FACULTY OF ENGINEERING

SCHOOL OF MECHANICAL AND MANUFACTURING ENGINEERING

MTRN9211

MODELLING AND CONTROL OF MECHATRONIC SYSTEMS

SESSION 2, 2013
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MTRN9211 MODELING 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 Monday–1600-1700 hours at the above mentioned office.

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

Mr. Mark Whitty
Room 303, Tyree Energy Technology Building
Tel(02) 93895 4125
Fax(02)9663 1222
Email: m.whitty@unsw.edu.au

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.
There is no parallel teaching in this course.

**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 the student 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 the students 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 5.

3. RATIONALE FOR INCLUSION OF CONTENT AND TEACHING APPROACH

Our primary goal is to provide the students a learning atmosphere within which knowledge dissemination by the lecturer and knowledge extraction by the student is
facilitated. Within this atmosphere the student 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 the students 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, the students are 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, tutorials and laboratory sessions. All laboratory work is individual work and must be completed to be successful in in-session assessments.

Tutorials are designed to provide you with feedback and discussion on the assignments, and to investigate problem areas in greater depth to ensure that you understand the application and can avoid making the same mistake again.

5. Assessment

General

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

The breakdown of the marks awarded is given below.

<table>
<thead>
<tr>
<th>Component</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Exercises</td>
<td>45</td>
</tr>
<tr>
<td>End of session examination</td>
<td>55</td>
</tr>
<tr>
<td>Mark required to pass the laboratory component</td>
<td>30</td>
</tr>
<tr>
<td>Mark required to pass the examination component</td>
<td>20</td>
</tr>
<tr>
<td>Mark required to pass the course</td>
<td>50</td>
</tr>
</tbody>
</table>
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>Modeling of a Monorail Crane</td>
<td>15</td>
<td>System modeling</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>
</tbody>
</table>
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:

\[ \Delta = \rho \nabla \]  
\[ = 1.025 \times 200 \]  
\[ = 205 \text{ t} \]

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 of one mark per day.

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 modeling 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://my.unsw.edu.au/student/academiclife/assessment/examinations/Calculator.html#CalculatorseligibleforapprovalforuseinexaminationsatUNSW

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

What is Plagiarism?
Plagiarism is the presentation of the thoughts or work of another as one’s own.* Examples include:

- direct duplication of the thoughts or work of another, including by copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person’s assignment without appropriate acknowledgement;
- paraphrasing another person’s work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- piecing together sections of the work of others into a new whole;
- presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and
- claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.†

For the purposes of this policy, submitting an assessment item that has already been submitted for academic credit elsewhere may be considered plagiarism.

Knowingly permitting your work to be copied by another student may also be considered to be plagiarism.

Note that an assessment item produced in oral, not written, form, or involving live presentation, may similarly contain plagiarised material.

The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does not amount to plagiarism.

The Learning Centre website is main repository for resources for staff and students on plagiarism and academic honesty. These resources can be located via: www.lc.unsw.edu.au/plagiarism

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.
Individual assistance is available on request from The Learning Centre.

Students 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 items.

* Based on that proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle
† Adapted with kind permission from the University of Melbourne.

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:** Monday 9-11, in Mech. EE 224
**Tutorial classes:** 2 hours per week of tutorial classes TBA. Start in Week 2 of the session
**Prerequisites:** MTRN3212, MMAN3200

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td><strong>Automatic Control Systems:</strong> Classical Control Systems, Terminology, Feedback versus Feedforward, Qualitative and Quantitative Analyses of Proportional, Integral and Derivative Controllers. Simulation of Classical Control Systems.</td>
</tr>
<tr>
<td>3</td>
<td><strong>s-Domain to z-Domain:</strong> z-transforms, Inversion Techniques, Pulse Transfer functions.</td>
</tr>
<tr>
<td>4</td>
<td><strong>Computer Controlled Systems:</strong> Signal Types, Samplers, Analog to Digital Controllers, Digital to Analog Controllers, PWM Amplifiers, Encoders, Actuators, Mathematical Representation of these Elements.</td>
</tr>
<tr>
<td>6</td>
<td><strong>Design Methods for Discrete Time Controllers:</strong> Root Locus Method, Direct Design Method</td>
</tr>
<tr>
<td>7</td>
<td><strong>Design Methods for Discrete Time Controllers:</strong> Indirect Design Method, State Space Method</td>
</tr>
<tr>
<td>8</td>
<td><strong>Design Methods for Discrete Time Controllers:</strong> Bode Design Method.</td>
</tr>
<tr>
<td>10</td>
<td><strong>Controllability and Observability:</strong></td>
</tr>
<tr>
<td>11</td>
<td><strong>Estimators:</strong> Observer Design, Kalman Filters.</td>
</tr>
<tr>
<td>12</td>
<td>Revision</td>
</tr>
</tbody>
</table>
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 Blackboard Learn.

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 Blackboard’s MTRN3020 Home page.

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

Recommended websites (This has been moved, however, directions to find course material is available there)

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.

10. ADMINISTRATIVE MATTERS

Information about each of the following matters is presented in a School handout, Administrative Matters for All Courses, available from the School website


It is essential that you obtain a copy, read it carefully and become familiar with the information, because it applies to this course and to each of the other courses in which you are enrolled.

Expectations of students (including attendance at lectures and tutorials/laboratory classes/seminars; and computer use, for example, in the use of email and online discussion forums)
Procedures for submission of assignments and the School’s policy concerning late submission

Information on relevant Occupational Health and Safety policies and expectations:

www.ohs.unsw.edu.au

Examination procedures and advice concerning illness or misadventure

Equity and disability

Students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Student Equity and Disability Unit (SEADU) by phone on 9385 4734, email seadu@unsw.edu.au or via the website

www.studentequity.unsw.edu.au/content/default.cfm?ss=0

The office is located on the Ground Floor of the John Goodsell building (F20).

Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

Jay Katupitiya
18 July 2013