Indian Institute of Engineering Science and Technology, Shibpur

Course Structure for Two-Year M. Tech Program

M TECH BIOMEDICAL ENGINEERING

Table - 1
Specialization: M TECH BIOMEDICAL ENGINEERING

A. First Semester

a) Departmental Core Papers for the specialization (Paper – I, II, III)

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	HC5101	Biomedical Imaging and Optics	3	0	0	3	3	100
2	HC5102	Fundamentals of Biomaterials	3	0	0	3	3	100
3	HC5103	Cellular and Systems Physiology	3	0	0	3	3	100

b) Departmental Elective Papers for the specialization (Paper – IV)

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	HC5121	Biomedical Sensors & Instrumentation (DE)	3	0	0	3	3	100
2	HC5122	Finite Element Analysis (DE)	3	0	0	3	3	100

c) Open Elective Papers

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	HC5161	Materials and Mechanics in Medicine (OE)	3	0	0	3	3	100
2	HC5163	Synthetic Drugs and Clinical trials (OE)	3	0	0	3	3	100
5	HC5164	Medical Device Technologies (OE)	3	0	0	3	3	100

d) Departmental Labs for the specialization (Lab – I, II, III)

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	HC5171	Biomedical Imaging and Optics Lab	0	0	2	4	2	100
2	HC5172	Fundamentals of Biomaterials Lab	0	0	2	4	2	100
3	HC5173	Cellular and Systems Physiology Lab	0	0	2	4	2	100

B. Second Semester

a) Departmental Core Papers for the specialization (Paper – VI, VII, VIII)

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	HC5201	Nano and Micro-fabrication Techniques	3	0	0	3	3	100
2	HC5202	Data Analytics and Soft Computing	3	0	0	3	3	100
3	HC5203	Implant Biomaterials and Medical Device Designing	3	0	0	3	3	100

b) Departmental Elective Papers for the specialization

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	HC5221	Medical Image and Signal Processing (DE)	3	0	0	3	3	100
2	HC5222	Tissue Engineering and Mechanobiology (DE)	3	0	0	3	3	100
3	HC5223	Bioinformatics, Drug Design and Functional Genomics (DE)	3	0	0	3	3	100

c) Open Electives

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
4	HC5261	Molecular Optimization and Natural Logic (OE)	3	0	0	3	3	100
5	HC5262	Polymer Engineering for Biomedical Applications (OE)	3	0	0	3	3	100
6	HC5263	Nanotechnology in medicine and biology (OE)	3	0	0	3	3	100
7	HC5264	Biotechniques for industrial applications (OE)	3	0	0	3	3	100

d) M. Tech Project Part - I

Sl. No	Subject code	Subject Name	Total load (h)	Credit	Marks
1	HC5271	M. Tech thesis Part - I (Term Paper)	8	4	200
2	HC5272	Term Paper Seminar & Viva-voce		2	100

C. Third Semester

M. Tech Project Part - II

Sl. No	Subject code	Subject Name	Total load (h)	Credit	Marks
1	HC6171	M. Tech Thesis Part - II (Progress Report)	24	12	300
2		Progress Report Seminar & Viva-voce		6	100

D. Fourth Semester

M. Tech Project Part – III

Sl. No	Subject code	Subject Name	Total load (h)	Credit	Marks
1	HC6271	M. Tech Final thesis	30	22	400
2		Thesis Seminar& Viva-voce		8	200

Total Credit: 21 + 21 + 18 + 30 = 90

M TECH BIOMEDICAL ENGINEERING

FIRST SEMESTER CORE COURSES BIOMEDICAL ENG

Course: HC5101 Biomedical Optics and Imaging (3-0-0-3-100)

