B.TECH. BIOMEDICAL ENGINEERING
(2022 Admission Onwards)

Year	THIRD SEMESTER						FOURTH SEMESTER					
	Subject Code	**Subject Name**	**L**	**T**	**P**	**C**	**Subject Code**	**Subject Name**	L	T	P	C
II	MAT 2123	Engineering Mathematics – III	2	1	0	3	MAT 2223	Engineering mathematics - IV	2	1	0	3
	BME 2121	Anatomy and Physiology	3	0	0	3	BME 2221	Basic Clinical Sciences I	4	0	0	4
	BME 2122	Electronics Circuits	3	0	0	3	BME 2222	Biomedical Instrumentation	3	0	0	3
	BME 2123	Digital System Design	2	1	0	3	BME 2223	Biomechanics	3	0	0	3
	BME 2124	Network Analysis	2	1	0	3	BME 2224	Microcontrollers	3	0	0	3
	BME 2125	Signals & Systems	3	0	0	3	BME 2225	Digital Signal processing	3	1	0	4
	BME 2141	Basic Programming Lab	0	0	3	1	BME 2241	Signal Processing Lab	0	0	3	1
	BME 2142	Electronics Circuits Lab	0	0	6	2	BME 2242	Microcontroller Lab	0	0	3	1
			15	**3**	**9**	**21**			**18**	**2**	**6**	**22**
	Total Contact Hours (L + T + P)		**27**				**Total Contact Hours (L + T+ P)**		**26**			
	FIFTH SEMESTER						SIXTH SEMESTER					
III	HUM 3021	Engg Economics & Financial Management	2	1	0	3	HUM 3022	Essentials of Management	2	1	0	3
	BME 3121	Basic Clinical Science II	4	0	0	4	BME ****	Flexible Core2 (A2/B2)	3	0	0	3
	BME 3122	Medical Devices	3	0	0	3	BME 3221	Digital Image Processing	4	0	0	4
	BME 3123	Biomaterials	3	0	0	3	BME****	Program Elective – I /(Minor Specialization)	3	0	0	3
	BME ****	Flexible Core – 1(A1 /B1)	3	0	0	3	BME****	Program Elective - II/(Minor Specialization)	3	0	0	3
	IPE 4302	Open Elective-1 Creativity, Problem Solving and Innovation	3	0	0	3	*** ****	Open Elective-2	3	0	0	3
	BME 3141	Biomaterials Lab	0	0	3	1	BME 3241	Digital Signal Processing Lab	0	0	3	1
	BME 3142	Biomedical Instrumentation Lab	0	0	3	1	BME 3242	Digital Image Processing Lab	0	0	3	1
			18	**1**	**6**	**21**			**18**	**1**	**6**	**21**
	Total Contact Hours (L + T + P)		**25**				**Total Contact Hours (L + T + P)**		**25**			
	SEVENTH SEMESTER						EIGHTH SEMESTER					
IV	BME ****	Program Elective – III / (Minor Specialization)	3	0	0	3	BME 4291	Industrial Training				1
	BME ****	Program Elective – IV/ (Minor Specialization)	3	0	0	3	BME 4292	Project Work / Practice School				12
	BME ****	Program Elective – V	3	0	0	3	BME 4293	Project Work (B. Tech Honours) **				20
	BME ****	Program Elective - VI	3	0	0	3	BME ****	B Tech Honours (Theory 1)** (V Semester)				4
	BME ****	Program Elective - VII	3	0	0	3	BME ****	B Tech Honours (Theory 2)** (VI Semester)				4
	*** ****	Open Elective-3	3	0	0	3	BME ****	B Tech Honours (Theory 3)** (VII Semester)				4
	BME 4191	Mini Project (Minor Specialization) *				8						
			18	**0**	**0**	**18/26**						**13/33**
	Total Contact Hours (L + T + P)		**18**									

*Applicable to students who opted for minor specialization

**Applicable to eligible students who opted for and successfully completed the B Tech – Honours requirements

Flexible Core – 1 BME 3124 Artificial Neural Networks (A1) BME 3125 Basics of Cell and Molecular Biology (B1) **Flexible Core – 2** BME 3222 Machine learning (A2) BME 3223 Electrical and magnetic materials (B2) **Minor Specialization** **I. Biomaterials** BME 4401: Introduction to Biomedical nanotechnology BME 4402: Biomaterial Characterization Techniques BME 4403: Bio-fabrication BME 4404: Drug Delivery **II. Informatics** BME 4405: Artificial Intelligence BME 4406: Biomedical Signal Processing BME 4407: Decision Support system BME 4408: Medical Imaging	**Other Program Electives** BME 4441: Bio-statistics BME 4442: Bio electromagnetism BME 4443: Biometrics BME 4444: Embedded Systems BME 4445: Fuzzy Logic Systems BME 4446: Health Care Management BME 4447: Pattern Recognition BME 4448: Physiological Control Systems BME 4449: Prosthetics BME 4450: Rehabilitation Engineering BME 4451: Telemedicine BME 4452: Tissue Engineering BME 4453: Virtual Reality **Open Electives** BME 4311: Bio-medical Instrumentation BME 4312: Bio-Mechanics BME 4313: Rehabilitation Engineering BME 4314: Introduction of Materials in Medicine BME 4315: Introduction to Nanotechnology and Characterization Techniques BME 4316: Nanomedicine	

THIRD SEMESTER

MAT 2123 ENGINEERING MATHEMATICS – III [3 0 0 3]

Linear Algebra: Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings, Affine Spaces.

Analytic Geometry: Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions, Orthogonal Projections, Rotations.

Matrix Decompositions: Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation

Fourier Series and Transforms: Periodic function, Fourier Series expansion. even and odd functions, functions with arbitrary periods, Half range expansions Fourier transform, basic properties, Parseval's identity and applications

References:

1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, *Mathematics for Machine Learning*, Cambridge University Press, 2020.
2. Grewal B.S. - *Higher Engineering Mathematics*, Khanna Publishers, 43rd edition, 2015
3. Stephen H. Friedberg Lawrence E Spence, *Arnold J Insel, Elementary Linear Algebra: A Matrix Approach Introduction to Linear Algebra*, Second Edition, 2019.
4. David Lay, Steven Lay, Judi McDonald, *Linear Algebra and Its Applications*, Pearson, 2019.
5. Gilbert Strang, *Introduction to Linear Algebra*, Fifth Edition (2016), Wellesley-Cambridge Press.
6. Mordechai Ben-Ari, *Mathematical Logic for Computer Science*, Third Edition, Springer.
7. Narayanan, Ramaniah and Manicavachagom Pillay, *Advanced Engineering Mathematics, Vol 2 and 3, Vishwanthan Publishers Pvt Ltd. 1998*
8. Erwin Kreyszig, Advanced Engineering Mathematics, 5th Edition., Wiley Eastern, 1985

BME 2121 ANATOMY AND PHYSIOLOGY [3 0 0 3]

PARTA: ANATOMY

Skeletal System: Types of bone, classification, Structure of bone, Blood supply, Cartilage: Type, Structure in brief, Joints: Classification, Structure of synovial joint, Major joints of the body. Muscle tissue: Types, Structure of skeletal muscle, Types of muscles, Brain: Parts, Brain stem, Ventricles, CSF, Meninges, Cranial nerves (names and functions only). Spinal cord: Gross features and structures, Spinal nerve, Nerve endings and receptors, Autonomic nervous system. Sensory system: Eye, Ear, Skin. Heart: Pericardium, Chambers, Blood supply Organs. Respiratory system: Parts, Trachea, Lungs. G I Tract: Parts, Stomach, Intestine, Liver, and Pancreas. Urinary system, Male and Female reproductive organs, and Endocrine glands.

Reference:

Sampath Madhyastha, Manipal Manual of Anatomy, CBS Publishers & Distributors, Edition 3, 2016.

PART-B PHYSIOLOGY

Basic concepts: Body fluid compartments; Nerve-Muscle physiology: Physiology of neuron, Membrane potential, Autonomic nervous system, Skeletal Muscle-Structure, Neuromuscular transmission, Excitation contraction coupling, Electromyogram [EMG]; Blood: Components and

functions, Hemostasis, Blood groups; Cardiovascular system: Functional anatomy, Origin of heart beat, Electrocardiogram (ECG),Heart sounds, Biophysical aspects of circulation, Cardiac output, Blood pressure; Respiratory system: Functional anatomy, Mechanics of respiration, Lung volumes and capacities, Gas exchange, Regulation of respiration; Excretory system: Functions of kidneys, Urine formation, Micturition, Thermoregulation; Central nervous system: General organization of nervous system, Synaptic transmission, Sensory receptors, Sensory pathways, Motor system, Electroencephalogram (EEG) and sleep; Special senses: Optics of eye, pitch and intensity discrimination of sound

References:

1. Basics of Medical Physiology,4th edition, D. Venkatesh, H. H. Sudhakar
2. Manipal Manual of Medical Physiology,1st edition, C. N. Chandra Shekar

BME 2122 ELECTRONIC CIRCUITS [3 0 0 3]

Field Effect transistors: JFET and MOSFETs, biasing of field effect transistors, JFET and MOSFET small signal amplifiers, and oscillators.

Operational amplifiers: characteristics, differential amplifiers, offset voltages and currents, linear applications of Op-Amps, Instrumentation amplifier, active filters, integrators and differentiators, non-linear applications of Op-Amps: Multivibrators, Schmitt trigger and function generators.

The Timer IC 555 and its applications: Multivibrators, voltage to frequency converters, tone burst generators etc.

IC voltage regulators: Fixed, adjustable and variable power supplies, switching regulators. Data converters: Analog-to-Digital Converters (ADC) and Digital-to-Analog Converters (DAC).

References:

1. R. L Boylestad, L. Nashelsky, "*Electronic Devices and Circuit Theory*", 11th Edition, Pearson India Education Services, 2015.
2. Ramakanth A Gayakwad, "*Op Amps and Linear Integrated Circuits*", Prentice Hall, Edition 4, 2000.
3. Jacob Millman, Christos C Halkias and Chetan D Parikh, "*Integrated Electronics*", 2nd Edition, McGraw Hill, 2009.
4. Sergio F, "*Design with Op Amps and Analog Integrated Circuits*", McGraw Hill, 2002.
5. William D. Stanley, "*Operational Amplifiers with Linear Integrated Circuits*", 4th Edition, Pearson Education, 2007.

BME 2123 DIGITAL SYSTEM DESIGN [2 1 0 3]

Combinational logic circuits: Overview of Algebraic simplification of Boolean expressions and realization using logic gates, minimization using Karnaugh map, Combinational circuit design using MSI chips: Multiplexers, demultiplexers, encoders, decoders, Arithmetic circuits: Half adder, full adder, adder-subtractor, ripple carry and carry look ahead adders, ALU; Sequential logic circuits: Overview of flipflops; Counters and Shift registers.

Logic families and their characteristics: TTL families, CMOS families, CMOS logic; Introduction to CMOS, CMOS gates and circuits. CMOS based combinational logic cells, Transmission Gates, Sequential Logic Cells, Data path logic cells, Data path elements, Examples (Adders/ multiplication). Combinational Circuits Design, Shannon's expansion theorem, design of Sequential circuit.

CAD tool based digital system design, Design flow, Design styles: Full-custom IC, Semi-custom IC, ASIC (Application Specific Integrated Circuit), Types of ASICs, Programmable ASICs and

logic cells, Programmable Logic Devices (PLD's) and applications, Programmable Array Logic, Complex Programmable Logic Devices (CPLD's), elements of CPLD, Example, Mask-programmable Gate Array (MPGA's), FPGA's architectures, Example, and applications.

References:

1. Roth C. H., Fundamentals of logic design, Thomson Brooks, Australia, Edition 5, 2007.
2. Morris Mano, Digital logic and computer design, Pearson, New Delhi, 2013.
3. Stephen Brown, Zvonko Vranesic, "Fundamentals of Digital Logic with Verilog Design", 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2014.
4. Charles Roth, Lizy Kurian John, Byeong Kil Lee, "Digital System Design Using Verilog", Cengage Learning US, 2016.
5. M.J.S. Smith, "Application Specific Integrated Circuits", Pearson, New Delhi, 2002.
6. J. Bhaskar "Verilog Primer", 3rd Edition, Addison Wesley Longman Singapore Pvt Ltd., 2005.
7. M. Morris Mano and Michael D. Cilleti, "Digital Design with Introduction to Verilog HDL", 5th Edition, Pearson, New Delhi, 2013.

