Course Title
Instrumentation and Sensing

Course Prefix and Number
EE519

Course Description
Introduction to instrumentation and sensing of the physical world from the electrical engineering perspective. The focus is on low-cost, low-power short and long range wireless sensing and monitoring techniques. Topics include small-signal electronics for interconnecting deployable sensors to analog and digital signal processing hardware, system noise floor and dynamic range, practical implementation of wireless systems with ultra low power and long life battery systems. The course progresses from sketched design of a new instrumentation and sensing system through working prototype hardware in ten weeks. This compressed schedule from concept through deployment provides a foundation for quick-turn application of graduate level engineering fundamentals to real world problems, as practiced in experimental research and industrial research and development.

Prerequisites
None

Course Objectives
The objective of this course is to immerse graduate students in a rapid research and development environment in which new and prior learning in small-signal electronics, wireless communications, signal processing theory and practice, and energy budgets are applied to solving a particular environmental sensing problem. Each class focuses on a different current problem, which introduces students to the need for creative design based on a foundation of textbook fundamentals. Upon completion, each student will have made a significant contribution to the project and their own personal portfolio.

Student Learning Outcomes
1. Ability to sketch an electronic instrument block diagram for sensing a measurable quantity
2. Divide a sketched design into small signal, wireless connection, and signal processing blocks
3. Ability to design a dc power system, including power budget, batteries, energy harvesting
4. Sketch, design and construction techniques for prototype deployable packages
5. Ability to rapidly progress from sketch to detailed design and on to practical working hardware
6. Ability to extract and record useful information from raw signals received from sensors

Course Outline
Week 1
- Introduction and block diagrams of instrumentation system
- Define a specific instrumentation and sensing problem
- Discover talent and interest within the class
- Divide up the problem into tasks that may be completed on the aggressive schedule necessary to deploy hardware the tenth week of the quarter.

Week 2
- Sketch hardware and software block designs
- Divide class into project teams
Week 3
- Detailed electronic designs, including input from sensors and output to signal processing
- Details of wireless link--design if necessary
- Detailed prototype deployable package design
- Detailed signal processing strategy

Week 4
- Presentation and critique of electronic, package, wireless, and signal processing plans
- Outline catalog of topics for midterm exam

Week 5
- Begin prototype construction:
  - Electronic breadboards--circuit boards
  - Package hardware
  - Signal processing software

Week 6
- Evaluation using comprehensive midterm and individual project contribution reports

Week 7
- Complete first-pass instrumentation and sensing prototype integration
- Identify problems to fix

Week 8
- Address all issues identified

Week 9
- Deploy hardware--first attempt

Week 10 and Final
- Collect data and prepare final report--2nd attempt at deployment

Course Requirements
Class will meet for 2 sessions of 2 hours each week. Class meetings will include lectures on the engineering fundamentals needed for the tasks on hand, progress reports, and problem solving sessions. Class attendance and participation are expected and essential. Grades will be based on individual written design contributions, a mid-term exam during the 6th week, and individual contributions to successful, deployed instrumentation and sensing hardware in the final week.

Text and Reading List
There is no required text. A reading list will be provided by the instructor the first week of class, including materials that apply to individual blocks in the complete instrumentation and sensing system being developed during that academic year.

Method of Evaluation
This course may be taken for letter grade only. Relative weighting of individual student design project reports, the mid-term exam, hardware contributions, and contribution to the final deployed instrumentation and sensing system may vary by instructor. A typical weighting is as follows:

- Design report 20%
- Midterm 30%
- Hardware contribution 30%
- Final prototype contribution 20%