ME171 Course Syllabus

CALIFORNIA STATE UNIVERSITY SACRAMENTO
The Department of Mechanical Engineering

ME171 – MODELING AND SIMULATION OF MECHATRONICS AND
CONTROL SYSTEMS

SYLLABUS

DESIGNATION: Mechanical Design and Mechatronic Systems

INSTRUCTOR: Prof. José J. Granda
Riverside 5002, 916-278-5711
Email: grandajj@ecs.csus.edu

OFFICE HOURS: 2:00 – 3:30 p.m. T, TH or by appointment

TIME: 10:30 – 11:45 p.m.
PLACE: ARC1014

TECHNOLOGY USED: Exchanges of materials will all be electronic. Notes, assignments, etc.

WEB PAGE. - Course documents will be posted on the instructor’s web site or on the University Web Sites.

OBJECTIVES: The objective of this course is to provide the student with an introduction to modeling and simulation of mechatronics and controls systems. The following topics will be emphasized. Computer modeling and mathematical representation of mechanical, electrical, hydraulic, thermal, and electronic systems or combinations of these. Development of system design criteria and solutions using computer modeling and simulation. Use of state of the art automated modeling and simulation methods to build models of multi-energy Mechatronics and Control Systems. Vibration concepts applied natural frequencies, eigenvectors, and solution of differential equations using computer simulation. Introduction to state variable feedback control systems. A design project using the computer is required. Lecture three hours.

PREREQUISITES: E110 UNITS: 3.0


CAMPG/MATLAB-SIMULINK User’s manual J. Granda
REFERENCES:
MODELING, ANALYSIS AND CONTROL OF DYNAMIC SYSTEMS
by William J. Palm III, John Wiley and Sons.
ENGINEERING SYSTEM DYNAMICS by Forbes T. Brown, CRC Taylor
and Francis. 2007
MATLAB/SIMULINK USER'S MANUAL

LEARNING PROCESS: You are the only one solely responsible for your learning success, not
your Professor, not the Department and not the University. You will have plenty of materials to
consult, to go over, examples on the class web site in form of presentations and videos. It is your
responsibility to look over these materials. Some will continue to be developed as we go along.

KNOWLEDGE, SKILLS, AND ABILITIES STUDENTS SHOULD HAVE BEFORE
ENTERING THIS COURSE: Communicate technical information accurately and concisely –
both orally and in writing, use analysis, computer software, word processors, etc., to define and
develop solutions to technical problems. The skills learned in dynamics courses are a good basis.
The student will be expected to study the assigned reading assignments and homework following the
schedule. Students are responsible for ALL material presented in class. This includes any
announcements, due dates, changes or clarifications made in class. The instructor and the materials
available to you will be your guidance, but the real learning process takes place on your own going
over examples in class and in communication with the instructor.

KNOWLEDGE, SKILLS, AND ABILITIES STUDENTS GAIN FROM THIS COURSE:
The objective of this course is to provide the student with the necessary skills to generate computer
models of real physical devices used for design and analysis using the computer as a tool.
After taking this class students will be able to:
1) To use automated methods to develop computer models of mechatronics systems,
   mechanical, electrical, hydraulic, thermal, systems using a common modeling technique.
2) To perform computer simulations of mechatronics systems in the time domain for linear or
   non-linear models using systems of first and second order differential equations.
3) To perform computer simulations in the frequency domain using computer generated state
   space and transfer functions with applications to sensors, actuators and controls.
4) Understand the concepts of natural frequency, eigenvalues, free and forced response.
5) To understand and use the different types of control systems. Use of frequency response
   and root locus methods.

IMPACT ON SUBSEQUENT COURSES IN CURRICULUM: For those enrolled students,
who have not yet participated in the capstone design course, provides a foundation for modeling
and simulation of the subsequent course topics of ME190, ME191. For students who want to learn more about automatic control, this class is an excellent basis for ME114.

**ABET CRITERIA 2000 OUTCOMES ACHIEVED:** This course contributes to the following EC2000 Criterion 3 outcomes and those specific to the EAC accredited _ program.

<table>
<thead>
<tr>
<th>Outcome</th>
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<tbody>
<tr>
<td>a. An ability to apply knowledge of mathematics, science, and engineering</td>
<td>g. An ability to communicate effectively</td>
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<tr>
<td>b. An ability to design and conduct experiments, as well as to analyze and interpret data</td>
<td>h. The broad education necessary to understand the impact of engineering solutions in a global/societal context</td>
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<tr>
<td>c. An ability to design a system, component, or process to meet desired needs</td>
<td>i. A recognition of the need for and an ability to engage in life-long learning</td>
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<tr>
<td>d. An ability to function on multi-disciplinary teams</td>
<td>j. A knowledge of contemporary issues</td>
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<tr>
<td>e. An ability to identify, formulate, and solve engineering problems</td>
<td>k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
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<tr>
<td>f. An understanding of professional and ethical responsibility</td>
<td>l. Begin list of any other outcomes unique to the program</td>
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**ABET PROGRAM CRITERIA OUTCOMES ACHIEVED:** Program criteria outcomes are unique to each degree program and are to be compiled from the program criteria given for each degree program and listed in bullet format below.

