BMS COLLEGE OF ENGINEERING

BANGALORE-19

(Autonomous College under VTU)

DEPARTMENT OF MEDICAL ELECTRONICS

SCHEME & SYLLABUS

M.Tech

in

BIOMEDICAL SIGNAL PROCESSING AND INSTRUMENTATION

INSTITUTE VISION & MISSION

VISION:

Promoting prosperity of mankind by augmenting human resource capital through quality Technical Education & Training

MISSION:

Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society.

DEPARTMENT VISION & MISSION

VISION

To promote quality education in Medical Electronics Engineering for Health and well-being of humankind through teaching and research platforms.

MISSION

- To impart knowledge and skills necessary for professional development of graduates in Medical Electronics Engineering
- To provide continuous up gradation of technical education with strong academic progression
- To propagate creativity, responsibility, commitment and leadership qualities and exhibit professional ethics and values

I Semester

Course Code	Name of the Course	CREDITS				TOTAL CREDITS
		L	**T**	Practical / Field Work/ Assignment	**S**	
16MLBI1CPE	Physiology for Engineers	2	1	0	0	3
16MLBI1CES	Electrophysiological signal acquisition and analysis	2	0	1	1	4
16MLBI1CIA	Biomedical Image analysis	2	0	1	1	4
16MLBI1CBI	Theory & Design of Biomedical Instruments	3	1	0	0	4
-	Research Methodologies	2	0	0	0	2
16MLBI1EZZ	Elective - 1	--	--	--	0	4
16MLBI1EZZ	Elective - 2	--	--	--	0	4

Note: Two electives to be chosen, one from each group

I Semester

Electives (Group 1)

Course Code	Name of the Course	CREDITS				TOTAL CREDITS
		L	T	Practical / Field Work / Assignment	S	
16MLBI1EEM	Embedded System design for Biomedical Applications	3	0	1	0	4
16MLBI1EIF	Bioinformatics and Applications	3	0	1	0	4
16MLBI1ERS	Real time biosignal processing	3	0	1	0	4
16MLBI1ELA	Linear algebra and its applications in biomedical engineering	3	0	1	0	4

Electives (Group 2)

Course Code	Name of the Course	CREDITS				TOTAL CREDITS
		L	T	Practical / Field Work / Assignment	S	
16MLBI1EMR	Biomechanics and Rehabilitation	3	1	0	0	4
16MLBI1EAM	Hospital Administration & management	3	1	0	0	4
16MLBI1EHS	Hearing and Speech Processing	3	1	0	0	4
16MLBI1ECN	Computational Neuroscience	3	1	0	0	4

II Semester

Course Code	Name of the Course	CREDITS				TOTAL CREDITS
		L	T	Practical / Field Work / Assignment	S	
16MLBI2CMI	Medical Imaging Techniques & Systems	3	0	1	1	5
16MLBI2CBM	Biomaterials	2	0	1	1	4
16MLBI2CBP	Biophotonics	3	1	0	0	4
16MLBI2EZZ	Elective - 1	--	--	--	--	4
16MLBI2EZZ	Elective - 2	--	--	--	--	4
16MLBI2EZZ	Institution Elective	--	--	--	--	4

Note: Three electives to be chosen, one from each group

II Semester

Electives (Group 1)

Course Code	Name of the Course	CREDITS				TOTAL CREDITS
		L	T	Practical / Field Work / Assignment	S	
16MLBI2EBS	Biosensors and Biosensor networks	3	1	0	0	4
16MLBI2EHT	Health technology assessment	3	1	0	0	4
16MLBI2ECS	Compressive sensing in biomedical applications	3	1	0	0	4
16MLBI2ENI	Neuroimaging and Brain Mapping	3	1	0	0	4

Electives (Group 2)

Course Code	Name of the Course	CREDITS				Total Credits
		L	T	Practical / Field Work / Assignment	S	
16MLBI2EBN	Bio-nanotechnology	3	0	1	0	4
16MLBI2ETM	Telemedicine	3	0	1	0	4
16MLBI2EAO	Optical Coherence Tomography and adaptive optics	3	0	1	0	4
16MLBI2EAS	Applied statistics for biomedical research	3	0	1	0	4

Institution Electives

Course Code	Name of the Course	CREDITS				Total Credits
		L	T	Practical / Field Work / Assignment	S	
16MLBI2EMD	Medical device development	3	0	1	0	4
16MLBI2ENN	Neural Networks & Fuzzy logic applications	3	0	1	0	4
16MLBI2EPR	Pattern recognition and applications	3	0	1	0	4

III Semester

Course Code	Course	CREDITS
16MLBI3IN	Internship/Industrial training	21
16MLBI3CIP	Project Phase: I	04

NOTE:

- **Internship:** The student shall undergo internship for 16 weeks.

