

## **B. Tech. in BIOMEDICAL ENGINEERING**

### **Syllabus of Paper – 1**

#### **ANALOG ELECTRONICS**

Bipolar Junction Transistor: Small Signal model, BJT biasing for discrete circuit design, single stage amplifier analysis, complete static characteristic, internal capacitances and second order effect.; Field-Effect Transistor: MOSFET as amplifier, biasing of MOS amplifier circuits, single stage IC-MOS amplifiers, MOSFET as analog switch, Small signal model of MOSFET for high and low frequencies.; Spice model and analysis of FET circuits.; Frequency Response Analysis: S-domain analysis, Bode plot, amplifier transfer function, low frequency and high frequency response of common-source and common drain amplifiers, Current Mirrors, Cascade Amplifier.; Feedback Amplifier: General feed-back structures, negative feedback, the 4 basis feedback topologies and their analysis, close loop gain calculation, Oscillators.; Output stage and Power Amplifier: Classification of output stages, Class A, Class B, Class AB amplifiers; Differential and Multistage Amplifier: BJT differential amplifier, Small signal operation of BJT differential amplifier, non-ideal characteristics of differential amplifier, multistage amplifiers. Phase Locked Loops: Simple PLL Operation, Applications.

#### **DIGITAL ELECTRONICS**

Design Concepts: Digital Hardware, Design Process, Hardware, Logic Circuit Design, Theory and Practice; Introduction to Logic Circuits: Variables and Functions, Inversion, Truth Tables, Logic Gates and Networks, Boolean Algebra, Synthesis using AND, OR AND NOT Gates, Design Examples, Introduction to Cad Tools, Introduction to VHDL.; Implementation Technology: Transistor Switches, NMOS Logic Gates, CMOS Logic Gates, Negative Logic System, Standard Chips, Programmable Logic Devices, Custom Chips, Standard Cells and Gate Arrays Practical Aspects, Transmission Gates, Implementation details for FPGAs.; Optimized Implementation of Logic Functions: Karnaugh Map, Strategy for Minimization, Minimization of Product-of-Sums Forms, Incompletely Specified Functions, Multiple Output Circuits, NAND and NOR Logic Networks, Multi-Level Synthesis, Analysis of Multi-Level Circuits, CAD Tools.; Number Representation And Arithmetic Circuits: Positional Number Representation, Addition of Unsigned Numbers, Signed Numbers, Fast Adders, Design of Arithmetic Circuits Using Cad Tools.; Combinational Circuit Building Blocks: Multiplexers, Decoders, Encoders, Code Converters, Arithmetic Comparison Circuits, VHDL for Combinational Circuits.; Flip-Flops, Registers And Counters, A Simple Processor: Basic Latch, Gated SR Latch, Gated D Latch. Master-Slave and Edge-Triggered D Flip-Flops, T Flip-Flop, JK Flip-Flop, Registers, Counters, Reset Synchronization, Other Types of Counters, Using Storage Elements with Cad Tools, Using Registers and Counters With Cad Tools, Design Examples.; Synchronous Sequential Circuits: Basic Design Steps, State Assignment Problem, Meanly State Model, Design of Finite State Machines using CAD Tools, Serial Adder Example, State Minimization, Design of a Counter using the Sequential Circuit Approach, FSM as an Arbiter Circuit, Analysis of Synchronous Sequential Circuits.

#### **BIOMECHANICS**

Introduction – Force vectors, Coplanar, collinear and concurrent forces, moment and torque, Statics: Analysis of systems in equilibrium, Applications of statistics to Biomechanics, Mechanics of elbow, shoulder, spinal column, hip, knee, ankle. Introduction to deformable body mechanics,

stress and strain, plastic deformation, multiaxial deformations and stress analysis, mechanical properties of biological tissues, various testing methods, empirical model of visco-elasticity, biomechanics of bone, tendons, ligaments, muscles and cartilages. Introduction to dynamics, linear kinematics and kinetics, angular kinematics and kinetics, work-energy methods, conservation of energy principle, Application to athletics, impulse and momentum. Computational biomechanics, continuum mechanics. Gait analysis, measurement of gait parameters, techniques for recording and measuring movements and forces - force platforms and motion analysis system, Applications of these equipments in biomechanics, performance improvement and injury prevention.