BME 2124 NETWORK ANALYSIS [3 1 0 4]

Network equations: (Basic concepts of Network), Coupled circuits. Resonant circuits, Property of duality in networks.

Network Theorems: Superposition, Reciprocity, Millman's theorems, Thevinin's and Norton's theorems, Maximum Power transfer theorem,

Laplace transformation and its application: Definition, Basic theorems in Laplace transformation, properties of Laplace transforms, inverse Laplace transforms, partial fraction expansion, initial and final value theorems, Shifting theorems, step, ramp and delayed functions. Solution of RL, RC, RLC networks using Laplace transformation method, Laplace transform of periodic and non-periodic signal.

Transient behaviour and Initial conditions in networks: Behaviour of circuit elements under switching condition and their representation. Evaluation of initial and final conditions in RL, RC and RLC circuits for AC and DC excitations. Frequency response of the elements

Linear wave shaping: Response of RC & RL circuits to step, pulse, square wave, ramp and exponential inputs, compensated attenuators.

Two port network and network functions: Open circuit impedance parameters, short circuit admittance parameters, Transmission parameters, Hybrid parameters, relationship between two port parameters, Parallel connection of two port networks, series connection of two port networks, cascade connection of two port networks.

References:

1). M E Van Valkenburg, "Network Analysis", Prentice Hall of India, New Delhi, Edition 3, 2007.

2). Joseph A Edminister, "Theory and Problems of Electric circuits", McGraw Hill, Edition 5, 2001.

3). C.L. Wadhwa, "Network Analysis and Synthesis", New Age International (P)Limited, Publishers, New Delhi, Edition 3, 2007.

4) Jacob Millman and Herbert Taub, "Pulse, Digital and Switching Waveforms" Mcgraw-Hill Book Company, New Delhi, 1992.

5) Engineering Circuit Analysis | 8th Edition by William H. Hayt , Jack Kemmerly , Steven M. Durbin

BME 2125 SIGNALS AND SYSTEMS [3 0 0 3]

Introduction to signals; Representations of continuous and discrete-time signals, Some special signals; Introduction to systems, system properties, Continuous time and discrete time Linear shift-invariant (LSI) systems, Frequency analysis of signals and systems, Fourier series representation, the Fourier Transform, The Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT), The Laplace Transform for continuous time signals and systems, The z-Transform for discrete time signals and systems, Sampling Theorem and its implications. Spectrum of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold, and so on. Aliasing and its effects. Relation between continuous and discrete time systems.

References:

1. A.V. Oppenheim, A.S. Willsky and I.T. Young, "Signals and Systems", Pearson Education India, 2nd Edition, 2015.
2. Simon Haykin and Van Veen, “Signals and Systems”, John Wiley, 2014.
3. Hwei Hsu, Schaum’s Outline of Signals and Systems, McGraw-Hill Education, 3rd edition, 2013.
4. M. J. Roberts, Signals and Systems - Analysis using Transform methods and MATLAB, McGraw-Hill Education, 2nd Edition, 2011.

BME 2141 BASIC PROGRAMMING LAB [0 0 3 1]

Programming in Python

Variables, expressions and statements, Conditional execution and iterations, creating functions and File handling, Plots in Python - Different types of plots, subplots and data visualization with Python, Linear algebra - Vectors, Matrices, basic matrix operations, Solving linear equations, example scripts and exercises.

References:

1. Hans-Petter Halvorsen. Python for science and engineering. Hans-Petter Halvorsen – a Blog about Technology, 2019, https://www.halvorsen.blog/
2. Sinan Kalkan, Onur Tolga Sehitoglu, and Gokturk Ucoluk. Programming with Python for Engineers. 2021, https://ceng240.github.io/

BME 2142 ELECTRONIC CIRCUITS LAB [0 0 6 2]

Analog electronics: To conduct experiments related to the characteristics of FET and MOSFETs. FET amplifiers. Oscillators – RC Phase shift, Wein Bridge, Hartley and Colpitts Oscillators. Digital Electronics: Combinational circuits- Arithmetic Circuits, Multiplexers, Decoder, comparator, Sequential circuits- Counters, Shift Registers, PLDs.

Integrated Circuits: Op-amp linear applications – Adder, Subtractor, Integrator, Differentiator, and voltage – to – current converter. Op-amp Non-linear applications – Comparators, square wave generator, multi-vibrators, function generators, oscillators, precision rectifiers. Binary weighted and ladder type DACs. IC voltage regulators, and Timer IC applications.

References:

1. R.L Boylestad, L. Nashelsky, “Electronic Devices and Circuit Theory”, 11th Edition, Pearson India Education Services, 2015.
2. Jacob Millman, Christos C Halkias and Chetan D Parikh, “*Integrated Electronics*”, 2nd Edition, McGraw Hill, 2009.
3. C. H. Roth, “Fundamentals of Logic Design”, 7th Edition, CL Publication, 2015.

4. Morris Mano, "Digital Logic and Computer Design", Pearson education, 2016.
5. Ramakanth A Gayakwad, "*Op Amps and Linear Integrated Circuits*", Prentice Hall, Edition 4, 2000.

FOURTH SEMESTER

MAT 2223 ENGINEERING MATHEMATICS – IV [3 0 0 3]

Probability and Distributions: Construction of a Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Summary Statistics and Independence, Distributions: Binomial, Poisson, uniform, normal, Chi-square and exponential distributions.

Multivariate Random variables and Stochastic Process: Two and higher dimensional random variables, covariance, correlation coefficient. Moment generating function, functions of one dimensional and two-dimensional random variables. Static probabilities: review and prerequisites generating functions, difference equations. Dynamic probability: definition and description with examples. Markov chains, transition probabilities.

Vector Calculus: Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series.

Optimization: Basic solution, Convex sets and function, Simplex Method, Optimization Using Gradient Descent, Constrained Optimization and Lagrange Multipliers.

References:

1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, *Mathematics for Machine Learning*, Cambridge University Press, 2020.
2. P L Meyer, Introductory Probability and Statistical Applications, Addison Wiley.
3. Medhi. J. Stochastic Processes, Wiley Eastern.
4. Murray R. Spiegel, Vector Analysis Theory and Problems, Schaum's Outline Series, 2019.
5. Hamdy A. Taha, "Operations Research: An Introduction", 8th Edn., Pearson Education (2008).
6. Sheldon M. Ross, Introduction to Probability Models Eleventh Edition Elsevier.
7. E. S. Page, L. B. Wilson, An Introduction to Computational Combinatorics, Cambridge University Press.
8. Bhat U R, Elements of Applied Stochastic Processes, John Wiley.

BME 2221 BASIC CLINICAL SCIENCES I [4 0 0 4]

PART-A: CARDIOLOGY

Heart structure and function – overview, Details of cardiovascular physiology – blood flow (circulation), Detail anatomy of human heart, principles of cardiovascular measurements-blood pressure, cardiac output, etc. Heart valves, Prosthetic heart valves – evolution, detail structure, functions and applications, Open heart surgery and Heart lung machines, Basics of 12-lead Electrocardiography – Einthoven's triangle, ECG potentials – generation and conduction, conduction system, Applications of ECG in cardiac clinics, Normal and abnormal ECGs, Diagnostic applications, Interpretation of ECG, Cardiac pacing. Assisted cardiac devices-concepts and applications from biomedical engineering perspective, Holter monitor. Cardiac Interventional hardware (Guide wires, catheters, stents)

References:

1. Kim E. Barrett, “Ganong's Review of Medical Physiology”, McGraw Hill, Edition 24, 2012.
2. C. C. Chatterjee S, “Human Physiology”, CBS Publisher, Edition 11, 2016.
3. Leo Schamroth Text book of electrophysiology
4. William Grossman-Interventional cardiology

PART-B: ANAESTHESIOLOGY

This course will provide an overview of basic physical principles and their applications in anaesthesia and intensive care. It will begin with the description of general and regional anaesthetic techniques fundamental to the practice of anaesthesia before going on to describe the anaesthesia machine, medical gas supply systems and intravenous drug delivery systems. The principles of equipment used in pain therapy will be discussed. Finally, students will learn about mechanical ventilation with special emphasis on mechanical ventilators and nebulizers. Humidifiers, Baby Incubators, Central oxygen supply. Principles of operation theatre tables and lights, phototherapy, surgical diathermy.

References:

1. M.K. Bykes and M.D. Vickers, “Measurements in Anesthesia”, Blackwell, 1981.
2. Mushin, “Automatic ventilation of lung”, Blackwell, 1970.

PART – C: SPEECH & HEARING

Introductory Lectures on Anatomy of the vocal tract and the ear; Audiometers, Middle ear analyzer, Evoked potentials, OAE, Hearing aids, Cochlear implants, ALD, Hearing aid analyzer, Electro Glottography, AAC, Introduction to speech assessment, DSP, Assessment of voice and fluency, Voice and fluency therapy assessment, Artificial larynx, Spirometry, Speech synthesis, Practical demonstration.

References:

1. Saunders, “Community based Rehabilitation”, ISBN 0-7020-1941-0. London, 1997.

PART-D: ORTHOPAEDICS

Bioengineering aspects of fracture management: Structure of bone-gross, Microscopic biochemical fractures: Types, Mechanism of injury, Normal Healing of Fractures, Treatment of fractures: General principles, Closed methods, External fixation and Internal fixation, Biomechanics of internal fixation and description of external fixators, Bioengineering principles of internal fixation, Intramedullary nails, Plates, and Screws.

The concepts of load bearing, load sharing and stress shielding by implants, Piezo electricity and electrical stimulation for bone healing, Bioengineering aspects of joint diseases, Structure of joints: Fibrous, Cartilaginous, Synovial, Lubrication of joints and the functions of articular cartilage, Degeneration of cartilage, Degenerative arthritis and Rheumatoid arthritis, Joint replacement, hip, knee, shoulder, small joints.

Biomaterials: Requirements of implant materials and biocompatibility, Material implants: Materials in external appliances, Materials in prosthetics, Materials in Orthotics, Bioengineering principles of management of paralytic problems, Gait analysis, Orthotics, Principles of tendon transfer, Bioengineering principles of amputation and prosthetics, Upper limb prosthesis, Lower limb prosthesis.

References:

1. Victor H Frankel and Margareta Nordin, “Basic Biomechanics of the skeletal system”. Lea and Febiger, 1980.
2. M. Dena Gardiner, “The principles of exercise therapy”, CBS press, Edition 4, 1985.

BME 2222 BIOMEDICAL INSTRUMENTATION [3 0 0 3]

Biomedical transducers: Classification and Selection; Pressure Transducers: Resistive, capacitive, Inductive & Piezo-electric transducers, Photoelectric transducers & its types; Thermal transducers & its types; Electrodes & Amplifiers: Principles of working and their characteristics, Half- cell potential, Types of electrodes, Electrode-Electrolyte model; Physiological Signals & Measurements: Basics of ECG, EMG, EEG, PCG, blood pressure & blood flow and the instrumentation for measuring these signals; Cardiac Pacemakers: Types of pacemakers, Modes of triggering, Pacemaker power supplies, pacemaker codes; Defibrillators: AC and DC defibrillators, Types of electrodes and their features, cardioverters; Lasers: Basic principles, types of lasers and their medical applications; X-ray systems, Fluoroscopic system, principles of tomography; Electrical Hazards & Safety: Safety code standards, Micro and Macro shock and its physiological effects, Methods of electrical safety.

References:

1. Webster JG, Eren H, "Measurement, Instrumentation, and Sensors Handbook" CRC press; Edition 2, 2018.
2 John G Webster, "Medical Instrumentation Applications and Design", John Wiley and Sons, New York, Edition 5, 2020.
2. R S Khandpur, "Handbook of Biomedical Instrumentation", McGraw Hill, Delhi, Edition 3, 2014.
3. L A Geddes, L E Baker, "Principles of Applied Medical Instrumentation", Wiley India, New Delhi, Edition 3, 2008.
4. Richard Aston, "Principles of biomedical Instrumentation and measurement", Merrill, New York, 1991.
5. Joseph J Carr, John M Brown, "Introduction to Biomedical Equipment technology", Prentice Hall, New Jersey, Edition 4, 2003.

