UNSW AUSTRALIA

Course Outline

Semester 1, 2015

Never Stand Still | Faculty of Engineering | School of Mechanical and Manufacturing Engineering

MMAN3200

Linear Systems and Control

Contents

Course Outline

MMAN3200 Linear Systems and Control

1. COURSE STAFF

Contact details and consultation times for the lecturing staff

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Consultation times with Dr Vulovic will be announced later.

Consultations are possible outside the set times, but a prior appointment with the lecturer is recommended. Face-to-face consultations are the preferred form, while Moodle discussion, phone or email should only be used as a last resort and only for resolving simple or more general issues.

Consultation with Dr Kwok concerning this course will be on Monday–Friday 0930–1630 by appointment. Direct consultation is preferred; email may also be used.

2. COURSE DETAILS

Units of credit

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.”

For a standard 24 UoC in the semester, this means 600 hours, spread over an effective 15 weeks of the semester (thirteen weeks plus stuvac plus one effective exam week), or 40 hours per week, for an average student aiming for a credit grade. Various factors, such as your own ability, your target grade, etc., will influence the time needed in your case.

Some students spend much more than 40 h/w, but you should aim for not less than 40 h/w on coursework for 24 UoC.

This means that you should aim to spend not less than about 10 h/w on this course, i.e. an additional 4 h/w of your own time. This should be spent in making sure that you understand the lecture material, completing the set assignments, further reading about the course material, and revising and learning for the examination.

Timetable

Lecture 1:	Tue 13:00 – 15:00	Burrows Theatre
Lecture 2:	Fri 16:00 – 18:00	Burrows Theatre
Class Demonstration 1:	Mon 17:00 – 18:00	as per the timetable (interactive CivEng G8)
	Tue 12:00 – 13:00	as per the timetable (interactive CivEng G1)
Class Demonstration 2:	Thu 11:00 – 12:00	as per the timetable (interactive OMB 151)
	Thu 12:00 – 13:00	as per the timetable (interactive OMB 151)

Parallel teaching

There is no parallel teaching in this course.

How the module relates to other course offerings and overall programs in the discipline

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.

The contents of the course also include an introduction to describing the systems and signals in the Fourier (Frequency) Domain. These concepts are necessary for the understanding of relevant engineering areas in such as signal processing, noise

filtering and many more that involve describing systems and signals in the frequency domain.

Expected student learning outcomes

By the end of this course it is expected that you will:

- learn how to create linear mathematical models of a variety of systems;
- learn how to analyse linear time invariant continuous systems;
- learn how behaviour of systems can be described in the complex domain;
- understand the relationships between the time and complex domains;
- master the block-diagram technique;
- improve your analytical abilities and understanding of different systems and components.
- learn how to evaluate the stability of the systems using state space;
- be introduced to the area of signal processing.

Graduate attributes

UNSW's graduate attributes are shown at
https://my.unsw.edu.au/student/atoz/GraduateAttributes.html

UNSW aspires to develop graduates who are rigorous scholars, capable of leadership and professional practice in a global community. The university has, thus, articulated the following Graduate Attributes as desired learning outcomes for ALL UNSW students.

UNSW graduates will be

1. Scholars who are:
   - (a) understanding of their discipline in its interdisciplinary context
   - (b) capable of independent and collaborative enquiry ✓
   - (c) rigorous in their analysis, critique, and reflection ✓
   - (d) able to apply their knowledge and skills to solving problems ✓
   - (e) ethical practitioners
   - (f) capable of effective communication ✓
   - (g) information literate ✓
   - (h) digitally literate

2. Leaders who are:
   - (a) enterprising, innovative and creative
   - (b) capable of initiating as well as embracing change
   - (c) collaborative team workers

3. Professionals who are:
   - (a) capable of independent, self-directed practice ✓
   - (b) capable of lifelong learning
   - (c) capable of operating within an agreed Code of Practice

4. Global Citizens who are:
   (a) capable of applying their discipline in local, national and international contexts ✓
   (b) culturally aware and capable of respecting diversity and acting in socially just/responsible ways ✓
   (c) capable of environmental responsibility

   ✓ = Developed in this course

In this course, you will be encouraged to develop graduate attributes 1(b), 1(c), 1(d), 1(f), 1(g), 3(a), 4(a) and 4(b) by undertaking the selected activities and knowledge content. These attributes will be assessed within the prescribed assessment tasks, as shown in the assessment table on Page 6.