<table>
<thead>
<tr>
<th>Criterion</th>
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<th>Criterion</th>
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<tbody>
<tr>
<td>A. Aerodynamics</td>
<td>G. Orbital Mechanics</td>
<td>M. Preliminary/Conceptual Design</td>
</tr>
<tr>
<td>B. Aerospace Materials</td>
<td>H. Space Environment</td>
<td>N. Other Design Content</td>
</tr>
<tr>
<td>C. Structures</td>
<td>I Attitude Determination and Control</td>
<td>O. Professionalism</td>
</tr>
<tr>
<td>D. Propulsion</td>
<td>J. Telecommunications</td>
<td>P. Computer Usage</td>
</tr>
<tr>
<td>E. Flight Mechanics</td>
<td>K. Space Structures</td>
<td></td>
</tr>
<tr>
<td>F. Stability and Control</td>
<td>L. Rocket Propulsion</td>
<td></td>
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</tbody>
</table>

**COMPUTER USAGE:** Computers are used for writing reports (WORD) and presentations (PowerPoint). Spreadsheets are used as appropriate in doing multiple trade studies. Computational tools such as CAMPG, MATLAB AND SIMULINK are used as these are the current state of the art tools.

**CLASS FORMAT:** This course follows a lecture format. Assignments will be both individual and group. Groups will be approximately 4 people, and pre-assigned by the instructor. Students are responsible for reading the assigned material prior to the scheduled class. Class participation is required and part of the course grading. Students are encouraged to actively participate and to ask questions freely. Students will be expected to present their work periodically.

**COURSE GRADING:**
Exams and assignments will be graded balancing the procedure used and the correctness of your answer on an equal basis. Presentation and organization of your assignments will also be considered in grading. There will be Quizzes approximately one to two weeks apart, including the last week of class. Quizzes and final exam will be closed book exams. If there is a discrepancy in grading, you have two weeks from the date you received it to bring up for discussion. After that period grades are final. Projects are due on the last day of class. Work turned in after the deadlines will not be computed in your final grade.

HOMEWORK, COMPUTER ASSIGNMENTS POLICY:
Assignments are issued each week and students work is due in one week unless otherwise noted in the accompanying class schedule. Assignments are due at the start of class on the due date. Late assignments may be accepted, but at a loss of 20% of the grade per 24 hours late. Homework assignments will be returned to students post grading. There will be reading homework and computer assignments. Students are responsible for ALL material presented in class. This includes any announcements, changes, clarifications on assignments, or due dates. It is expected that the assignments will be completed and turned in before or on the specified deadlines. There will be no make up tests except in cases of confirmed and documented illness or emergency.

As the semester goes on and you realize "things" are not going well for you in this class or you become frustrated with the computer, be aware of the policy on drops and incomplete. To drop the class you must meet deadlines and an incomplete is rarely granted and can not be used to "bail out" of the class.

EXAMINATIONS:
There will be quizzes and exams. These will be announced to cover specific modules of the course. The final exam will be administered in accordance with the University scheduled time. Make-up exams require the permission of the instructor prior to the day of the exam.

ATTENDANCE:
Regular attendance is expected. Note that a portion of your grade is based on class participation and self-initiative. Professional contribution is a goal of this course.

SCHEDULE / CRITICAL DATES:

- Last Day of Official Adds/Drops
- Holidays
- Last Drop Day for Possible Refund
• Mid-Term Exam
• Fall Break
• Last Drop Day (with Approval)
• Final Book Reports Due
• Final Exam

Other important dates are available from the University Academic Calendar web site.

SPECIAL NOTES:

Students with Disabilities: The California State University provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students or the College of Engineering Director of Students with Disabilities.

Class Web Sites and Student Privacy: Web-based, password-protected class sites are associated with all academic courses taught at The University. Syllabi, handouts, assignments and other resources are types of information that may be available within these sites. Site activities could include exchanging e-mail, engaging in class discussions and chats, and exchanging files. In addition, electronic class rosters will be a component of the sites. Students who do not want their names included in these electronic class rosters must restrict their directory information in the Office of the Registrar.

EVALUATION:
The Measurement and Evaluation Center forms for the College of Engineering will be used during the last week of class to evaluate the course and the instructor.

