Study Guide for the Final Exam

The three-hour final will follow the same format as the quizzes: closed book, closed note. Bring a calculator for some simple math as usual. You do not need any paper or bluebooks.

The final will be based on material from the entire quarter. This includes all material covered in the three quizzes, in addition to materials in the homework, lectures, and guest lectures offered in weeks 9 and 10.

A practice final exam, representative of the actual exam, is posted on the class web page. A summary of topics covered and items to review (combining the three quiz study guides along with additional items for weeks 9 and 10) is given below (see Webster, 4th Ed.):

Instrument characteristics and linear circuits [Ch. 1]:

a. General properties of bioinstruments [Sec. 1.2, 1.3, 1.5, 1.8]. Operational modes, and performance characteristics. Know and apply formulas for sensitivity, accuracy, precision, and resolution.
b. Transfer function, input impedance, and output impedance of a dynamical system in the Fourier domain [Sec. 1.9]. Derive these circuit parameters, as a function of radial frequency, for a given circuit.
c. First-order and second-order dynamical systems [Sec. 1.10]. No need to remember formulas for second-order systems.
d. Linear circuit analysis [MAE 140]. KCL and KVL, nodal or mesh analysis. Thevenin equivalents.

Basic sensors, potentiometers, and switches [Ch. 2]:

e. Displacement, strain, and temperature sensors [Sec. 2.1].
f. Resistive, inductive, and capacitive sensors [Sec. 2.2-2.5]. Includes strain gauge, and bridge circuits.
g. Piezoelectric sensors, thermocouples, and thermistors [Sec. 2.6-2.9].
h. Potentiometers, switches, and relays.

Active circuits, amplifiers, and signal processing [Ch. 3]:

i. Power supplies: you do not need to memorize the circuit diagram, only be familiar with the components and their functions
j. Op-amp analysis [Sec. 3.1-3.4]: ideal op-amp analysis, use KCL. Non-ideal characteristics
k. Filters [Sec. 3.10]: op-amp circuits, using impedances instead of resistances
l. Input and output impedance [Sec. 3.14]: calculate each for a given circuit. Use Thevenin equivalent for output impedance, and add a source and find impedance seen by that source for input impedance
m. Comparators [Sec. 3.5], timers [Sec. 3.16] and digital circuits: only components/devices given in lecture. This includes the 2 modes of the 555 circuit, you do not need to memorize the wiring configurations or timing equations, but should know the function of each (monostable and astable) and how they are used, and what the output would look like, and if you saw the circuit with components, know which external components are used in the timing equations

Origin of biopotentials [Ch. 4]:

f. Electrical activitity of excitable cells [Sec. 4.1]: Cell membranes, ion transport, and permeability of ions through membranes. Nernst potential and Goldman-Hodgkin-Katz resting potential (you do not need memorize the equations or constants in the equations, just know how to use them). Action potentials, and myelinated axons.

g. Volume conduction [Sec. 4.2]: Current monopoles and dipoles (no need to remember the equations).

h. Electrocardiogram [Sec. 4.6]: P wave, QRS complex, T wave. Atrial and ventricular depolarization and repolarization. See also Sec. 6.2

i. Other biopotentials [Sec. 4.4, 4.5, 4.7, 4.8]: EEG, ECoG, ENG, EMG, ERG, EOG: fundamentals of where these potentials originate and where/how they are measured.

Biopotential electrodes [Ch. 5]:

j. The electrode-electrolyte interface [Sec. 5.1] and polarization [Sec. 5.2]: Half-cell potential, and total (polarization) potential with the different overpotentials (no need to memorize the equation but know how to use it).

k. Polarizable and non-polarizable electrodes [Sec. 5.3]: The Ag/AgCl non-polarizable electrode.

l. Electrode behavior and circuit models [Sec. 5.4]: equivalent circuit of the electrode, and its DC and AC operation.

m. The electrode-skin interface [Sec. 5.5]: no need to memorize the equivalent circuit diagram but know how to use and analyze its behavior for different values of the parameters.

Biopotential amplifiers and signal processing [Ch. 6]:

n. Electrocardiogram [Sec. 6.2]: Current dipole, and cardiac vector. Electrode placement, and leads. Vectorial interpretation of ECG signals as inner product between cardiac vector and lead vector. 10-electrode, 12-lead ECG. Wilson central terminal. Frontal plane and transversal plane leads.

o. Interference and common mode rejection [Sec. 6.3]: Sources of interference. Common mode interference noise rejection. Common mode rejection ratio (CMRR, see also Ch. 3). Grounding of the body, and the effect of electrode impedance mismatch and input impedance on common node interference noise (Fig. 6.11).

p. Input and transient protection [Sec. 6.4]: diode protection.

q. Common-mode and interference reduction circuits [Sec. 6.5]: Driven-right-leg system.

Blood pressure [Ch. 7], blood volume and blood flow [Ch. 8]:

r. General concepts of blood pressure, volume and flow measurement techniques [Sec. 7.1-7.4, Sec. 7.13-7.14, Sec. 8.1-8.4].

s. Simplified analogous electrical circuit (Fig. 7.8(c)) and corresponding dynamic pressure response [Sec. 7.3]. No need to memorize second-order equations but need to be able to derive R, L, and C, and find natural frequency and damping ratio when the transfer function is given.

t. Doppler frequency shift for ultrasonic blood velocity measurement.

Chemical biosensors [Ch. 10]:

j. Blood-gas and acid-base physiology [Sec. 10.1]: pH, PO2 and SO2, PCO2.

k. Electrochemical sensors [Sec. 10.2]: pH Nernst cell, pO2 Clark electrode, PCO2 electrode. When reactions and the relevant parameters are given, use these to find pH, PO2, or PCO2.

l. Ion-sensitive [Sec. 10.4] and immunologically sensitive [Sec. 10.5] field-effect transistors.

m. Chemical fibrosensors [Sec. 10.3], and non-invasive optical techniques [Sec 10.6]. When Beer's law is given, use it with relative absorptivities and concentrations of HbO2 and Hb

Electrical safety and protection [Ch. 14]:

n. Physiological effects of macroshock and microshock [Sec. 14.1 and 14.2]: physiological thresholds, and parameters affecting them. Rheobase current. No need to remember rheobase current formula but use when shown.
o. Electrical distribution and ground faults [Sec. 14.3]: proper chassis grounding.
p. Basic protection against shock and equipment damage [Sec. 14.4-14.9]: electrical isolation, ESD and overload protection with protection diodes and series resistance.

Guest lectures: Cursory material from each. See the practice final exam for examples.

Enjoy reviewing and studying these materials, and success with your final exam!