Elec_Eng 395-0-80/495-0-80 CARDIOVASCULAR INSTRUMENTATION
Alan V. Sahakian Winter Quarter 2021 *Tentative Schedule V. 1.3*

Course Description; Theory, design and application of instrumentation used for diagnosis, monitoring, treatment and research investigation of cardiac and cardiovascular diseases. Examples will be taken from the current literature. (Equivalent to BMD_ENG 383).

Instructor: Alan V. Sahakian, If I'm on campus I'm generally in room M394 (faculty office) or L253 (Associate Dean's office) of Tech. Office hours via Zoom (tentative): M, W, F 1:50 to 2:30 pm. Additional times whenever office door is open, or as available if closed (knock), or by appointment: a-sahakian@northwestern.edu.

Lecture times and room: M,W,F 1:00 – 1:50pm, via ZOOM. (Additional times as needed for demonstrations and experiments).

Required books:

You should buy, rent or borrow this book: J.G. Webster (ed.) "Medical Instrumentation: Application and Design," Wiley, 4th edition, 2010. (Abbreviated as "MI" below).

You do not need to buy this book: J.G. Webster (ed.) "Design of Cardiac Pacemakers," IEEE Press, 1995. (Abbreviated as "CP" below), available on loan from A. Sahakian or on-line.

Labs: Students will build an ECG amplifier and record their own ECGs using the following equipment which will be mailed to them and must be returned to A. Sahakian by the end of the quarter: NI/Digilent Analog Discovery II with Analog Parts Kit (Part # 240-000), clip leads, disposable electrodes.

TENTATIVE SCHEDULE (This may change)

WEEK	DATES	TOPIC	READINGS
1	Jan 11,13,15	Cardiac electrophysiology, the cardiac arrhythmias	MI: 126-158 CP: 1-63
2	Jan18	NO CLASS: Dr. Martin Luther King, Jr. Day	
2	Jan20,22	Biopotential electrodes, simple filters	MI: Chap. 3,
3	Jan 25,27,29	Biopotential amplifiers	MI: Chap. 6
4	Feb 1,3,5	Arrhythmia diagnosis	CP: 64-103
5	Feb 8,10,12	Cardiac pacing	CP: 105-128
6	Feb 15	Cardiac Pacing Cont'd.	
	Feb 17	**MIDTERM EXAM** (available in the morning, due in the afternoon)	
	Feb 19	Midterm Exam returned. Cardioversion and defibrillation (Project proposals due)	CP: 405-446
7	Feb 22,24,26	Hemodynamic models and parameters	Handouts, web
8	Mar 1,3,5	Blood pressure measurement	MI: Chap. 7
		Blood flow and volume measurement	MI: Chap. 8
9	Mar 8,10,12	Pulse Oximetry	Handouts
	Mar 12	**PROJECT REPORTS DUE.**	

FINAL EXAM will be due by Friday March 19.

GRADING: There will be Midterm and Final Exams, regular homework/dorm experiments and a written report. Tentatively, these four elements will be given equal weight.

PREREQUISITES: Circuits and Signals concepts (i.e. EECS 202 or BME 307 or equivalent), or consent of instructor, and engineering math, basic physics and chemistry.

COURSE PHILOSOPHY:
This course covers the engineering and physiological principles necessary to develop instrumentation for the diagnosis, monitoring, treatment and research investigation of cardiac and cardiovascular diseases. This is an immense field and unfortunately not all of the important topics can be given the coverage which they deserve in a single quarter.

The course is arranged into two major sections, separated approximately by the midterm exam. The first half of the course deals with the origins, measurement, processing and automatic interpretation of cardiac biopotentials such as the electrocardiogram. In addition, cardiac electrical stimulation (both pacing and defibrillation) will be discussed during the first half of the course. The second half of the course defines hemodynamic parameters and describes their measurement, including both invasive and non-invasive techniques for measuring blood pressure, blood flow and cardiac output. This winter quarter is one week shorter than normal so some material may be compressed or cut.

There is always a wide range of backgrounds among students in this class, from undergraduates with little or no background in this subject to graduate students who have had, or are currently taking, similar or overlapping courses here or elsewhere. If you are in the latter group, please pitch in and help everyone learn. If you are in the former group, I need for you to give me some indication (as early as possible) as to whether you are getting lost in the material. I am willing to emphasize or de-emphasize material, as I perceive to be necessary and appropriate.

The prerequisite for this course is one quarter of electric circuits (ideally including second-order circuits). I also expect students to be able to use the basic mathematical tools of engineering, and to have a good grasp of elementary physics. Students should also be able to use Matlab, Python or other tools to plot data.

The report will be a discussion of material from the current literature, which you have researched. This is an opportunity for you to explore in more depth some topic introduced in or related to the course, which you may find interesting. Possible topics include: magnetocardiography, fetal electrocardiography, fetal monitoring, diagnosis and treatment of atrial fibrillation and flutter including ablation, pulse oximetry, new techniques for non-invasive blood-flow measurement, late potential measurements, heart-rate variability measurements, some of the latest advances in cardiac pacemakers such as biventricular pacing, implantable defibrillators, new instrumentation for heart sounds, etc. You might also implement some algorithm or even build some hardware using the Analog Discovery and parts kit as part of your project. Although the report should be long enough to discuss the most-important results in the current literature, based on experience a good report is typically about 15 double-spaced pages (including figures). I strongly recommend that you get started on your project early and spread it out over the quarter.

Special Considerations arising due to Online Delivery: *This class or portions of this class will be recorded by the instructor for educational purpose and available to the class during the quarter. Your instructor will communicate how you can access the recordings. Portions of the course that contain images, questions or commentary/discussion by students will be edited out of any recordings that are saved beyond the current term.*

Unauthorized student recording of classroom or other academic activities (including advising sessions or office hours) is prohibited. Unauthorized recording is unethical and may also be a violation of University policy and state law. Students requesting the use of assistive technology as an accommodation should contact AccessibleNU. Unauthorized use of classroom recordings – including distributing or posting them – is also prohibited. Under the University's Copyright Policy, faculty own the copyright to instructional materials – including those resources created specifically for the purposes of instruction, such as syllabi, lectures and lecture notes, and presentations. Students cannot copy, reproduce, display, or distribute these materials. Students who engage in unauthorized recording, unauthorized use of a recording, or unauthorized distribution of instructional materials will be referred to the appropriate University office for follow-up.