## **BIOMEDICAL INSTRUMENTATION**

Introduction: general vs. biomedical instrumentation, block concept of biomedical instruments (sensor, processor and display), properties of each part in general, Processing functions of an instrument (amplification, modulation/demodulation, ADC and DAC, frequency selection, wave shaping etc.); Characteristics of Instruments: static characteristics, dynamic characteristics with order of instruments, principle of working of 1<sup>st</sup> and 2<sup>nd</sup> order instruments in response to pulse, step and sinusoidal inputs; Controller: Concept of instrument control (feed backward and feed forward), principles of proportional, integral and derivative control, PID algorithm; Sensors of Biomedical importance: variable resistive transducers (strain gauge), variable inductive transducers (LVDT), variable capacitive transducers, photoelectric transducers, piezoelectric transducers, Body temperature measurement: thermal equilibrium of human body, routes of temperature measurement, core and brain temperature, thermal transducers (Thermistors, RTDs, Thermocouples, Pyrometers), new concepts of brain temperature measurement.

## **BIOMEDICAL SIGNAL PROCESSING**

Basics of digital signal processing: Sampling theorem, continuous and discrete LTI system; Introduction to Z Transform: The Z transform, properties of Z transform, inverse Z transform, transfer function in Z domain, location of poles and zeroes of Z- domain; Discrete Fourier Series and Transform-Discrete Fourier series, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT); Digital Filters Realizations: Characteristics of FIR filters, frequency response, design of FIR filters. Design of IIR filters from analog filters: bilinear transformation method, step and impulse invariance techniques. Introduction to biomedical signals: ECG, EMG, EOG, EEG. Digital signal processing techniques for biomedical signals. Designing criterion for pacemaker and biofeedback systems.

## **MEDICAL IMAGING AND IMAGE PROCESSING**

Brief introduction to medical imaging techniques: X-ray, CT scan, PET scan, SPECT scan, MRI scan, and Ultrasound imaging. Digital image fundamentals: Image digitization, sampling & quantization, Different types of transform- Discrete Fourier Transform, Fast Fourier Transform, and 2-D Fourier and inverse Fourier Transform. Image enhancement fundamentals: Spatial and frequency domain methods, contrast enhancement, histogram processing, image smoothing, image averaging, masking, image sharpening, and enhancement in the frequency domain. Image restoration fundamentals: Degradation model, discrete formulation, and algebraic approach to restoration—unconstrained and constrained. Image compression and segmentation fundamentals: Image compression models, and lossy and lossless compression techniques. Image segmentation: point detection, line detection, edge detection, edge linking and boundary detection. Algorithms used in medical image processing.

## **MEASUREMENTS, SENSORS AND TRANSDUCERS**

Measurements: 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. Measurement of voltage, current and power in single and three phase circuits; ac and dc current probes; true rms meters, voltage and current scaling, instrument transformers, timer/counter, time, phase and frequency measurements, digital voltmeter, digital multimeter; oscilloscope, shielding and grounding. Sensors and Transducers: Resistive-, capacitive-, inductive-, piezoelectric-, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation: displacement (linear and angular), velocity, acceleration, force, torque, vibration, shock, pressure (including low pressure), flow (differential pressure, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters) temperature (thermocouple, bolometer, RTD (3/4 wire), thermistor, pyrometer and semiconductor); liquid level, pH, conductivity and viscosity measurement.

## **Syllabus of Paper - 2**

### **CELL AND MOLECULAR BIOLOGY**

Introduction to cell, Cell theory, Cell ultra structure of Prokaryotes and Eukaryotes, Nucleus, Cell organelles, Cytoskeleton, Plasma membrane, Extracellular matrix, DNA and Chromosome, Euchromatin, Heterochromatin, Telomere, Prokaryotic and Eukaryotic Chromosomal organization, DNA replication – Semi conservative, Discontinuous and Bidirectional replication of circular and linear DNA, Central Dogma, Transcription, Translation, Gene regulation, Cell cycle, Cell division, Programmed cell death, Cellular Communication and Signalling.

### **MEDICAL SCIENCE**

Living cell: Definition, structure and function, prokaryotic vs. eukaryotic cells, sub cellular organelles, function of cell organelles, structure and function of cell membrane, transport of substances across cell membrane, cell to cell junctions and communications; Cellular Metabolism: Carbohydrate metabolism, lipid metabolism, amino acids and protein metabolism, introduction to nucleic acid chemistry; Redox potential, Oxidative phosphorylation; Electrolytes: Acid base balance and biochemical measurement of acids –base and electrolyte status of the patients. Classification and identification of bacteria, microbial nutrition, microbial growth, sterilization and disinfection chemotherapeutic agents, genes: structure, replication, and mutation, expression and regulation, microbial recombination and plasmids, recombinant DNA technology, microbial genomics, the viruses: introduction and general characteristics, bacteriophages, viruses of eukaryotes, the fungi, the algae, the protozoa, microorganism interactions and microbial ecology, microorganisms in aquatic environments and terrestrial environments, pathogenicity of microorganisms, antimicrobial chemotherapy, clinical microbiology, the epidemiology of infectious disease, human diseases caused by microorganisms, industrial application of microorganisms.

