EMET 330 – Measurement Theory and Instrumentation

Standard Course Outline (Updated – Fall 2005)

Catalog Description:	**330: Measurement Theory & Instrumentation** (3 Credits). Fundamentals of measuring, transmitting, and recording temperatures, pressure, flow, force, displacement, and velocity; laboratory component emphasizes systems used in manufacturing. Course Prerequisites: EMET 320 or EET 216; and EMET 322 or MET 206; Concurrent: Math 250
Goals of the Course:	**Measurement Theory & Instrumentation** is a required course for junior-level students who enter the Electro-Mechanical Engineering Technology (EMET) baccalaureate degree program. The purpose of this course is to teach students the fundamental concepts, principle, procedures, and computations used by engineers and technologists to analyze, select, specify, design, and maintain modern instrumentation and control systems. Students will gain a sound understanding of the language used to describe modern instrumentation, measurement, and control systems and an appreciation of the various types of systems in common use in industry. Particular emphasis will be given to electrical, mechanical, flow, and thermal measurement systems. The course will also cover statistical tests to evaluate quality of measurements, standard methods of characterizing measurement results, and methods for characterizing measurement system response. Finally, the course will provide a sound understanding of the important characteristics of a range of modern process sensors, transmitters, and signal conditioning equipment.
Relationship to EMET Program Outcomes:	EMET 330 contributes to the following EMET program outcomes: • Students should be able to identify, analyze, and solve technical problems related to integration of electrical, mechanical, instrumentation, computers, and control components to perform industrial and manufacturing functions. (Outcome 1) • Students should be able to apply concepts of calculus, differential equations, and probability and statistics to the design and analysis of electromechanical systems. (Outcome 2) • Students should be able to plan and conduct experimental measurements, use modern test and data acquisition equipment, and be able to analyze and interpret the results. (Outcome 3) • Students should be able to apply electrical, electronic, and mechanical devices; computers; and instrumentation systems to the development, operation, troubleshooting, and maintenance of electromechanical systems. (Outcome 4) • Students should be able to effectively communicate their ideas and solutions orally, in writing, and graphically. (Outcome 10)
Course Outcomes:	The specific course outcomes supporting the program outcome are presented below (numbers in parentheses refer to specific course assessment methods used for measurement of these course outcomes): <u>OUTCOME 1:</u> • Students will be able to correctly predict the key performance characteristics of commonly used sensors such as resistive devices, RTDs, thermistors, thermocouples, variable inductance/reluctance devices, semiconductor based sensors, and piezoelectric devices using standard component models and assumptions. (Assessment methods 1&3) • Students will be able to correctly predict the key performance characteristics of signal conditioning equipment such as ballast circuits, voltage divider circuits, and voltage and current sensitive bridge circuits using standard component models and assumptions.

	(Assessment methods 1 & 3) OUTCOME 2: • Students will be able to correctly calculate the quality of their measurements including concepts of data error, propagation of uncertainty, data samples and data populations using standard statistical methods including Gaussian, ^{2} , Student’s-t distributions, confidence intervals, standard deviations, and uncertainty analysis. (Assessment methods 1 & 3) • Students will be able to correctly calculate a system’s amplitude, frequency, and phase response using standard methods of frequency spectrum and harmonic Fourier analysis.. (Assessment methods 1 & 3) OUTCOME 3: • Students will be able correctly set up and test/analyze the performance of commonly used sensors and signal conditioning equipment using standard laboratory test equipment. (Assessment method 2) • Students will be able to correctly acquire, interpret, and synthesize laboratory data to characterize sensor/signal conditioning circuit performance in accepted standard forms. (Assessment method 2) OUTCOME 4: • Students will be able to correctly apply temperature, displacement, pressure and flow sensors to the design and operation of electromechanical systems using standard electrical and electromechanical models. (Assessment methods 1,2, & 3) • Students will be able to correctly apply signal conditioning circuits, including ballast circuits, voltage divider circuits, and voltage and current sensitive bridge circuits, to the design and operation of electromechanical systems using standard circuit models. (Assessment methods 1,2, & 3) OUTCOME 10: • Students will be able to correctly prepare high quality written reports that document laboratory investigations of sensors, transmitters, and signal conditioning systems. (Assessment methods 2) • Students will be able to correctly prepare high quality graphical and tabular presentations based on the appropriate data analysis and synthesis of data taken from laboratory experiments with sensors commonly encountered in industry. (Assessment method 2)
Suggested Texts:	The following are suitable texts and/or references for this course: Beckwith, et. al., Mechanical Measurements, Addison Wesley (distributed by Prentice-Hall) Doebelin, Measurement Systems; Application and Design, McGraw-Hill Figliola & Beasley, Theory and Design for Mechanical Measurements, Wiley Keithley, Low Level Measurements Handbook, Keithley Instruments, Inc. Klaassen, Electronic Measurement and Instrumentation, Cambridge Press Bateson, Introduction to Control Systems Technology, Prentice-Hall Bishop, Learning with LabView, Prentice-Hall