UNIVERSITY AND CLASSROOM POLICIES

• You are the only one responsible for your success in learning, not the Professor, not the Department, not the University.
• CSUS is a high level educational institution and fosters a professional environment. However discipline problems or attempts to disrupt any aspect of the course, or influence other students to do the same will not be allowed.
• Assignments are to be individual unless assigned as a group. The honor code is to prevail in all assignments. Copying assignments or exams will at the very least, result in zeroes assigned to ALL involved.
• It is the Mechanical Engineering Department's policy to remove from the major students who copy an exam or to expel them from the university. Copying or deleting unauthorized disk files will have the same effect. Logging onto somebody else's account is not permitted.
• Students are expected to answer questions on any of the work they hand in and proof they have done the work themselves.
• Students are encouraged to make constructive suggestions to the instructor about any aspect of the course. Please feel welcome to come and see the Professor.
• Students are encouraged also to suggest projects, particular engineering problems or research topics of interest to the whole class.
• The Professor will assist students and conduct the in class as follows:
  ➢ Encourage free pursuit of learning by students.
  ➢ Students will be guided by the Professor, but the learning process is the responsibility of the students themselves.
  ➢ Students are evaluated solely on an academic basis.
  ➢ Provide timely and relevant feedback to students
  ➢ Report incidents of student plagiarism and cheating to the Campus Judicial Officer.
  ➢ Follow campus procedures in dealing with disruptive student behavior.
  ➢ Resolve complaints. If students are unhappy with any aspect of the course, they must meet with the professor and attempt to resolve the issue between them. If they are not able to resolve the issue, students can address their concerns with the department chair. No complains will be processed or documents received by the Department or administrative offices in the College without the knowledge of the Professor and after an attempt has been made to resolve the issue. Otherwise, such actions constitute backstabbing of Professors, which are unethical at a University level and may carry disciplinary actions.
  ➢ Implement accommodation for students authorized by Services to Students with Disabilities (SSWD) and/or discuss concerns only with SSWD.
  ➢ Accommodate reasonable student absences for religious observances.

INSTRUCTOR RESERVES THE RIGHT TO REVISE SCHEDULE AS NECESSARY
<table>
<thead>
<tr>
<th>WEEK BEGIN</th>
<th>TOPICS</th>
<th>READING</th>
<th>HOMEWORK</th>
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<tbody>
<tr>
<td>1</td>
<td>Practical examples to present the concept of mechatronics systems and components with unique function.</td>
<td>Chap 1</td>
<td>1-1, 4, 7, 9</td>
</tr>
<tr>
<td>2</td>
<td>Basic elements and their equations. Single and multiport devices. Block Diagrams</td>
<td>2.1, 2.2, 3.1, 3.3</td>
<td>2-1, 3, 4, 5, 11</td>
</tr>
<tr>
<td>3</td>
<td>Sign conventions, equations of motion. Block Diagram approach, Bond Graph Approach</td>
<td>3.4, 3.5</td>
<td>3-6, 7, 8, 12, 15, 16</td>
</tr>
<tr>
<td>4</td>
<td>Modeling electrical and electronic Systems.</td>
<td>4.1</td>
<td>4-1, 2</td>
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<tr>
<td>5</td>
<td>Modeling mechanical systems.</td>
<td>4.2, 4.3</td>
<td>4-3, 4, 5</td>
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<tr>
<td>6</td>
<td>Modeling Hydraulic systems.</td>
<td>4.4</td>
<td>4-7, 8, 9</td>
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<td></td>
<td>Modeling transducers</td>
<td>4.5</td>
<td>4-10, 11, 12</td>
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<tr>
<td>7</td>
<td>System Differential equations.</td>
<td>5.1, 5.2</td>
<td>5-1, 3(a,b,c,e)</td>
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<td></td>
<td>Causality, Derivations using models.</td>
<td>5.3</td>
<td>5-4</td>
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<tr>
<td>8</td>
<td>Automated modeling methods</td>
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<td></td>
<td>Computer Generation of Physical System Models.</td>
<td></td>
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<tr>
<td>9</td>
<td>Modeling problems. Derivative causality. Algebraic loops. Output equations.</td>
<td>5.4, 5.5, 5.6</td>
<td>5-8, 9, 10, 11, 14</td>
</tr>
<tr>
<td>10</td>
<td>Computer Simulation Techniques</td>
<td>6.1, 6.2, 6.3, 6.4</td>
<td>6-1, 6-2, 6-3, 6-4</td>
</tr>
<tr>
<td>11</td>
<td>Control Systems</td>
<td>6.5, 6.6, 6.7</td>
<td>6-6, 7, 8, 12, 15</td>
</tr>
<tr>
<td>12</td>
<td>Operational Amplifier Models</td>
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<tr>
<td>13</td>
<td>Mechatronic Devices, sensors, transducers, Amplifiers and instruments.</td>
<td>8.1, 8.2, 8.3, 8.11</td>
<td>8-1, 5, 7, 11</td>
</tr>
<tr>
<td>14</td>
<td>Final Projects Presentations</td>
<td></td>
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