1. X-rays and CT: electromagnetic radiation & interaction with matter, Radiation dosimetry, risk and protection, Radiation Biology, Radiography, Film-screen and digital Mammography & Fluoroscopy, generation and characteristics of x-rays, x-ray tube.
2. Magnetic resonance imaging (MRI): concept of spin and nuclear magnetic resonance, spin decay through interaction with tissues, use of different magnets in MRI systems, one or two simple imaging sequences.
3. Ultrasound: characteristics of sound waves, piezoelectricity and generation of ultrasound, interaction of ultrasound with tissues, Doppler Effect and its uses.
4. Nuclear Medicine Imaging Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET).
5. OCT
6. Fundamentals of tissue optics: Propagation of optical radiation in tissues; Skin Tissue Optics, Hard tissue Optics. Eye Optics, Blood optics: Composition of blood. Spectral properties of erythrocytes, thrombocytes and blood plasma; Differences between oxygenated and unoxygenated haemoglobin absorption spectra.
7. Microscopy and its applications
8. Lasers in Medical Applications.
9. Radiation Biology: Interaction of radiation with matter, Application of Radioisotopes: Alpha, Beta and Gamma emission, Principle of radiation detectors, dot scanners, Nuclear angiogram, Principles of Radiation therapy. Introduction to Radiation safety, Hazardous effect of Radiation, Radiation Protection Techniques, Safety limits, Radiation monitoring.

Books and References:

1. Farr's Physics for Medical Imaging (Second Edition), Book • 2nd Edition • 2008; Penelope Allisy-Roberts and Jerry Williams; ISBN: 978-0-7020-2844-1.
2. 1. Biomedical Imaging: Karen M. Mudry, Robert Plonsey, Joseph D. Bronzino, March 26, 2003 by CRC Press, Reference - 360 Pages - 149 B/W Illustrations, ISBN 9780849318108 - CAT# 1810.
3. Biomedical Optics: Principles and Imaging, Lihong V. Wang, Hsin-i Wu, ISBN: 9780-471-74304-0, 376 pages, May 2007

Course: HC5102 Fundamentals of Biomaterials: (3-0-0-3-100)
1. Introduction to material science and engineering; nature of chemical bonds and the basis of material classification. 2. Nature of Solid state of materials and importance of defects in solids. 3. Materials Characterization techniques: Spectroscopy-IR, Raman, NMR, UV; XRD; Microscopy-TEM, SEM and AFM; DLS 4. Wound Healing and Biocompatibility Assessment. 5. Biodegradation of materials. 6. Biomaterial-blood (bio-fluid) interface, Surface modifications for improved compatibility. 7. Surface characterization of materials and their relevance to biocompatibility. 8. Metals, Phase Diagrams, Ceramics properties for biomedical applications. Mechanical properties of materials. 9. Basics of Polymer Science, Structure, Synthesis, Characterization. Molecular weight. 10. Structure Property relationships in biomaterials. Representatives from synthetic and natural polymers.
Books and References: 1. Biomaterials Science (Third Edition), an Introduction to Materials in Medicine, Edited by: Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons, ISBN: 978-0-12-374626-9. 2. An Introduction to Biomaterials, Second Edition, Jeffrey O. Hollinger, November 28, 2011 by CRC Press, Textbook - 644 Pages - 223 B/W Illustrations. ISBN 9781439812563 - CAT# K10637. 3. Agrawal, C.M., Ong, J.L., Appleford, M.R. And Mani, G. (2014) Introduction to Biomaterials: Basic Theory with Engineering Applications. Cambridge University Press, Cambridge.

