FACULTY OF ENGINEERING

SCHOOL OF MECHANICAL AND MANUFACTURING ENGINEERING

MTRN9211

MODELLING AND CONTROL OF MECHATRONIC SYSTEMS

SESSION 2, 2009

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MTRN 9211 MODELLING AND CONTROL OF MECHATRONIC SYSTEMS

COURSE OUTLINE

COURSE STAFF

Dr Jayantha Katupitiya
Room M9
Mezzanine Level
Mechanical Engineering Laboratory Building
Tel (02) 9385 4096
Fax (02) 9663 1222
Email: J.Katupitiya@unsw.edu.au

Consultation times:

A/Prof. J. Katupitiya **Monday 5-7pm**

Consultation is through direct contact at the office of the staff member named above. If you wish to make an appointment outside these times, please call his office number.

COURSE DETAILS

Units of credit

This is a 6 units-of-credit (UoC) course and involves 6 hours per week face-to-face contact.

There will be one 2 hour lecture and one 1 hour /tutorial laboratory classes a week for each student.

UNSW expects that you will put in on average 40 h/w for 24 UoC (including both in-class and out-of-class time) for an effective 14 weeks of the session (12 weeks plus stuvac plus one effective exam 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 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, practice tutorial questions, further reading about the course material, and revising and learning for the examinations.

Parallel Teaching

There is no parallel teaching in this course.

COURSE AIMS

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 modeling 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 modeled and controlled are largely motion control systems.

The course has laboratory experiments to design and implement digital control systems on speed and position control rigs.

How the course relates to other course offerings and overall program(s) in the discipline

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 can be seen the contributions from this course to the Mechatronic Engineering degree program is absolutely essential and vital.

STUDENT LEARNING OUTCOMES

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

- Develop an understanding of the purpose of control systems and their use.
- Be familiar with the terminology used in control systems.
- Be able to understand that a plant is given and a control system is to be designed to satisfy performance specifications.
- Develop the ability to differentiate between the classical control system principles and discrete-time control system applications.
- 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.
- Be able to implement the designed control systems.
- Will be able to design current and predictive observers that are useful in stste estimation.

THE RATIONALE BEHIND YOUR APPROACH TO LEARNING AND TEACHING

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 enhance 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.

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.

ASSESSMENT

Speed Control Experiment	20 marks
Position Control Experiment	20 marks
Total mark for laboratory component	40 marks
Mark required to pass the laboratory component	**30 marks**
End of session examination	60 marks
Mark required to pass the end examination component	**20 marks**
Mark required to pass the course	**50 marks**

Academic honesty and plagiarism

- The following extract must appear in *all* course outlines:

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.

COURSE SCHEDULE

Lectures: **Tuesday, 9- 11 am, in Elect. Eng. G25**
Tutorial classes: **Thursday, 2 – 3 pm, in Mech. Eng. 203**
Prerequisites: **MTRN3212**

Week	Topics
1	**Introduction**: Mechatronic Systems, Computer Controlled Systems, Mathematical Modeling 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, Integral and Derivative Controllers. Simulation of Classical Control Systems.
3	**s Domain to z Domain**: z-transforms, Inversion Techniques, Pulse Transfer functions.
4	**Computer Controlled Systems**: Signal Types, Samplers, Analog to Digital Controllers, Digital to Analog Controllers, PWM Amplifiers, Encoders, Actuators, Mathematical Representation of these Elements.
5	**Modeling of Mechatronic Systems**: Mathematical Modeling 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 Controllers.
10	**Controlability and Observability:**
11	**Estimators**: Observer Design, Kalman Filters.
12	Revision

Resources for students

As part of the course some handouts will be made available to the students during the course.

Recommended Textbooks

- Dorsey, J., “Continuous and Discrete Control Systems”, McGraw Hill
- Golten, J. and A. Verwer, “Control System Design and Simulation” McGraw Hill

Additional Readings

A number of additional documents will be available on the web. Some materials from earlier years may also be available at WebCT Vista’s MTRN9211 Home page

WebCT

Under MTRN3200 a number of documents including the complete 68HC11 technical data book and other data sheets are be available.

Recommended websites

http://ocw.mit.edu/OcwWeb/Mechanical-Engineering/2-737Spring1999/Syllabus/index.htm - MIT Open Courseware

Library

info.library.unsw.edu.au/web/services/services.html

COURSE EVALUATION AND DEVELOPMENT

This course is continuously developed based on the students’ feedback. Whenever possible, the course participates in Course and Teaching Evaluation and Improvement (CATEI) Process. Students are invited to provide any feedback or comments at other times.

ADMINISTRATIVE MATTERS

Information about each of the following matters is presented in a School handout, *Administrative Matters for All Courses*, available from the School office separately or as part of *The Guide*.

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

> 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.hr.unsw.edu.au/ohswc/ohs/ohs_home.html**
>
> Examination procedures and advice concerning illness or misadventure.

Equity and diversity 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 Equity and Diversity Unit (9385 4734 or www.studentequity.unsw.edu.au/content/default.cfm?ss=0). 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.

A/Prof. Jay Katupitiya
1 July 2009