Syllabus for MAE 491 & MAE 591

Mechatronics

Spring Semester 2004
Tuesday, Thursday
6:00-7:15 PM
Room EGC 208

Instructor: Hodge Jenkins, Ph.D., P.E.
Assistant Professor
Department of Mechanical and Industrial Engineering

Office: Suite 101-D, School of Engineering
Hours: As posted, drop by, or by appointment

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Textbooks and Supplies:
Required: Mechatronics, Dan Necsulescu, publisher: Prentice Hall, 2002,
ISBN: 0-201-44491-7
www.campusestore.com

Web Sites: http://faculty.mercer.edu/jenkins_he/Mechatronics.htm
http://www.mathworks.com

Catalog Description:
Mechatronics, as an engineering discipline, is the synergetic integration of mechanical engineering,
control engineering, electronics, and computers, through the design process. Mechatronics, a multi-
disciplinary approach to engineering design, has become the key to many different products and
processes in many areas, such automotive, aerospace, precision machining, and computer drive
industries.

Modern systems have reached a level of sophistication not possible using traditional methods. The
integration of mechanics, electronics, control and computing exploits and exceeds the relative
advantages of single disciplines, and when they are integrated, the synergy ensures that
performances reach unprecedented levels.

This course studies mechatronics at a theoretical and practical level, balancing theory, analysis,
simulation, with implementation issues. Topics will include sensors, actuators, system modeling and
identification, analog and digital control, and filtering.
Course Objectives:
Upon successful completion of this course, you should be able to do the following:

- Understand the importance of the integration of modeling and controls in the design of mechatronic systems and be able to apply it to a variety of dynamic physical systems.
- Be able to model and analyze mechanical, electrical, electromechanical, fluid, thermal, and multidisciplinary systems, using both first principles and system identification techniques.
- Become proficient in the use of MatLab/Simulink to model and analyze mechatronic systems.
- Understand the key elements of measurement systems and devices, including the basic performance specifications and physical/mathematical models of a variety of analog and digital sensors.
- Develop an understanding of the characteristics and models of various electromechanical actuators (brushed dc motor, brushless dc motor, and stepper motor) and hydraulic and pneumatic actuators.
- Understand analog circuits, digital devices and semiconductor electronics as they apply to mechatronic systems.
- Apply signal analog and digital signal processing techniques to sensors and actuators of a mechatronic system.
- Apply and understand various control system design techniques: open-loop feedforward control, classical feedback control (root-locus and frequency response), and state-space control.
- Have a general grasp of advanced control design techniques: cascade controls, model predictive control, adaptive control, and multivariable control.
- Be competent in the digital implementation of control and basic digital control design techniques.
- Understand programming and interfacing issues associated with controllers in a mechatronic system.
- Be able to apply all these skills to the design of a mechatronic system.

Prerequisites: EGR 386

Course Content:

- Introduction to Mechatronics
- General Concepts in Physical & Mathematical Modeling of Real Systems
- Dynamic Systems: Time Response and Frequency Response
- Measurement Systems, Sensors, and I/O Considerations
- Analog Electronics for Mechatronics
- Filtering and signal conditioning
- Actuators: Electromechanical (Brushed DC Motors, Brushless Servo Motors, Stepper Motors), and Fluid (Hydraulic and Pneumatic)
- System Identification Techniques
- Introduction to Controls: Process Sequence Control and Servo Control
- Open-Loop and Feedforward Control, Feedback Control, Analog and Digital Control
- Feedback Control: PID Control, Stability, Performance
- Root-Locus and Frequency-Response Analysis and Design Techniques
- State-Space Control Design
- Digital Implementation of Control and Filtering
- Controller and Microcontroller Interfacing and Real-Time Programming Issues
- Introduction to Advanced Control Techniques: Gain Scheduling, Model Reference Adaptive Control
Grading *: Grade Averages: A (90-100), B (80-89), C (70-79), D (60-69), F(<60)
Homework 15%
Quizzes 15%
Project 15%
Tests (2) 15% each
Final Exam 25%

*Weighting is only for MAE491. MAE 591 have a research paper worth an additional 10% of their grade.

Graduate Students Research Paper: DUE MARCH 4, 2004
Graduate Students must and perform an academic journal literature research summarizing the current state of a particular mechatronic topic of their choosing. This is worth an additional 10% of your grade.

Homework:
Homework is a significant part of the grade as performing the homework is the only way to have a good understanding of the course material. Problems will be assigned and will be collected at the beginning of class on the due date. Late homework will not be accepted. The lowest homework grade will be discarded.