BME 2223 BIOMECHANICS [3 0 0 3]

Bio-fluid mechanics: Viscosity, classification of fluids, blood rheology, fundamental method for measuring viscosity, rheology of blood in micro-vessels, mechanical model of cardiovascular system, relationship among blood velocity, blood pressure and blood vessel diameter in the vascular tree, resistance against blood flow, types of blood flow, prosthesis-related complications attributable to valve fluid dynamics. Mechanics of breathing, physical aspects of alveoli, diffusion, airway resistance. Connective tissue mechanics: structure and biomechanical properties of collagen, tendon, ligament & cartilage; composition, structure and biomechanical properties of bone, bone fracture and failure mechanics, skeletal muscle tissue properties and functions, skeletal muscle architecture, force generation in the muscle, role of skeletal muscle, force-velocity relationship in skeletal muscle, joint flexibility. Human movement mechanics: linear kinematics- kinematic parameters, fundamental concepts of gait, projectile motion, linear kinematics of walking & running, angular kinematics- types of angles, lower extremity joint angles, angular motion relationships, relationship between linear and angular motion, angle-angle diagrams, linear kinetics- laws of motion, types of forces, representation of forces acting on a system, angular kinetics- Newton's laws of motion (angular analogs), center of mass calculation, Rotation and Leverage, Pulley systems, Analysis using Newton's laws of motion.

References:

1. Lee Waite and Jerry Fine, Applied Biofluid Mechanics, McGraw-Hill Education, Second Edition, 2017, USA.
2. C. Ross Ethier, Craig A. Simmons, Introductory Biomechanics, Cambridge University Press, First Edition, 2009, New York, USA.
3. W. Mark Saltzman, Biomedical Engineering: Bridging Medicine and Technology, Cambridge University Press, Second Edition, 2015, USA.
4. Joseph Hamill and Kathleen M. Knutzen, Biomechanical Basis of Human Movement, Lippincott Williams & Wilkins, Third Edition, 2008, Philadelphia, USA.
5. Susan J. Hall, Basic Biomechanics, McGraw-Hill International Editions, Seventh Edition, 2014, Singapore.

BME 2224 MICROCONTROLLERS [3 0 0 3]

Introduction to the Microprocessor and microcontrollers, Microcontroller architectures.
CISC Microcontroller- The Intel 8051 Microcontroller: Hardware architecture and software architecture, Programming.
RISC Microcontroller – The ARM Cortex-M3 Microcontroller: Hardware architecture and software architecture, Programming.
Interfacing: External memory, UART, Keyboard, Display, ADC and DAC interfaces, temperature monitoring system, Stepper motor interface, and Real-Time-Clock (RTC) interface.

References:

1. Kenneth J. Ayala, "8051 Microcontrolelr and Embedded System Using Assembly and C", 2nd Edition, Cengage Learning, New delhi, 2009.
2. Muhammad Ali Mazidi, Janice Gillispie Mazidi, "8051 Microcontroller and Embedded System Using Assembly and C", 2nd Edition, Pearson Education, New Delhi, 2013.
3. Joseph Yiu, "The definitive Guide to the ARM Cortex-M3", 2nd Edition, Elsevier, 2010.
4. Steve Furber, "ARM System-On-Chip Architecture", 2nd Edition, Pearson Education, New Delhi, 2012.

BME 2225 DIGITAL SIGNAL PROCESSING [3 1 0 4]

Introduction to Discrete time signal and systems. Z Transform: Definition and properties, region of convergence, inverse Z transform, transfer function, poles and zeros, application of Z transforms to discrete-time systems, representation of systems – signal flow graph, realization of a z-domain transfer function; relation between s-plane and z-plane. Discrete Fourier Transform: properties, linear convolution using the DFT, Divide and Conquer algorithm to implement DFT, The fast Fourier transform: radix 2. Discrete Time Systems in Frequency Domain, Simple Digital Filters, All Pass filters, Linear phase filters. Analog Filter Design: Chebyshev and Butterworth filter design, Analog frequency transformations. Digital Filter Structure: FIR & IIR Realizations and Lattice Synthesis; IIR Filter Design: IIR filter Design by Bilinear Transformation; FIR Filter Design: FIR Digital Filter Design by Windowing, Minimum Phase filter design.

References:

1. Ronald W. Schafer, Alan V. Oppenheim, Discrete-Time Signal Processing, PEARSON 3rd Edition, 2014.
2. Dimitris G Manolakis, John G. Proakis, Digital Signal Processing: Principles, Algorithms, and Applications, PEARSON, 4th Edition, 2007.
3. Sanjit K. Mitra, Digital Signal Processing: A Computer - Based Approach, McGraw Hill Education; 4th Edition, 2013.

BME 2241 SIGNAL PROCESSING LAB [0 0 3 1]

Signal Processing in MATLAB

Introduction, Convolution, Discrete Fourier Transform and its properties, Simple filter design, FIR and IIR filters - design and implementation, Periodogram, Waveform analysis, event detection in biomedical signals.

References:

1. Houcque, David. "Introduction to Matlab for engineering students." Northwestern University 1 2005.
2. Mohindru, P., & Mohindru, P., MATLAB and SIMULINK (A Basic Understanding for Engineers). Cambridge Scholars Publishing, 2020.

BME 2242MICROCONTROLLERS LAB [0 0 3 1]

Familiarization of the 8051 microcontroller Simulation tool and trainer kits, and experiments based on the 8051 microcontrollers.

Familiarization of ARM programming tools and ARM kits and experiments based on ARM Cortex-M3 Microcontroller.

Interfacing experiments based on the 8051 and ARM Cortex-M3 microcontrollers.

References:

1. Kenneth J. Ayala, "8051 Microcontroller and Embedded System Using Assembly and C", 2nd Edition, Cengage Learning, New Delhi, 2009.
2. Muhammad Ali Mazidi, Janice Gillispie Mazidi, "8051 Microcontroller and Embedded System Using Assembly and C", 2nd Edition, Pearson Education, New Delhi, 2013.
3. Joseph Yiu, "The definitive Guide to the ARM Cortex-M3", 2nd Edition, Elsevier, 2010.

FIFTH SEMESTER

HUM 3021 ENGG ECONOMICS AND FINANCIAL MANAGEMENT [2 1 0 3]

Nature and significance, Micro & macro differences, Law of demand and supply, Elasticity & equilibrium of demand & supply. Time value of money, Interest factors for discrete compounding, Nominal & effective interest rates, Present and future worth of single, Uniform gradient cash flow. Bases for comparison of alternatives, Present worth amount, Capitalized equivalent amount, Annual equivalent amount, Future worth amount, Capital recovery with return, Rate of return method, Incremental approach for economic analysis of alternatives, Replacement analysis. Break even analysis for single product and multi product firms, Break even analysis for evaluation of investment alternatives. Physical & functional depreciation, Straight line depreciation, declining balance method of depreciation, Sum-of-the-years digits method of depreciation, sinking fund and service output methods, Introduction to balance sheet and profit & loss statement. Ratio analysis - Financial ratios such as liquidity ratios, Leverage ratios, Turn over ratios, and profitability ratios.

References:

1. **Prasanna Chandra (2005),** "Fundamentals of Financial Management", Tata Mc-Graw Hill Companies, New Delhi.
2. **James L Riggs, David D Bedworth and Sabah U Randhawa**, **(2004),** "Engineering Economics", Tata McGraw – Hill Publishing Company Ltd, New Delhi
3. **T. Ramachandran (2001),** "Accounting and Financial Management", Scitech Publications Pvt. Ltd. India.

4. **Eugene F. B. & Joel F. H. (2009),** "Fundamentals of Financial Management", 12th ed., Cengage Learning Publisher.
5. **M. Y. Khan & P. K. Jain (2008),** "Financial Management", 5th edition Tata McGraw Hill Publication, New Delhi.
6. **Thuesen G.J (2005)**, "Engineering Economics" Prentice Hall of India, New Delhi.
7. **Blank Leland T. Tarquin Anthony J**. **(2002)**, "Engineering Economy", McGraw Hill, Delhi.
8. **Chan S. Park, (2013),** "Fundamentals of Engineering Economics", 3rd edition, Pearson Publication.

BME 3121 BASIC CLINICAL SCIENCES – II [4 0 0 4]

PART-A: RADIOTHERAPY

Principles of radiation oncology and cancer radio therapy, LET and RBE, Radio sensitivity and Radio resistance tumors and tissues, Clinical definition of tumor radio sensitivity, Classification of tumors according to cell Radio sensitivity, Cell survival theory, Cell cycle kinetics and age response function, Cell survival curves, Oxygen effect, OER, Cell repair- sublethal and potentially damage repair. Radio curability of tumors, Therapeutic ratio, Normal tissue tolerance dose, Modification of radiation response, Physical, Chemical and Biomedical modifiers, Radiation biology stages of radiation actions, Physical stage LEI-RBE, Physiochemical reactions, Chemical stage. Radioactive effect of important Biological macromolecules, Radiation on cell site in cells, DNA repair process, Effects of radiation on cell cycle process, Cell death survival curves, Oxygen effect, Fractionation, Biological effects of Radiation, Radioactive protection, Acute Radiation syndromes, Somatic effects LD-50, Cause of radiation death - skin - blood and blood forming organs, Reproductive organs, Embryo-Late effects of Radiation, Radiation carcinogenesis, Leukemogenesis, Cataract, Genetic effects, Hazards and permissible exposures, maximum permissible occupational doses, Hazards in various branches of radiation, Protective lines of defense, Protective measures, Physical measurements and medical investigations.

References:

1. Meredith W J, Massey J B, Fundamental Physics of Radiology, John Wright, Edition 3, 1977.
2. Johns H E, Cunningham John Robert, The Physics of Radiology, Charle C Thomas, Edition 4, 1983.
3. Romesh Chandra, Introduction to Nuclear Medicine.

PART B: RADIOLOGY

X-ray tube, Target material, focal spot, size, shape of filament rotating anode, cooling of target tube, Interaction of X-ray with matter, Use of filters, scattered rays, quality of X-rays, HVL, CONES, Grids, Photographic effects on X-ray film, density, contrast, distortion, Speed of X-ray film, Fluorescent & Intensifying screen, Computed Tomography; Image Intensifier, Digital Subtraction Angiography, Radiation hazards & protective measures; X-Ray Exposure Parameters; Ultrasonography, Principles of Magnetic Resonance Imaging; Brachy Therapy.

References:

1. Thomas S. Curry, James E. Dowdey, Robert C. Murray, "Christensen's Physics of Diagnostic Radiology", Illustrated Edition, Lippincott Williams and Wilkins, 1990.
2. Joseph Selman", The fundamentals of Imaging Physics and Radiobiology", 9th Edition, Charles C. Thomas, 2000.
3. Penelope Allisy-Roberts, Jerry R Williams, "Farr's Physics of Medical Imaging", Illustrated Edition, Elsevier Health Sciences, 2007.

PART C: NEUROLOGY

Introduction to neurology; Review of the structure, development, and function of the nervous system: Central, peripheral and autonomic nervous system, Part of the brain structure, The motor system, Sensation, Cranial nerves. Functional topography of brain. Spinal cord, Consciousness, Higher functions, somatosensations, Neurons and glia, membrane potential, postsynaptic potential, action potential, signal transductions, neurotransmitters, synaptic transmissions, neural plasticity-LTP and LTD, Motor spinal control, cortical and subcortical motor control, Sleep and its disorders, Diagnostic investigations, Electroencephalography, Computerized Axial Tomography, Radioactive brain scanning, Angiography, Pneumoencephalography, The motor unit recording, The methods of Electro diagnosis, Neuromuscular stimulation, Electromyography, Clinical Applications, Diseases of muscle, Motor neuron disorders, The electrical study of reflexes, The silent period, The F Response, The H Reflex, The Axon reflexes, Disorders of neuromuscular transmission.