  Preliminary Report submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 100 marks

  Final Report submission and Evaluation after 16th week of Internship to be carried out by the Internal Guide of the college and a senior faculty. Report Evaluation to be completed within two weeks of submission for 100 marks.

  Viva-Voce on Internship - To be conducted by the Internship Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HoD as chairman for 100 marks

- **Project Phase: I**

  Problem formulation and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HoD as Chairman.

  Literature survey and progress done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HoD as chairman for 50 marks

IV Semester

Course Code	Course	CREDITS
16MLBI4CPR	Project Phase-II	23
16MLBI4CPS	Technical Seminar	02

- **Project Phase-II** - Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HoD as Chairman
- **Project Phase-III** - Internal Evaluation of Project Demonstration, which shall be evaluated after 15 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department.
- **Final Evaluation of Project Work and Viva-voce**.
  - Final evaluation of project to be carried out after 16 weeks from the date of commencement of 4th semester.
  - The Internal Examiner (the project guide with a teaching experience of at least three years) and External Examiner with HoD as chairman will complete the final evaluation of Project.
- Internal and External Examiners shall carry out the evaluation for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.
- **Viva – Voce** : The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HoD as chairman for 100 Marks

SEMESTER - I

CORE SUBJECTS

Course Title	PHYSIOLOGY FOR ENGINEERS	Course Code	16MLBI1CPE
Credits	03	L-T-P-S	2-1-0-0

CO1 Ability to apply basic concepts of physiology to develop in-depth understanding that will enable engineering analysis of human physiological systems

CO2 Ability to translate the understanding of physiological function into an engineering based model.

CO3 Ability to analyze and comprehend the model as an engineering solution.

General Physiology: Cell, Cell junctions, Transport through cell membrane, Homeostasis, Acid base balance.

Respiratory System & Environmental Physiology: Physiological anatomy of respiratory tract, Pulmonary circulation, Mechanics of respiration, Pulmonary function tests, Ventilation, Exchange of respiratory gases, Transport of respiratory gases, Regulation of respiration, Artificial respiration.

Renal Physiology : Kidney, Nephron, Juxtaglomerular apparatus, Renal circulation, Urine formation, Concentration of urine, Acidification of urine, Renal function tests, Renal disorders, Micturition, Uro flow studies, Dialysis.

Cardiovascular System : Introduction to cardiovascular system, Properties of cardiac muscle, Cardiac cycle, Heart sounds, Cardiac murmurs, Electrocardiogram, Vector, Arrhythmia, Cardiac output, Regulation of heart rate, Hemodynamics, Arterial blood pressure, Hemorrhage.

GIS: GIS, Functions of stomach, pancreas, liver, intestine, function tests: endoscopies.

Nervous System : Introduction to nervous system, Neuron, Classification of nerve fibers, Properties of nerve fibers, Degeneration & regeneration of nerve fibers, Neuroglia, Receptors, Synapse, Neurotransmitters, Reflex activity, Physiology of pain, Hypothalamus, Electroencephalogram Physiology of sleep, Epilepsy, cerebrospinal fluid, Autonomic nervous system and ANS tests. Evoked potentials. Cerebral circulation and tests.

Muscle Physiology: Classification of muscles, Structure of skeletal muscles, Properties of skeletal muscles, Changes during muscular contraction, Neuromuscular junction, Electromyogram & disorders of skeletal muscles Types of joint- Fibrous, Cartilaginous, Synovial, characteristics of synovial joints, shoulder joint, elbow joint, radioulnar joint, wrist joint, joints of hands and fingers, Hip joint, Knee joint, ankle joint, joints of foot and toes.

Physiology of Eye and Ear: Structure of the Eye, Visual process, Field of vision, Visual pathway, Pupillary reflexes, Colour vision, Errors of refraction. ERG and EOG. Structure of ear, Auditory defects.