Homework must be done neatly on paper in pencil or using computer-based programs such as Word and Matlab/Simulink. Please place your name, date and assignment number on each page in the upper right hand corner. Messy, unorganized papers will receive less than full credit. Show all necessary diagrams, coordinate systems, and governing equations that are used in the solution. Equations and solutions must follow logically, step by step. Thus, your complete solution is supported by what you have presented. Show all your work. Generally, leave variables in the equations until the solution is found, then substitute the values for the variables to obtain the specific answer in the correct units. Begin each problem on a new sheet of paper, and staple all the sheets together in order.

You may work together in small groups, but copying is not permitted. Each student must turn in his own work. DO NOT COPY HOMEWORK.

Quizzes:
Short, 10-minute problem or question will be handed out periodically. Quizzes may or may not be announced. Quizzes will be closed notes and closed book. A calculator is recommended.

Tests:
There will be two 50-minute tests of 3 or 4 problems during the semester. Problems will be similar to the homework and quizzes. All tests will be open book. A calculator is recommended. No make-up tests will be given without a documented excuse.

Project: DUE APRIL 20, 2004
This is a group project. Teams should ideally be 3 people. Model a real world mechatronics system of your choosing. Determine the characteristics of the system in terms of the frequency response and identified transfer function. Successfully apply an analog and digital control methodology for the system (regulation or trajectory following) for disturbance rejection. Compare and discuss results. Graduate students must have an academically more rigorous project by selecting either a non-linear SISO system or multi-variable system (MIMO).
NOTE: Hardware projects are also acceptable for students with sufficient background.

Final Exam:
There will be a comprehensive final exam. It will be open notes and book. The final exam will be given on: Tuesday 05/04 7:00 p.m. - 10:00 p.m
Course Standards:

1. **Assignments are due at the beginning of the class period on the date due.** In an exceptional circumstance you may petition to hand in an assignment late. If granted, the grade will be reduced one letter grade per day late.

2. **Attendance is required** due to the large amount of in-class work and team activities we will be doing. You can’t “make up” experiential learning. More than three absences will result in grade penalties. If you miss a class, it is your responsibility to obtain the notes, handouts, homework, and announcements from a classmate.

3. **Grading** encompasses every aspect of the course, from participation through final products. You can assume that every task requested directly or indirectly factors into your grade. For example, having your work prepared for your group is as important as having it ready for me. Regular feedback will be given on documents handed in.

4. You are encouraged to schedule a conference at any point that you need it. If you need to see me, catch me after class to schedule a time or call Ms. Dee Ryburn, the MAE Secretary, at 301-2223 to get on my calendar.

5. Please turn off cell phones and pagers before entering the classroom.

6. The honor code provisions as outlined in the Bulletin and in the student handbook, The Lair, will be assumed for everyone. It should be clear from class discussion which projects will be collaborative and which ones must be individual. When in doubt, please ask to avoid potentially embarrassing situations. Plagiarism is a violation of the honor code and is prohibited.

7. This syllabus is subject to change.

8. Students with a documented disability should inform the instructor at the close of the first class meeting. The instructor will refer you to the office of Student Support Services (SSS) for consultation regarding evaluation, documentation of your disability, and recommendations for accommodation, if needed. Students will receive from SSS the Faculty Accommodation Form. On this form SSS will identify reasonable accommodations for this class. The form must be given to the course instructor for signature and then returned to SSS.

   To take full advantage of disability services, it is recommended that students contact the Office of Student Support Services, immediately. The office is located on the third floor of the Connell Student Center.

**Electronic Communication:**

Electronic communication is an important adjunct to face-to-face communication, including from professor to students, students to professor, and students to students. You must have regular access to your e-mail. If you do not have an active e-mail address on the first day of class, please secure one. Access to the Web and to the Internet is also integral to the class work. A number of laboratories on campus will provide access, in addition to EGC 102 and ECG 111-B.

Subscribe to the class listserv within 24 hours of the first class meeting.

File-naming conventions will be prescribed in order to avoid needless confusion about electronically submitted documents. Set your e-mail so as to assure that you get a time-and-date confirmation of any assignments submitted electronically. You are responsible for using the correct mailing address either to me individually, or to the class listserv.
LISTSERV INSTRUCTIONS

Note that entries are not case sensitive.

To subscribe, enter the following on email:

To: mailserv@mercer.edu
Subject: (Do not type anything here)

Body of message: sub HJenkins3-L
end

You will get a return email message confirming that you have been added to the mailing list. Make sure the email message does not contain text.

To send mail to listserv, enter the following on email:

To: HJenkins3-L @mercer.edu
Subject: Descriptive title of email content

Note: make sure to include MAE-491 or MAE-591 in the subject line

To unsubscribe, enter the following on email:

To: mailserv@mercer.edu
Subject: (Do not type anything here)

Body of message: unsub HJenkins3-L
end

To get a list of everyone who has subscribed to the listserv:

To: mailserv@mercer.edu
Subject: (do not type anything here)

Body of message: Send/list listserv name (i.e., send/list HJenkins3-L)