References:

1. Victor Maurice, Adams Raymond D, Principles of Neurology, McGraw Hill, Edition 5, 1993.
2. Erodal, Neuroanatomy.
3. Lance and Moleod, Physiological approach to Clinical Neurology

PART D: OPHTHALMOLOGY

Physiology of Eye: Structure of eye, function, Generation of signals and transmission to brain Electrophysiology, Aqueous humor production: Intraocular pressure fluctuations.

Equipment Used: Vision testing equipment (Computerized & Manual.), Snellens's Chart, Keratometer, Refractometer, Colour Vision, Eye Examination equipment: Slit lamp biomicroscope & Camera, Fundus Camera, Opthalmoscope – Direct & Indirect, Retinoscope, Tonometers - contact & Noncontact, Perimeters – Listers, Bjerrums, Octopus, and Goldmann, Ophthalmodynamometers, Ultrasound Scanners, Synoptophore + Hesschart, Electromagnet, Lathes, Specialized equipment used in treatment: Argon laser, Nd-YAG Laser, Contact Lenses, Intraocular Lenses, Operating Microscope, Cryosurgical equipment, Vitrectomy instrument.

References:

1. Tandon, Radhika, Parson Diseases of the Eye, Elsevier, Edition 21, 2010.
2. Duke Elder, System of Ophthalmology, Vol. VII, Mosby, St. Louis, 1965.

BME 3122 MEDICAL DEVICES [3 0 0 3]

Respiratory measurements and aids: Principle of Impedance Pneumography & Pneumotachograph; Ventilators, Impulse Oscillometry, Clinical Laboratory Instrumentation: Spectrophotometry, Auto analysers, Electrosurgical units: Principle of working, modes of operation, Risks and the safety measures associated with ESU. Ultrasonography: Interaction of ultrasound with tissues, scanning modules, echocardiograph, Endoscopes, Neonatal instrumentation: Incubators, Apnea monitors and neonatal ventilators (High frequency ventilators (HFO); Anaesthesia equipment, Lithotripsy, Heart-Lung Machine: Qualitative requirements, Functional details of the types of blood oxygenators, Hemodialysers: Type of exchangers, Hemodialysis machine; Principles and applications of Thermograph, Blood cell counter; General constraints in design of medical instrumentation systems, Regulation of medical devices: Types of Standards & regulatory requirements.

References:

1. John G Webster, "Medical Instrumentation Applications and Design", John Wiley and Sons, New York, 5th Edition, 2020.

2. R S Khandpur, “Handbook of Biomedical Instrumentation”, McGraw Hill, Delhi, 3rd Edition, 2014.
3. L A Geddes, L E Baker, “Principles of Applied Medical Instrumentation”, Wiley India, New Delhi, 3rd Edition, 2008.
4. Joseph J. Carr, John M Brown, “Introduction to Biomedical Equipment Technology”, Prentice Hall, New Jersey, 4Th Edition, 2003.
5. Richard Aston, “Principles of biomedical Instrumentation and measurement”, Merrill, New York, 1991.

BME 3123 BIOMATERIALS 3 0 0 3]

Introduction to Bio-materials: definition of biomaterials, requirements and its uses, classification of biomaterials, performance of biomaterials

Types of biomaterials: Metallic Biomaterials- introduction, types - Stainless steel, Co-Cr alloys, Ti alloys, dental metals and other metals, corrosion behavior. Ceramic Biomaterials: introduction, Classification - Non-absorbable or relatively bioinert bio ceramics. Biodegradable or Resorbable ceramics. Bioactive or surface reactive ceramics. Polymeric Biomaterials: introduction, polymerization and its types, basic structure, classification solid state properties, discussion on different class of synthetic non-degradable polymers Biodegradable Polymeric Biomaterials, Biologic Biomaterials: Tissue Derived Biomaterials; Composite Biomaterials: introduction, structure, types, properties and applications.

Implantable Medical devices: (a) Orthopaedics-joint replacement, bone defects, bone fracture, cartilage defects, (b) Cardiovascular system- arteries and veins, Heart valve prostheses-introduction, causes, mechanical and bioprosthetic heart valves. (c) eyes and ears-contact lenses, IOL, cochlear implant, (d) dentistry, maxillofacial and craniofacial – dental implants, craniofacial reconstruction, (e) general soft tissue repair

Biomaterials for regenerative medicine-background, tissue engineering templates, types of template materials, fabrication route

References:

1. Joseph D Bronzino, “The Biomedical Engineering Handbook”, 3rd Edition, CRC press, USA, 2006.
2. Park Joon Bu, “Biomaterials Science and Engineering”, Plenum Press, University of Michigan, 1984.
3. Buddy D Ratner & Allen S Hoffman, “Biomaterials Science and Introduction to Materials in Medicine”, 3rd Edition, Academic Press, Canada, 2012.
4. David Williams, Essentials Biomaterials Science, Cambridge university press, 2013.
5. Lisa A Pruitt and A M Chakravartula, Mechanics of Biomaterials, Cambridge, 2011

BME 3141 BIOMATERIALS LAB [0 0 3 1]

Preparation of hydroxyapatite bio ceramic particles, Characterization of hydroxyapatite particles by X-ray powder diffraction (XRD), Synthesis of ZnS nanoparticles by reverse micelle method, Synthesis of ZnS nanoparticles by reverse micelle method, Characterization of ZnS nanoparticles by UV Vis absorption spectroscopy, Preparation of alginate micro beads and encapsulation and release study of food colour, Characterization of Alginate beads by Fourier Transform Infrared Spectroscopy (FTIR), Thawing frozen cells and starting a new batch of culture, Sub culturing of confluent cells: splitting, counting and seeding cells, Freezing cells for long term storage in liquid nitrogen

References:

1. William D. Callister, Jr., David G. Rethwisch, Materials Science and Engineering: An Introduction, 9th Edition, Wiley, 2014.
2. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons, *Biomaterial science- An introduction to Materials in medicine,* 3rd edition, Academic press, 2012.
3. T. Pradeep, A Textbook of Nanoscience and Nanotechnology, McGraw Hill Education, 1st edition, 2017.

BME 3142 BIOMEDICAL INSTRUMENTATION LAB [0 0 3 1]

Design and realize bioelectric amplifier, filters for biomedical applications, Pacemaker circuit; Study the characteristics of thermal transducers- RTD, Thermocouple; Optical sensors- LDR, Photodiode and Phototransistor; pressure transducers, Inductive and Capacitive transducers, bio-signal acquisition using Physiography, Familiarization of Audiometer, Defibrillator and Recording of ECG using Electrocardiograph.

References:

1. Ramakanth A Gayakwad, "OPAMPS and Linear Integrated Circuits", Prentice Hall, 4Th Edition, 2015.
2. John G Webster, "Medical Instrumentation Applications and Design", John Wiley and Sons, New York, 3rd Edition, 2011.
3. Richard Aston, "Principles of biomedical Instrumentation and measurement", Merrill, New York, 1991.

SIXTH SEMESTER

HUM 3022 ESSENTIALS OF MANAGEMENT [2 1 0 3]

Definition of management and systems approach, Nature & scope. The functions of managers. Corporate social responsibility. Planning: Types of plans, Steps in planning, Process of MBO, how to set objectives, Strategies, Policies & planning premises. Strategic planning process and tools. Nature & purpose of organising, Span of management, Factors determining the span, Basic departmentation, Line & staff concepts, Functional authority, Art of delegation, Decentralization of authority. HR planning, Recruitment, Development and training. Theories of motivation, Special motivational techniques. Leadership- leadership behaviour & styles, Managerial grid. Basic control process, Critical control points & standards, Budgets, Non-budgetary control devices. Profit & loss control, Control through ROI, Direct, Preventive control. Managerial practices in Japan & USA, Application of Theory Z. The nature & purpose of international business & multinational corporations, Unified global theory of management. Entrepreneurial traits, Creativity, Innovation management, Market analysis, Business plan concepts, Development of financial projections.

References:

1. Harold Koontz & Heinz Weihrich (2012**)**, "Essentials of Management", McGraw Hill, New Delhi.
2. Peter Drucker (1993), "Management: Tasks, Responsibilities and Practices", Harper and Row, New York.
3. Peter Drucker (2004), "The Practice of Management", Harper and Row, New York.

BME 3221 DIGITAL IMAGE PROCESSING [4 0 0 4]

Review of signals, systems & transforms; 2D signals & systems, 2D DFT and its computation. Image perception – the human vision system, psycho-visual experiments, monochrome vision model, temporal properties. Image compression – the discrete cosine transforms (DCT), properties, computation, practical compression algorithm. Image Enhancement: Point operations – Histogram modification, Histogram equalization; Spatial filtering: linear filters & the median filter. Edge Detection, Hough transform – detection of straight lines and curves in images; Invariant descriptors: Fourier Descriptor, Moment-based invariants; Morphological Image Processing techniques, Thresholding, Connected Component Labeling.

References:

1) R.C. Gonzalez and R.E. Woods, *Digital Image Processing*, 4Th Edition, Pearson Education Inc., 2017.

2) Jae S. Lim, *Two-dimensional Signal and Image Processing*, Prentice-Hall, Englewood Cliffs, New Jersey, 1990.

3) A.K. Jain, *Fundamentals of Digital Image Processing*, Prentice-Hall, 1989, Fourth Indian Reprint.

BME 3241 DIGITAL SIGNAL PROCESSING LAB [0 0 3 1]

Signal Processing in MATLAB

Introduction, Basic sequences and operations, Discrete Time System and its properties, Convolution, Discrete Fourier Transform and its properties, Simple filter design, FIR and IIR filters - design and implementation

References:

1. Houcque, David. "Introduction to Matlab for engineering students." Northwestern University 1 2005.
2. Mohindru, P., & Mohindru, P., MATLAB and SIMULINK (A Basic Understanding for Engineers). Cambridge Scholars Publishing, 2020.

BME 3242 DIGITAL IMAGE PROCESSING LAB [0 0 3 1]

Image Processing in Python

Introduction, Image processing - Display and Simple Manipulations, Contrast Enhancement and Discrete Fourier Transform of an Image, Image filtering - Spatial and Frequency domain filtering, Discrete Cosine Transform of an Image - examples and exercises with CT/MRI data, Geometrical Transformation of an Image - Applications, Radon Transform

References:

1. Hans-Petter Halvorsen. Python for science and engineering. Hans-Petter Halvorsen – a Blog about Technology, 2019, https://www.halvorsen.blog/
2. Sinan Kalkan, Onur Tolga Sehitoglu, and Gokturk Ucoluk. Programming with Python for Engineers. 2021, https://ceng240.github.io/
3. Jan Erik Solem. Programming Computer Vision with Python: Tools and algorithms for analyzing images. " O'Reilly Media, Inc.", 2012.

FLEXIBLE CORE 1 (A - Informatics/B- Materials):
BME 3124 ARTIFICIAL NEURAL NETWORKS (A1) [3 0 0 3]

Fundamental concepts: neuron models and basic learning rules, Pattern and data, biological foundations of neural network, Components, and topology of artificial neural network. Basic

network properties: Activation functions, computational properties of nodes, learning methods, Training and Testing. Single layer networks, Perceptron, Feed forward neural networks, Supervised Learning networks, Multilayer neural networks, Associative memory networks, training algorithm for pattern association, pattern correction, pattern retrieval, Feedback neural networks, analysis of pattern clustering, Recurrent neurodynamical systems, Unsupervised learning network: Maxnet, Kohonen Self-organizing feature Map and Special networks. Deep learning network: Introduction, Example, Functional units of ANN for object recognition, Neural network for medical diagnosis: Bio-signal Analysis, recognition of diagnostic information from brain MRI images, ANN for digital pathology application.

