Course Outline
Semester 2, 2014

MTRN3020
Modelling and Control of Mechatronic Systems
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MTRN3020 MODELLING AND CONTROL OF MECHATRONIC SYSTEMS

COURSE OUTLINE

1. STAFF CONTACT DETAILS

Contact details and consultation times for course convener

A/Prof. Jay Katupitiya
Room 304 (Tyree Energy Technology Building) Tel
(02) 9385 4096
Fax (02) 9663 1222
Email j.katupitiya@unsw.edu.au

Consultation concerning this course is available on Thursday, 1600-1700 hours at the above mentioned office.

Contact details and consultation times for additional lecturers and tutorial/laboratory teaching staff

None

2. COURSE DETAILS

Units of credit

This is a 6 unit-of-credit (UoC) course, and involves 3 hours per week (h/w) of face-to-face contact. In addition, there will be an hour each laboratory sessions per student, in weeks 4, 7 and 12.

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 session, this means 600 hours, spread over an effective 15 weeks of the session (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 5 h/w on this course, i.e. an additional 2 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.
This course has parallel teaching with MTRN9211 course. One assignment and one examination question are at a higher level for MTRN9211.

Summary of the course

This course focuses on the design of digital control systems and their implementation on linear time invariant systems.

Aims of the course

Description: This course will give you a thorough understanding of computer controlled systems. Its core content can be broadly categorized into mathematical and experimental means of modelling Mechatronic Systems, model validation, design of digital controllers using a variety of different methods and the implementation of controllers on real-life systems. The systems being modelled and controlled are largely motion control systems.

The course has laboratory experiments to model a monorail crane system and to design and implement digital control systems on speed and position control rigs.

The courses in the Mechatronics discipline are built up on four different areas. They are; mechanical design, computing, electronics and microprocessors, and control systems. The latter three areas are interrelated and this course forms a corner stone of the fundamental courses on which the Mechatronic Engineering course at UNSW is built up on. A thorough understanding of the control of dynamical mechanical systems to achieve desired motions is essential for the design and development of any sophisticated Mechatronic System. Using the fundamental classical control system knowledge gained in the third year, this course builds your knowledge on designing and implementing computer-controlled systems. Control systems provide a methodical way of carrying out the motion control that also needs programming and computing. As such the contributions from this course to the Mechatronic Engineering degree program are absolutely essential and vital.

Student learning outcomes

At the conclusion of this course, it is expected that you will be able to:

- Develop an understanding of the purpose of control systems and their use.
- Be able to understand that a plant is given and a control system is to be designed to satisfy performance specifications.
- Be thoroughly conversant with the available design methodologies and have the ability to choose the appropriate design methods to enable the control system design.
- Have a thorough understanding of the control system application environment and be able to implement the designed control systems.
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(a), 1(b), 1(d), 1(f), 2(a), 3(a), and 4(a) 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 7.

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**

Our primary goal is to provide you a learning atmosphere within which knowledge dissemination by the lecturer and knowledge extraction by the student is facilitated. Within this atmosphere you will be given a sound theoretical basis for the subject matter. They will also be provided stimuli and resources that they can use to extract further knowledge outside the classroom. This will further be enhanced by the compulsory laboratory sessions in which you will be guided to develop their own (i) understanding of the principles of discrete time control systems, (ii) ability to choose a design method and design a control system and, (iii) ability to implement their designs. Students learn most effectively when they are confronted with practical systems that relate to lecture content. This will be achieved in this course by requiring compulsory laboratory exercises. Effective learning requires a system that demands problem solving by students rather than problems solved by the teacher. To facilitate the development of problem solving, you will be provided ample guidance to develop solutions to problems. The essential attributes are the desire to continuously find out the methodologies available in discrete-time control systems primarily through reading and the use of Matlab/Simulink environment to expand thinking horizons to generate innovative solutions and to develop problem solving skills.

4. **TEACHING STRATEGIES**

Teaching of this course is through lectures, demonstrations and laboratory sessions. All laboratory work is individual work and must be completed to be successful in in-session assessments.

Demonstrations and laboratory exercises are designed to provide you with feedback and necessary clarifications on the assignments, and to investigate problem areas in greater depth to ensure that you understand the application and help you develop confidence in managing them.

5. **ASSESSMENT**

**General**

You will be assessed by way of laboratory tasks and an examination, all of which involve calculations and descriptive material.

The breakdown of the marks awarded is given below.