Text Book:

1. **Essentials of Medical Physiology,** K Sembulingam & Prema Sembulingam (Jaypee Publications, 2004)

Reference Book:

2. **"Concise Medical Physiology"** Sujit K. Chaudhuri, 5th Ed, New Central Book Agency

Course Title	ELECTROPHYSIOLOGICAL SIGNAL ACQUISITION AND ANALYSIS	Course Code	16MLBI1CES
Credits	4	L-T-P-S	2-0-1-1

CO1 Ability to understand the knowledge of acquiring the signal from sensors as electrophysiological signal
CO2 Ability to know the signal for suitable analysis that facilitate to use in medical diagnosis
CO3 Ability to distinguish the signal characteristics in normal and ailment conditions based on signal
CO4 Ability to analyze real world electrophysiological signal using modern tools

Basic concept of biomedical instrumentation: Introduction to bioelectric phenomena. electrodes, transducers, biosensors and their characteristics. Synaptic transmission and transduction process in receptors. Frequency modulation of the electrical signals. Use of mathematical models particularly electrical circuit models in describing behaviour of cell membranes.

Cardiovascular Signal Acquisition: Generation, propagation, characteristics and recording of ECG and evoked potentials, Bio potential amplifiers. Biotelemetry.

Basic Neural Signal Acquisition and analysis: Acquisition of neural data, Generation, transmission and interaction of signals in nervous systems. Discussion of initiation and propagation of action potential along nerve fibers. Voltage clamp experiments.

Basic Neural Signal Analysis: Spectral estimation for finding the pulse rhythms present in the EEG signal. The short segment of EEG data analysis for spectral parameters such as location and amount of spectral energy. Wave shaping filters. Periodogram for the estimation of spectral density. Maximum entropy method as a measure of the randomness and uncertainty associated with the EEG signal. Autoregressive (AR) and ARMA (autoregressive moving average) methods for modelling signals with sharp peaks and valleys in their frequency signal with severe background noise. Maximum likelihood method

Analysis of neural data: firing rates, spike statistics, spike statistics and the neural code, neural encoding, neural decoding, discrimination and population decoding, information theory, statistical analysis of EEG) data, spatial filters, classification, adaptive classifiers.

Measurement of the respiratory related signal: Analytical instruments in Biomedical Engineering; oximeter, spectro-photometer, colorimeter, blood gas analyzer, blood cell counter. Therapeutic & assist devices for cardiovascular system and respiratory system. Physiotherapy devices. Electrosurgical units. Safety aspects of biomedical equipment

Self-Study Component: Computer analysis of real world ECG & EEG signals

Text Books:

1. Introduction to Electrophysilogical methods and instrumentation, Franclin Bretschneider and Jan R De Weille, ISBN 978-0-12-370588-4.
2. Computer Analysis of Electrophysiological Signals, John Dempster,
3. http://iitr.vlab.co.in/?sub=49&brch=267&sim=1305&cnt=1

Course Title	BIOMEDICAL IMAGE ANALYSIS	Course Code	16MLBI1CIA
Credits	4	L-T-P-S	2-0-1-1

CO1 Identify major processes involved in formation of medical images and recognize the imaging modality from their visualizations
CO2 Classify the various medical image processing algorithms and describe fundamental methods for image enhancement
CO3 Enhance medical images using appropriate software and visualize all types of medical image data using modern tools
CO4 Appraise efficacy and drawbacks of several techniques for image segmentation and acquire the fundamental concepts for texture analysis
CO5 Explain the basic principles of medical image communication, image coding the various techniques of Data compression

The Nature of Biomedical Images: Body Temperature as an Image, Transillumination, Light Microscopy, Electron Microscopy, X- ray Imaging, Breast cancer and mammography, Tomography, Nuclear Medicine Imaging, Ultrasonography, Magnetic Resonance Imaging, Objectives of Biomedical Image Analysis, Computer aided Diagnosis

Image Quality and Information Content: Characterization of image quality, Digitization, optical density, dynamic range, histogram, entropy, resolution, signal to noise ratio, removal of Image artifacts, Matrix representation of Images

Image Enhancement, Detection of region of interest, Analysis of shape, texture and oriented patterns, Image reconstruction, Deconvolution

Image coding and Data compression: Fundamentals, Types of coding, Image coding and compression standards, Scanning and adaptive scanning

Pattern Classification and Diagnostic Decision: Pattern Classification, Supervised Classification, Unsupervised Classification, Probabilistic models, linear regression, neural networks, measures of diagnostic accuracy reliability of features classifiers and decisions.