Course: HC5103 Cellular and Systems Physiology (3-0-0-3-100)
1. Organization and Structure of Cell. 2. Biomolecules: Information and Function. Nucleic acids: Synthesis and Properties. The Central Dogma: DNA as genetic material. Protein structure and Dynamics. 3. Information Processing in Biology: Translation, transcription and post-translational modifications. 4. Bioenergetics and metabolism, ATP generation pathways 5. Cardiovascular System. The cardiac cycle, regulation of blood pressure and haemodynamics, blood composition and haemostasis. 6. Respiratory System. Pulmonary ventilation, gas exchange and transport, regulation of respiration. 7. Digestive System and Endocrine system: Digestion and absorption of nutrients; gastrointestinal motility and secretions. 8. Renal System. Mechanisms of filtration, reabsorption and secretion; integrated regulation of fluid and electrolyte balance. 9. Immune system and Integrated neural control mechanisms for these body systems 10. Pathophysiology of some common human diseases
Books and References: 1. Molecular Cell Biology, 4th edition, Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. New York: W. H. Freeman; 2000. ISBN-10: 0-7167-3136-3 2. Cell Biology (Third Edition), A Laboratory Handbook, Edited by:Julio E. Celis, ISBN: 978-0-12-164730-8. 3. Ross & Wilson, " Anatomy and Physiology in Health and Illness," Churchill Livingstone, ISBN0 - 443 - 04243 - 8. 4. Guyton and Hall Textbook of Medical Physiology: with STUDENT CONSULT Online Access, 12e (Guyton Physiology) – by John E. Hall.

FIRST SEMESTER DEPT ELECTIVES BIOMEDICAL ENG

Course: HC5122 (DE) Finite Element Analysis: (3-0-0-3-100)
Introduction, basic concept, comparison with finite difference method; Variational methods - calculus of variation, Rayleigh-Ritz and Galerkin methods; One-dimensional problems - formulation by different approaches, derivation of elemental equations, assembly, solutions and post-processing, bending of beams, analysis of truss and frame, other problems of solid mechanics, fluid mechanics and heat transfer; Two-dimensional problems - modeling of single variable problems, triangular and rectangular elements, applications insolid mechanics, fluid mechanics and heat transfer; Numerical considerations - numerical integration, error analysis, mesh refinement; Plane stress and plane strain problems; Bending of plates; Eigen value and time dependent problems; Discussion about preprocessors, postprocessors; Application of commercial software packages; Assignment and mini-project.
Books and References: 1. Finite Element Analysis for Biomedical Engineering Applications; 1st Edition; Z. C. Yang; CRC Press; 2019; ISBN 9780367182182 - CAT# K416341.

Course: HC5121 (DE) Biomedical Instrumentation: (3-0-0-3-100)
1. Medical measurands; Sensor architecture and Classification; Medically significant measurands, functional specifications of medical sensors; Category of measurement, factors in making measurement, biometrics, problems encountered in measuring a living system (2) 11. Cell Potentials and origin of bioelectricity. (4) 2. Muscle electrophysiology, Resting and Action Potentials, Propagation of Action Potentials. 3. Introduction to biotransducers and classification. Different physiological transduction mechanisms in sensors. Types of recognition layers. Examples and functioning of different types of biosensors including, but not restricted to, optical, mechanical (e.g. microcantilever, piezo, SAW, etc), electrochemical, FET, thermal, etc. Analytical modelling of biosensors. Transducers: Classifications, working principle, construction and design of various active and passive transducers. Voltage and current transducers, Tap position transducers. Hall Effect transducers, optical transducers. Semiconductor traducers for physical and chemical parameters measurement. (8) 4. Basic Biomedical electronics, Instrumentation System, performance requirements, biomedical recording Systems, patients monitoring systems, recording of bioelectric events: Recording of ECG, EMG & EEG signals. Holter monitor and cardiac stress test. (4) 5. Cardiovascular and Pulmonary function measurement systems, oximeters, blood flow measurement 6. Automated clinical Analyzers, blood gas analyzers. (4) 7. Cardiac Pacemakers, Defibrillators and Robotics Surgical Instrumentation. Physiotherapy equipments. (4) 8. Automation systems, Advantages of automation, adaptive filters, Control and Data acquisition (SCADA) Systems. (4) 9. Design of detection electronics and signal conditioning circuits for various resistive, capacitive, inductive transducers. Active filters, Impedance matching, loading effect. Introduction to electromagnetic coupling (EMC), inference coupling mechanism, shielding. Concepts of interfaces with digital device like computer, microcontroller microprocessor. 10. IoT in preventive maintenance.
Books and References: 1. John G. Webster, “Medical Instrumentation Application and Design”, John Wiley and sons, New York, 2004. 2. Leslie Cromwell, “Biomedical Instrumentation an d measurement”, Prentice hall of India, New Delhi, 2007.

