

# Medical Instrumentation

## 1. Description

Designs and applications of electronic medical instruments for ENG, ECG, EEG, EMG, EOG, pressure, flow, volume, bioimpedance, temperature, concentration, cell count and so on. Origins and physiology of biological signals. Electrodes and sensors. Analog and digital processing of biological signals. Electrical safety. Clinical analyzers and therapeutic devices.

## 2. Prerequisites

Physiology, Electric Circuit, Electronic Circuit, Signal and System

## 3. Text and References

Title	Author	Publisher	Year	Remark
Medical Instrumentation: Application and Design (4th ed.)	Webster	Wiley	2010	Main Text
Principles of Applied Biomedical Instrumentation	Geddes & Baker	Wiley Interscience	1989	Reference
Introduction to Biomedical Equipment Technology (3rd ed.)	Carr & Brown	Prentice - Hall	1998	Reference

## 4. Online Lecture

Online lectures are available at the KLAS site (<http://klas.khu.ac.kr/>).

## 5. Topics of Biomedical Instrumentation

Topic	Contents
Introduction to instrumentation	Measurand, sensor, signal processing, output, operating mode, accuracy, precision, resolution, SNR, analog and digital, calibration, least square method, transfer function, amplitude and phase distortion, design criteria
Basics: electric field, circuit and system	Charge, voltage, current, R/L/C, series/parallel, Thevenin/Norton, loading effect, linear system, superposition, sinusoid, frequency, Fourier analysis, spectrum, sampling, quantization
Biopotential	Neuron, electrolyte, ion conduction, diffusion, cellular membrane, RMP, action potential, volume conductor, nerve conduction, ENG, EMG, ECG, EEG, EOG, ERG, EP, MCG, MEG
Electrode	Electronic current, ionic current, electrode-electrolyte interface, charge double layer, polarization, half-cell potential, circuit model, contact impedance, contact potential, surface electrode, internal electrode, microelectrode
Biopotential amplifier	Signal model, lead, specifications, Op amp, loading effect, common-mode and differential mode, differential amplifier, CMRR, voltage gain, bandwidth, gain-bandwidth product, noise, interference, distortion, analog filter
Digital biosignal processing	Microprocessor, memory map, firmware, embedded software, compiler, linker, integer, float point variable, global, local and static variable, initialization, main loop, timer, ADC, LPF, HPF, differentiator, absolute value, moving-window integral, ring buffer, thresholding, averaging
Electrical safety	Physiological effect of current, let go, earth, ground, transformer, green ground, macro and micro shock, stray capacitance, leakage current, insulation, isolation, signal coupling, isolated power supply, electrical safety test
Electromechanical and optical sensors	Electromagnetic spectrum, resistive sensor, capacitive sensor, inductive sensor, piezoelectric sensor, temperature sensor, optical sensor, bridge circuit, modulation and demodulation, phase-sensitive demodulation, Op amp, signal conditioning
Blood pressure and heart sound	Invasive blood pressure measurement and equivalent circuit model, noninvasive blood pressure measurement using oscillometric method, tonometry, stethoscope
Blood flow and plethysmography	Indicator dilution method, thermodilution method, ultrasound flowmeter, thermal convection flowmeter, chamber plethysmography, photoplethysmography
Bioimpedance	Conductivity and permittivity, sinusoid, phasor, impedance, two- and four-electrode methods, constant current source, voltmeter using phase-sensitive demodulation, bioimpedance spectroscopy
Respiratory system measurement	Gas pressure and flow measurement, respiratory mechanics, gas distribution and diffusion, spirometer, He dilution, N <sub>2</sub> washout, CO diffusion
Biochemical sensors	pH, O <sub>2</sub> , CO <sub>2</sub> , optical fiber sensor, oximetry, ISFET, blood glucose
Clinical analyzers	Spectrophotometer, Beer's law, chromatography, electrophoresis, hematology, cell counter, morphological analyzer, clinical analyzer
Electrical stimulators	Cardiac pacemaker, bladder stimulator, muscle stimulator, nerve stimulator, cochlear implant, defibrillator, cardioverter, DBS, biofeedback system, magnetic stimulator
Therapeutic devices	Balloon pump, VAD, pump oxygenator, TAH, dialyzer, lithotripsy, ventilator, incubator, drug delivery, anesthesia machine, ESU, ablation, laser

## 6. Schedule

Week	Topic	KLAS Online Lecture
1	Introduction to instrumentation	Lecture 1 and 2
2	Basics of instrumentation	Lecture 3 and 4
3	Origin of biopotential and volume conduction	Lecture 5 and 6
4	Biopotentials of ENG, EMG, ECG, EOG, ERG, EEG	Lecture 7 and 8
5	Electrode	Lecture 9, 10 and 11
6	ECG amplifier design	Lecture 12 and 13
7	Digital biosignal processing	Lecture 14 and 15
8	QRS detector and biosignal processing	Lecture 16 and 17
9	Midterm	
10	Bioimpedance	Lecture 18 and 19
11	Electrical safety	Lecture 20
12	Sensors for biomedical instrumentation	
13	Blood pressure, blood flow and blood volume	
14	Respiratory measurement biosensor and clinical analyzer	
15	Electrical stimulator and therapeutic devices	
16	Final	