Elec_Eng 395-0-80/495-0-80 CARDIOVASCULAR INSTRUMENTATION
Alan V. Sahakian Winter Quarter 2020 *Tentative Schedule*

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, room M394 (faculty office) or L253 (Associate Dean's office) of Tech. Office hours (tentative): M, W, F 2-3pm. Additional times whenever office door is open, or as available if closed (knock), or by appointment:
(847-491-7007, a-sahakian@northwestern.edu).

Lecture times and room: M,W,F 1:00 – 1:50pm, Tech A110. (Additional times as needed for demonstrations and experiments).

Required books:

You should buy, rent, borrow or read this book at the Mudd library: J.G. Webster (ed.) "Medical Instrumentation: Application and Design," Wiley, 4th edition, 2010.

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 work in teams of two. Students will build an ECG amplifier and record their own ECGs for processing using the following equipment, checked out from the EECS Department:

Loaned to student lab teams: NI/Digilent Analog Discovery II with Analog Parts Kit (Part # 240-000). Electrodes will also be available.

TENTATIVE SCHEDULE

WEEK	DATES	TOPIC	READINGS
1	Jan 6,8,10	Cardiac electrophysiology, the cardiac arrhythmias	MI: 126-158
			CP: 1-63
2	Jan13,15,17	Biopotential electrodes, analog signal processing	MI: Chap. 3,
3	Jan 20	NO CLASS: Dr. Martin Luther King, Jr. Day	
3	Jan 22,24	Biopotential amplifiers	MI: Chap. 6
4	Jan 27,29,31	Arrhythmia diagnosis	CP: 64-103
5	Feb 3,5,7	Cardiac pacing	CP: 105-128
6	Feb 10	Cardiac Pacing Cont'd.	
	Feb 12	**MIDTERM EXAM**	
	Feb 14	Midterm Exam returned. Cardioversion and defibrillation	
		(Project proposals due)	CP: 405-446
7	Feb 17,19,21	Cardiac Signal Processing	Handouts, web
8	Feb 24,26,28	Hemodynamic models and parameters	Handouts
		Blood pressure measurement	MI: Chap. 7
9	Mar 2,4,6	Blood flow and volume measurement	MI: Chap. 8
10	Mar 9,11	Ablation, Pulse Oximetry	Handouts
	Mar 13	**PROJECT REPORTS DUE.**	

FINAL EXAM: Monday March 16, 9:00 to 11:00 AM

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.

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 or a Matlab-like language to plot data and equations.

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 as part of your project. Although the report should be long enough to discuss the most-important results in the current literature, I expect that a length of 15 double-spaced pages (including figures) will be adequate in most cases. I strongly recommend that you get started on your project early.

This quarter I will be including some simple “dorm experiments” (done in teams of two) using the NI/Digilent Analog Discovery II and parts kit to reinforce lecture topics. Some students may also want to incorporate this hardware/software into their projects.