References:

1. Simon O. Haykin, "Neural Networks and Learning Machines", 3rd Edition, Perason, Prentice Hall, New Delhi, 2019
2. Sathish Kumar, "Neural Networks - A Classroom Approach", McGraw Hill, 2nd Edition 2017.
3. S. N. Sivanandam, and S. N. Deepa, "Principles of Soft Computing", Wiley India Pvt. Ltd., New Delhi, 2011.
4. B Yegnanarayana, Artificial Neural Networks, Prentice Hall India, New Delhi,2001.
5. Emmanuel C. Ifeachor, Piotr S Szczepaniak, Paulo J. G. Lisboa, "Artificial Neural Networks in Biomedicine", Springer-Verlag London, 2000.
6. D L Hudson and M E Cohen, "Neural Networks and Artificial Intelligence for Biomedical Engineering", IEEE Press Series on Biomedical Engineering, IEEE Press, IEEE Publications, U.S, 2000.
7. Utku Kose, Omer Deperlioglu, D. Jude Hemanth, Deep Learning for Biomedical Applications, ISBN 9780367422509, CRC Press, 2021
8. E. Golden Julie, Y. Harold Robinson, S. M. Jaisakthi. Handbook of Deep Learning in Biomedical Engineering and Health Informatics, CRC Press,2022

BME 3125 BASICS OF CELL AND MOLECULAR BIOLOGY (B1) [3 0 0 3]

Basic properties of cells, different classes of cells, prokaryotic and eukaryotic cells, the chemical basis of life, nature of biological molecules, types of biological molecule, cellular metabolism, structure and function of the plasma membrane, interactions between cells and their environment, cytoplasmic membrane systems: structure, function, and membrane trafficking, the cytoskeleton and cell motility, the nature of the gene and the genome, gene expression: from transcription to translation, the cell nucleus and the control of gene expression, DNA replication and repair, cellular reproduction, cell signaling and signal transduction: communication between cells, cancer, the immune response, techniques in cell and molecular biology,

References:

1. Karp G. Cell and molecular biology: concepts and experiments. John Wiley & Sons; 2009 Oct 19.
2. Alberts B, Bray D, Hopkin K, Johnson AD, Lewis J, Raff M, Roberts K, Walter P. Essential cell biology. Garland Science; 2015.
3. Rastogi SC. Cell and molecular biology. New Age International; 2006.
4. Chandar N, Viselli S. Cell and molecular biology. Lippincott Williams & Wilkins; 2012 Aug 14

FLEXIBLE CORE 2 (A - Informatics/B- Materials):

BME 3222 MACHINE LEARNING (A2) [3 0 0 3]

Introduction: Basic Concepts-Supervised Learning, Discriminative Algorithms. Supervised learning: Supervised learning setup, LMS, Linear Algebra, Logistic regression. Perceptron. Exponential family, Generative learning algorithms. Gaussian discriminant analysis. Naive Bayes approach, Support vector machines, Vectorization. Practice ML advice: Bias/variance tradeoff, Model selection and feature selection, Evaluating and debugging learning algorithms, Practical advice on structuring an ML project, Convex Optimization. Deep Learning: NN architecture, Forward/Back propagation, Vectorization, Other optimization tricks, Evaluation Metrics. Unsupervised learning: Clustering. K-means, EM. Mixture of Gaussians, Factor analysis, PCA (Principal components analysis), ICA (Independent components analysis). Reinforcement learning and control: MDPs. Bellman equations, Value iteration and policy iteration, Linear quadratic regulation (LQR), LQG, Q-learning. Value function approximation.

Reference:

1. Christopher Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics), Springer; 1st Edition. 2006. Corr. 2nd Print, 2011.
2. Stephen Marsland, Machine Learning: An Algorithmic Perspective, Chapman and Hall/CRC, 2nd Edition, 2014.
3. Duda, Richard, Peter Hart, and David Stork. *Pattern Classification*. 2nd Edition, New York, NY: Wiley-Interscience, 2007.

BME 3223 Electrical and Magnetic materials (B2)[3 0 0 3]

Atomic structure and interatomic bonding, metals, semiconductors, insulators. Conductivity of metals and semiconductors- Drude model, dependence on temperature and composition, Matthiessen's rule. Insulating materials, Inorganic, organic, liquid and gaseous insulators. Dielectrics: Introduction to Dielectric polarization and classification – Clausius-Mossotti relation. Dielectric Breakdown: Mechanism of breakdown in gases, liquids and solids –basic theories including Townsend's criterion, Streamer mechanism, suspended particle theory, intrinsic breakdown, electro-mechanical breakdown- Factors influencing Ageing of insulators- Application of vacuum insulation- Breakdown in high vacuum. Ferroelectricity, piezoelectricity. Magnetic Materials: Magnetization of matter, Classification of magnetic materials -Curie-Weiss law- Hard and soft magnetic materials– Ferrites. Optical Properties: Light Interactions with Solids, Refraction, Reflection, Transmission, Absorption, Luminescence, Lasers, Photoconductivity.

Self-Directed Learning:

(1) Dielectrics: Introduction to Dielectric polarization and classification – Clausius-Mossotti relation. **Duration:** 1Hr

(2) Optical Properties: Light Interactions with Solids, Refraction, Reflection, Transmission, Absorption, Luminescence, Lasers, Photoconductivity. **Duration:** 36 Min.

References

1) William D. Callister, Jr., David G. Rethwisch, *Materials Science and Engineering: An Introduction*, 9th Edition, Wiley, 2014.
2) Dekker A.J., *Solid state physics*, Macmillan publishers India, 2012
3) James F. Shackelford, *Introduction to Materials Science for Engineers*, 8th edition, Pearson, 2014

BME 4291 INDUSTRIAL TRAINING

Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken in a phased manner during the vacation starting from the end of third semester. Student has to submit to the department a training report in the prescribed format and also make a presentation of the same. The report should include the certificates issued by the industry

BME 4292 PROJECT WORK/PRACTICE SCHOOL

The project work may be carried out in the institution/industry/ research laboratory or any other competent institutions. The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation of the project work shall be done after about 8 weeks. An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation. The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form. Student has to make a presentation on the work carried out, before the department committee as part of project evaluation.

MINOR SPECIALIZATION IN BIOMATERIALS

BME 4401 INTRODUCTION TO BIOMEDICAL NANOTECHNOLOGY [3 0 0 3]

Introduction nanotechnology: Nanomaterials- classifications, synthesis methods, nanostructured system by self-assembly, biomimetic and biomolecular recognition assembly, surface functionalization of nanoparticles, nanocomposites. Characterization tools for nanomaterials and Nano systems- structural and chemical characterization techniques. Properties of nanomaterials: - mechanical properties, optical properties, surface plasmon resonance, quantum size effects, introduction to nanoelectronics. Nanotechnology for drug delivery, nanotechnology for diagnosis, prognosis, and disease status: - biomedical imaging, biosensors and drug delivery. Therapeutic nanotechnology, nanotechnology for implant materials and tissue engineering, cosmetics, nanotechnology safety concerns.

Self-Directed Learning: mechanical properties, optical properties, surface plasmon resonance, quantum size effects, **Duration:** 3Hr

References:

1. Guozhong Cao, *Nanostructures and nanomaterials Synthesis*, Imperial Press, 2011.
2. Neelina H. Malsch, *Biomedical nanotechnology*, CRC Press, 2005.
3. G.A. Ozin and A.C. Arsenault, *Nanochemistry: A chemical approach to Nanomaterials,* Royal Society of Chemistry, 2005.
4. Kenneth E. Gonsalves, Craig R. Halberstadt, Cato T. Laurencin, Lakshmi S. Nair, Mott, *Biomedical Nanostructures,* Weily-Blackwell, 1st edition, 2008.
5. Jun Li, Nianqiang Wu, *Biosensors based on Nanomaterials and nanodevices*, CRC Press, 1st edition, 2014.
6. T. Pradeep, *A Textbook of Nanoscience and Nanotechnology*, McGraw Hill Education, 1st edition, 2017.
7. Challa S. S. R. Kumar, Josef Horms, Csrola Leuschner, *Nanofabrication Towards Biomedical Application: Techniques, Tools, Applications and impact*, Wiley- VCH, 1st edition, 2015.

BME 4402 BIOMATERIAL CHARACTERIZATION TECHNIQUES [3 0 0 3]

Physical and chemical characterization of Biomaterials: optical microscopy, UV-Vis spectroscopy, fluorescence spectroscopy, transmission electron microscope (TEM), scanning electron microscope (SEM), scanning tunneling microscope (STM), atomic force microscope (AFM), X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FT-IR), dynamic light scattering (DLS), contact angle, gas adsorption, mass spectroscopy, chromatography. Thermal characterization of biomaterials: thermogravimetric analysis (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC). Surface Characterization of Biomaterials: X-ray photoelectron spectroscopy (XPS), auger electron spectroscopy (AES), secondary ion mass spectroscopy (SIMS), light microscopy and confocal microscopy.

References

1. Amit Bandhyopadhya and Susmita Bose, *Characterization of Biomaterials*, Elsevier, 2013.
2. Douglas B. Murphy, *Fundamentals of light microscopy and electronic imaging*, Wiley-Liss, Inc. USA, 2001.
3. B.D. Cullity and S.R. Stock, *Elements of X-ray diffraction*, Prentice Hall, Inc. USA, 2001.
4. D.B. Williams and C. Barry Carter, *Transmission electron microscopy* 4 volumes, Springer, USA, 1996.
5. Gerhard Huebschen Iris Altpeter, Ralf Tschuncky Hans-Georg Herrmann, *Materials Characterization Using Nondestructive Evaluation (NDE) Methods*, Elsevier, 2016.
6. M. Jaffe, W. Hammond, P. Tolias, T. Arinzeh, *Characterization of Biomaterials*, Elsevier, 2012.
7. Crankovic GM. ASM Handbook, Volume 10: *Materials Characterization*. ASM International; 1986.

BME 4403 BIO FABRICATION [3 0 0 3]

Biomaterials: polymers, bio inks, tissue--derived matrices, tissue engineering and biofabrication description of extracellular matrix, bioprinting, inorganic powder printing, stereolithography, selective laser sintering, melt electrospinning writing, self-healing hydrogel system, polymers in 3D printing, introduction to rheology, 3D printing history, techniques, applications, CAD/CAM, 3D modelling, Medical imaging to printing, 3D printing techniques: additive manufacturing, 3D printing in the clinic: devices and implants

Cell printing, Applications: cartilage, liver, cardiovascular system, organ--on--a--chip, in vitro models

Nano/micro fabrication techniques: Photolithography, Soft lithography- micro-stamping, stencil patterning, and microfluidic patterning, Electron beam lithography, Focused ion beam lithography, Colloid monolayer lithography, Molecular self-assembly, Electrically induced nanopatterning,

References:

1. Aleksandr Ovsianikov, James Yoo, Vladimir Mironov, 3D Printing and Bio fabrication, Springer, 2018, ISBN 978-3-319-45445-0
2. Zhang et al., 3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine. 1st edition, ISBN 9780128005477.
3. Forgacs et al., Biofabrication - Micro- and Nano-fabrication, Printing, Patterning and Assemblies, 1st Edition, ISBN 9781455728527
4. Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, 2011, 3rd edition, CRC Press, ISBN 0849331803

5. Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, 2nd edition ISBN 9789814324557

BME 4404 DRUG DELIVERY [3 0 0 3]

Drug delivery system: overview, dosage form-tablet, capsule, parenteral etc. classification of drug delivery system, chemically controlled system, diffusion-controlled system, controlled release mechanism- Membrane reservoir system, Matrix system, swelling controlled release system, biodegradable controlled release system

Fundamental aspects of drug delivery: introduction of pharmacokinetics and pharmacodynamics, diffusive transport, diffusion in heterogeneous system, passage of drug through membrane drug release kinetics from different biopolymer matrices

Pharmacokinetics: common routes of systemic drug administration, drug absorption, bioavailability, determinants of bioavailability- disintegration, dissolution, drug distribution, drug elimination.

Matrix based drug delivery system: Delivery materials, polymer-based matrices; hydrogels- drug carriers, transdermal and trans-mucosal drug delivery system, measuring in vitro diffusions, measuring controlled release kinetics, drug targeting approaches, biocompatibility aspects of matrices

Immunity and immunological preparations: immunity, types, immunological preparations; bacterial vaccines, vaccines containing living viruses, vaccines containing toxoids

Fundamentals of vaccine delivery

References:

1. B. Wang, T. J. Sahaan, R. A. Soltero, Drug Delivery: Principles and applications, John Wiley & Sons Inc., 2016.
2. L Shargel, S Wu-Pong, A Yu, Applied Biopharmaceutics& Pharmacokinetics, 6Th Edition, The McGraw Hill, 2005.
3. S. Rosenbaum, Basic Pharmacokinetics and Pharmacokinetics, Wiley, 2011.
4. Juergen Siepmann, Ronald A. Siegel, Michael J. Rathbone (Editors), Fundamentals and Applications of Controlled Release Drug Delivery, Springer, 2012.
5. Eric P. Holowka, Sujata K. Bhatia, Drug Delivery-Materials Design and Clinical Perspective, Springer, 2014.
6. David Williams, Essentials of Biomaterials Science, Cambridge University press, 2014.

