CE 5250 – System Identification
Spring Semester 2012

Professor: Dr. Andrew Swartz, Ph.D. raswartz@mtu.edu
201D Dillman Hall (906) 487-2439

Office Hours: Monday 11 AM-Noon, Wednesday and Thursday 9-10 AM, or by arrangement.

Lecture Hours: MWF 2:05 - 2:55 PM; Dillman Hall 214
Course Website: http://www.cee.mtu.edu/~raswartz/CE5250/CE5250home.htm

Textbook: Subspace Methods for System Identification: Katayama (2010).

Course Description: This course it intended to introduce to the student the basic tools required for the process of system identification. The system identification process allows engineers to develop data-driven models mapping system inputs to measured outputs for systems that may be too complicated to model mechanistically or those with mechanistic models that require validation or refinement.

Prerequisites: Graduate standing. It is expected that all students understand (and are able to apply) general concepts from integral and differential calculus, linear algebra, statistics and probability, as well as partial differential equations as required during the course of an ABET accredited undergraduate degree in engineering.

Grading:

Homework Assignments (about 8)	40%
Exam (Midterm – Take home)	25%
Final Project	35%
Total	**100%**

Attendance: Attendance is required.

Exams: There will be one exam midway through the semester. The exam will be a take home exam with the duration and timing to be determined using input from the class.

Computing Policy: It is expected that students will have access to a computer running Matlab for homework assignments, the exam, as well as the final project.

Final Project: Students will complete a final project applying the system identification techniques learned in class to a topic selected by the student. In the course of the project, students will form models from data make observations about the models that they have made. Students will present their findings in a report. Topics may be drawn from existing research projects or other areas of interest to the student.

Homework: All homework will be collected on the date due. Homework may be turned in in-class or overnight under my office door (201D Dillman Hall). **Assignments should be written neatly and legibly. Begin each new problem on a new page. Supporting work and Matlab code is necessary to receive credit.** Detailed assignment guidelines specific to each homework set will be distributed via the course website.

Scheduling of the Final Exam: There is no final exam for this course.

Collaboration Policy: Collaboration on homework sets is encouraged. Multi-student homework collaborations (*i.e.*, a single solution set submitted for multiple students) will be accepted so long as the students represented agree to share the same grade for the assignment. Exams are to be strictly non-collaborative.

Course Email List: Dr. Swartz maintains an email list for CE5250 to share information he thinks may benefit the class on an *ad-hoc* basis. Dr. Swartz considers this information to be a supplement to the classroom experience, not a replacement for lecture attendance.

Final Grade Basis:

A 93 – 100	AB 87 – 92.9	B 83 – 86.9	BC 77 – 82.9
C 73 – 76.9	CD 67 – 72.9	D 63 – 66.9	F Below 63

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Course Objectives: After completing this special topics section, students should be able to:

- Describe the difference between signals and systems.
- Be able to describe signals and systems in the frequency domain.
- Understand the effect that sampling and quantization has on data.
- Describe input and output relationships and understand the role of process and measurement noise.
- Represent system relationships as discrete transfer functions and in state-space.
- Derive classical system ID models from data and understand how to interpret these models for system stability.
- Derive modern system ID models from state-space realizations, understand the relationship these models have to classical models, and understand how to interpret these models for input and output sensitivity as well as system stability.
- Time permitting, we will explore some student selected specialty topics in system identification.

CE 5250 Spring Semester 2012

<u>Core Course Topics:</u> .... **<u>Week:</u>**

1. Introduction to systems and signals: 1
    a. Linearity
    b. Time-variance
    c. Memorylessness
    d. Causality
    e. Block diagrams, delays, and noise
2. The frequency domain: 2-4
    a. Frequency representations of signals and systems
    b. Fourier Series and Fourier Transforms
    c. Sampling theory:
        i. Aliasing, quantization, and leakage
        ii. Sensor dynamics and filtering
    d. The Z-transform
3. Discrete-time transfer functions:.. 5
    a. Theory and interpretation
    b. Stability and bandwidth
4. State-Space models: 6-7
    a. Theory and interpretation
    b. Relationship to transfer functions
    c. Similarity transforms
    d. Stability and bandwidth
    e. Input/output sensitivity (controllability and observability)
5. Projection theory 8
6. Classical System ID models: 9-10
    a. AR/ARX/ARMA(X)
    b. Least squares and projection
7. Modern Subspace Realization (State-space) Methods.. 11-12

<u>Additional Topics (to be selected by students):</u> 13-14

1. Relationship to stochastic models
    a. Markov chains
    b. The Kalman filter
2. Non-linear system identification
3. Recursive filter least-squares
4. Search algorithms
5. 2D Fourier transforms
6. Wavelet analysis