Summer 2017

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

Undergraduate Class Number: 31032
Course: 4400:469-381, Intro: Sensors and Actuators
Period: **6/12/17 – 8/6/17**
Time: **10:00 – 11:35** *
Location: **LH 307** *
Credits: 3
Prerequisites: Senior standing or permission.

- **See: Mode of delivery**

Graduate Class Number: 31856
Course: 4400:598-381, ST: Electrical Engineering – Seminar: Introduction to Sensors and Actuators
Period: **6/12/17 – 8/6/17**
Time: **10:00 – 11:35** *
Location: **LH 307** *
Credits: 3
Prerequisites: None.

- **See: Mode of delivery**

Taught by: Nathan Ida, Electrical and Computer Engineering
Office Hours: See method of delivery.

Breadth and Depth for undergraduate students taking this class as an elective:
Electrical Engineers:
Please see the current EE list, available in the EE office or from your advisor.

Computer Engineers:
Please see the current CpE list, available in the EE office or from your advisor.

The class 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: **N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.**

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,

Note: The two books listed here are general purpose books and are quite good but I do not recommend you buy these books. I will follow the material in the required textbook.

Homework: **There will be a number of homework assignment plus a project towards the end of the class. More details will be available during the semester.**

Grading:	**Homework assignments:**	**40%**
	Project:	**60%**

There will be no formal exams in this class.

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. MEMS and Smart Sensors

11. Interfacing Methods and Circuits
12. Interfacing to Microprocessors:

During Summer 2017, the course will be web-based. This means the following:

- **The lectures will be available on Springboard or in Dropbox for download. An invitation will be sent to you so you can view or download the files in Dropbox if you choose to use this route rather than Springboard.**
- **Prior to each scheduled lecture date, there will be two 50 minutes lectures available for viewing/downloading. This means that each week you will have to go through 6, 50 minute lectures. I will place all 6 lectures for the week on Springboard or in Dropbox on Saturday so you can download them before the week begins.**
- **These will be available until the next scheduled lecture. After that they will be removed. Please make sure you download them early.**
- **The classroom and times assigned for this class are only in case we need to meet for any reason. You should disregard these.**
- **I will assign homework by e-mail using your University of Akron e-mail address unless you wish to use a different e-mail. If you do, send me an e-mail to that effect.**
- **Each homework will list the due date.**
- **The homework can be submitted in person, or sent as a scanned pdf file to me by e-mail.**
- **One of the major components of this class is a project. Details on the project will be communicated towards the 4th week of the Summer Semester.**
- **Office hours. I will be available in my office at all times and encourage you to come and see me regarding class material, homework, etc. Best time is before noon every day. If you cannot see me in person:**
    - **Call me on skype from your computer: My skype name is nathanida**
    - **Send me an e-mail**
    - **Call me on my office phone at 330-972-6525.**

Finally, I very strongly recommend that you schedule the viewing of the lectures and your work on homework so that you complete everything on time. The class is intense and the time short. If you fall behind it is difficult to catch up. For this reason alone, I will not accept late homework. The student assistant will be instructed to this effect.

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), 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 Opticalchemical sensors), Chemical Actuators

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

10. MEMs and Smart Sensors
(Micro-Electro-Mechanical (MEMs) Sensors and Actuators, Smart sensors, ASIC based sensors, Wireless Sensors and Issues Associated with Wireless Sensors, Sensor Arrays). Note: the current videos do not cover this material – it is intended for the future but the notes are complete.

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)), noise and errors.

Bibliography:

1. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.
2. 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.