You will be supported in developing the above attributes through:
(i) the design of academic programs;
(ii) course planning and documentation;
(iii) learning and teaching strategies; and
(iv) assessment strategies.

3. RATIONALE FOR INCLUSION OF CONTENT AND TEACHING APPROACH

This course is included to give you the understanding as well as the analytical skills related to control theory and its applications.

Effective learning is supported when you are actively engaged in the learning process and by a climate of enquiry, and these are both an integral part of the lectures and demonstrations.

You become more engaged in the learning process if you can see the relevance of your studies to professional, disciplinary and/or personal contexts, and the relevance is shown in the lectures and assignments by way of most examples being drawn from real applications.

Dialogue is encouraged between you, others in the class and the lecturer. Diversity of experiences is acknowledged, as some students in each class have prior industrial experience. Your experiences are drawn on to illustrate various aspects, and this helps to increase motivation and engagement.

It is expected that assignments will be marked and handed back in the week following submission. You will have feedback and discussion while fresh in your mind to improve the learning experience.

4. TEACHING STRATEGIES

Lectures in the course are designed to provide the basic theory behind the concepts taught. In addition, a number of worked examples will be presented as well, in order

to illustrate the significance of the theory. For most classes lecture notes will be available on-line and beforehand. Students are encouraged to ask questions during the classes.

Demonstrations are designed to provide you with the practical aspect of the analytical concept presented in lectures. Demonstration example sets, which will form the backbone for all tutorial classes, will be provided at the beginning of the semester. Two types of demonstrations will run in parallel, “passive” (or standard) and “interactive”.

Standard demonstrations are those you enrolled into via myUNSW. They are structured such that the demonstrator will solve a select number of examples from the demonstration sets on the board. Students’ participation is welcome.

Interactive demonstrations will run at the same time as the “passive” ones. The structure will be less formal and no examples will be solved on the board. Instead it is envisaged that students will work independently, either individually or in small groups, on any demonstration problem they choose. Demonstrators will be available to answer your questions and assist you in solving problems. **You are advised to attend interactive demonstrations instead of standard ones.**

5. ASSESSMENT

General

You will be assessed by way of quizzes, a test, a lab report and an examination.

The composition of the total mark will be as follows:

Quiz 1 (Week 3)	10%
Test (Week 6)	30%
Lab 1 report (due Week 11)	15%
Quiz 2 (Week 8)	15%
Lab 2 report (due Week 13)	10%
Final examination	20%
Total	**100%**

Assignments

The assignment will be based on the work completed in the laboratory. The electronic copy of the assignment will be available on Moodle website before the experiment.

Presentation

A standard specification is available from the School office to aid presentation of your assignments (in all courses). All submissions should have a standard School cover sheet. All submissions are expected to be neat and clearly set out. All

calculations should be shown as, in the event of incorrect answers, marks are awarded for method and understanding.

The preferred set-out of any numerical calculation is similar to the following:

$p = \frac{1}{2}\rho v^2$	(Equation in symbols)
$= 0.5 \times 1.025 \times 100$	(Numbers substituted)
$= 51.25$ Pa	(Answer with units)

Submission

Assignments are due in Week 11 on the day and time that will be announced later. They should be submitted in hard copy via the assignment boxes.

Late submission of assignments attracts a penalty of **1 mark per day**, unless prior dispensation has been given.

Criteria

The following criteria will be used to grade assignments:

For written answers:
- Identification of key facts and the integration of those facts in a logical development.
- Clarity of communication—this includes development of a clear and orderly structure and the highlighting of core arguments.
- Sentences in clear and plain English—this includes correct grammar, spelling and punctuation.
- Correct referencing in accordance with the prescribed citation and style guide.