### **THERMODYNAMICS AND BIOCHEMICAL REACTION**

Introduction, Energy Transformation, system and surroundings, Internal energy, Work, heat capacity, First law of thermodynamics, energy conservation in the living organisms. The second law of thermodynamics, entropy, isothermal systems, Protein denaturation, The third law and biology, Irreversibility and life. Gibbs free energy – reversible processes, phase transitions, chemical potential, effect of solutes on boiling points and freezing points, ionic solutions, equilibrium constant, chemical coupling, redox reactions. Applications of Gibbs free energy (photosynthesis, substrate cycling, osmosis, dialysis, membrane transport, enzyme substrate interaction, protein solubility, stability and dynamics, ELISA, non equilibrium thermodynamics etc). Statistical thermodynamics, binding equilibria. Reaction kinetics – Introduction, Rate of reaction, rate constant and order of reaction, First and second order reaction, temperature effects, collision theory, transition state theory, electron transfer kinetics, enzyme kinetics, inhibition, reaction mechanism of lysozyme, hydrogen exchange, protein folding and pathological misfolding, polymerization, muscle contraction and molecular motors. The frontier of biological thermodynamics.

### **BIOMATERIALS**

Properties of materials, Structure of solids, Introduction of biomaterials, Metallic implant materials: Austenitic stainless steel, Co-based alloys, Titanium-based alloys and Dental alloys, Degradation processes on metallic surfaces, Ceramics implant materials: Glasses and Glass-

ceramics, Alumina, Zirconia and Calcium phosphate, Bioresorbable and bioactive ceramics, Polymeric implant materials: Inert polymers, Natural polymers, Bioactive polymers, Biodegradable polymers, Composite implant materials: Mechanics of composite, Different composite biomaterials, Application of composite biomaterials. Structure-property relationships of biological materials, Tissue response to implant surface, Soft tissue replacement: Skin, Sutures, Maxillofacial implants and Blood interfacing implants, Hard tissue replacement: Long bone repair-wires, pins, screws, fractures plates, intramedullary devices, joint replacement-knee and hip joint, dental restorations and spinal implants. Characterization of biomaterials: Physical and physicochemical surface characterization: Mechanical, Optical and Electrochemical characterization. Biocompatibility and Biological tests. Infection and sterilization.

### **MEDICAL DIAGNOSTICS TECHNIQUES**

Introduction to Clinical Laboratory Science, Safety in the Clinical Laboratory, Collection and Processing Laboratory Specimens, Clinical Chemistry , Principles of biochemical tests, complete blood count (CBC), comprehensive metabolic panel (CMP), electrolyte panel, liver function tests (LFT), renal function tests (RFT), thyroid function test (TFT), urinalysis, coagulation profile, lipid profile, blood type, semen analysis (for fertility and post-vasectomy studies), serological studies and routine cultures, Use of the Microscope, Fixation, Decalcification, Dehydration, Impregnation and Embedding Techniques, Biological Staining, Staining Procedures, Sterilization, Serological tests, antigen-antibody test kits, PCR, RT-PCR, Forensic tests, Cytological Techniques, ELISA and Chemiluminescence assays, Immuno fluorescence assay, Diagnostic tests in medicine, dermatology, obstetrics & gynaecology, ophthalmology, ENT, orthopaedic etc, Rapid diagnostic tests and kits, Laboratory Measurements: Apparatus and Principles, Photometry, Laboratory Mathematics, Quality Assurance in the Clinical Laboratory, Automation in the Clinical Laboratory. ECG, EEG, EMG signal acquisition and interpretation, X-RAY, CT-Scan, MRI, USG imaging and image analysis and interpretation.

### **TISSUE ENGINEERING**

Introduction to mammalian cell & tissue engineering for human therapeutic applications. Cell adhesion and cell migration, extracellular matrix, cell aggregates, designing scaffolds, fabrication of scaffolds, cell-materials interactions, growth factors and their role in tissue genesis, delivery of growth factors, types of bioreactors used for tissue engineering, design & production of functional tissue units, Clinical applications & regulatory issues.

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