OPEN ELECTIVES:

Course: HC5161 (OE) Materials and Mechanics In Medicine: (3-0-0-3-100)
Examples of mechanics in medicine: Cardiovascular system, Skeletal system, Pulmonary mechanics Concepts of biomaterials and biocompatibility: Host reactions, blood material interactions, material properties and characterization by IR, Raman spectroscopy, Surface properties relevant for biomedical performance, emerging techniques in biomaterial fabrication. Mass transfer in medical applications: Bioreactor, Hill equation for oxygen-hemoglobin equilibrium, Model oxygen transport in lungs and calculate the oxygen profile in an alveolar capillary, Understand the Krogh model for oxygen transport in tissues and identify the oxygen starved region, Develop pharmacokinetic models to predict drug metabolism, Mesoscopic model for a dialysis system and link it to model a patient-hemodialyzer system. Heat transfer applications in medicine: bioheat transfer equation, laser ablation therapy, Microfluidics systems for medical applications.
Books and References: 1. Biomaterials Science, Buddy Ratner. 2. Heat Transfer in Biology and Medicine, Avraham Shitzer, Rohert C. Eherhart.

Course: HC5163 (OE) Synthetic Drugs Design: (3-0-0-3-100)
1. Traditional Drugs, types, Biopharmaceuticals and Biosimilars, RNA therapeutics, Nanomedicine. 2. Computer aided drug design, targeted drug delivery, Molecular dynamics, *in silico* modeling techniques, software used, ADMET prediction. 3. Preclinical trials, stages, animal models and Trangenics and limitations. 4. Bioreactors: structure, types, unit operations and downstream processing. 5. Way to commercialization of new therapeutics.
Books and References: 1. Drug Design, 1st Edition, Elsevier

Course: HC5164 (OE) Medical Device Technologies: (3-0-0-3-100)
1. Biomedical Engineering design consideration 2. Classification of devices 3. Survey of Physiology 4. Survey of material properties for medical devices 5. In vitro diagnostic devices: POC devices, lab-on-Chips, MEMS in medical devices, principles of analysis 6. Diagnostics devices: MRI, CT 7. Implanatable devices- neural prosthesis, rehabilitation devices.
Books and References: 1. Andrés D. Lantada. Handbook on Advanced Design and Manufacturing Technologies for Biomedical Devices. Springer London 2013 2. Aimé Lay-Ekuakille and Subhas C. Mukhopadhyay, Wearable and Autonomous Biomedical Devices and Systems for Smart Environment. Springer-Verlag Berlin, 2010. 3. Medical Device Technologies: A Systems Based Overview Using Engineering Standards.

FIRST SEMESTER LABORATORY COURSES BIOMEDICAL ENG

Course: HC5171 Biomedical Optics and Imaging Lab: (3-0-0-3-100)
1. Study of different modes of optical microscopy 2. Quantitative interpretation of biological smaples (cells/tissues) using PAP and H&E staining 3. DIC imaging and comparitive assessment with phase contrast for label-free cell analyis 4. Fluorescene microscopy and representation of cellular autofluorescence intensities 5. Morphological and textural feature identification for disease diagnosis 6. Synthesize and characterize gold nanoparticles for cell imaging

Course: HC5172 Fundamentals of biomaterials Lab: (3-0-0-3-100)
1. Synthesis and Characterization of polyaniline and polypyrrole- conductive polymers. 2. Synthesis and characterization of hydrosxyapatite- bioceramic 3. Surface modification of titanium implant surface and characterization 4. Design of human organ models and 3d printing of the same 5. Fabrication of electrospun nanofibers 6. Mechanical characterization of implants 7. Fabrication of micro- and nano-drug delivery system 8. Studying the viscosity and rheological properties of polymer solutions 9. Demonstration of 3d extrusion printing of biomaterials 10. Evaluation of antibiofilm and biocorrosion properties of metallic implants

Course: HC5173 Cellular and Systems Physiology Lab: (3-0-0-3-100)
Several experiments on molecular biology, microbial culture, sterilization, DNA isolation etc.

