Summer 2008

INTRODUCTION TO SENSORS AND ACTUATORS

This course is an elective and will be offered as an undergraduate/graduate class. If you require a more detailed outline or any additional information, please send me an e-mail (ida@uakron.edu), call me at 330-972-6525 or download it from http://ee.ascs3.uakron.edu/ida/

Undergraduate Class Number: 32859
Course: 4400:490-381, Intro: Sensors and Actuators
Period: 6/23/08 – 8/16/08
Time: 5:10 PM – 7:45 PM, Monday and Wednesday
Location: Knight 321
Credits: 3
Prerequisites: Senior standing or permission.

Graduate Class Number: 32376
Course: 4400:693-381, SP: Electrical Engineering – Introduction to Sensors and Actuators
Period: 6/23/08 – 8/16/08
Time: 5:10 PM – 7:45 PM, Monday and Wednesday
Location: Knight 321
Credits: 3
Prerequisites: None.

Taught by: Nathan Ida, Electrical and Computer Engineering

Breadth and Depth for undergraduate students taking this class as an elective:
Electrical Engineers:
Breadth requirements – This course is listed under Controls and Communication (CC)
Depth Requirement – Sequence with 4400:470 Microprocessor Interfacing

Computer Engineers:
Breadth requirements – This course is listed under Hardware (HW)
Depth Requirement – This course is a sequence in itself (it satisfies the breadth requirement by itself)

A complete outline and some additional information is available at
http://ee.ascs3.uakron.edu/ida/
Click on the sensors button and download or view the course outline

To register: please see or call Gay at 330-972-7649

Rationale:

Almost any modern electrical or electromechanical system includes sensors as inputs and actuators as outputs. These may be as simple as a microphone and a speaker in a public address system or more complex such as a car with temperature, pressure, speed, position and chemical sensors and various valves, electric and vacuum motors, as well as other types of actuators.
It is therefore important that engineering students have a firm understanding of the various strategies for sensing and actuating as well as knowledge of the classes of sensors and actuators available, their properties, manufacturing and the theory behind them. This need has been further accentuated with the introduction of the Senior Design sequence, which has shown that almost all designs have to specify and implement sensors and actuators as well as to interface these to amplifiers drivers and microprocessors.

The present course fulfils these needs by providing an introduction to sensors and actuators based on the various sensing and actuating strategies. Topics included are classification of sensors and actuators, materials and manufacturing, sensitivity analysis, strategies for measurement and interfacing as well as discussion of specific sensors and actuators.

Although this course addresses specific needs in the electrical and computer engineering curricula, it is also relevant to other engineering disciplines including Mechanical Engineering, Biomedical Engineering, Civil Engineering and Chemical Engineering.

Textbooks:
Required: None
Recommended:
J. Fraden, "AIP Handbook of Modern Sensors, Physics, Designs and Applications," American Institute of Physics.
C.W. de Silva, "Sensors and Actuators, CRC Press,

Course Topics:

1. **Introduction**
2. **Performance Characteristics of Sensors and Actuator**
3. **Optical sensors**
4. **Temperature Sensors**
5. **Magnetic and Electromagnetic Sensors and Actuators**
6. **Mechanical Sensors**
7. **Acoustic Sensors and Actuators**
8. **Chemical Sensor**
9. **Radiation Sensors**
10. **Additional Topics (emerging technologies)**
11. **Interfacing Methods and Circuits**
12. **Interfacing to Microprocessors:**

Additional details on the topics above:

1. Introduction
(Classification of sensors and actuators, sensing and actuating strategies, general requirements for interfacing and actuation, sensing, transduction, actuation)

2. Performance Characteristics of Sensors and Actuators
(Input/output characteristics, accuracy, errors, repeatability, sensitivity analysis, hysteresis, nonlinearity, saturation, frequency response, dynamic characteriostics, calibration, resolution, excitation, impedance, applications)

3. Optical sensors:
(Photodiodes, phototransistors and photoresistors based sensors, Photomultipliers, light-to-light detectors, Intrared sensors (thermal, PIR, AFIR, thermopiles), CCD sensors and detectors)

4. Temperature Sensors:
(Thermoresistive sensors: Thermistors, Resistance temperature sensors, Silicon resistive sensors, Thermoelectric sensors, PN junction temperature sensors, Optical and acoustic temperature sensor

5. Magnetic and Electromagnetic Sensors and Actuators:
(Motors as actuators (linear, rotational, stepping motors), magnetic valves, inductive sensors (eddy current, LVDT, RVDT, Proximity), Hall effect sensors, Magnetoresistive sensors, Magnetostrictive sensors and actuators, Magnetometers (fluxgate, search-coil, Squid), Voice coil actuators (speakers and speaker-like actuators), Electrorheological and magnetorheological actuators, Bolometers (microwaves))

6. Mechanical Sensors:
(Accelerometers (capacitive, piezoelectric, piezoresistive, thermal), Force sensors (strain gauges, tactile sensors), Pressure sensors (semiconductor, piezoresistive, capacitive, VRP), Gyroscopes (mechanical, optical, fiber-optics))

7. Acoustic Sensors and Actuators:
(Ultrasonic sensors (piezoelectric, electromagnetic), Piezoelectric actuators, Piezoelectric resonators, Microphones, hydrophones, speakers, buzzers)

8. Chemical Sensor:
(Electrochemical, Thermo-chemical, ChemFET, Gas, pH, Humidity, moisture and Optical-chemical sensors)

9. Radiation Sensors:
(Ionization detectors, Scintillation detectors, Geiger-Mueller counters, Semiconductor radiation detectors, Microwave sensors (resonant, reflection, transmission), Antennas as sensors)

10. Additional Topics
(Micro-Electro-Mechanical (MEMs) Sensors and Actuators, Smart sensors, ASIC based sensors, Wireless Sensors and Issues Associated with Wireless Sensors, Sensor Arrays)

11. Interfacing Methods and Circuits:

(Amplifiers: operational amplifiers, power amplifiers, A/D and D/A converters, Bridge circuits, Interfacing to microprocessors, Data transmission, Excitation methods and circuits, Power requirements, Signal translation, Isolation, Noise, Interference, Compensation (temperature, drift, etc.))

12. Interfacing to Microprocessors:

(General requirements for sensors and actuators, Input signal conditioning (offset, scaling, isolation, hysteresis, etc.), Output signals (level, power, isolation, etc.), Driving metods (direct, PWM), Errors (A/D and D/A))

Bibliography:

1. J. Fraden, "AIP Handbook of Modern Sensors, Physics, Designs and Applications," American Institute of Physics.
2. C.W. de Silva, "Sensors and Actuators, CRC Press,
3. A. D. Khazan, "Transducers and their Elements," Prentice Hall.
4. R.S. Muller and T.I. Kamins, "Device Electronics for Integrated Circuits," John Wiley & Sons.
5. S.M. Sze, "Physics of Semiconductor Devices," newest version.
6. S.M. Sze, "Semiconductor Sensors," John Wiley & Sons.
7. L. Ristic, "Sensor Technology and Devices," Artech House, Inc.
8. R. Seippel, "Transducers, Sensors and Detectors," ,Reston Publishing Company.
9. "Microsensors," Eddited by RS. Muller, R. Howe, etc., IEEE Press.
10. A.S. Grove, "Physics and Technology of Semiconductor Devices," John Wiley & Sons.
11. H.F. Wolf, "Semiconductors," John Wiley & Sons Inc.