AGEN/BSEN 460/860: Instrumentation and Controls

General Information:

Lecture Time:	Tuesdays and Thursdays: 14:00-14:50
Lab Time:	Tuesday and Thursday 15:00-16:50, Wednesday 10:00-11:50
Lecture Location:	L.W. Chase Hall 116
Lab Location:	L.W. Chase Hall 110
Instructor:	Yufeng Ge, Chase 203, 2-3435 Yge2@unl.edu
Teaching Assistants:	Md Didarul Islam, mislam8@huskers.unl.edu Junxiao Zhang, jzhang95@huskers.unl.edu Shiva Paudel, spaudel6@huskers.unl.edu
Office Hours:	Make appointment via email. Office hours will be conducted on a need basis.

Catalog Description:

3 credit hours
Prerequisites: AGEN/BSEN 260 or ECEN 211 or ECEN 215

Analysis and design of instrumentation and controls for agricultural, biological, and biomedical applications. Theory of basic sensors and transducers, analog and digital electrical control circuits, and the interfacing of computers with instruments and controls. LabVIEW Programming. Emphasis on signal analysis and interpretation for improving system performance.

Course Overview:

Modern biological, biomedical, environmental, processing and agricultural systems all use electronic instrumentation, sensors, electronic circuits, and computers for acquisition of scientific and engineering data. Acquired data is used for hypothesis testing, scientific discovery, and engineering design. Instrumentation is used for almost all commercial product development, testing, and research. This course addresses the fundamental of sensors, signal types, measurement principles, electronic conditioning circuits, software application, and data management for applications of modern instrumentation and control systems. Sensors include both contact and non-contact devices: thermal, mechanical, ultrasonic, piezoelectric, resistive, capacitive, inductive, optical, and a few selected biosensors. The course provides students the opportunity to program and operate modern electronic measurement and controls equipment: including the oscilloscope, multifunction devices, microcontrollers, and digital control systems. This course especially features hands-on laboratory exercises, in-class demonstrations, and a student team project. Laboratory exercises include basic analog and digital electronic circuits, signal processing, experiments with temperature, positioning, force (stress-strain) and load cells, ultrasonic proximity, optical sensing, and a simple control exercise. LabVIEW is used throughout this class to interface hardware with computers. Computer interfacing and software programming with instrumentation features digital serial communication, analog-to-digital, digital-to-analog conversion, and final control devices. Student teams develop an instrumentation and controls project according to their interests and emphasis area, and present the project to the instructor and peer students at the end of the semester.

Learning Outcomes:

1. Recall technical language, terms, and definitions for electronic sensors, instrumentation, and control. (**Remembering)**
2. Recognize and identify the physical mechanisms of basic sensors and how they interact with the measurand for biological, biomedical, and agricultural applications. (**Understanding)**
3. Demonstrate the ability to select instrumentation and controls components in order to design, assemble, and operate a measurement system for specific applications. (**Applying)**

4. Differentiate applications for electronic sensors and modern data-logging equipment (**Analyzing)**
5. Design, develop and communicate a specific measurement system relative to area of technical interest (**Creating)**
6. Present and defend a project with an electronic instrumentation system at a public forum. (**Evaluating)**

Required Materials: No textbook is required for this class.

Supplemental Material:

1. Class notes in PowerPoint and PDF will be available on the class website in Canvas

Policies:

Attendance. None

Homework. Homework will be assigned, collected and graded in Canvas. Late homework will be accepted within one week following submission deadline (receive 70% of the total score)

Exams. Two 1-hour exams. Open note.

Final project. A final group project (4 students) with a demonstration and a project report.

Quizzes. Quizzes will be given at the beginning of the lecture. Quiz is to cover the topics being discussed at previous lectures. 5 minutes to take the Quiz.

Participation. None

Special policies. None

Well-Being: (Home campus = Lincoln campus)

UNL offers a variety of options to students to aid them in dealing with stress and adversity. Counseling and Psychological Services (CAPS) is a multidisciplinary team of psychologists and counselors that works collaboratively with Nebraska students to help them explore their feelings and thoughts and learn helpful ways to improve their mental, psychological and emotional well-being when issues arise. CAPS can be reached by calling 402-472-7450. Big Red Resilience & Well-Being (BRRWB) provides one-on-one well-being coaching to any student who wants to enhance their well-being. Trained well-being coaches help students create and be grateful for positive experiences, practice resilience and self-compassion, and find support as they need it. BRRWB can be reached by calling 402-472-8770.