SECOND SEMESTER CORE COURSES BIOMEDICAL ENG

Course: HC5201 Nano- and Micro-fabrication Techniques: (3-0-0-3-100)
1. Fluid mechanics at the microscale; issues with flow characterization and control (mixing and separation, pumps and valves); introduction to droplet manipulation and digital microfluidics; specific examples from different with emphasis on biomedical applications. 2. Thin Film Techniques: Introduction - Necessity for a clean room- different types of clean rooms-construction and maintenance of a clean room- thin film deposition techniques, oxidation chamber, CVD, PVD, 3. Lithography – Forming electron beams of sub-micron cross section, Optical lithography- Optical projection lithography- Photomask- Binary mask- Optical immersion lithography- Optical interferometric lithography- Holographic lithography. maskless optical lithography, electron beam lithography: x-ray lithography, ion beam lithography-., nanoimprint lithography and soft lithography: uv-nil- Soft Lithography- Moulding/Replica moulding: Printing with soft stamps- Edge lithography - 4. Physics of Nanomaterials. 5. Lab-on-chip devices and Nanobiotechnology applications.
Books and References: 1. HANDBOOK OF THIN-FILM DEPOSITION PROCESSES AND TECHNIQUES: Principles, Methods, Equipment and Applications, Second Edition, Edited by Krishna Seshan; NOYES PUBLICATIONS; WILLIAM ANDREW PUBLISHING Norwich, New York, U.S.A. 2. Microfabrication and Nanomanufacturing; Mark J. Jackson; CRC Press. 3. Handbook of Microlithography, Micromachining, and Microfabrication; By P. Rai-Choudhury; SPIE.

Course: HC5202 Data Analytics and Soft Computing : (3-0-0-3-100)
1 Soft Computing Hard Computing: Features of Hard Computing, Soft Computing: features of soft computing, Hybrid Computing, Fuzzy Set Theory: fuzzy versus crisp sets, basic fuzzy set operations, linguistic variables, membership functions, fuzzy Cartesian product, fuzzy relations, fuzzy rules. 2 Fuzzy Implications Approximate reasoning, fuzzy modelling, fuzzification, inferencing and defuzzification, fuzzy modeling and control schemes for nonlinear systems. 3 Fundamentals of Neural Networks Biological neural networks, models of an artificial neuron, neural network architectures, characteristics of neural networks, McCulloch-Pitts neuron, learning methods, Hebbian learning rules, Hebb nets. 4 Backpropagation Networks Architecture of backpropagation networks, perceptron model, single layer and multi-layer perceptron models, backpropagation learning, tuning parameters of backpropagation networks, neuro-fuzzy models, adaptive neuro-fuzzy inference system (ANFIS), applications 5 Neuro-Fuzzy Systems Architectures of neuro-fuzzy systems; Cooperative neuro-fuzzy systems, Neural Network driven fuzzy reasoning, Hybrid neuro-fuzzy system; Construction of neuro-fuzzy systems. 6 Biomedical Databases, Data Searching 7 Cloud computing, clustering, classification methods, Support Vector Machine, K nearest neighbor method, Data mining and knowledge discovery methods 8 Automatic analysis, alignment, comparison and annotation of biological sequences; analysis of genome evolution and variation; molecular biology databases. 9 An introduction to experimental methods used in determining the structure of biomolecules, protein structure prediction and biomolecular systems simulation. 10 Machine Learning Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naive Bayes 11 Support Vector Machines, Nonlinearity and Kernel Methods, Beyond Binary Classification: Multi-class/Structured Outputs, Ranking 12 Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning
Books and References: 1. Soft Computing Techniques in Engineering Applications, Editors: Patnaik, Srikanta, Zhong, Baojiang (Eds.), Springer. ISBN 978-3-319-04693-8. 2. Neuro-fuzzy and soft computing: a computational approach to learning and machine intelligence; Prentice-Hall, Inc. Upper Saddle River, NJ, USA ©1997; ISBN:0-13-261066.

