ME 560 *Modeling and Analysis of Dynamic Systems*

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Department of Mechanical Engineering
The University of Michigan

Course Motivation and Purpose:

In an effort to continue to produce competitive products, industry has been forced to shorten the design life cycle while simultaneously producing higher performance products. This has resulted in the increased utilization of cross-functional design teams to perform true systems design. Part of the systems design process includes the use of models that allows what-if? design engineering. The use of models has both been fueled by and fueled an explosion of computer tools for manipulating analyzing models and the data they produce. These computer based techniques demand skills from engineers in the area of modeling. The purpose of this course is to provide engineers with these fundamental modeling skills. More specifically, to provide information and tools to help students develop skills for creating mathematical models of physical, multi-media (muti-energy domain) systems that can be effectively solved on a digital computer for purposes of control system design, performance evaluation, design sensitivity studies, model-based monitoring, etc.

Course Idea and Methods:

The idea behind this course is to use a unified approach to abstracting real mechanical, fluid, and electrical systems into proper models in graphical and state equation form to meet engineering design and control system objectives. The emphasis is not on the mechanics of deriving equations but rather on understanding how the engineering task defines the modeling objectives that in turn determine what modeling assumptions are appropriate. A hierarchical modeling software 20SIM is used to develop and simulate models. Low level models can be entered as: state equations, constraint equations, block diagrams, and bond graphs. High level model description can be entered as interconnected words or icons whose specific definitions can created, or modified at any time. Bond graphs, which is a graphical power topology language, is taught to help the students be able to easily represent the models of the multi-energy domain systems. This then allows causality, as well as system analysis tools to be used to determine the correctness of the modeling assumptions. System analysis techniques include: free and forced response, model solutions, eigenvalues and eigenvectors, s-plane analysis and frequency response methods. In addition, numerical integration techniques, linearization, system representation techniques are presented. A number of project like problem sets are required to reinforce the theoretical concepts presented in the lecture. Most of the projects require computer simulation and thus a complete array of modeling skills will be developed in this course. The key exception to this is that only a minimum of skills with regard to the design of experiments needed to determine model parameters or to perform model validation studies are developed.

Instructors:

J.L. Stein, Professor
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Class Time: 12:10 – 1:30, 2211 G.G. Brown
Office Hours: 1:30 – 2:30 Tu & Thurs

Rahul Ahlawat, Emergency Computer Consultant
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Grading:

Problem Sets	40 %
MidTerm Exam	25 %
Final Exam	35 %

Problem Set Weights from a previous year: (as an example of how the vary, not as a statement of what they will be this year)

3.8	11.4	9.5	13.3	9.5	9.5	13.3	15.2	14.2	100
PS 1	PS 2	PS 3	PS 4	PS 5	PS 6	PS 7	PS 8	PS 9	Total

Grading Policy:

There will be a premium placed on submitting work on time. Late materials will not be accepted. Please keep abreast with the schedule.

Policy on Homework Preparation

All problem sets (home work assignments) are to be completed on your own. You **are** allowed to consult with other students in the current class during the conceptualization of a problem **but** all written work, whether in scrap or final form, are to be generated by you working alone. You are not allowed to sit together and work out the details of the problems with anyone. You are not allowed to discuss the problem set with previous class members, nor anyone else who has significant knowledge of the details of the problem set except those class assistants identified in this document. Nor should you compare your written solutions, whether in scrap paper form, or your final work product, to other students (and vice versa). You are also not allowed to possess, look at, use, or in anyway derive advantage from the existence of solutions prepared in prior years, whether these solutions were former students' work product or copies of solutions that had been made available by me. Violation of this policy is grounds for me to initiate an action that would be filed with the Dean's office and would come before the College of Engineering's Honor Council. If you have any questions about this policy, PLEASE do not hesitate to contact me.

Problem Set Grading

The purpose of the problem sets is to develop your skills and insights with the course material. I provide you with the brick and mortar during class, but only you can build your systems knowledge house by doing the problem sets. If you wish to learn the course material, if you wish to do well on the exams then you should complete the problem sets. Grading of the problem sets is designed to reinforce their purpose. Problem sets are graded on a scale of 0-5, where:

O not submitted.
1 less than % 25 correct
2 25-49% correct
3 50-69% correct
4 70-85% correct
5 86-100% correct

Classroom Etiquette

- Please do not engage in any activities during class that might interfere with your classmates.
- Please carry out all materials that you bring to class. This is particularly true for newspapers, coffee cups, snack food wrappers.

References

Course Text:

Karnopp, Rosenberg and Margolis, System Dynamics: Modeling and Simulation of Mechatronic Systems, 4th Edition, Wiley, 2005, ISBN 0471709654.

Course Software:

20SIM This software is on CAEN, PC platforms. It was developed at Twente University, The Netherlands and is marketed by Controllab Products B.V., University of Twente, Enschede, Netherlands http://www.20sim.com/.

Additional References: Most are available at the North Engineering Library.

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Brown, Forbes T. “Engineering System Dynamics: A Graph Centered Approach, Publ. Marcel Dekker, Inc., New York, NY. 2001, ISBN 0-8247-0616-1.

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Kailath, Thomas, Linear Systems, Prentice Hall, 1980

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Karnopp and Rosenberg, System Dynamics: A Unified Approach, 1st Edition, Wiley, 1975

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Karnopp, Rosenberg and Margolis, System Dynamics: Modeling and Simulation of Mechatronic Systema, 3rd Edition, Wiley, 2000, ISBN 0471333018.

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Ross, Sheldon M Simulation, Academic Press, 4th edition, 2006 (ISBN 13: 978-0-12-598063-0)

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Rowell, D. and Wormley, D.N. System Dynamics: An Introduction, Prentice Hall, 1997.

Schultz and Melsa, State Functions and Linear Control Systems, McGraw Hill, 1967

Shearer and Kulakowski, Dynamic Modeling and Control of Engineering Systems, MacMillan, 1990.

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Smith, Introduction to Dynamic Systems Modeling for Design, Prentice Hall, 1994.

Takahashi, Rabins & Auslander, Introducing Systems and Control, Addison & Wesley, 1972

Wellstead, P.E., Introduction to Physical System Modeling, Academic Press, 1980, ISBN-10: 0127443800, ISBN-13: 978-0127443805