Self-Study Component: Image processing and analysis of biomedical images

Text Books

1. Biomedical Image Analysis, Rangaraj. M Rangayyan, CRC 2005

Course Title	THEORY & DESIGN OF BIOMEDICAL INSTRUMENTS	Course Code	16MLBI1CBI
Credits	4	L-T-P-S	3-1-0-0

CO1 Demonstrate a comprehensive knowledge of the theory of biomedical equipment design components by applying appropriate technique to prototype and validate design specifications.
CO2 Design and develop functional elements of biomedical instruments
CO3 Analyze static and dynamic performance characteristics of medical instrumentation systems
CO4 Understand the health, safety, environmental, legal and ethical issues while designing/working of a biomedical circuits and instruments.

Basic theory: Terminology of medicine and medical devices, generalized medical instrumentation system, classification, alternative operational modes, medical measurement constraints, interfering and modifying inputs, compensation techniques, biostatistics, generalized static and dynamic characteristics, design criteria, commercial medical instrumentation development process, regulations, Sensors for medical instrumentation-an overview. Case study.

The origin of biopotentials: Electrical activity of excitable cells, volume conductor fields, functional organization of the peripheral nervous system, the electroneurogram (ENG), the electromyogram(EMG), the electrocardiogram(ECG), the electroretinogram (ERG),the electroencephalogram(EEG), the magnetoencephalogram (MEG), Case study.

Biopotential electrodes: The electrode-electrolyte interface, polarization, polarizable and nonpolarizable electrodes, electrode behavior and circuit models, the electrode-skin interface and motion artifact, Various electrode designs and practical hints in using electrodes, Biopotential amplifiers – The Electrocardiograph, Amplifiers for other biopotential signals. Case study.

Blood pressure and sound: Introduction, Direct measurements, harmonic analysis of blood-pressure waveforms, dynamic properties, system response, bandwidth, typical pressure-waveform distortion, systems for measuring venous pressure, heart sounds, cardiac catheterization, effects of potential and kinetic energy of pressure measurements, indirect measurements of blood pressure, Case study.

Electrical safety: Physiological effects of electricity, susceptibility parameters, distribution of electric power, shock hazards, electrical-safety codes and standards, basic approaches to protection against shock, protection: power distribution, protection: equipment design, electrical-safety analyzers, testing the electric system, tests of electric appliances. Case study.

Text Book:

1. Medical Instrumentation, application and design, John G. Webster, Wiley, 3rd ed, 1998

Reference Books:

1. Biomedical Instrumentation systems, Shakti Chatterjee, Aubert Miller, Cengage , 2010
2. Handbook of Biomedical Instrumentation, R.S. Khandpur, TMH, 3rd ed, 2014
3. Barbara Christe, Introduction to Biomedical Instrumentation, Cambridge University Press, 2009 Online ISBN:9780511808937, Hardback ISBN:9780521515122

SEMESTER I

ELECTIVES (GROUP 1)

Course Title	EMBEDDED SYSTEM DESIGN FOR BIOMEDICAL APPLICATIONS	Course Code	16MLBI1EEM
Credits	4	L-T-P-S	3-0-1-0

CO1 Evaluate and analyze the functional and non-functional requirements of an embedded system designed for health care applications

CO2 Conceptualize and design embedded systems for optimal solutions considering issues related to safety, societal and environmental factors in the biomedical domain

CO3 Extract information on concurrent problems through literature survey and analyze complex problems independently or in groups

Embedded systems: Introduction, Characteristics, Classification, Generic architectures, Communication protocols, Overview of Real time operating systems, Medical applications with embedded software

Wireless medical systems: Introduction, Advances on Technologies for Implantable Bioelectronics, Lab on a Cell phone, A Wireless Intraoral Tongue–Computer Interface, Energy-Efficient Hierarchical Wireless Sensor Networks Based on Wake-Up Receiver Usage, Review of Signal processing for classification in wireless medical embedded systems

Algorithms and data processing : Framework for Biomedical Algorithm Design Cooperative Data Fusion for Advanced Monitoring and Assessment in Healthcare Infrastructures, Energy-Efficient High Data Rate Transmitter for Biomedical Applications

