

## **BM: Biomedical Engineering**

### Section 1: Engineering Mathematics

**Linear Algebra:** Matrix algebra, systems of linear equations, Eigenvalues 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, locus diagrams, realization of basic filters with R, L and Capacitors.

### Section 3: Signals and Systems

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, pulse transfer function; DFT; basics of IIR and FIR filters.

### Section 4: Analog and Digital Electronics

Characteristics and applications of diode, Zener diode, BJT and MOSFET; small signal analysis of transistor circuits, feedback amplifiers. Characteristics of operational amplifiers; applications of opamps: difference amplifier, adder, subtractor, integrator, differentiator, instrumentation amplifier, buffer.

Combinational logic circuits, minimization of Boolean functions. IC families: TTL and CMOS. Arithmetic circuits, comparators, Schmitt trigger, multi-vibrators, sequential circuits, flipflops, shift registers, timers and counters; sample-and-hold circuit, multiplexer. Characteristics of ADC and DAC (resolution, quantization, significant bits, conversion/settling time); basics of number systems, 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 and state-space model, stability analysis: time domain and frequency domain analysis.

## Section 6: Sensors and Bioinstrumentation

Types of Instruments: Resistive-, capacitive-, inductive-, piezoelectric-, Hall Effect sensors and associated signal conditioning circuits; Optical sources and detectors: LED, Photo-diode, p-i-n avalanche photodiode (APD), light dependent resistor and their characteristics; basics of magnetic sensing; Interferometer: applications in metrology; basics of fiber optic sensing. Basics of LASERS.

Origin, nature, and types of Biosignals, Principles of sensing physiological parameters, types of transducers and their characteristics, Electrodes for bioelectric signals, Bioelectric signals and their characteristics. Biopotential Amplifiers, Noise and artifacts and their management, Electrical Isolation (optical and electrical) and Safety of Biomedical Instruments. Generation, Acquisition, and signal conditioning and analysis of biosignals: ECG, EMG, EEG, EOG, Blood ERG, PCG, GSR. Principles of measuring blood pressure, Core temperature, volume & flow in arteries, veins and tissues – Lung volumes, respiration and cardiac rate.

## Section 7: Human Anatomy and Physiology

Basic elements of human body-musculoskeletal system, respiratory system, circulatory system, excretory system, endocrine system, nervous system, digestive, nervous, immune, integumentary, and reproductive systems, Basics of cell and molecular biology.

## Section 8: Biomechanics

**Engineering Mechanics:** Free-body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations, collisions.

**Hard Tissues:** Definition of Stress and Strain; Deformation Mechanics. Bone structure & composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voigt models – anisotropy, Fatigue Analysis,

**Soft Tissues:** Structure, functions, material properties and modeling of Soft Tissues: Cartilage, Tendon, Ligament, Muscle - Hodgkin-Huxley Model.

**Human Joints and Movements:** Skeletal joints, forces and stresses in human joints, types of joint, biomechanical analysis joints, parameterization and analysis in Gait,

**Biofluid mechanics:** Flow properties of blood, Dynamics of fluid flow in the intact human cardiovascular system - modeling and experimental approaches, Pulse wave velocities in arteries, Measurement/Estimation of In-vivo elasticity of blood vessels,

## Section 9: Medical Imaging Systems

Basic physics and Instrumentation of medical images in X-Ray, Ultrasound, CT, MRI, PET, FMRI, SPECT, and their characteristics.

## Section 10: Biomaterials

Basic properties of biomaterials, biocompatibility, bioactivity, biodegradable materials, Fundamentals of implants and medical devices, drug delivery carriers, scaffolds for tissue engineering.