Prerequisites by Topic:	• Satisfactory completion of basic circuits and basic electronics courses. • Concurrent study of concepts and applications of ordinary differential equations. • Ability to use a computer to analyze complex analytical problems using standard analytical software such as Excel, Mathcad, Matlab, etc. • Ability to use a computer to prepare written reports and to perform basic data reduction, graphing, and engineering data presentation.
Course Topics:	Coverage times shown in parentheses are <u>suggestions</u> only *Note – One hour as indicated here represents one 50-minute class.* 1. Concepts of data error, measurement uncertainty, data samples and data populations. (2 hours) 2. Curve fits, harmonics, frequency spectrum, sampling, and Fourier representations. (3 hours) 3. Amplitude, frequency, phase response, system delays, & rise time; 1^{st} and 2^{nd} –order systems. (3 hours) 4. Sensors & transducers: Resistive devices; RTDs, thermistors, & thermocouples; variable inductance/reluctance devices; semiconductor devices; & piezoelectric devices. (3 hours) 5. Signal conditioning, voltage- and current-sensing circuits, bridge circuits. (2 hours) 6. Resonant circuits, impedance matching, A/D and D/A conversion. (3 hours) 7. Temperature measurement systems. (3 hours) 8. Pressure and force measurement systems. (3 hours) 9. Flow measurement systems. (3 hours) 10. System modeling techniques, control block methods, & basics of Laplace transforms. (6 hours)
Computer Use:	Students are expected to use computers to perform lab predictions and analyses, to prepare lab reports, and to conduct out-of –class assignments. Computers will be used to analyze lab data, prepare engineering graphs for reports, and perform analytic studies of typical electronic circuits. Knowledge of word-processing, spreadsheet, and analysis software (i.e., Excel, MathCad, Matlab, PSpice, Electronics Workbench, MicroCap, etc.) is required.
Laboratory Exercises:	Typical laboratory exercises should include the following: 1. Lab orientation and safety procedures 2. Variable resistance transducers 3. Strain gage transducers 4. Bridge circuits 5. Variable capacitance transducers 6. Variable reluctance/inductance transducers 7. Thermocouples 8. Thermistors 9. Optional laboratory projects prepared at the discretion of the instructor
Required Equipment:	The following is the minimum equipment required to conduct the course: • Dual trace oscilloscope • Digital multimeters • Adjustable, multi-output DC power supplies • Adjustable frequency generators • Appropriate transducers and sensors • Suitable prototyping boards or electronic trainers
Course Grading:	Course grading policies are left to the discretion of the individual instructor.
Library Usage:	Students should be encouraged to use library technical resources in the preparation of laboratory.

Course Assessment:	The following may be useful methods for assessing the success of this course in achieving the intended outcome listed above: 1. Traditional exams covering lecture material 2. Comprehensive laboratory based sensor/signal conditioning system characterization tests analyzed and documented in written reports *3.* Graded assignments which support outcomes
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