Power-Aware Scheduling Scheme for Medical Sensor SoC-Based WBAN Systems: Introduction, On-Time Power-Aware Scheduler, State transition models, Design, Typical power mode transition scenario, Structure of on-time power-aware scheduling system, Implementation details of implantable cardioverter-defibrillator (ICD) device and results

Case Studies: Embedded systems in a life supporting system, Embedded data logging platform for ECG and blood oxygenation monitoring, Real time monitoring systems, RTOS kernel in portable electrocardiograph, An Advanced Insulin Bolus Calculator for Type 1 Diabetes Combining Android and RTOS for medical devices, Embedded Software Quality Challenges in Medical Device Development

Text Books:-

1. Shibu K V: Introduction to Embedded Systems, Tata McGraw Hill, 2009
2. Wireless Medical Systems and Algorithms: Design and Applications, Pietro Salvo, Miguel Hernandez-Silveira, 2016, CRC Press
3. Tae-Ho Hwang et al. Sensors 2013, 13, 375-392

References:-

1. Missomi Conti, Simone Orcioni et all, Lecture notes in electrical engineering Solutions on embedded systems, Springer science + business media BV 2011
2. Hassan Ghasemzadeh, Sarah Ostadabbas ,IEEE SENSORS JOURNAL, VOL. 13, NO. 2, FEBRUARY 2013
3. Journal of Physics: Conference Series 332 (2011) 012006, IOP publishing
4. White papers: Embedded-computing.com, medsmagazine.com, mentor.com/embedded

Course Title	BIOINFORMATICS AND APPLICATIONS	Course Code	16MLBI1EIF
Credits	4	L-T-P-S	3-0-1-0

CO1: Ability to interpret relationships among living things and analyze and solve biological problems, from the molecular to ecosystem level using basic biological concepts, grounded in foundational theories.

CO2: Demonstrate cognitive skills in mastery of advanced theoretical knowledge in biomedical engineering and apply this knowledge to solve complex problems in existing and allied areas using modern tools.

CO3: Acquire knowledge of descriptive and inferential statistics related to bioinformatics problems.

CO4: Describe the contents and properties of the most important bioinformatical databases, perform text- and sequence-based searches, and analyze and discuss the results in light of molecular biological knowledge

The Central Dogma: Watson's definition, information flow, from data to knowledge, Convergence, the organization of DNA, the organization of Proteins. XML (Bio XML) for Bioinformatics: Introduction, Differences between HTML and XML, fundamentals of XML, fundamentals of XML namespaces. Introduction to DTDs, Document type Declarations, Declaring elements, declaring attributes, working with entities XML Schemas, Essential Concepts, working with simple types, working with complex types, Basic namespaces issues.

Perl (Bioperl) for Bioinformatics: Representing sequence data, program to store a DNA sequence, concatenating DNA fragments, Transcription, Calculating the reverse complement in Perl, Proteins, files, reading proteins in files, Arrays, Flow control, finding motifs, counting Nucleotides, exploding strings into arrays, operating on strings, writing to files, subroutines and bugs.

Databases: Flat file, Relational, object oriented databases, object Relational and Hypertext, Introduction to database design, DBMS Architecture, Schema Architecture, SQL and Introduction to database application development.

Sequence Alignment Algorithms: Biological motivations of sequence analysis, the models for sequence analysis and their biological motivation, global alignment, local alignment, End free-space alignment and gap penalty, Sequence Analysis tools and techniques.

Phylogenetic Analysis: Introduction, methods of Phylogenetic analysis, distance methods, the neighbor- Joining (NJ) method, The Fitch/ Margoliash method, character -based methods, Other methods, Tree evaluation and problems in phylogenetic analysis. Clustering**:** Protein structure visualization and Protein structure prediction

TEXT BOOK:

1. Bioinformatics Methods and Applications, S.C.Rastogi, N. Mendiratta, PHI 2004

REFERENCE BOOKS:

1. XML for Bioinformatics. CERAMI, Springer 2005
2. Beginning Perl for Bioinformatics, James D. Tisdall, O'Reilly 2001
3. Bioinformatics Computing Bryan Bergeron, M.D, Pearson 2003

Course Title	REAL TIME BIOSIGNAL PROCESSING	Course Code	16MLBI1 ERS
Credits	4	L-T-P-S	3-0-1-0

CO1 Ability to understand the architecture and basic operation of fixed-point and floating-point DSPs to perform worst-case timing analysis on real-time DSP systems. Develop and realize computationally efficient algorithms on the DSP platform.