MINOR IN INFORMATICS

BME 4405 ARTIFICIAL INTELLIGENCE [3 0 0 3]

Basics of Artificial Intelligence (AI), Healthcare IT and the Growing Need for AI Operations, AI Healthcare Operations (Clinical): Clinical Impact of AIOps, Design and Innovation, AIOps for Healthcare Delivery, Clinical AI, AIOps. Deploying AI in practice, Real world applications of AI in medicine., Automation, Workflow, Process, and Intelligence Design Security, Ethics of intelligence, Policy and law, confidentiality, privacy aspects of medical software development, The future of AI, The Convergence of Healthcare AI Technology. Case studies: AI for Electronic Health Records Data, AI and 2D Medical imaging data, 3D Medical imaging data, AI to wearable device data.

References:

1. Robert Shimonski, AI in healthcare, Wiley, 2020
2. Arjun Panesar, Machine learning & AI for healthcare, 1st Edition, Apress,2019

3. Ankur Saxena, Shivani Chandra, Artificial intelligence and machine learning in healthcare, 2021.

BME 4406 BIOMEDICAL SIGNAL PROCESSING [3 0 0 3]

Review of Probability theory, random variables and stochastic processes; Spectral estimation techniques; Estimation of the autocorrelation and power spectrum density (PSD): Nonparametric methods of power spectrum estimation: The Periodogram & its modifications, The Welch method, Biomedical applications. Cepstrum analysis: The cepstrum, power cepstrum, complex cepstrum, Biomedical applications; Adaptive Filters: Weiner filter, Adaptive noise canceling, Principles of adaptive noise canceling with LMS and RLS adaptation algorithm. Adaptive line enhancer, principles of adaptive line enhancer using the LMS and GAL algorithm and Biomedical engineering applications. Parametric methods of power spectrum estimation: AR modeling – The Yule-Walker method and least square method of parameter-estimation; selection of AR model order; Autoregressive Moving Average (ARMA) modeling; Adaptive methods of estimating the PSD, Biomedical engineering applications.

References:

1. John G. Proakis and Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", Pearson, 4th edition, 2007
2. Simon Haykin, "Adaptive Filter Theory", Pearson, 5th edition, 2013
3. M. Akay, "Biomedical signal processing", Academic press, 1994.
4. Rangaraj M Rangayyan, "Biomedical Signal Analysis", John Wiley and Sons, Illustrated edition, 2015.

BME 4407 DECISION SUPPORT SYSTEMS [3 0 0 3]

Computer-based Clinical Decision Support: Overview, Status, and Challenges, Features of CDSS, Mathematical Foundations of Decision Support Systems, Data Mining and Clinical Decision Support Systems, Usability and Clinical Decision Support, Architectures for Clinical Decision Support. Role of Quality Measurement and Reporting Feedback as a Driver for Care Improvement, Decision support delivered using the outpatient electronic health record, Knowledge for Clinical Decision Support: Statistical and Machine Learning Techniques, Evidence-Based Medicine, statistical methods in meta-analysis, Meta-analysis of complex datasets. Big Data and Population-Based Decision Support, Clinical Decision Support for Personalized Medicine, Decision Rules and Expressions, Formal methods for modelling. Best Practices for Implementation of Clinical Decision Support, National Policies on the Use of Clinical Decision Support, Ethical and Legal Issues in Decision Support, Evaluation of Clinical Decision Support, Adoption of Clinical Decision Support system, Decision Support for Patients, Diagnostic Decision Support Systems, Applications.

References:

1. Decision Making in Health and Medicine, Myriam Hunink and Paul Glasziou, 6th printing 2007; Publisher: Cambridge University Press
2. Clinical Decision Support Systems: Theory and Practice, Berner, Eta S. (Ed.), 2nd ed., 2007, Publisher: Springer, Health Informatics Series (springer.com NOT springerpub.com)
3. Osheroff, Pifer, Teich, Sittig, Jenders, 2005; Publisher: Health Information and Management Systems Society (HIMSS)
4. Robert Greenes, Clinical Decision Support, The Road to Broad Adoption, 2nd Edition - March 26, 2014, eBook ISBN: 9780128005422, Hardcover ISBN: 9780123984760, Elsevier

BME 4408 MEDICAL IMAGING [3 0 0 3]

Review of signals, systems & transforms; 2D signals & systems; Medical Imaging: Imaging modalities and their applications; Computed tomography (CT): mathematical basis, the Radon transform & the central slice theorem; Image reconstruction from projections: the Direct Fourier Method, convolution back projection (CBP) algorithm, Algebraic Reconstruction Techniques (ART); reconstruction from fan-beam projections; Extension to 3D – cone-beam CT, spiral CT. Tomosynthesis; X-rays: utility, generation and detection; X-ray CT systems. Emission CT: principles, Positron emission tomography (PET); attenuation correction in ECT; Ultrasound in clinic: benefits/risks, Basics of Ultrasound - review, Ultrasound imaging; Contrast enhanced ultrasound imaging; Motion artifacts in ultrasound imaging. Clutter filtering; elastography, plane wave imaging; Magnetic resonance imaging: Principles of data-generation, resolving the tissues, resolving the spatial locations, and extension to 2D. Resolution & Field of View; Data sampling and the concept of bandwidth.

References:

1. R.C Gonzalez and R.E. Woods, *Digital Image Processing*, 4Th Edition, Pearson Education Inc., 2017.
2. A.K. Jain, *Fundamentals of Digital Image Processing*, Prentice-Hall, 1989, Fourth Indian Reprint.
3. A.C. Kak and M. Slaney, *Principles of Computerized Tomographic Imaging*, SIAM's Classics in Applied Mathematics, Philadelphia, SIAM, 2001.
4. Kline Jacob, *Handbook of Biomedical Engineering*, Academic Press, 1988.
5. Carol M. Rumack, Deborah Levine, Diagnostic Ultrasound, 5Th Edition, Elsevier, 2017.
6. Thomas L. Szabo, Diagnostic Ultrasound Imaging: Inside Out, 2nd Edition, Elsevier, 2014.
7. James A. Zagzebski, Essentials Of Ultrasound Physics, 2nd Edition, Mosby, 2010.
8. Barbara S. Hertzberg, William D. Middleton, Ultrasound: The Requisites, EBook (Requisites in Radiology), 2015.
9. HH Schild, "MRI made easy", Schering AG, Berlin, 1990.

PROGRAM ELECTIVES

BME 4441 BIOSTATISTICS [3 0 0 3]

Introduction, Summarizing Quantitative Data, Summarizing Categorical Data; Prevalence, Incidence, Relative Risk, Risk Difference, Sampling Bias, Confidence Intervals, Study Design, Probability & Screening; Probability distributions: Binomial & Normal Distributions, Sampling Distributions, Confidence Intervals.

Hypothesis Test: Introduction, One-sample proportion, Chi-square test, t tests, Continued MCW, Power and Sample Size.

Correlation & Regression, Multiple Regression, Regression to the Mean MCW.

References:

[1] Sullivan, L.M., Essentials of biostatistics for the health sciences, 3rd Edition, Jones & Bartlett Learning, 2018.
[2] Machin, Campbell and Walters, Medical Statistics, 4th ed., Wiley, 2007.
[3] Motulsky, H., Intuitive Biostatistics: A nonmathematical guide to statistical thinking, 3rd Edition, Oxford University Press, New York, 2014.
[4] Utts, J and Heckard, R., Mind on statistics, 5Th Edition, Cengage Learning, USA.

BME 4442 BIOELECTROMAGNETISM [3 0 0 3]

Introduction

Fundamental physical knowledge and electrostatic and magnetic field equations. Fundamentals of bio electromagnetism. Vector Analysis, Electrical Sources and Fields, Introduction to Membrane Biophysics, Action Potentials, Volume Conductor Fields, Bioelectric sources and conductive environment. Electrodynamics of bioelectrical fields. Concepts of bioelectrical and bio magnetic measurement. Measurement methods, modelling and simulation techniques.

Bioelectric Sources and Conductors and their Modelling

Anatomical and Physiological Basis of Bio electromagnetism - Nerve and Muscle Cells, Subthreshold Membrane Phenomena, Active Behavior of the Membrane, Synapses, Receptor Cells, and Brain, The Heart, Volume Source and Volume Conductor, Source-Field Models, Bidomain Model of Multicellular Volume Conductors, Electronic Neuron Models

Theoretical Methods in Bioelectromagnetism

Theoretical Methods for Analyzing Volume Sources and Volume Conductors, Theory of Biomagnetic Measurements

Electric and Magnetic Measurement of the Neural tissue and the Heart

Electroencephalography, Magnetoencephalography, 12-Lead ECG System, Vectorcardiography Lead Systems, Other ECG Lead Systems, The Basis of ECG Diagnosis, Magnetocardiography

References:

1. Computational Cardiology: Modeling of Anatomy, Electrophysiology, And Mechanics by Frank Sachse. Springer-Verlag New York, Inc. Secaucus, NJ, USA
2. Bioelectromagnetism by Jaakko Malmivuo and Robert Plonsey. Good too and very cheap-free in fact on the web site http://www.bem.fi/book/
3. Mathematical Physiology by James Keener and James Sneyd. Springer Verlag. (great all-around book on modeling and simulation in physiology).
4. Mathematically Modeling the Electrical Activity of the Heart: From Cell to Body Surface and Back by Andrew Pullan. World Scientific Publishing Company (September 30, 2005)

BME 4443 BIOMETRICS [3 0 0 3]

Basic image operations, Interpolation, Special filters, enhancement filter, Edge detection, thresholding, localization. Introduction of biometric traits and its aim, Biometric system, authentication, physiological and behavioral properties, Identification and verification, Threshold, Score distribution, FAR and FRR, System design issues - Expected overall error, EER, ROC curve, DET curve, FAR/FRR curve. Existing Biometric Technologies: Fingerprints, Face, Iris, Hand Geometry, Ear, Voice, Retina, Gait. Introduction to physiological and behavioral biometrics in hospitals or care units, Biometric authentication based on ECG, EMG, and Phonocardiograph (PCG) signals. Multimodal identification and Verification system, normalization strategy, Fusion methods, Biometric system security. Face and ECG Based Multimodal Biometric Authentication.

References:

1. Girija Chetty and Jucheng Yang, Advanced Biometric Technologies, InTech, 2011.
2. Jain, A.K., Ross, A., Nandakumar, K. Introduction to Biometrics. Springer; 2011.
3. David Zhang, Fengxi Song, Zhizhen Liang, Yong Xu, Advanced Pattern Recognition Technologies with Applications to Biometrics (Premier Reference Source), Medical Information Science Reference; 1st edition, 2009.

4. Ruud M. Bolle, Sharath Pankanti, Nalini K. Ratha, Andrew W. Senior, Jonathan H. Connell Guide to Biometrics, By, Springer, 2009.
5. Duda, Richard, Peter Hart, and David Stork. *Pattern Classification*. 2nd Edition, New York, NY: Wiley-Interscience, 2007.
6. Rafael C. Gonzalez, Richard Eugene Woods, Digital Image Processing using MATLAB, 2nd Edition, Tata McGraw-Hill Education, 2010.

BME 4444 EMBEDDED SYSTEMS [3 0 0 3]

Introduction to Embedded systems, processor and memory organization, Devices, Serial & Parallel buses for device networks, Device drivers and interrupt servicing mechanisms. Programming concepts, and embedded programming in C. Real-Time Operating systems and Task Scheduling algorithms. Hardware Software Co-simulation: Co-simulation approaches, Embedded System Development Life Cycle (EDLC). Representative Embedded systems.