For numerical calculations:
- Accuracy of numerical answers.
- All working shown (see *Presentation* above).
- Use of diagrams, where appropriate, to support or illustrate the calculations.
- Use of graphs, were appropriate, to support or illustrate the calculations.
- Use of tables, where appropriate, to support or shorten the calculations.
- Neatness.

Quizzes, Test and Examination

There will be a two-hour test in Week 5. Topics for the test will be those presented in Weeks 1 – 4.

There will one three-hour examination at the end of the semester, covering material presented in Weeks 5 - 12.

You will need to provide your own calculator, of a make and model approved by UNSW, for the examination. The list of approved calculators is shown at https://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 *Administrative Matters for All Courses*, available from the School website.

6. TOPICS

Week	Topic
1	Introduction. Linearisation of non-linear equations and operating curves. Laplace Transform. Transfer function.
2	Inverse Laplace Transform. Initial and final value theorems. Shift theorems. Use of tables. Mechanical, electrical, thermal and fluid components. Input-output relations. Analogy between elements of different systems. Derivation of differential equations describing simple systems.
3	Mathematical models of complex systems by combining simultaneous equations associated with the physical model. **Quiz 1**
4	Use of block diagrams. Reduction of block diagrams. Simple rules for manipulations. Time response of first and second order systems. Impulse, step, ramp and sinusoidal inputs. Transient process and the steady state.
5	Performance criteria. The time constant, percentage overshoot, rise time, settling time. Analysis in the s-plane. The pole-zero pattern. The pole position and its relation to stability and other performance characteristics.
6	Concept of control. Open and closed loop systems. Negative feedback loops. Revision. **Mid-semester test**
7	Steady state errors. Root Locus. Contingency time.
8	Lab 1 **Quiz 2**
9	Control system frequency response - Fourier Series and Fourier Transform.

10 Frequency based control system design - Bode plot.
Lab 2

11 State-space notation. Canonical forms in state space. **Lab 1 report due.**

12 State space design and system responses.
Lab 2

13 Contingency time. Revision. **Lab 2 report due.**

The schedule shown may be subject to change at short notice to suit exigencies.

7. ACADEMIC HONESTY AND PLAGIARISM

Plagiarism is using the words or ideas of others and presenting them 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 booklet which provides essential information for avoiding plagiarism: https://my.unsw.edu.au/student/academiclife/Plagiarism.pdf

There is a range of resources to support students to avoid 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. Information is available on the dedicated website Plagiarism and Academic Integrity website: http://www.lc.unsw.edu.au/plagiarism/index.html

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 a honours thesis) even suspension from the university. The Student Misconduct Procedures are available here: http://www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Further information on School policy and procedures in the event of plagiarism is presented in a School handout, *Administrative Matters for All Courses*, available on the School website.

8. 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 demonstrations 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: www.library.unsw.edu.au/servicesfor/index.html

9. COURSE EVALUATION AND DEVELOPMENT

Feedback on the course is gathered periodically using various means, including the Course and Teaching Evaluation and Improvement (CATEI) process, informal discussion in the final demonstration 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 2014 this course underwent major changes. With the introduction of new plans for the degrees offered by the School of Mechanical and Manufacturing engineering, some topics were regarded as unnecessary and some new topics are introduced instead. However, it transpired that the order of the topic was less than perfect according to the students’ feedback. In particular Bode plot and related lectures were presented too early in the course so their relevance in the context of the subject was difficult to understand. This year those topics are going to be covered in Weeks 9 and 10.

The other point of dissatisfaction in 2014 was the lack of practical applications due to the ongoing refurbishment of the J18 building. The plan for 2015 is based on the assumption that the teaching lab will be finished and equipped for the experiment

suitable for the course. This should enable us to run two labs which in turn should give you a better appreciation of the theoretical work presented in lectures.

10. ADMINISTRATIVE MATTERS

You are expected to have read and be familiar with *Administrative Matters for All Courses*, available on the School website. This document contains important information on student responsibilities and support, including special consideration, assessment, health and safety, and student equity and diversity.

Zoran Vulovic
9 January 2015