BME COURSE SUMMARY

INTRODUCTION

1. COURSE INFORMATION

Course Name	Biomedical Instrumentation and Design
Institution	University of Michigan
Course Number	458
# credits	4
Meeting times	LEC: M 4-6PM; LAB: (1) T/R 2:30-5:30PM; (2) T/R 6:30-9:30PM; (3) T/R 9:30AM-12:30PM; (4) M/W 6:30-9:30PM
Is this a required course?	Yes
Pre-requisites	(BIOMEDE 221 – "Circuits and Systems for Biomedical Engineering" and BIOMEDE 241 – "Biomedical Undergraduate Laboratory") or EECS 215 – "Introduction to Electronic Circuits" or EECS 314 – "Electrical Circuits, Systems, and Applications" or graduate standing
Target audience (e.g. 1st, 2nd year):	Seniors, Masters-level graduates
Textbook	Optional: *Medical Instrumentation: Application and Design*, J. G. Webster (Ed.), 4th edition. John Wiley & Sons
Course Website (if it exists)	http://bme.umich.edu/course/biomede-458/ and Canvas (restricted)

2. COURSE DESCRIPTION

In the space below, “paste” the description of the course. This can be the actual description listed in the syllabus from the course.

From UM-BME Department description: Students design and construct functioning biomedical instruments. Hardware includes instrumentation amplifiers and active filters constructed using operational amplifiers. Signal acquisition, processing analysis and display are performed. Project modules include measurement of respiratory volume and flow rates, biopotentials (electrocardiogram), and optical analysis of arterial blood oxygen saturation (pulse-oximetry).

3. COURSE LEARNING OBJECTIVES

In the space below, “paste” the course learning objectives if explicitly stated.

From syllabus:

1. To teach students how to design, select, and configure the appropriate transducer to acquire a biopotential from a living system.
2. To teach students how to select and configure the appropriate biosensor to acquire physiologic information from a living system.
3. To teach students how to interface sensing devices to an appropriate digital acquisition system
4. To teach students how to process experimental data for quantitative analysis
5. To enhance students’ communication skills thorough formal reports and presentations.

4. FUNDAMENTAL TOOLS AND SKILLS

In the space below, describe the fundamental tools and skills that are addressed in the class. For example, labvview, arduino’s, the design process etc.

LabView, electronics design and debugging (including use of signal generator, oscilloscope, and DC power supply), minimal soldering, device characterization (including frequency response and calibration)

5. EXERCISES OR EXPERIENTIAL PROJECTS OF INTEREST

Exercise/Project	Project Overview	Learning Activities and Assessments	Required Resources for Project Completion
1 – Introductory Lab	Introduction to lab instruments, electronic circuits, programming, testing, data acquisition, signal processing theory, and lab safety.	**Learning Activities** • Students use op-amps, resistors, and capacitors to develop simple low-, high- and bandpass filters, testing them with a function generator and an oscilloscope • Students use op-amps, resistors, and capacitors to develop a voltage differential amplifier circuit and implement common-mode rejection **Assessment** • Two homework assignments on simple circuits knowledge • A lab practical for students to demonstrate a basic command of the equipment and software programs they will be using throughout the semester.	**Electronic components** Resistors, capacitors, op-amps, wires, breadboards **Equipment** DAQ (and an associated computer with acquisition software, e.g., LabVIEW), function generator, oscilloscope, DC power supply, connectors for each and to interface with breadboards
2 - Spirometry	Develop a spirometer system to measure respiratory flow rates.	**Learning Activities** • Students use op-amps, resistors, and capacitors to develop a voltage amplifying circuit capable of taking the signal from the pressure sensor and reading it in using LabVIEW • Students must interface the pressure sensor with a self-made Venturi tube that someone can blow into; they must also calibrate their pressure sensor+Venturi tube set up to determine volumetric flow rates and ultimate how much volume a particular breath from a person is **Assessment** • A lab report reporting the findings of the circuit design, documentation of their calibration experiments, and they must test some hypothesis they themselves come up with in regards to the physiology of respiration	**Electronic components** Resistors, capacitors, op-amps, wires, breadboards, pressure sensor **Non-electronic components** Plastic tubes (e.g., PVC pipe), flexible tubes **Electronic equipment** DAQ (and an associated computer with acquisition software, e.g., LabVIEW), function generator, oscilloscope, DC power supply, connectors for each and to interface with breadboards **Non-electronic equipment** Drills, drill bits, hot glue (sealant), tape
3 – ECG	Develop an electrocardiography (ECG) system to acquire, analyze, and display electrocardiograms.	**Learning Activities** • Students must make a minimum of three voltage differential amplifying circuits paired with corresponding bandpass filters • Students must determine how to add the signals they acquire from their differential amplifiers to recapitulate Einthoven's triangle (a simplified vector cardiography technique)	**Electronic components** Resistors, capacitors, op-amps, wires, breadboards, electrodes (Ag/AgCl-gel) **Electronic equipment** DAQ (and an associated computer with acquisition