CO2 Exploiting structures of FIR and IIR filters realization for various realization structures and advantages and disadvantages of each realization structure for bio-signal analysis.

CO3 Implement real-time FIR, IIR filter and lattice realization designs on the DSP platform, compare experimental results to theoretical expectations, and identify the source of performance discrepancies using modern tools.

Overview on Hardware and Software Tools: The ARM Cortex M4 Architecture or DSP Platform C6x family processor

Real time Signals and Systems: Real time Convolutions (linear and circular) Real time correlations, Linear filtering aspects of convolutions. Case studies on 1-D and 2-D implementation

Real time Digital Filters: Exposition on Filter designs structures. Real-Time FIR Digital Filters, Real-Time IIR Digital Filters, Real time Lattice structures and its implementation issues

Real time Transforms and its Algorithms: Real-Time Fast Fourier Transform (1-D and 2-D cases), Discrete Cosine Transform (1-D and 2-D cases) Walsh Hadamard Transforms Basics and algorithms (1-D and 2-D Cases), Haar Transform (1-D & 2-D cases), Basic of Discrete Wavelet Transform (1-D and 2-D Cases).

Multi-rate filters: Basics principles of decimations and interpolation, Noble identities and its advantages, Quadrature mirror Structures and Poly-phase structures, rational Sample Rate converters.

Adaptive Filters: Basics optimum signal processing, Wiener filters adaptive structures, LMS algorithms and simple variations. RLS algorithms, Basic Kalman Filters with implementions.

Text Books:

1. Modern Digital Signal Processing by Roberto Cristi, Cengage Learning, 2004
2. Joseph Yiu, The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors

Reference Books

1. Digital Signal Processing and Applications with the OMAP - L138 eXperimenter, Wiley 2012

Course Title	LINEAR ALGEBRA AND ITS APPLICATIONS IN BIOMEDICAL ENGINEERING	Course Code	16MLBI1ELA
Credits	**4**	**L-T-P-S**	**3-0-1-0**

CO1 Ability to discriminate, evaluate, analyze and synthesize solutions using linear algebra concepts.

CO2 Ability to conceptualize hypothesis and develop computer based algorithms for linear algebra concepts using modern tools

CO3 Ability to research the concepts of Linear algebra for manage projects efficiently by working as an individual, document and present the conceptualized work concepts

CO4 Ability to engage in self-study for lifelong learning by ethical and social responsibility to explore needs in biomedical computing using linear algebra

Mathematical basics: Sets. Complex numbers and trigonometric functions: Definition and basic operations, Geometric co-ordinates, Polar co-ordinates.

Linear algebra and analytic geometry: Vectors and Vector spaces, Linear Impedance, Planes, Matrices, systems of linear equations and the Gauss algorithm, Inverse matrices and determinants, Sequences, series and limits

Functions and graphs: Continuous functions, Differentiable functions, Applications of differentiability

Power series: The Riemann integral and its properties, Integration techniques, Extensions of the Riemann integral

Eigen vectors and Eigen values: Eigen values and eigenvectors, Diagonalization, Differential equations, Fibonacci sequence, singular value decomposition

Text Books:

1. Numerical Linear Algebra and Applications Paperback – 2010,by Datta B.N (Author)

SEMESTER I

ELECTIVES (GROUP 2)

Course Title	BIOMECHANICS AND REHABILITATION	Course Code	16MLBI1EMR
Credits	4	L-T-P-S	3-1-0-0

CO1: Ability to apply knowledge of mathematics science and engineering to understand the fundamentals of moving systems and familiarity with human anatomy to competently analyze the movement of the human body.

CO2: Ability to analyze the dynamics of human movement and comprehend the biomechanical principles that relate to movement and communication disabilities.

CO3: Ability to discuss, develop and apply the principles of biomechanics to a range of rehabilitation strategies and problem solving.

Introduction To Biomechanics –What Is Biomechanics, Mechanics In Physiology. Definition Of Stress ,Strain And Strain Rate ,The Non viscous Fluid, Newtonian Viscous Fluid, The Hookean Elastic Solid, Viscoelasticity, Response Of A Viscoelastic Body To Harmonic Excitation, Use of Viscoelastic Models ,Methods Of Testing .

