



Course Syllabus: Experimental Methods in Research - DSP - ERPE 370

Division	Physical Science and Engineering Division
Course Number	ERPE 370
Course Title	Experimental Methods in Research - DSP
Academic Semester	Fall
Academic Year	2018/2019
Semester Start Date	08/26/2018
Semester End Date	12/11/2018
Class Schedule (Days & Time)	04:00 PM - 06:00 PM Sun Thu

Instructor(s)

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Teaching Assistant(s)

Name	Email

Course Information

Comprehensive Course Description	Experimental methods are reinforced and gain a new role in research following the IT-sensor revolution. The course is divided into 8 interrelated units. (1) The experimentalist: guiding principles and cognitive issues. (2) Theoretical concepts in experimental design: measurement theory. (3) Preliminary design of experiments: statistics, dimensional analysis, models. (4) Devices: cells and instrumentation, boundary conditions, sensing concepts, instruments, transducer, electronics. (5) Conducting the tests. (6) Complimentary analytical and numerical tools: signal processing, regression and inversion. (7) Advanced testing technologies. (8) Reporting and presentation.
Course Description from Program Guide	(1) The experimentalist: guiding principles and cognitive issues. (2) Theoretical concepts in experimental design: measurement theory. (3) Preliminary design of experiments: statistics, dimensional analysis and models. (4) Devices: cells and instrumentation, boundary conditions, sensing concepts, instruments, transducer, electronics. (5) Conducting the tests. (6) Complimentary analytical and numerical tools: signal processing, regression and inversion. (7) Advanced testing technologies. (8) Reporting and presentation.
Goals and Objectives	To explore the role of experimentation in knowledge generation, through the design and execution of experimental programs using classical and advanced experimental tools and instrumentation.
Required Knowledge	Requirement You must take and pass (go to blackboard): -HSE 100: Laboratory Safety Training -HSE 101: Hazardous Waste Training -HSE 114: Emergency Incident Preparedness
Reference Texts	Collection of papers and essays Literature: -Santamarina and Fratta – Signals and inverse problems (pdf) -Class notes
Method of evaluation	30.00% - Homework /Assignments 70.00% - Course Project(s)

Nature of the assignments	-Homework. All assignments due Sunday the following week. -Project - Exploratory experimental study (teams of 1 or 2)
Course Policies	Honor Code -This course will be conducted under the guidelines of KAUST's Academic Honor Code. -Cheating of any kind is unethical and unacceptable. -Plagiarism: Do not cut-and-paste any part of your homework or lab reports. Quote and attribute any words that are not your own. -Wireless communication system of all kinds must be turned off while in the classroom and during laboratories.
Additional Information	<u>Syllabus changes</u> The instructor reserves the right to make changes to this syllabus as necessary. <u>Lab Rules</u> General -Leave the laboratory cleaner than you found it. -Return all components where you found them. -Do not remove any device (equipment, tools, etc.) from a laboratory without explicit consent from the Faculty in charge of that laboratory. -Dispose all waste as prescribed in KAUST's safety guidelines. -Be kind to equipment and devices. Costs are prohibitive. Yet, if something breaks, do not hesitate to let us know so we can fix it or replace it (glassware, equipment, hoses, etc.). -Do not leave equipment running unattended. -All devices have manuals for proper usage. REVIEW manuals before using devices ! Safety -You must wear shoes at all times. -Be extra careful with high energy systems (transmission lines, power engines, compressors, cells which are pressurized). -Many devices combine electrical sensors with water-based testing. Water (with electrolytes - always the case) conducts electricity. -Chemicals: read MDS sheets on how to handle and how to dispose of them. Follow instructions carefully. In case of doubt ask us. -Do NOT run tests alone. In case of an accident, a second person must be there to take action. IN CASE OF DOUBTS OR CONCERNS ASK US !!