Exercise/Project	Project Overview	Learning Activities and Assessments	Required Resources for Project Completion
		Assessment • A lab report detailing the students' circuit design, calibration thereof, and the results of a self-generated hypothesis regarding heart physiology (for instance, the effects of taking deep breaths on heart rate or the effects of running)	software, e.g., LabVIEW), function generator, oscilloscope, DC power supply, connectors for each and to interface with breadboards **Non-electronic equipment** Drills, drill bits, hot glue (sealant), tape
4 – Pulse Oximetry	Develop a system for determining the saturation level of hemoglobin in arterial blood using optical measurements.	**Learning Activities** • Students must once again make a voltage differential amplifier for a set of paired photodiodes and LEDs (one set in the visible red, the other in the infrared range) • Students must use Beer's law to determine from the transmission of light through their fingers the oxygen content of their blood (from provided absorption curves) **Assessment** • Another lab report detailing their circuit design, software interface, calibrations, and results of a self-imposed hypothesis in regards to the oxygen content of their blood (say by holding their breaths)	**Electronic components** Resistors, capacitors, op-amps, wires, breadboards, LEDs, photodiodes, photoresistors **Non-electronic components** Plastic tubes (e.g., PVC pipe) **Electronic equipment** DAQ (and an associated computer with acquisition software, e.g., LabVIEW), function generator, oscilloscope, DC power supply, connectors for each and to interface with breadboards **Non-electronic equipment** Drills, drill bits, hot glue (sealant), tape
5 – Design Project	Develop a prototype instrumentation system that demonstrates proof-of-concept of a biomedical instrument that is selected by the lab group.	**Learning Activities** • Students use all the knowledge gained to this point to develop their own biomedical instrumentation **Assessment** • A final lab report and group presentation on their developed instrumentation	**Electronic components** Resistors, capacitors, op-amps, wires, breadboards, and whatever components students request (such as LEDs, Arduino boards, etc.) **Non-electronic components** Whatever students request (such as plastic tube, blood pressure cuffs, electrodes, etc.) **Electronic equipment** DAQ (and an associated computer with acquisition software, e.g., LabVIEW), function generator, oscilloscope, DC power supply, connectors for each and to interface with breadboards **Non-electronic equipment** Minimal tools (drills, saws, etc.)

6. ADDITIONAL THOUGHTS

If you have any other thoughts about this course, but have not been able to reflect it elsewhere in the document, please feel free to do so here.

This experiential module assumes a familiarity with the two facets of this topic – namely physiology and its translation into usable data via electrical circuitry – that may be too great. From the syllabus, the lectures are few and far between and focus almost exclusively on the overarching exercise/project and not on “biomedical instrumentation” as a field/topic/approach to biomedical engineering unto itself with both generalizable and specific engineering principles that can be leveraged further. That is, the class teaches the modules, but does not appear to teach beyond them or to teach in furtherance of the student’s education.