Course: HC5203 Implant Biomaterials and Medical Device Designing: (3-0-0-3-100)
1. Basics of Design Process: Adoptive and Adaptive design, safety, Standardisation, 2. Regulatory and IPR issues in medical devices 3. the design process, design considerations: review of basics of work, energy, torque, power, load analysis, equilibrium equations, free - body diagrams, internal loads, force flow concept, locating critical sections, practical considerations 4. Creativity and problem solving, Decision Theory, Modeling – Role of models in Engineering Design, Optimization 5. Implantable Devices: Implantable Cardiovascular Assist Devices, Artificial RBC Substitutes, 6. Orthopedic Applications, Dental Implants, Adhesives and Sealants, Ophthalmological Applications (Various types of contact lenses, Intra Ocular Lens Implant), Cochlear Prostheses, neural biomaterials 7. Cardiovascular biomaterials, Hemodialysis membranes 8. Smart materials 9. Controlled drug delivery devices 10. Introduction to Rehabilitation Engineering, Principles involved in rehabilitation engineering. Assistive Technology, Steps in patient management, Epidemiology of Rehabilitation, Health, Levels of Prevention, Preventive Rehabilitation, Diagnosis of Disability and Functional Diagnosis, Medical Rehabilitation, Telerehabilitation, Vocational Rehabilitation. Prosthetics.
Books and References: 1. Medical Device Development: Regulation and Law Hardcover – 1 Mar 2014; by Jonathan S. Kahan (Author), Hogan Lovells US LLP (Author); 2. The Medical Device R&D Handbook, Second Edition; Theodore R. Kucklick; December 5, 2012 by CRC Press; Reference - 510 Pages - 15 Color & 141 B/W Illustrations; ISBN 9781439811894 - CAT# K10598. 3. Implantable Electronic Medical Devices, 1st Edition; Implantable Electronic Medical Devices, 1st Edition,Dennis Fitzpatrick,ISBN9780124165564; Academic Press. 4. Advanced Biomaterials in Biomedical Engineering and Drug Delivery Systems; Editors: Ogata, N., Kim, S.W., Feijen, J., Okano, T. (Eds.); Springer; ISBN 978-4431-65883-2.

SECOND SEMESTER DEPT ELECTIVES BIOMEDICAL ENG

Course: HC5221 Medical Image and Signal Processing: (3-0-0-3-100)
1. Analog signal and its processing, Digital signal, analog to digital signal, Noise, Signal to Noise ratio, Signal analysis. 2. Mathematical tools, Convolution, Correlation and Covariance, Digital filters. 3. Spatial Filtering, Frequency filtering, Fourier Transform, DFT, DCT, Wavelet and Multi resolution processing, denoising. 4. Image sensing, acquisition, sampling and quantization, and enhancement 5. Image Analysis, Segmentation, edge detection, feature extraction. 6. Image classification, Clustering, Support Vector Machine, and Neural nets
Books and References: 1. Biomedical Signal and Image Processing, Second Edition; KayvanNajarian, Robert Splinter; May 4, 2012 by CRC Press; Textbook - ISBN 9781439870334 - CAT# K13235. 2. Biosignal and Medical Image Processing, Third Edition; By John L. Semmlow, Benjamin Griffel, CRC Press.

