# UNIVERSITY OF BRITISH COLUMBIA

## Department of Mechanical Engineering

## MECH 368 – Engineering Measurements and Instrumentation

### Course Syllabus Fall 2016

**Instructor:** Mu Chiao (muchiao@mech.ubc.ca); Office hours: immediately after lecture or by appointment.

**Teaching Assistants** Guangyi Cao (guang1cao@gmail.com), Alex Reddy (alexjreddy123@gmail.com) and Hashem Jeihooni <hashem0110@yahoo.com>. Office hours: by appointment

**Lectures and Labs**

Lectures: MWF 8-9 AM in MacLeod 228
Labs: MWF 4-6 PM
KAISER 1180 (for Labs 1-4)
PACE lab (for Lab 5)

**Websites:** Private site on UBC Connect

**Learning Objectives:** Develop analytic knowledge to analyze analog circuit networks and determine input/output relations both in time and frequency domain; Develop abilities to implement operational amplifiers in analog circuits and use electronic instruments such as oscilloscopes and function generators to verify the results; Develop abilities to implement micro processor circuits and read sensor data from a computer.

**Grading Scheme:** Final: 50%, Midterm: 25%, Labs 25% (5% each)

**Emails to Instructor and TAs**

Questions are best answered in person. Expect delays when emailing. Add 'MECH368' to the subject line.

**Policy on Deadlines and Excused Absences**

All deadlines are non-negotiable. Excused absences from labs and exams are only granted in exceptional circumstances, such as for documented medical emergencies. Unexcused absences will result in a grade of 0.

**Problem Sets**

It is important to practice doing problems in order to prepare for exams and lab exams. Problem sets will not be graded, but you are encouraged to discuss the problem set with the TAs.

**Exams**

Midterm and final exams are closed book. One 8.5"X11" formula sheet (both sides) are allowed. All electronic devices must be turned off and stowed away. Midterm is tentatively scheduled on October 21$^{th}$ .

**Textbook and Reference Material**

**Textbook:** A.H. Robbins and W.C. Miller "Circuit Analysis, theory and Practice". Nelson Education

**References**: Scherz, Paul et al., "Practical Electronics for Inventors," (available at the UBC library)

Karris, Steven, "Circuit Analysis I: With MATLAB Computing and Simulink / SimPowerSystems Modeling" (available at the UBC library)

McRoberts, Michael, "Beginning Arduino". (available at the UBC library)

## Lab Structure and Logistics

Laboratory exercises are an essential part of MECH 368. There are a total of 5 labs worth 25% of the total grade. Labs help develop your kills in electronic circuits for analog signal processing. Each lab consists of practice sessions where students can familiarize themselves with the equipment and the lab exercises, as well as a lab exam where students are expected to complete lab exercises.

Labs will require access to a laptop with Matlab/Simulink/Arduino IDE installed. Students have the option of using their own computers (encouraged) or the PACE lab computers. Labs 1-4 have some components that requires Arduino and a computer, students can chose to use their own laptop computers or use the 3 computers provided in Kaiser 1180, alternatively, PACE lab computers can also be used. Lab 5 will only need a computer and Arduino and will use only the PACE lab computers.

Students will check out boxes containing Arduino boards, cables and miscellaneous electronic components from the Instrumentation Lab. One team per box.

**Labs are performed in teams of 2.** Sign up sheets are available on Connect. Each lab consists of pre-lab exercises and in-lab exercises. Pre-lab exercises will perform calculations for in-lab exercises. It is essential to complete the pre-lab exercises before starting the lab. After completing the in-lab exercises, students are expected to demonstrate the result to a TA, who will confirm the completion of the exercise and the time of completion. 100% grades will be assigned for completion of lab exercises.

## Course Outline

1. **Introduction**
    - **a.** Architecture of instrumentation systems
    - **b.** Electrical representation of physical quantities: time-domain and frequency-domain signals
2. **Readout using Arduino (Lab 1)**
    - **a.** Introduction to Arduino
    - **b.** A/D converter and sampling theory
3. **Analog Signal Processing I: Circuits for Time-domain Signals (Lab 2)**
    - **a.** Resistance: KCL and KVL, source and load, Thevenin and Norton equivalents
    - **b.** Capacitance: RC time response, switch de-bouncing
    - **c.** Diode circuits
    - d. Comparator and hysteresis
4. **Analog Signal Processing II: Operational Amplifier Circuits (Lab 3)**
    - **a.** Negative feedback: transfer functions, block diagrams, feedback loops
    - **b.** Standard op amp circuits: inverting, non-inverting, input/output resistance
    - **c.** Signal scaling and offsetting
    - **d.** Bridge amplifier
    - **e.** Op amp peak detector
5. **Analog Signal Processing III: Circuits for Frequency-domain Signals (Lab 4)**
    - **a.** Complex representation of sinusoidal signals
    - **b.** Laplace transforms, Laplace circuits, Bode plots
    - **c.** RC impedance in frequency domain
    - **d.** Passive filters
    - **e.** Active filters

6. **Fourier Transformation (Lab 5)**
    a. Fourier transform theory
    b. Read microphone time-domain signals from Arduino circuits
7. **Sensors (Discussed throughout)**
    a. Accuracy, precision, and resolution
    b. Resistive sensors
    c. Capacitive sensors

## Lecture and Lab Schedule (Tentative)

| Monday Lecture | Wednesday Lecture | Friday Lecture | Lab Activity |
|---|---|---|---|
| | 9/7 Introduction | 9/9 Arduino introduction | Lab 1 Practice |
| 9/12 Arduino introduction | 9/14 Sampling Theory | 9/16 Sampling Theory | Lab 1 Exam |
| 9/19 Intro to circuit components | 9/21 Circuit analysis 1 | 9/23 RC circuits | Lab 2 Practice (Monday group lab 1 exam) |
| 9/26 RC circuits | 9/28 Comparator | 9/30 Comparator | Lab 2 Practice |
| 10/3 Comparator | 10/5 Comparator | 10/7 Circuit analysis 3 | Lab 2 Exam |
| 10/10 No class | 10/12 Circuit analysis 4 | 10/14 Circuit analysis 5 | Lab 3 Practice |
| 10/17 Op Amps 1 | 10/19 Midterm | 10/21 Op Amps 2 | Lab 3 Practice |
| 10/24 Op Amps 3 | 10/26 Op Amps 4 | 10/28 Op Amps 5 | Lab 3 Exam |
| 10/31 Op Amps 6 | 11/2 Op Amps 7 | 11/4 Op Amps 8 | Lab 4 Practice (Monday group lab 3 exam) |
| 11/7 F-domain circuits 1 | 11/9 F-domain circuits 2 | 11/11 No class | Lab 4 Practice |
| 11/14 F-domain circuits 3 | 11/16 F-domain circuits 4 | 11/18 F-domain circuits 5 | Lab 4 Exam |
| 11/21 F-domain circuits 6 | 11/23 F-domain circuits 7 | 11/25 F-domain circuits 8 | Lab 5 Practice (Friday group Lab 4 exam) |
| 11/28 Sensors/ Actuators | 11/30 Final review 1 | 12/2 Final review 2 | Lab 5 Exam |