The Flow Properties of Blood-Blood rheology, the constitutive equation of blood based on viscometric Data and casson's equation, Laminar flow of blood in tube, blood with viscosity described by casson's equation.

Bioviscoelastic fluids: Introduction, small deformation experiments, mucus from the respiratory tract, saliva, cervical mucus and semen, synovial fluid, flow properties of synovial fluid,

Bioviscoelastic solids: Introduction, some elastic materials-actin, elastin, resilin and abduction, fibers, collagen, Quasi-linear viscoelasticity of soft tissues, the concept of pseudo-elasticity.

Introduction to Rehabilitation and Rehabilitation Team: What is Rehabilitation? Epidemiology of Rehabilitation, Health, Levels of Prevention, Preventive Rehabilitation, Diagnosis of Disability, Functional, Diagnosis, Importance of Physiatry in Functional Diagnosis, Impairment Disability Handicap, Primary and Secondary disabilities, Effects of Prolonged inactivity and Bed rest on body system.

Rehabilitation Team: classification of members, The Role of members, The Role of Physiatrist, Occupational therapist, Recreation therapist, Prosthetist- Orthotist, speech pathologist, Rehabilitation nurse, social worker, Corrective Therapist, Psychologist, Music therapist, Dance therapist and Biomedical Engineer.

Therapeutic Exercise Technique: Co-ordination exercises, Freckles exercises, Gait analyses-pathological Gaits, Gait Training, Relaxation Exercises- Methods for training Relaxation, Strengthening exercises- strength training, Types of contraction, Mobilization exercises, Endurance Exercises

Principles in management of communication: Impairment –introduction to communication, Aphasia, Types of Aphasia, Treatment of aphasic patient, Augmentative communication-general form of communication, types of visual aids, Hearing aids, Types of conventional hearing aid, writing aids.

TEXT BOOKS:

1. Biomechanics- Mechanical Properties of Living tissues -Y.C.Fung -Second Edition- Springer Verlag.
2. Text book of Rehabilitation- S Sunder- 3rd Edition-Jaypee Brothers Medical Publishers (P) Ltd. New Delhi

REFERENCE BOOKS:

1. Biomechanics principles and applications by Schneck and Bronzino, CRC Press, 2003
2. Physical Rehabilitation by Susan B O'Sullivan, Thomas J Schmitz. 5th Edition

Course Title	HOSPITAL ADMINISTRATION & MANAGEMENT	Course Code	16MLBI1EAM
Credits	4	L-T-P-S	3-1-0-0

CO1 Ability to explain and compare the organizational elements and structure, delivery modalities, barriers to system and process improvement.

CO2 Ability to create policy and processes, and execute decisions in compliance with the legal, regulatory and ethical considerations inherent in managing healthcare systems and organizations.

CO3 Ability to identify barriers to continuous improvement processes and using a variety of tools, design and build innovative systems for measurement, analysis and accountability as they apply to healthcare settings.

Overview of Hospital Administration: Distinction between Hospital and Industry, Challenges in Hospital Administration – Hospital Planning – Equipment Planning – Functional Planning - Current Issues in Hospital Management - Telemedicine - Bio-Medical Waste Management

Human Resource Management In Hospital: Principles of HRM – Functions of HRM – Profile of HRD Manager – Tools of HRD –Human Resource Inventory – Manpower Planning. Different Departments of Hospital, Recruitment, Selection, Training Guidelines –Methods of Training – Evaluation of Training – Leadership grooming and Training, Promotion – Transfer.

Marketing Research & Consumer Behaviour: Marketing information systems - assessing information needs, developing & disseminating information - Market Research process - Other market research considerations – Consumer Markets & Consumer Buyer Behaviour - Model of consumer behaviour - Types of buying decision behaviour - The buyer decision process - Model of business buyer behaviour – Major types of buying situations - global marketing in the medical sector - WTO and its implications

Hospital Information Systems & Supportive Services: Management Decisions and Related Information Requirement - Clinical Information Systems - Administrative Information Systems - Support Service Technical Information Systems – Medical Transcription, Medical Records Department – Central Sterilization and Supply Department – Pharmacy– Food Services - Laundry Services.

Quality And Safety Aspects In Hospital: Quality system – Elements, implementation of quality system, Documentation, Quality auditing, International Standards ISO 9000 – 9004 – Features of ISO 9001 – ISO 14000 – Environment Management Systems. NABA, JCI, NABL. Security – Loss Prevention – Fire Safety – Alarm System – Safety Rules. Health Insurance & Managing Health Care – Medical Audit – Hazard and Safety in a hospital Setup.