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Sun 08/26/2018	Preview. Historical developments. Great historical experiments. The relative roles of experimental research and analytical/numerical modeling and simulation. Identifying the space for experimentation. Measurement in research and practice (standardized testing). Direct & indirect, active & passive, intrusive & non-intrusive, destructive & non-destructive measurements.
1	Thu 08/30/2018	Guiding Principles. Literature review. Elegance. Simplicity. Robustness. Order. Documentation. Safety.
2	Sun 09/02/2018	Cognitive Issues. Mental models. Preconception in perception. Human biases. Interactive perception. Creativity in experimental research. Pathological science.
2	Thu 09/06/2018	Conceptual Issues in Experimental Research. Research questions: why & how. The scientific method. Pre-existence of models about material behavior. Measurement and measurand. Uncertainty. Energy. Popper & Carnap. Exploratory experimental research. Pre-testing hypotheses with published data.
3	Sun 09/09/2018	Measurement Theory. Measurables. Conceptual and operational definitions. Standards. Axioms.
3	Thu 09/13/2018	Statistics – Experimental Design. Errors: sources, classification, correction, statistics. Precision and accuracy. The central limit theorem. Multifactorial design of experiments. Sampling and scale effects.
4	Sun 09/16/2018	Statistics – Experimental Design (continued). Errors: sources, classification, correction, statistics. Precision and accuracy. The central limit theorem. Multifactorial design of experiments. Sampling and scale effects.
4	Thu 09/20/2018	Dimensional Analysis. Buckingham's Similarity. Scale effects and boundary effects in laboratory experiments and models.
5	Sun 09/23/2018	Experiments and Models. Analogies. 1g and geotechnical centrifuge modeling. Simple tests with variable isolation vs. complex multivariate testing. Magnification of effects; enhancing the experiment.
5	Thu 09/27/2018	Experiments and Models (continued). Analogies. 1g and geotechnical centrifuge modeling. Simple tests with variable isolation vs. complex multivariate testing. Magnification of effects; enhancing the experiment.
6	Sun 09/30/2018	Boundary Conditions. Load vs. deformation control. Long term and accelerated testing (Arrhenius activation energy).
6	Thu 10/04/2018	Sensing Concepts. History: The senses and the brain (capacity and limitations). Coupled phenomena: Mecano-electro (piezoelectricity, induction, resistivity, thermocouples). Thermo-electric, Chemo-electric.
7	Sun 10/07/2018	Sensing Concepts (continued). History: The senses and the brain (capacity and limitations). Coupled phenomena: Mecano-electro (piezoelectricity, induction, resistivity, thermocouples). Thermo-electric, Chemo-electric.
7	Thu 10/11/2018	Instruments. Mechanical transducers: material and form (spring, proving ring, pressure loop), thermoelasticity (thermometers), resonance (vibrating wires). Electrical transducers: resistance (strain gauges, thermistors), induction (LVDT), capacitance (proximeters), piezoelectricity (crystals and ceramic), pyroelectricity (thermocouples), other coupled-energy sensing systems. Optical transducers (photography; fiber optic based systems; microscopy). Magnetic transducers.
8	Sun 10/14/2018	Instruments (continued). Mechanical transducers: material and form (spring, proving ring, pressure loop), thermoelasticity (thermometers), resonance (vibrating wires). Electrical transducers: resistance (strain gauges, thermistors), induction (LVDT), capacitance (proximeters), piezoelectricity (crystals and ceramic), pyroelectricity (thermocouples), other coupled-energy sensing systems. Optical transducers (photography; fiber optic based systems; microscopy). Magnetic transducers.
8	Thu 10/18/2018	Transducer Response. Performance (dynamic response, drift, hysteresis, linearity, range, resolution, precision, accuracy). Transfer function (energy and energy coupling).
9	Sun 10/21/2018	Transducer Response (continued). Performance (dynamic response, drift, hysteresis, linearity, range, resolution, precision, accuracy). Transfer function (energy and energy coupling).
9	Thu 10/25/2018	Peripheral electronics. A/D converters. Scopes. Filters. Amplifiers. Signal analyzers. Computerization. Performance. Transfer function. Drivers and controllers.
10	Sun 10/28/2018	Mid Semester Break - No Class
10	Thu 11/01/2018	Peripheral electronics (continued). A/D converters. Scopes. Filters. Amplifiers. Signal analyzers. Computerization. Performance. Transfer function. Drivers and controllers.
11	Sun 11/04/2018	Cell/Chamber Design. Mechanical, electrical, thermal, chemical, biological considerations. Codes.

11	Thu 11/08/2018	Implementation. Test sequencing. Safety. Order. Noise control (mechanical, electrical, thermal, chemical, biological). The power of observation.
12	Sun 11/11/2018	Analysis.
12	Thu 11/15/2018	Signal Processing. A/D sampling. Aliasing. Signal-to-noise ratio. Time and frequency analyses. Guidelines for proper signal capture and storage.
13	Sun 11/18/2018	Signal Processing (continued). A/D sampling. Aliasing. Signal-to-noise ratio. Time and frequency analyses. Guidelines for proper signal capture and storage.
13	Thu 11/22/2018	Signal Processing (continued). A/D sampling. Aliasing. Signal-to-noise ratio. Time and frequency analyses. Guidelines for proper signal capture and storage.
14	Sun 11/25/2018	Regression Analyses – Inversion. Information: content in the data, distribution, preservation. Noise magnification. Theory. Ockham's criterion. Error driven solution. Test design for optimal inversion.
14	Thu 11/29/2018	Numerical methods.
15	Sun 12/02/2018	Advanced Testing Technologies. Wave-based techniques: IR sensors, optical (microscopy, photography), interferometry (lasers, fiber optics, holography), X-rays (plates, diffraction), scanning electron microscopy, pulse and resonance of stress waves. Computerized techniques: CAT scan, sonogram, magnetic resonance imaging, positron emission tomography. Dopplermeters.
15	Thu 12/06/2018	Documentation - Data Reduction - Presentation. The lab book. Reports. Data plotting and presentation. References. Handbook of material parameters. Plagiarism. Presentation of research results.
16	Sun 12/09/2018	Project Presentations: 2 PM to 6 PM

Note

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