MECH 420

SENSORS AND ACTUATORS

3 Credits; First Semester, 2020/21

Class Times (On-line Classes; Recorded and their URL posted on Canvas): Wed, Fri, 3:00 to 4:00 pm

Instructor

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Office Hours (On-line): Tuesdays, 3:00 pm to 4:00 pm; 11:00 pm to 12:00 mid-night

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Office Hours	Mondays, 9:00 am to 10:00 am; Mondays, 6:00 pm to 7:00 pm	Wednesdays, 3:00 pm to 4:00 pm; Wednesdays, 11:00 pm to 12:00 mid-night

Prerequisites: All of MECH 360, MECH 463, MECH 366 and one of ELEC 343, EECE 376.

Introduction

Actuators are needed to perform control "actions" as well as to directly "drive" a plant (e.g., process, machine, engine). Sensors and transducers are necessary to: 1. "measure" output signals for *feedback control*; 2. to "measure" input signals for *feedforward control*; 3. to "measure" signals from a process to estimate some parameters of the process; 4. to "measure" process variables for system monitoring, diagnosis and supervisory control; 5. To "measure" input-output signal pair for experimental modeling (i.e., model identification); and for a variety of other purposes of measurement. The approach taken in the course is to study some useful general procedures of instrumentation and a selected set of sensors and actuators, as employed in practical engineering systems (e.g., robots, mechatronic systems), while giving due consideration to the fact that various components in a control system have to function as an *interdependent*, *interconnected*, and *interacting* group. General and practical issues of sensors and actuators in an engineering/mechatronic system are discussed. Operating principles, modeling, design considerations, ratings, specifications, selection, and applications of typical sensors and actuators in several engineering applications are studied.

Learning Objectives

By the end of this course, the students will be able to:

- Understand various needs of sensors and actuators in instrumenting an engineering/mechatronic system, particularly those associated with a control system
- Understand and apply practical methods of component interconnection and signal conditioning in instrumentation applications
- Know the physical principles, important parameters, and useful specifications of a variety of analog sensors and transducers, and use them in the selection and application of the sensors
- Know the physical principles, important parameters, and useful specifications of some digital transducers, and use them in the selection and application of the transducers
- Know the physical principles, important parameters, and useful specifications of stepper motors, and use them in the selection and application of the stepper motors
- Know the physical principles, important parameters, and useful specifications of dc motors, and use them in the selection and application of the dc motors
- Know the physical principles, important parameters, and useful specifications of ac motors (induction, synchronous, etc.), and use them in the selection and application of the ac motors
- Know the physical principles, important parameters, and useful specifications of several types of hydraulic and pneumatic actuators, and use them in the selection and application of the actuators
- Gain practical experience (primarily through laboratory exercises) and apply the learned methods of instrumentation in an engineering/mechatronic system.

Course Outline

Introduction; Component Matching and Interconnection; Signal Conditioning; Performance Specification; Rating Parameters; Bandwidth Issues; Instrument Error Considerations; Analog Motion Sensors; Torque, Force and Tactile Sensors; Digital Motion Transducers; Stepper Motors; DC and AC Motors; Hydraulic Actuators.

Grade Composition

Laboratory work and report	=	25%
Intermediate exam	=	25%
Homework assignments	=	0%
Final exam	=	50%
		100%
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Textbook

De Silva, C.W., *Sensors and Actuators—Engineering System Instrumentation*, 2nd Edition, Taylor & Francis, CRC Press, Boca Raton, FL, 2016. **(E-book available from UBC Library;** link: http://resolve.library.ubc.ca/cgi-bin/catsearch?bid=9917842,**)**

Course Plan

Week	Starts	Topic	Read
1	Sept. 09	Introduction	Chapter 1
2	Sept. 16	Component Interconnection	Chapter 2
3	Sept. 23	Signal Conditioning, Conversion, Modification	Chapter 2
4	Sept. 30	Performance Specification and Instrument Rating Parameters	Chapter 3
5	Oct. 07	Bandwidth Issues, Error Considerations	Chapter 3
6	Oct. 14	Analog Motion Sensors	Chapter 5
7	Oct. 21	Torque, Force, and Tactile Sensors	Chapter 5
8	Oct. 28	Digital Motion Transducers	Chapter 6
9	Nov. 04	Stepper Motors **Intermediate exam: The grade will depend on the exam written on Friday, Nov. 06, followed by a face-to-face interview on the subject material, if needed**	Chapter 8
10	Nov. 11	DC Motors	Chapter 9
11	Nov. 18	AC Motors	Chapter 9
12	Nov. 25	Hydraulic Actuators	Chapter 9
13	Dec. 02	Review	
	Date to be decided	Final Exam: **The grade will depend on the written exam, followed by a face-to-face interview on the subject material, if needed**	

Resources Needed by the Students for the Exams:
A good web cam, ruled papers and pen
Reliable Internet connection

MECH 420 Laboratory

Lab Schedule (Date on which, the experimental data sent to students):

Lab	Data Provided on	Experiment (Lab Report) Title
# 1	Nov. 02 2019	Data Acquisition and Proximity Sensors for Object Detection
# 2	Nov. 09 2019	Optical Encoder and Torque Sensor
# 3	Nov. 16 2019	Dynamic Transducer Transfer Characteristics – Time Domain
# 4	Nov. 23 2019	Dynamic Transducer Characteristics – Frequency Domain
# 5	Nov. 30 2019	Hydraulic System with Servo Valves and Sensors

Please see Canvas for the Lab Manuals and the videos of the experiments. TA will send you the lab data, individually, by email (different data for each student).

The individual lab reports (different for each student. No lab groups) should be submitted to a TA (pdf by email) no later than 1 week from the date of receiving the data for the particular lab experiment.

Departmental Policies for This Course:

Passing Requirement: ***Students will pass this course based on their overall course mark (labs, mid-term exam, and final exam). A weighted average examination grade alone, of at least 50% is not required for passing the course. Note: The "examination grade" combines the scores from the mid-term exam and the final-exam, but it is not used in the present requirement.***

Live Lecture Recordings: ***Live (synchronous) lectures will be recorded and posted on Canvas, for use by students enrolled in this course, but these recordings will not be used beyond the current section of the course. Please be aware that student participation, such as when asking questions in class, will be captured as well in these recordings.***

Academic Integrity: ***In this course you are asked to agree to an academic integrity statement as part of testing or other assessment activities. As a student in a professional program, doing your part to adhere to course rules and upholding the academic integrity of your educational experience is in your best interest. Every effort will be made to ensure that assessment is fair for all students in the course. You can do your part by following the rules set out by your course instructor, and seeking assistance or clarification if you have any questions.***

Further Note:

During this pandemic, the shift to online learning has greatly altered teaching and studying at UBC, including changes to health and safety considerations. Keep in mind that some UBC courses might cover topics that are censored or considered illegal by non-Canadian governments. This may include, but is not limited to, human rights, representative government, defamation, obscenity, gender or sexuality, and historical or current geopolitical controversies. If you are a student living abroad, you will be subject to the laws of your local jurisdiction, and your local authorities might limit your access to course material or take punitive action against you. UBC is strongly committed to academic freedom, but has no control over foreign authorities (please visit http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,33,86,0 for an articulation of the values of the University conveyed in the Senate Statement on Academic Freedom). Thus, we recognize that students will have legitimate reason to exercise caution in studying certain subjects. If you have concerns regarding your personal situation, consider postponing taking a course with manifest risks, until you are back on campus or reach out to your academic advisor to find substitute courses. For further information and support, please visit: http://academic.ubc.ca/support-resources/freedom-expression