Course: HC5222 Tissue Engineering and Mechanobiology: (3-0-0-3-100)
1. Principle of tissue engineering and Regenerative medicine, 2. Cell-matrix and cell-cell interactions, role of epigenetics 3. Tissue dynamics and Cell sources: Stem cells, stem cell programming 4. Scaffolds Fabrication 5. Bioreactors 6. Case studies involving skin, bone, liver, muscle tissue engineering 7. Angiogenesis, vascularization 8. Vascular tissue engineering; Brain tissue engineering; Biomimetics engineering: Organoids; Clinical application, 3D cell culture 9. Standardization of TE products 10. Cellular Mechanics and Mechanobiology:- Mechanics of receptor binding; Arterial wall stress/strain analysis; Fluid mechanobiology; Mechanosensors; Mechanotransduction; Mechanical regulation of cell fate; Cytoskeletal dynamics and mechanics; Viscoelasticity; Mechanical testing of cells.
Books and References: 1. Fundamentals of Tissue Engineering and Regenerative Medicine, Editors: Meyer, U., Meyer, Th., Handschel, J., Wiesmann, H.P. (Eds.); ISBN 978-3-540-77755-7. 2. Stem Cells, Tissue Engineering and Regenerative Medicine 1st Edition; by David Warburton; World Scientific; I SBN-13: 978-9814612777. 3. Principles of Regenerative Medicine, 2nd Edition; Principles of Regenerative Medicine, 2nd Edition, Anthony Atala,Robert Lanza,James Thomson,Robert Nerem, ISBN9780123814227; Academic Press. 4. Introduction to Cell Mechanics and Mechanobiology, 1st Edition, Christopher R. Jacobs, Hayden Huang, Ronald Y. Kwon,ISBN 9780429171277 - CAT# KE84426.

Course: HC5223 Functional Genomics and Bioinformatics in Drug Designing: (3-0-0-3-100)
1. Functional genomics, microarray and gene expression analyses, pathway analyses prediction of gene functions 2. Biomedical Databases, Data Searching 3. Cloud computing, clustering, classification methods, Support Vector Machine, K nearest neighbor method, Data mining and knowledge discovery methods 4. Automatic analysis, alignment, comparison and annotation of biological sequences; analysis of genome evolution and variation; molecular biology databases. 5. An introduction to experimental methods used in determining the structure of biomolecules, protein structure prediction and biomolecular systems simulation. 6. Artificial neural networks, fuzzy sets and fuzzy logic 7. Applied bioinformatic tools: Entrez, ExPASY, BLAST, Motif search, phylogeny, Target analysis
Books and References: 1. Bioinformatics for Geneticists: A Bioinformatics Primer for the Analysis of Genetic Data, 2nd Edition; Michael R. Barnes (Editor); ISBN: 978-0-470-02620-5, Wiley. 2. Fundamentals of Bioinformatics and Computational Biology; Authors: Singh, Gautam B.; ISBN 978-3-319-11403-3; Springer. 3. Computational Intelligence in Bioinformatics; edited by Gary B. Fogel, David W. Corne, Yi Pan; IEEE Press.

OPEN ELECTIVES:

Course: HC5261 Molecular Optimization and Natural Logic: (3-0-0-3-100)
1. Organization of Organs and Tissues. Structure of Cell and Subcellular Organization 2. Heart and Circulatory System 3. Blood - A flowing tissue; Normal & Abnormal states. 4. Respiration – Cellular. 5. Metabolism - normal and abnormal events and control. 6. Neural Tissue –Organization & Control 7. Immune System – Components & Co-ordination. 8. Antibiotics – an era coming to an end; what next? 9. Diabetes, Hypertension – which way? 10. Open discussion in different clinical conditions; Therapeutic rationality – a long forgotten story; Vaccines
Books and References: 1. Arthur C Guyton: Human Physiology. 2. Davidson's Principle of Internal Medicine.

