Code: BM

Biomedical Engineering

Section 1: Engineering Mathematics

Linear Algebra: Matrix algebra, systems of linear equations, Eigen values and Eigenvectors.

Calculus: Mean value theorems, theorems of integral calculus, partial derivatives, maxima and minima, multiple integrals, Fourier series, vector identities, line, surface and volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equation (linear and nonlinear), higher order linear differential equations with constant coefficients, method of variation of parameters, Cauchy's and Euler's equations, initial and boundary value problems, solution of partial differential equations: variable separable method.

Analysis of complex variables: Analytic functions, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, residue theorem, solution of integrals.

Probability and Statistics: Sampling theorems, conditional probability, mean, median, mode and standard deviation, random variables, discrete and continuous distributions: Normal, Poisson and Binomial distributions. Tests of Significance, statistical power analysis, and sample size estimation. Regression and correlation analysis.

Numerical Methods: Matrix inversion, solutions of nonlinear algebraic equations, iterative methods for solving differential equations, numerical integration.

Section 2: Electrical Circuits:

Voltage and current sources: independent, dependent, ideal and practical; V-I relationships of resistor, inductor, mutual inductor and capacitor; transient analysis of RLC circuits with dc excitation.

Kirchoff's laws; mesh and nodal analysis; Superposition, Thevenin, Norton, maximum power transfer and reciprocity theorems.

Peak, average and RMS values of ac quantities; apparent, active and reactive powers; phasor analysis, impedance and admittance; series and parallel resonance, realization of basic filters with R, L and C elements.

Section 3: Signals and systems for Bioengineers

Continuous and Discrete Signal and Systems: Periodic, aperiodic and impulse signals; Sampling theorem; Laplace, Fourier and Z-transforms; transfer function, frequency response of first and second order linear time invariant systems, impulse response of systems; convolution, correlation. Discrete time system: impulse response, frequency response, DFT; basics of IIR and FIR filters, pre-processing of Bio-signals, QRS detection methods, ECG Data Compression Algorithms, EEG segmentation and Sleep EEG, Detection of resting rhythms.

Section 4: Analog and Digital Electronics

Characteristics and applications of diode, zener diode, BJT and MOSFET; feedback amplifiers. Characteristics of operational amplifiers; applications of opamps: difference amplifier, adder, subtractor, integrator, differentiator, Analog filters and wave form generators, instrumentation amplifier, buffer.

Number Systems, Logic gates, Boolean algebra, Combinational logic circuits, Arithmetic circuits, comparators, Schmitt trigger, multi-vibrators, sequential circuits, flipflops, shift registers, timers and counters; sample-and-hold circuit, multiplexer. Principles and characteristics of ADC and DAC (resolution, quantization, significant bits, conversion/settling time); microprocessor and microcontroller: applications, memory and input- output interfacing; elements of data acquisition systems.

Section 5: Measurements and Control Systems

SI units, systematic and random errors in measurement, expression of uncertainty – accuracy and precision index, propagation of errors; PMMC, MI and dynamometer type instruments; dc potentiometer; bridges for measurement of R, L and C, Q-meter. Basics of control engineering – modeling system: transfer function.

Section 6: Sensors and Bioinstrumentation

Resistive, capacitive, inductive, piezoelectric, Hall Effect electro chemical and optical sensors and their associated signal conditioning circuits;

Physiological signals and their characteristics. Biopotential Amplifiers, Generation, acquisition, and signal conditioning of biosignals: ECG, EMG, EEG, EOG, ERG, PCG, GSR. Noise and artifacts and their management, Electrical Isolation (optical and electrical) and patient safety systems. Principles of measuring blood pressure,Body tempature, volume and flow in arteries.

Operating Principles of medical equipment-cardiac pacemaker, defibrillator, pulse oximeter, hemodialyser, ventilator, anaesthesia machine, spirometer.

Section 7: Human Anatomy and Physiology:

Basics of cell, types of tissues and organ systems; Homeostasis; Basics of organ systems-musculoskeletal, respiratory, circulatory, endocrine, nervous, gastro-intestinal and reproductive.

Section 8: Biomechanics

Hard Tissues: Structure, functions, composition and mechanical properties of cortical and cancellous bones.

Soft Tissues: Structure, functions, composition and mechanical properties of Soft Tissues: Cartilage, Tendon, Ligament, Muscle.

Viscoelasticity: Features and models.

Human Joints and Movements: Skeletal joints, types of joints, forces and stresses in human joints, free body diagrams and equilibrium, biomechanical of analysis joints, Gait parameters and their analysis.

Biofluid mechanics: Flow properties of blood, Blood flow in arteries, veins and micro vessels.

Section 9: Medical Imaging Systems

Basic physics, instrumentation and image formation techniques in medical imaging modalities-X-Ray, CT, Ultrasound, MRI, PET, SPECT.

Section 10: Biomaterials

Basic properties of biomaterials, types of biomaterials-metals, ceramics, polymers and composites. Characteristics of implants-biocompaibility, bioactivity, biodegradability. Biomaterial characterization techniques- Atomic Force Microscopy, Electron Microscopy, Transmission Electron Microscopy, Infrared Spectroscopy.