References:

1. Peckol James K, "Embedded Systems" John Wiley and Sons, New Delhi, 2013.
2. Valvano Jonathan W, "Embedded Systems", Jonathan W.V, U. K., 2014.
3. Frank Vahid and Tony Givargis, "Embedded system Design – A Unified Hardware/Software Introduction", Wiley India Pvt. Ltd, 2014.
4. Tim Wilmshurst, "An Introduction to the design of Small-Scale Embedded Systems" Palgrave, New York, 2003.
5. Shibu K.V, "Introduction to Embedded Systems", TMH, New Delhi, 2010.

BME 4445 FUZZY LOGIC SYSTEMS [3 0 0 3]

Introduction to Fuzzy Sets and Fuzzy Logic: Crisp Sets, Fuzzy Sets, Linguistic variables, Membership functions, Set theory operations on Crisp and Fuzzy sets, Relations and Compositions, Hedges, Extension Principles, Crisp logic, Fuzzy logic, Sources of Uncertainty, small applications. Membership functions: Type-1 Membership functions, Type-2 Membership functions, Multivariable Membership functions, Case studies. Singleton and Non-Singleton Type-1 Fuzzy logic systems: Introduction, Rules, Fuzzy Inference Engine, Fuzzification and its effect on Inference, Defuzzification, Fuzzy basis functions, Universal approximators, Designing FLSs, Case studies. Type-2 Fuzzy Sets: Operations on and Properties of Type-2 Fuzzy Sets, Type-2 Relations and Compositions, Type reduction. Type-2 Fuzzy Logic Systems: Singleton Type-2 FLSs, Type-1 Non-singleton Type-2 FLSs, Type-2 Non-singleton Type-2 FLSs, Respective Case Studies.

References

1. Jerry M. Mendel, Uncertain Rule-based Fuzzy Logic System: Introduction and New Directions, Springer; 2nd Edition, 2017.
2. Timothy J. Ross, Fuzzy Logic with Engineering Applications, Wiley, 3rd Edition, 2011.
3. George J. Klir, Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall, Facsimile Edition, 1995.

BME 4446 HEALTH CARE MANAGEMENT [3 0 0 3]

Introduction: ABC of Hospital Administration, Principles of Management

Human Resources: Motivation, Time Management, Leadership and Supervision, Nursing Services, Effective Communication, Conflicts, Monitoring and Control, Public Relations, Medical Social Service department, Professional Hazards, Clinical Services: Indoor Services, Outpatient Department, Casualty and Emergency Wing, Intensive Care areas, Operating room and post-operative units, Support Services: Laboratories, Blood Bank, Radiology Services, Pharmacy, Central sterile supply department, Medical Record department, Materials Management, Housekeeping and maintenance, Linen and laundry, Dietary Services, Hospital Information system and computerization, Security and safety, Finance and Budget, Costing, Medical Ethics, Law and medical profession, Hospital acquired infections, Waste disposal, Quality assurance and medical audit, Disaster Management.

References:

1. Colonel (Retd) B.M.Sakharkar , Principles of Hospital Administration and Planning , Jaypee Brothers.
2. C M Francis, Hospital Administration, Jaypee Brothers Edition 2, 1995.
3. S L Goel, R Kumar, Hospital Administration and Management, Vol 1,2,3, Deep & Deep.
4. Humble John W, Management By Objectives in Action, McGraw Hill, 1970.

BME 4447 PATTERN RECOGNITION [3 0 0 3]

Introduction to Pattern Recognition (PR) system; Application domains, Feature, Feature space, Class, Feature vector, Classifier, Classification and approaches, Design cycle; Linear Regression, Logistic Regression & General Linear Model; Introduction to Statistical decision making, Bayesian Decision Theory: continuous and discrete features, Multiple features, conditionally independent features, Maximum likelihood estimation, Decision boundaries, unequal costs of error, Estimation of error rates, the leaving one-out technique. Non-Parametric Techniques: K-nearest neighbourhood estimation, clustering: Hierarchical clustering, Agglomerative clustering algorithm, Single, Average and Complete linkage algorithms, Partitional clustering, K means, Ward's algorithm, Problems. Gaussian Mixture Models – with Expectation Maximization algorithm, Principal Component Analysis; Introduction to Neural Networks; performance analysis of a classifier.

References:

1. Earl Gose, Richard, Johnson Baugh and Steve Jost, "Pattern recognition and Image analysis", Prentice Hall, New Delhi, 2002.
2. Schalkoff Robert J, "Pattern recognition", John Wiley & Sons, New York, 1992.
3. Richchard O Duda, Peter E. Hart, David G. Strok, "Pattern Classification", 2nd Edition, Wiley, Singapore, 2005.
4. S. N. Sivanandam, S. Sumathi and S. N. Deepa, "Introduction to Neural Networks using MATLAB 6.0", TATA McGRAW HILL, New Delhi, 2006
5. S. N. Sivanandam, and S. N. Deepa, "Principles of Soft Computing", 2nd Edition, Wiley India Pvt. Ltd, New Delhi, 2011

6. Sara Moein, "Medical Diagnosis Using Artificial Neural Networks", IGI Publications, USA,2014
7. Volker Schmid Anke Meyer-Baese Schmid Meyer-Baese "Pattern Recognition and Signal Analysis in Medical Imaging", 2nd Edition, Academic Press, 2014.

BME 4448 PHYSIOLOGICAL CONTROL SYSTEM [3 0 0 3]

Introduction to physiological modeling: Introduction; Multi-scale organization of living organisms: cell to organ Homeostasis. Examples of physiological control systems. Review of linear systems concepts, Fourier series: Modeling signals using Fourier series, Deterministic and stochastic signals and systems. **Mathematical tools:** Basic concepts of control systems; Open vs. closed loop Steady state and transient analysis of control systems. Linear model's vs nonlinear models Distributed vs. lumped parameter models Compartment models. **Cardiovascular and Respiratory system:** Circulatory system. Key events in the cardiac cycle. Blood pressure and flow, vascular impedance. Lumped parameter models, windkessel model of circulation Cardiac mechanics. Respiratory mechanics, lung models. **Nervous system:** Anatomy and physiology of nerves Action potentials, Hodgkin-Huxley model. **Musculoskeletal system:** Muscle anatomy and physiology. How muscles contract, Hill model of muscle contraction, Muscle stretch reflex**. Eye Movement Model:** Types of Eye movement, Eye movement system and Wetheimer's saccade eye model. Robinson's Model, Oculomotor muscle model, Linear Reciprocal Innervations Oculomotor Model.

References:

1. Michael C. K. Khoo, Physiological Control Systems: Analysis, Simulation and Estimation, Wiley IEEE Press, 1999.
2. John D. Enderle, "Model of Horizontal eye movements: Early models of saccades and smooth pursuit", Morgan & Claypool Publishers, 2010.

BME 4449 PROSTHETICS [3 0 0 3]

Familiarity with the operation/working principles of various prosthesis used in neural and urological applications Soft Tissue Replacements: Cardiac Anatomy and Pathophysiology, mechanical and bioprosthetic heart valves, Artificial heart and cardiac assist devices, vascular prosthesis: stent grafts

Hard Tissue Replacements: Bone structure, cortical and cancellous bone, viscoelastic properties. Fracture and fixators, healing of bones. Joint replacements -Hip and knee implants, dental implants: introduction, artificial dental implants, implant fixations

Neural Prostheses: Origins of the field of neural prostheses, Motor prosthesis: Neuromuscular Stimulation for Control of Limb Movement, Sensory prosthesis: Visual, auditory (cochlear implant) and tactile

Artificial Kidney: Structure and function of the kidney, Kidney disease, Renal failure, Mass transfer in dialysis, Clearance, Permeability, Membranes, Hemofiltration

Artificial Pancreas: Structure and function of pancreas. Endocrine pancreas & insulin secretion. Diabetes, insulin therapy, insulin administration systems, implantable insulin pumps (artificial pancreas)

Orthopaedic and Urologic prosthesis

References:

1. Andrej Kral, Felix Aplin, Hannes Maier, 'Prostheses for The Brain', Academic Press, 2021.
2. Joseph D Bronzino, "The Biomedical Engineering Handbook", Third Edition, 2006, CRC press, USA.
3. Gerald E. Miller, 'Artificial organs', Morgan & Claypool Publishers, 2006.
4. Finn WE, LoPresti PG, editors. Handbook of neuroprosthetic methods. CRC Press; Dec 16, 2002.

BME 4450 REHABILITATION ENGINEERING [3 0 0 3]

Introduction to rehabilitation engineering in general.: The need and importance of rehabilitation engineering, Different categories of rehabilitation needed for the society, Understanding different stages through which rehabilitation has to be implemented on a case to case basis, A brief review of different physical disabilities: Definition of physical disability and its quantitative assessment, Concept of compensation for disabilities and importance of assistive devices, Popularly available assistive technology in general, Quantification of disability , methods and it's need , feasibility in the rehabilitation process for assistive technology, Categories of popularly available assistive devices; Special emphasis on the physical disability like disability on leg, hand etc., Relevance about the knowledge requirement about the biological signals in rehabilitation engineering, Important features of EMG,MMG signals in rehabilitation engineering, Need and importance of models; Different modeling tools and techniques in rehabilitation engineering, Significance modeling in assessing the disability of individuals, Popular models used for assessing disability, Electronic hardware used for assistive technology: Utility of micro controller in the development of assistive devices, Knowledge about the characteristic of human locomotion and its relevance in rehabilitation engineering, Dynamics of human organs, it's parameters, its utility in assistive limb technology, Possible case studies of different developed assistive devices.

References:

1) Joseph D Bronzino, THE Biomedical Engineering Handbook, VOL11, CRCPRESS, Edition 2, 2000

2) John G. Webster, Albertm. Cook, Willis J Tompkins, GREGG C Vanderheiden, Electronic devices for Rehabilitation, Chapman and Hall Ltd, 1985.

3) John Enderle, Dusan Blanchard, Joseph Bronzino, Introduction to Biomedical Engineering, Academic press,2000.

4) Arthur C Guyton, Textbook Of Medical Physiology, Edition 9, 1996

BME 4451 TELEMEDICINE [3 0 0 3]

History of Telemedicine, Block diagram of telemedicine system, origin and development of Telemedicine, Benefits and limitations of Telemedicine; Data & Signal, transmission impairments & channel capacity, Guided & Unguided transmission media, transmission of digital signal and analog signal; Analog modulation techniques: AM & FM, analog to digital conversions and digital modulation techniques like ASK, FSK, PSK and DPSK; Multiplexing techniques: TDM & FDM, Multiple access techniques: TDMA, FDMA & CDMA; Types of Network; Switching techniques: Circuit switching and Packet switching; Types of wireless network like Bluetooth, Wi-Fi, Zig Bee, Satellite network etc.; Data Security and Standards: Encryption, Cryptography, digital signature,

biometric security; Ethical and legal aspects of Telemedicine; Applications of Telemedicine: Teleradiology, telepathology, teleoncology, and other applications including videoconferencing.

References:

1. Behrouz A Forouzan, "Data Communication and Networking", McGraw Hill Education (India) Pvt. Ltd., 5th Edition, 2013.
2. Shashi Bhushan Gogia, "Fundamentals of telemedicine and telehealth", Academic Press, ist Edition, 2019.
3. Bernard Fong, A.C.M. Fong, C.K. Li, "Telemedicine technologies: Information technologies in Medicine and telehealth", John Wiley & Sons, UK, 2011.
4. Olga Ferrer-Roca, M.Sosa Ludicissa, Handbook of Telemedicine, IOS Press 2002.
5. Konstantina S.Nikita, Handbook of Biomedical Telemetry, John Wiley & Sons, 2014.
6. A.C. Norris, Essentials of Telemedicine and Telecare, John Wiley & Sons, 2002.
7. R S Khandpur, "Telemedicine technology and applications", PHI Learning Pvt. Ltd, New Delhi, 2017.