Course: HC5262 Polymer Engineering and Mechanics for Biomedical Applications: (3-0-0-3-100)
1. Rheology and rheological equations; Definition of biorheology, its connection with physics and biology; Need for biorheology and rheological concepts; Haemorheology : definition and clinical aspects; Haemodynamics, blood viscosity factors, cardiovascular haemorheology; Rheology of body fluids; Application of rheology in diagnosis, treatment and fundamental understanding of diseases; Experimental determination of blood and plasma viscosity. 2. Flow of Newtonian and non-Newtonian fluids, different flow equations, dependence of shear modulus on temperature, molecular/segmental deformations at different zones and transitions. Measurements of rheological parameters by capillary rotating, parallel plate, cone-plate rheometer. viscoelasticity-creep and stress relaxations, mechanical models, control of rheological characteristics through compounding, rubber curing in parallel plate viscometer, ODR and MDR. 3. Controlled Radical Polymerization 4. Functionalization of polymers 5. Polymer blends and composites: Difference between blends and composites, their significance, choice of polymers for blending, blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends, FRP, particulate, long and short fibre reinforced composites. 6. Specialty Polymers: Shape memory polymers, Smart polymers, Conducting and Piezoelectric polymers.
Books and References: 1. Introduction to Polymer Rheology; Montgomery T. Shaw; 2011; 2. Fundamentals of Controlled/Living Radical Polymerization Editors: Nicolay V Tsarevsky, Brent S Sumerlin; RSC. 3. Functional Polymers: Design, Synthesis, and Applications; 1st Edition; Raja Shunmugam.

Course: HC5263 Nanotechnology in medicine and biology: (3-0-0-3-100)
1. Nanomaterials: Classification and size dependent properties. 2. Colloidal and Interfacial Science: Stability and thermodynamics. 3. Preparation of nanomaterials and specific nano-fabrication techniques: impact of miniaturization across different industry sectors. 4. Special Characterization techniques for nanomaterials. 5. Fate and transport of nanomaterials in the human body: Kinetics and Distribution. 6. Nanotechnology of nature: Self assembly. 7. Biologically Inspired Nanoengineering and Their Applications. 8. Nanofluidics, magnetorheological and electrorheological fluids. 9. Nanotechnology applications in different industries: from microelectronics, energy, life sciences, mining, energy, food, water, gold mines, 10. Applications of nanotechnology in diagnosis, and therapy applications. 11. The toxicology of nanomaterials, Environmental and risk assessments of nanotechnology. Health implications, sustainable nanotechnology initiatives, nanomaterials and occupational health. 12. Nanotechnology for healthy air and water.
Books and References: 1. Nanotechnology: An Introduction to Synthesis, Properties and Applications of Nanomaterials, Thomas Varghese & K.M. Balakrishna. 2. Nanotechnology for Biology and Medicine: At the Building Block Level, Editors (view affiliations), Gabriel A. SilvaVladimir Parpura, Springer. 3. Nanotechnology in Biology and Medicine: Methods, Devices, and Applications, Second Edition, 2nd Edition, Tuan Vo-Dinh, CRC press.

Course: HC5264 Biotechniques for industrial applications: (3-0-0-3-100)
• Traditional Biological techniques for Therapeutics, Diagnostics (ELISA, RIA), Processed Food, Waste Management, Energy Production, Genetically Modified Crops • Cutting edge tools and techniques- Medical imaging techniques, Spectrometry, HPLC, MALDI-TOF • High throughput techniques: Microarray, Sequencing techniques • Bioreactors: Commercial Production of Antibiotics, Biopharmaceuticals, vaccines • Translational Bioinformatics: biological data and computerized databases to store, organize, and index the data are required, RNA therapeutics, Gene therapy • Transgenic animals, and Clinical trials, Some case reports • Soil and water remediation, Pollution abatement techniques • Biofuel and fermentation based products, biomining • Challenges in Translational Biomedical research from multiple perspectives