Academic Honesty Policy: (see Student Code of Conduct, Section B. Conduct – rules and regulations, 1. Acts of Academic Dishonesty)

ADA and Accommodation:

Students with disabilities are encouraged to contact the instructor for a confidential discussion of their individual needs for academic accommodation. It is the policy of the University of Nebraska-Lincoln to provide flexible and individualized accommodation to students with documented disabilities that may affect their ability to fully participate in course activities or to meet course requirements. To receive accommodation services, students must be registered with the Services for Students with Disabilities (SSD) office, 232 Canfield Administration, 472-3787 voice or TTY.

Evaluation schedule:

1. Exams (2)
2. Homework Assignments (10)
3. in-class quizzes (10)

4. Project (1)
5. Lab Report (5)

Exam 1 is scheduled on Oct/6/2022
Exam 2 is scheduled on Dec/1/2022

Grading breakdown.

Exams	35%
Homework	15%
Final project	20%
Quizzes	15%
Lab Report	15%

Assignment of Letter Grades

89 %+ = A-	92 %+ = A	96 %+ = A+
79 %+ = B-	82 %+ = B	86 %+ = B+
69 %+ = C-	72 %+ = C	76 %+ = C+
59 %+ = D-	62 %+ = D	66 %+ = D+
	< 59 % = F	

Additional requirements for students who take the class at "860" level

For the students who take the class at "860" level, they will be required to complete an additional group project. This project is designed to be comprehensive and technically more challenging. Students will work in groups of 3. A project demonstration and a report will be required for grading. This additional group project will account for 20% of the final grade (all other grade items will be scaled by 0.8).

Topics:

Review of electronics and Circuits used in instrumentation and controls:
- DC and AC.
- Ohm's law, KCL, KVL, circuit analysis.
- Electronic components: resistance, capacitance, impedance.
- Voltage divider and Wheatstone bridge.
- Thevenin/Norten equivalent circuit.
- Loading effects.

Semiconductors and their uses:
- Semiconductor materials, doping.
- P-N junction.
- Diodes and special purpose diodes.
- Transistors, BJT and MOSFET.
- TTL and CMOS.
- Integrated circuits.

Analog signal processing:
- Signal types.
- Op-amps and In-amps, various feedback configurations of op-amps.
- Time domain vs. frequency domain analysis.
- High-pass and low-pass filter, bode diagram, RC filter circuit design.

Digital signal processing:

- Sampling and Quantization.
- Binary number system.
- Combinatory and sequential logic gates.
- A/D and D/A conversion.
- Data acquisition system.
- A brief introduction to microcontroller systems.

LabVIEW Programming:
- Useful concepts programming principles for instrumentation and controls.
- *myDAQ* programming.
- The State Machine.

Sensors:
- Sensor basics – precision, accuracy, and resolution; 1st order response, calibration.
- Temperature sensor – RTD, thermistor, thermocouple, infrared thermal sensor.
- Force sensor – strain gages and load cells.
- Optical sensor – photodiode – basic optic sensing and fiber optics.
- Electrochemical sensing.

Actuators:
- Brushed DC motor principle.
- Pulse width modulation and H-bridge bidirectional drive.
- Motor speed control.
- Step motor and motor drive.

Controls:
- Process control diagram.
- Open loop and closed loop control.
- ON-OFF and PID control.
- Computer based supervisory control.

Tentative Laboratory Schedule

The laboratories focus on electronic principles using hands-on, bread boarding techniques (building on EE 211 curriculum): use of basic instruments to test circuits; observe signals and their characteristics; conduct basic process studies using contemporary instrumentation devices; and to engage building and testing a fundamental control system.

Week 1	Electronic components and bread boarding circuits 1.
Week 2	Electronic components and bread boarding circuits 2.
Week 3	LabVIEW programming 1 – basics.
Week 4	LabVIEW programming 2 – control external components.
Week 5	RC filtering and Bode diagram.
Week 6	Op-amps.
Week 7	Strain gauge instrumentation.
Week 8	Digital circuits
Week 9	No-lab (Fall Break)
Week 10	New lab on Beer's Law Transmission Measurement
Week 11	Motor control 1
Week 12	Class Project
Week 13	Class Project
Week 14	No-lab (Thanksgiving)
Week 15	Class Project
Week 16	Class Project (final week)
Week 17	Project demonstration

Prepared By:

Yufeng Ge, Biological Systems Engineering Department, 8/15/2022