ME 260W – Measurement Techniques

Catalog Description:

Theory and practice of measurement including analysis and application of electromechanical transducers. Methods of measuring stress, strain, pressure, force, displacement and frequency. The determination of the phase relation between a driving potential and the response of a system. The application of statistical methods to analysis of experimental data.

Prerequisites:

- ECE 220 – Electrical and Computer Engineering Principles

Texts:

- Required Text: Measurement and Data Analysis for Engineering and Science, Patrick Dunn, McGraw Hill Companies, 2005.
- Reference Text: *Theory and Design for Mechanical Measurements*, by R.S. Figliola and D.E. Beasley, 2nd Edition, John Wiley and Sons, 1995.
- Reference Text: *Mechanical Measurements*, by T.G. Beckwith, R.D. Marangoni, and J.H. Lienhard V, 5th Edition, Addison-Wesley Publishing Company, 1993.
- Reference Text: *Introduction to Engineering Experimentation*, by A.J. Wheeler and A.R. Ganji, Prentice Hall, 1996.

Course Objectives:

The course provides students with a fundamental knowledge of the concepts involved in measurement techniques and data analysis. The structure entails hands-on experiments in which students apply these concepts to practical measurements of mechanical quantities including: displacement, strain, acceleration, force etc. In this course, students will be able to conduct multiple labs using state-of-the-art facilities, such as piezoelectric actuators, shakers, piezoelectric force transducers, accelerometers and data acquisition computers. In parallel, numerical/analytical models are developed and their predictions are used to compare with the experimental findings. As such, the students learn to interpret the measurements in terms of the fundamental physics of the system. This course also provides students with an opportunity for teaming in the execution of the labs. In addition, students learn to write scientific reports based on their experimental/analytical studies.

Topics:

- Visual interface construction using LabVIEW software
- Principles of strain gages and strain measurement
- Time response of first order systems, theory and experiments
- Time response of second order systems, theory and experiments
- Piezoelectric positioning drive
- Design of experiments
- Statistics (including gaussian distribution, confidence intervals, linear regression and T-Distributions)

Design Projects: There is one Experimental Design project in this class, which requires students to (i) develop the test apparatus, (ii) develop the sensing techniques, (iii) validate the system, and (iv) take and interpret final data. The entire class is given the same overall design parameters but each group is expected to develop their own design solution.

Computer Use:

Students are required to conduct data acquisition based on LabVIEW software. All lab reports are typed. All figures are generated by computer and must be embedded into the final report. Modeling activities may require the use of software packages such as MATLAB.

Evaluation Methods:

Homework, Lab Reports, Midterm Exam, Final Exam

Contribution to Professional Component:

Measurement Techniques draws on fundamental knowledge gained from other courses in the areas of mathematics, physics, mechanics, materials and modeling of dynamic systems, to conduct experiments and interpret the experimental data. This course introduces the basic concepts involved in measurements using modern instrumentation and provides a mechanism for the students to gain hands-on experience in the use of various measurement equipment.

Relationship of Course Objectives to Program Educational Objectives:

As an intermediate course, Measurement Techniques emphasizes abilities and skills leading to the fulfillment of Program Educational Objective #1: "our alumni practice mechanical engineering by designing systems and solving problems using mathematical, scientific and engineering principles and tools," and Program Educational Objective #2: "our alumni approach engineering decisions with an informed consideration of global and societal contexts and consequences."

Relationship of Course Objectives to ABET 3a-k:

a) an ability to apply knowledge of mathematics, science, and engineering:
This course emphasizes the student's ability to apply their knowledge in mathematics, strength of materials and dynamics to the experimental phenomena associated with the indicated topics. The students are expected to utilize energy principles, Newton's 2nd Law, statistics and differential equations as applied to mechanical systems.

b) an ability to design and conduct experiments, as well as analyze and interpret data:
Students are heavily engaged in conducting experiments and performing the associated analysis of the experimental data. In addition, they are required to construct simple analytical models of all experiments and develop physical insight to the response of the systems.

c) an ability to design a system, component, or process to meet desired needs: *Students' final experiment involves designing an experiment and conducting tests.*

d) an ability to function on multi-disciplinary teams: *not applicable*

e) an ability to identify, formulate, and solve engineering problems:
In this course students perform the experiments, analyze the associated data, identify the fundamental system model, analyze the model and compare the response of the model to the response of the experiment.

f) an understanding of professional and ethical responsibility: *not applicable*

g) an ability to communicate effectively:
Students are engaged in written communication through laboratory reports. This aspect is taken into account in grading all reports and exams.

h) the broad education necessary to understand the impact of engineering solutions in a global and societal context: *not applicable*

i) a recognition of the need for, and an ability to engage in life-long learning:
The need for life-long learning is emphasized with respect to new instrumentation, modern digital data acquisition systems and the continual enhancement of the laboratory to include up to date equipment.

j) a knowledge of contemporary issues: *not applicable*

k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice:

Students learn to use modern data acquisition techniques necessary in experimental research.

Relationship of Course Objectives to Course Outcomes:

1) Students will be able to mount strain gages and use them to obtain measurements of strain and stress.
2) Students will be able to construct a wheatstone bridge of various configurations and calculate the sensitivity coefficient of the configuration.
3) Students will be able to model a 1st order dynamic system, identify its mechanical characteristics, and interpret its response characteristics.
4) Students will be able to work with a DC servo-motor and analyze its dynamic features (motor torque constant, viscous damping, inertia etc.).
5) Students will be able to model a 2nd order dynamic system, identify its mechanical characteristics, and interpret its response characteristics.
6) Students will be able to experimentally describe the dynamic characteristics of a compound pendulum (including its center of mass, the moment of inertia, pin friction etc.).
7) Students will be able to use regression techniques to find best fit curves through data.
8) Students will be able to analyze data using statistical methods including Gaussian distributions, T-distributions, confidence intervals etc.
9) Students will be able to write a clear and complete technical report describing an experiment and the results.

Approval Block:

Prepared by: Bi Zhang, January 2007
Reviewed by: Kevin Murphy, January 2007
Revised by: Bi Zhang, January 2007
C&C Approval: N. Olgac, June 2007
Dept. Head Approval:  B. Cetegen, June 2007