BME 4452 TISSUE ENGINEERING [3 0 0 3]

Introduction: Basic definition, Structural and organization of tissues: epithelial, connective tissues. Sterilization Process: Introduction, different sterilization methods: physical, chemicals; applications. Morphogenesis, Generation of Tissue in the Embryo: introduction, different germ layers, cardiac cell development, blood vessels development, skin tissue development; development of bone and cartilage, future development. Cellular Signaling: introduction, cellular signaling in skin, bone cartilage biology; understanding and implementing principles of cell signaling in tissue engineering. Stem Cell: introduction, types, self-renewal, differentiation, embryonic stem cell: isolation, properties; adult stem cells: isolation, properties, stem cell niche, future perspective. Cell and Tissue Culture: introduction, cell harvest, selection, expansion, differentiation, co-culture, source, types of tissue culture (animal), cell lines, culture media, maintenance of cell in vitro. Scaffolds: polymer, natural polymer for tissue engineering, degradable materials, various type of scaffold, cell –matrix interaction, ECM. Methods to monitor tissue re-modeling Engineering tissues (like skin, cartilage, bone).

References:

1. Satya Prakash, D.S. Tim, Stem cell bioengineering and tissue engineering microenvironment, World Scientific, 2012.
2. Endarle, Blanchard & Bronzino, Introduction to Biomedical Engineering, Academic press, 1998.
3. C.W. Patrick Jr., A. G. Mikos, L.V. Mcintire, Frontiers in tissue engineering, Pergamon, Elsevier, 1998.
4. C.V. Blitterswijk, Tissue Engineering, Academic Press, 2008.
5. B.O. Palsson and S N Bhatia, Tissue Engineering, Pearson Prentice Hall, 2004.
6. David Williams, Essentials Biomaterials Science, Cambridge University Press, 2014.
7. Julia Polak,(Ed), Advances in Tissue Engineering, Imperial College Press, 2008.

BME 4453 VIRTUAL REALITY [3 0 0 3]

Definition and goals of Extended Reality, historical perspective, different applications of VR (news, sports, entertainment, surgery, training etc.)
Psychology of VR: Place illusion, plausibility illusion, embodiment illusion
Graphics in VR: Transformations, 3D audio, Tracking in VR (Tilting/Yawing/SfM), general outline of content creation in VR
Interaction in VR: Natural Interaction, Magic/Active/Passive Interaction, Teleportation in VR, Virtual Navigation, redirected walking, walk-in-place, Interacting with objects in VR, hyper-natural interaction, evaluation metrics, physics-based interaction, state machines
User interfaces in VR: Abstract Interfaces, Diegetic/Non-diegetic interfaces, gestural interaction, issues in VR interaction
User Interfaces in Unity3D: Unity gesture plugin, Bespoke VR
Virtual Characters in VR, Body Animation in VR, Facial Animation, Social VR

References:

1. Grigore C. Burdea, Philippe Coiffet, Virtual Reality Technology, Wiley 2016
2. Alan Craig, William Sherman and Jeffrey Will, Developing Virtual Reality Applications, Foundations of Effective Design, Morgan Kaufmann, 2009.
3. John Vince, "Virtual Reality Systems ", Pearson Education Asia, 2007.

OPEN ELECTIVES:

BME 4311 BIOMEDICAL INSTRUMENTATION [3 0 0 3]

Biomedical transducers: Classification and Selection; Pressure Transducers: Resistive, capacitive, Inductive transducers & Piezo-electric, Photoelectric transducers & its types; Thermal transducers & its types; Electrodes & Amplifiers: Principles of working and their characteristics, Half- cell potential, Types of electrodes, Electrode-Electrolyte model, Amplifiers for biomedical instrumentation; Physiological Signals & Measurements: Basics of ECG, EMG, EEG, PCG, blood pressure & blood flow and the instrumentation for measuring these signals; Cardiac Pacemakers: Types of pacemakers, Modes of triggering, Pacemaker power supplies, pacemaker codes; Defibrillators: AC and DC defibrillators, Types of electrodes and their features, cardioverters; Lasers: Basic principles, types of lasers and their medical applications; X-ray systems, Fluoroscopic system, principles of tomography; Electrical Hazards & Safety: Safety code standards, Micro and Macro shock and its physiological effects, Methods of electrical safety.

References:

1. John G Webster, "Medical Instrumentation Applications and Design", John Wiley and Sons, New York, 3rd Edition, 2011.
2. R S Khandpur, "Handbook of Biomedical Instrumentation", McGraw Hill, Delhi, 3rd Edition, 2014.
3. L A Geddes, L E Baker, "Principles of Applied Medical Instrumentation", Wiley India, New Delhi, 3rd Edition, 2008.
4. Richard Aston, "Principles of biomedical Instrumentation and measurement", Merrill, New York, 1991.
5. Joseph J Carr, John M Brown, "Introduction to Biomedical Equipment technology", Prentice Hall, New Jersey, 4Th Edition, 2003.

BME 4312 BIOMECHANICS [3 0 0 3]

Basic terminology, Anatomical movement descriptors. Skeletal considerations for movement: Composition & Structure of bone, mechanical properties of bone, bone fracture & failure mechanics. Muscular considerations for movement: Skeletal muscle tissue properties, function and structure, Force generation in the muscle, Role of muscle, Force-velocity relationships in skeletal muscle, Joint flexibility. Fundamental concepts of gait. Linear Kinematics: kinematic parameters, projectile motion, linear kinematics of walking and running. Angular Kinematics: types of Angles, lower extremity joint angles, angular motion relationships, relationship between linear and angular motion, angle-angle diagrams. Linear Kinetics: laws of motion, types of forces, representation of forces acting on a system. Angular Kinetics: Newton's laws of motion (angular analogs), center of mass calculation, rotation and leverage, pulley system, analysis using Newton's laws of motion. Application of Aerodynamics in Sports: aerodynamic drag force - effects of drag on the body and objects in sport- activities, aerodynamic lift force - lift force acting on shapes and surfaces, effects of lift on projected objects, the Magnus effect. Application of Hydrodynamics in Aquatics: buoyancy and floatation, floating ability of the human body, types of floaters, different floating positions of the human body, resistive & propulsive forces in swimming skills, Swimming efficiency and speed.

References:

1. Joseph Hamill and Kathleen M. Knutzen, Biomechanical Basis of Human Movement, Lippincott Williams & Wilkins, Fourth Edition, 2014, Philadelphia, USA.
2. Susan J. Hall, Basic Biomechanics, McGraw-Hill International Editions, Seventh Edition, 2014, Singapore.
3. Peter M. McGinnis, Biomechanics of Sport and Exercise, Human Kinetics, Third Edition, 2013, USA.
4. P. Grimshaw and A. Burden, Sport & Exercise Biomechanics, Taylor & Francis Group, First Edition, 2007, UK.
5. Ellen Kreighbaum, Katharine M Barthels, Biomechanics-A Qualitative Approach for studying Human Movement, Allyn and Bacon Publishers, Fourth Edition, 1995, USA.

BME 4313 REHABILITATION ENGINEERING [3 0 0 3]

Introduction to rehabilitation engineering and assistive technology: principles, engineering concepts in sensory rehabilitation, motor rehabilitation and communication disorders. Orthopedic prosthetics & orthosis in rehabilitation technology: fundamentals of design of upper and lower extremity prosthetic and orthotic devices, applications. Mobility aids: mobility aids for the blind, discussion of design and function of robotic aids, wheel chairs. Sensory augmentation & substitution: visual, auditory and tactile sensory augmentation & substitution. Conversion aids for non-vocal physically impaired persons: characteristics and design considerations for conversion aids, biofeedback in communicative disorders, artificial larynx. Principles and applications of electrical stimulation: artificial electrical stimulation of nerves and muscles, applications. Conceptual frameworks, education and quality assurance.

References:

1. Joseph D. Bronzino and Donald R. Peterson, "The Biomedical Engineering Handbook", volume II, CRC press, fourth edition, 2015.
2. John G. Webster, Albert M. Cook, Willis J. Tompkins, Gregg C. Vanderheiden, "Electronic devices for Rehabilitation", John Wiley & Sons Inc, second edition, 1989.

3. John Enderle and Joseph Bronzino, “Introduction to Biomedical Engineering”, academic press, third edition, 2011.
4. Rory A. Cooper, “An introduction to Rehabilitation Engineering”, Taylor and Francis Inc, first edition, 2007.

BME 4314 INTRODUCTION OF MATERIALS IN MEDICINE [3 0 0 3]

Structure, properties and performance of materials: nature of materials, molecular assembly; bulk properties; surface properties; elasticity and viscoelasticity

Classes of materials used in medicine: versatility of materials, Polymers –synthetic, natural, Metal, Ceramics, Composites, Hydrogels, medical fibers, porous materials, biomimetic materials.

Characterization of materials-contact angle, spectroscopy

Background concept of biological system: biological environment, biology in medicine, cells and surfaces, signaling pathways

Host reaction to Materials: biological responses to materials, inflammation, foreign body response, device related infection

Biological testing of Materials: testing materials, biocompatibility, blood-material interaction

Application of materials in Medicine and functional tissue engineering: orthopedic, dental, ophthalmic, burn dressing, sutures, implants and inserts, tissue engineering templates

References:

1. Buddy D Ratner & Allen S Hoffman, Biomaterials Science, 3rd Edition, 2012, Academic Press, Canada.
2. David Williams, Essentials Biomaterials Science, 2014, Cambridge university press. ISBN:978052189908-6
3. Mark Meyers and Krishnan Chawla, Mechanical Behaviour of Materials, 2nd Ed, Cambridge University Press, 2009 ISBN: 978-0-521-18620-9
4. Lisa A. Pruitt and Ayyana M. Chakravartula, Mechanics of Biomaterials Fundamental Principles for Implant Design, Cambridge university Press 2011
5. M. Jaffe, W. Hammond, P.Tolias and T. Arinzeh, Characterization of biomaterials, Woodhead Publishing Limited, 2013

BME 4315 INTRODUCTION TO NANOMATERIALS & CHARACTERIZATION TECHNIQUES [3 0 0 3]

Introduction nanotechnology: Nanomaterials- classifications, synthesis methods, surface functionalization of nanoparticles, nanocomposites. Properties of nanomaterials: - mechanical properties, optical properties, magnetic properties. Characterization tools for nanomaterials and nanosystems- structural and chemical characterization techniques. Physical and chemical characterization of Nanomaterials: Transmission electron microscope (TEM), scanning electron microscope (SEM), scanning tunneling microscope (STM), atomic force microscope (AFM), X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FT-IR), dynamic light scattering (DLS), Mass spectroscopy, chromatography. Thermal characterization of nanomaterials: Thermogravimetric analysis (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC). Surface Characterization of nanomaterials: X-ray photoelectron spectroscopy (XPS), auger electron spectroscopy (AES), secondary ion mass spectroscopy (SIMS), Raman spectroscopy, electron energy loss spectroscopy (EELS) and ultraviolet spectroscopy.

Self-Directed Learning: Properties of nanomaterials: - mechanical properties, optical properties,;
Duration: 3Hr

References:

1. Guozhong Cao, *Nanostructures and nanomaterials Synthesis*, Imperial Press 2011.
2. G.A. Ozin and A.C. Arsenault, *Nanochemistry: A chemical approach to Nanomaterials,* Royal Society of Chemistry, 2005.
3. T. Pradeep, *A Textbook of Nanoscience and Nanotechnology*, McGraw Hill Education, 1st edition, 2017.
4. P. M. Ajayan, L. S. Schadler, P. V. Braun, Nanocomposite Science and Technology, Wiley-VCH; 1 edition.

BME 4316 NANOMEDICINE [3 0 0 3]

This course gives an overview of nanotechnology and its applications in the field of medicine. The course includes: fundamental concepts in nanotechnology, fundamental concepts in cell, molecular and tissue biology, nanoparticles and their synthesis, nanotechnology platforms, characterization of nanomaterials, Nano pharmaceuticals, Nano-biosensors and diagnostics, role of nanotechnology in biological therapies, Nano devices for medicine and surgery, application in orthopaedics, cardiology, microbiology, ophthalmology, imaging, role of nanotechnology in regenerative medicine and tissue engineering, Nano toxicity, case studies in Nanomedicine.

References:

1. Jain KK, Jain KK. The handbook of nanomedicine. NJ: Humana Press; 2008.
2. Tibbals HF. Medical nanotechnology and nanomedicine. Crc Press; 2017.
3. Torchilin V, Amiji MM, editors. Handbook of materials for Nano medicine. Pan Stanford Publishing; 2011.
4. Prasad PN. Introduction to nanomedicine and Nano bioengineering. John Wiley & Sons; 2012 Jun 19.