelines and policies, available on the intranet. In particular, students should be familiar with the following:

- [Attendance, Participation and Class Etiquette](#)
- [UNSW Email Address](#)
- [Computing Facilities](#)
- [Assessment Matters](#) (including guidelines for assignments, exams and special consideration)
- [Academic Honesty and Plagiarism](#)
- [Student Equity and Disabilities Unit](#)
- [Health and Safety](#)
- [Student Support Services](#)

*Zoran Vulovic
6th February 2017*

Appendix A: Engineers Australia (EA) Professional Engineer Competency Standards

| | Program Intended Learning Outcomes |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| PE1: Knowledge and Skill Base | PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals |
| | PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing |
| | PE1.3 In-depth understanding of specialist bodies of knowledge |
| | PE1.4 Discernment of knowledge development and research directions |
| | PE1.5 Knowledge of engineering design practice |
| | PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice |
| PE2: Engineering Application Ability | PE2.1 Application of established engineering methods to complex 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 |
| PE3: Professional and Personal Attributes | PE3.1 Ethical conduct and professional accountability |
| | PE3.2 Effective oral and written communication (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 |