Intelligent Structural Systems - An Introduction

A Dual-Level Class – Open to Senior (5397) and Graduate Students (7397)

Fall 2004

M, W 2:30 – 4:00 pm
Location: E312-D3

SYLLABUS

Instructor: Dr. G. Song, Associate Professor, Room N235
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Office Hours: 11:00-12:30pm, M. W., or by appointment

2004 Course Description prepared for Catalogue Data:
MECE 5397 or 7397: Intelligent Structural Systems - An Introduction, Cr. 3(3-0). Prerequisite: System Dynamics for 5397 and System Dynamics and Control System Design for 7397. This course exposes the rapid growing field of intelligent materials and structures, also often called smart materials and structures, to senior and graduate students and gives students necessary theoretic knowledge to design simple applications of smart materials and structures. This course will cover basics, modeling, design and control of smart structures using various smart materials such as piezo-ceramics, shape memory alloy, magneto-rheological (MR) fluid, fiber optic sensors, among others. Innovation and research oriented projects will be involved. Requirements will be different for undergraduate and graduate students.

Textbook or Course Materials: Intelligent Structural Systems - An Introduction, Song, class notes will be also available online via Blackboard.

Prerequisites by Topic:
1. Laplace transform
2. Transfer function and block diagram representation of a linear time invariant (LTI) dynamic system
3. First order LTI system and Second order LTI system
4. Root locus plot and Bode diagram
5. For 7393: Control design (lead, lag, or lag-lead compensators) based on root locus plot and control design based on Bode diagram

Topics: (each class is 80 minutes, two classes per week)
1. Course Description
2. Introduction
3. State-of-the-Art in Smart Materials & Structures (SM&S) Development
4. Dynamics and Controls Related Knowledge
5. Shape Memory Alloy Materials
6. Shape Memory Alloy Actuators
7. Civil Engineering Applications of Shape Memory Alloy Actuators
8. Introduction to Control Design for Shape Memory Alloy Systems
9. Introduction to Magneto-Rheological (MR) Fluid and its Engineering Applications
10. Designing with MR Fluids
11. MR Fluid Valve Design and Magnetic Circuit Design
12. Introduction to Modeling and Controller Design of MR Dampers
13. Basics about Fiber Optic Sensors
14. Engineering Applications of Fiber Optic Sensors
15. Basics about Piezoceramic Materials
16. Introduction to Vibration and Modal Analysis
17. Introduction to Finite Element Method
18. Finite Element Modeling of Piezoceramic Smart Structures
19. Introduction to Vibration Control Using Lead Compensators with PZT actuators
22. Introduction to Smart MEMS
23. Magnetic Shape Memory Materials

- The order of actual teaching may be different from the above sequence.
- Experimental demonstrations will be often used to assist teaching.

**Educational Objectives:**

Objective 1  Apply principles of engineering physics, mathematics, and dynamics systems to the smart structural systems. (A, B, C, D, E)

Objective 2  Integrate knowledge from lecture courses in physics, mechanics, and dynamics in understanding the behavior and control of practical dynamic systems involving smart materials (B, E).

Objective 3  To expose the rapid growing field of intelligent materials and structures, also often called smart materials and structures, to senior and graduate students (D, E)

Objective 4  To teach gives students necessary theoretic knowledge to design simple applications of smart materials and structures (A, B, C, D, E)

**Program Outcomes:**

1.1 Students will demonstrate the ability to identify major smart materials and their properties (a, e, k).
1.2 Students will demonstrate the ability to identify which smart material is suitable for an application as either a sensor or an actuator or both (a, e, k).
2.1 Students will demonstrate the ability to represent some smart (intelligent) structural systems in physical/mathematical terms (a, c, e).
3.1 Students will demonstrate the ability to use these new materials in innovative ways (a, e, j, k).
4.1 Students will demonstrate the ability to design some basic applications using smart materials (e, h, k).

**Reference Books:**


Reference Journals:

Other References:

Evaluation:
FINAL GRADE will be comprehensive, but mainly depends on your performance in the exams, projects, quizzes, and homework.

NOTES:
• Requirements will be different for undergraduate and graduate students.
  - Prerequisites for undergraduate student: System Dynamics (or equivalent)
  - Prerequisites for graduate student: System Dynamics (or equivalent) and Control System Design (or equivalent)
• Matlab/Simulink is required for this course.
• All project reports should be professionally presented and hand in on time.
• All project reports should be typed using a computer word processor and all associate drawings should be done using a software.
• Both hard copy and electronic copy of project reports should be handed in.

Department’s Undergraduate Program Educational Objectives are to produce graduates with the abilities to:
A. apply knowledge of mathematics, science and engineering,
B. integrate knowledge in the practice of engineering
C. function successfully as an engineer in a professional environment,
D. function as an informed citizen and a conscientious engineer in society, and
E. secure employment or placement after graduation.

The Department’s Undergraduate Program Outcomes expect all graduates receiving the BSME degree to have:

a. an ability to apply knowledge of mathematics (through multivariable calculus and partial differential equations), science, and engineering;
b. an ability to design and conduct experiments, as well as to analyze and interpret data;
c. an ability to design and system, component, or process to meet desired needs;
d. an ability to function on multi-disciplinary teams;
e. an ability to identify, formulate, and solve engineering problems;
f. an understanding of professional and ethical responsibility;
g. an ability to communicate effectively;
h. the broad education necessary to understand the impact of engineering solutions in a global and societal context;
i. a recognition of the need for, and the ability to engage in, life-long learning;
j. a knowledge of contemporary issues;
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice;
l. a basic knowledge of chemistry and a knowledge of calculus-based physics;
m. a familiarity with statistics and linear algebra;
n. an ability to work professionally in both thermal and mechanical systems including design and fabrication of such systems; and
o. the ability to move up to their next professional opportunity.

1 Upper case letters in ( ) refer to Department’s Undergraduate Program Educational Objectives
2 Lower case letter in ( ) refer to Department’s Undergraduate Program Outcomes