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:	Bidhan Ghimire, bghimire2@huskers.unl.edu Jackson Stansell, jstansell2@unl.edu Jiating Li, jiatingli@huskers.unl.edu
Office Hours:	Make appointment via email. Office hours will be conducted on zoom on a need basis.

Catalog Description:

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

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 tentatively scheduled on Oct/7/2021
Exam 2 is tentatively scheduled on Nov/18/2021

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	No Lab
Week 2	Electronic components and bread boarding circuits 1.
Week 3	Electronic components and bread boarding circuits 2.
Week 4	LabVIEW programming 1 – basics.
Week 5	RC filtering and Bode diagram.
Week 6	LabVIEW programming 2 – control external components.
Week 7	Op-amps.
Week 8	No-lab
Week 9	Digital circuits 1.
Week 10	Strain gauge instrumentation.
Week 11	Digital circuits 2.
Week 12	Motor control 1.
Week 13	Motor control 2.

Prepared By:

Yufeng Ge, Biological Systems Engineering Department, 8/15/2021

FACE COVERINGS SYLLABUS STATEMENT
Approved by the Faculty Senate Executive Committee
July 14, 2020

Required Use of Face Coverings for On-Campus Shared Learning Environments*
As of July 17, 2020 and until further notice, all University of Nebraska–Lincoln (UNL) faculty, staff, students, and visitors (including contractors, service providers, and others) are required to use a facial covering at all times when indoors except under specific conditions outlined in the COVID 19 face covering policy found at: https://covid19.unl.edu/face-covering-policy. This statement is meant to clarify classroom policies for face coverings:

To protect the health and well-being of the University and wider community, UNL has implemented a policy requiring all people, including students, faculty, and staff, to wear a face covering that covers the mouth and nose while on campus. The classroom is a community, and as a community, we seek to maintain the health and safety of all members by wearing face coverings when in the classroom. Failure to comply with this policy is interpreted as a disruption of the classroom and may be a violation of UNL's Student Code of Conduct.

Individuals who have health or medical reasons for not wearing face coverings should work with the Office of Services for Students with Disabilities (for students) or the Office of Faculty/Staff Disability Services (for faculty and staff) to establish accommodations to address the health concern. Students who prefer not to wear a face covering should work with their advisor to arrange a fully online course schedule that does not require their presence on campus.

Students in the classroom:

1. If a student is not properly wearing a face covering, the instructor will remind the student of the policy and ask them to comply with it.
2. If the student will not comply with the face covering policy, the instructor will ask the student to leave the classroom, and the student may only return when they are properly wearing a face covering.
3. If the student refuses to properly wear a face covering or leave the classroom, the instructor will dismiss the class and will report the student to Student Conduct & Community Standards for misconduct, where the student will be subject to disciplinary action.

Instructors in the classroom:

1. If an instructor is not properly wearing a face covering, students will remind the instructor of the policy and ask them to comply with it.
2. If an instructor will not properly wear a face covering, students may leave the classroom and should report the misconduct to the department chair or via the TIPS system for disciplinary action through faculty governance processes.

*Courses that have been granted an exception to the Face Covering Policy for pedagogical reasons are excluded. Exceptions to the Face Covering Policy are only granted after an approved health safety plan is developed.

~~FACE COVERINGS SYLLABUS STATEMENT~~

~~*Requirements of face coverings for the lectures in Chase Hall 116: An individual in this course has a documented need for face coverings to be required in this course. Without divulging personal or identifying information, such a documented need might be that a member of their household is unable to be vaccinated or has a health condition that makes vaccines less effective for them. As a result, the College of Agricultural Sciences and Natural Resources has determined that face coverings will be required in this course. If you are unwilling to comply with this requirement, please visit with your advisor about different sections or possible alternative courses that you might take in lieu of this one.*~~

~~*Requirements of face coverings for the lab sessions in Chase Hall 110: Students in this course must work in close physical proximity to one another for extended periods of time in order to achieve the academic goals of the course. For this reason, the Department of Biological Systems Engineering and the College of Agricultural Sciences and Natural Resources have determined that face coverings will be required in this course. If you are unwilling to comply with this requirement, please visit with your advisor about possible alternative courses that you might take in lieu of this one.*~~