<table>
<thead>
<tr>
<th>Laboratory Exercises</th>
<th>Marks</th>
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<tbody>
<tr>
<td>Monorail Crane Modelling</td>
<td>15</td>
</tr>
<tr>
<td>Speed Control Experiment</td>
<td>15</td>
</tr>
<tr>
<td>Position Control Experiment</td>
<td>15</td>
</tr>
<tr>
<td>End of session examination</td>
<td>55</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Total mark required to pass the course**

50 marks
Laboratory Exercises

The set laboratory exercises to be assessed are listed in the table below. The course has no assignments.

<table>
<thead>
<tr>
<th>No.</th>
<th>Laboratory</th>
<th>Mark</th>
<th>Learning outcomes assessed</th>
<th>Graduate attrib assessed</th>
<th>Due Fri</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modelling of a Monorail Crane</td>
<td>15</td>
<td>System modelling</td>
<td>1(a) 1(b) 1(d) 1(f)</td>
<td>Week 6</td>
</tr>
<tr>
<td>2</td>
<td>Speed Control Experiment</td>
<td>15</td>
<td>Design and Implementation of controllers</td>
<td>1(a) 1(b) 1(d) 1(f) 2(a) 3(a)</td>
<td>Week 9</td>
</tr>
<tr>
<td>3</td>
<td>Position Control Experiments</td>
<td>15</td>
<td>Design and Implementation of controllers</td>
<td>1(a) 1(b) 1(d) 1(f) 2(a) 3(a)</td>
<td>Week 11</td>
</tr>
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Presentation

All submissions should have a standard School cover sheet available on the School website at www.engineering.unsw.edu.au/mechanical-engineering/forms-and-guidelines. 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:

\[ \Delta = \rho \nabla \]

\[ = 1.025 \times 200 \]

\[ = 205 \text{ t} \]

Submission

All laboratory reports must be submitted online on or before 5.00 pm on the Friday of the due week listed in the table above. The submission details will be included in the laboratory instruction sheets.

Late submission of laboratory reports attracts a penalty as described in the respective laboratory instruction sheet.

For more information on submission of assignments, see Administrative Matters for All Courses available on the School website.

Criteria

A detailed marking criteria is included in the laboratory instruction sheet. The following areas must be highlighted in your reports.

- Mathematical representation of systems using differential equations or the transfer functions.
- Detailed system modelling using Matlab/Simulink model building.
- A thorough comparison of the simulation and experimental results highlighting the reasons for any disparities.

Examination

There will be one two-hour examination at the end of the session, covering all material taught in the whole session.

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. 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 from the School website.
7. COURSE SCHEDULE

All lectures and tutorials in this course are given by the course convener.

Lectures: Tuesday 10-12, Colombo Theatre A (K-B16-LG03)
Practice sessions: Two hours per week of sample problem solving
Tuesday 3 – 5 pm, Tyree Room G17
Start in Week 2 of the session
Prerequisites: MTRN3212, MMAN3200

Week Topic
1 Introduction: Mechatronic Systems, Computer Controlled Systems,
Mathematical Modelling of Systems, System Identification, Design of
Discrete Time Control Systems, Use of Design Packages, Rapid
Controller Prototyping, Implementation of Control Algorithms
2 Automatic Control Systems: Classical Control Systems, Terminology,
Feedback versus Feed forward, Qualitative and Quantitative Analyses of
Proportional,
3 s-Domain to z-Domain: z-transforms, Inversion Techniques, Pulse
Transfer functions.
4 Computer Controlled Systems: Signal Types, Samplers,Analogue to
Digital Controllers, Digital to Analogue Controllers, PWM Amplifiers,
Encoders, Actuators, Mathematical Representation of these Elements.
5 Modelling of Mechatronic Systems: Mathematical Modelling of a DC
Servo Motor Driving a Positioning System, Experimental System
Identification of a Linear Robot Axis. Conversion of Continuous Time
Models to Discrete Time Models.
6 Design Methods for Discrete Time Controllers: Root Locus Method,
Direct Design Method
7 Design Methods for Discrete Time Controllers: Indirect Design Method,
State Space Method
8 Design Methods for Discrete Time Controllers: Bode Design Method.
9 Design and Implementation of Controllers: Design of a Position
Controller, Design of a Speed Controller, Real-Time Implementation of
Controllability and Observability:
11 Estimators: Observer Design, Kalman Filters.
12 Revision

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

8. RESOURCES FOR STUDENTS

As part of the course some handouts will be made available to the students during
the course by placing them on Moodle Learning Platform.

Recommended Textbooks

Additional Readings

A number of additional documents will be available on the web. Some materials from earlier years may also be available at Moodle’s MTRN3020 Home page.

Moodle

Under MTRN3020 a set of pdf files with lecture topics will be made available.

Recommended websites

None.

Library

http://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 tutorial 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.

As a result of student feedback, additional lecture notes will be made to cover content towards the end of the lecture series.

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.

Jay Katupitiya
11 July 2014