Text Books:

1. R.C.Goyal, “Hospital Administration and Human Resource Management”, PHI – Fourth Edition, 2006 (Units I, II & III).

2. G.D.Kunders, “Hospitals – Facilities Planning and Management – TMH, New Delhi – Fifth Reprint 2007 (Units III, IV & V).

Course Title	HEARING AND SPEECH PROCESSING	Course Code	116MLBI1EHS
Credits	4	L-T-P-S	3-1-0-0

CO1: To understand for analyzing the sound and speech data with mathematical foundations.

CO2: Ability to use various speech parameters associated with multiple sources for Bi-aural Hearing to design speech ailment devices.

CO3: Ability for clear hearing loss for non-ailed hearing.

CO4: Ability to distinguish ailment hearing loss and normal hearing loss.

Sound Measurement: Amplitude, Frequency and Phase of Simple and Complex Sounds (rms vs peak, FFT and Spectrum, Relationship between Time Waveform, FFT and Impulse Response), Lumped Elements and Waves Sound Propagation in Space

Sound Modeling: Plane Waves, Characteristic Impedance, Traveling Waves, Trading of Time and Space

Sound Spatial Models: Spherical Waves, Multiple Sources, Diffraction of Sound, Localization Cues, Localization and Binaural Hearing. Thresholds and Discrimination, Lumped Elements, Combinations of Elements, Equivalent Circuits, Loudspeaker, Microphone and middle ear, The Normal and Diseased Middle Ear.

Psychoacoustics: Masking and Frequency selectivity. Frequency Selectivity and Hearing Loss, Dimensional equations. Natural frequencies. Equivalent Circuits, The Loudspeaker, Microphones and middle ears, The Normal and Diseased Middle Ear, Perturbation Theory, Non-uniformities and losses,

Sound Mechanics: Hair Cells, The Passive Cochlea, Vowels, The Active Cochlea, Fricative Sources and Consonants, Speech Sound Production, Speech Perception

Text / Reference Books:

1. Textbook of Hearing Aid Amplification, Robert E. Sandlinion
2. Sataloff's Comprehensive Textbook of Otolaryngology: Head & Neck Surgery, Robert T Sataloff, Anil K Lalwani, JP Medical Ltd, 2015.
3. Signals and Systems for Speech and Hearing: Second Edition 2nd ed. Edition, ISBN-13: 978-9004252431.
4. http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-551j-acoustics-of-speech-and-hearing-fall-2004/lecture-notes/

Course Title	COMPUTATIONAL NEUROSCIENCE	Course Code	16MLBI1ECN
Credits	4	L-T-P-S	3-1-0-0

CO1 Ability to describe the cellular composition of the nervous system and the process of communication between these cells.

CO2 Apply knowledge of the functional anatomy of the nervous system to the analysis of human behaviour.

CO3 Ability to emphasize on the interdisciplinary nature of modern neuroscience and opportunities to contribute to it

Synaptic physiology in hippocampus and prefrontal cortex.Sensory-motor integration and neural prosthetics
Computational and theoretical models of neural and muscle physiology.

Neural control of coordinated oculomotor and skeletomotor movements.Synaptic integration in sympathetic ganglia and in midbrain dopamine neurons. Biophysics, pharmacology, and regulation of glutamate receptors
Bayesian statistics and statistical analysis of neuronal data.

Abstract mathematical and computational principles underlying learning at the synaptic, neuronal, and systems levels
Computational and electrophysiological study of visual perception, perceptual organization, neural plasticity and neural coding; computer vision

Computational neuroscience, neuronal excitability, and central mechanisms of pain. Computational models of eye-movement control during reading; the neural systems mediating the "eye-mind" link.Theoretical and computational modeling of dynamics in neuronal networks. Cognitive neuroscience, semantic representation, skill acquisition, connectionist/hybrid modeling, brain imaging.Cerebral basis for volitional movement and cortical neural prosthetics

Spatially realistic simulations of neurotransmitter release, synaptic transmission and plasticity.Neurophysiology of basal ganglia-cortical networks in health and disease.Physiology imaging and computation in the olfactory system.
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Text Books

1.Computational Neuroscience and Cognitive Modelling by Britt Anderson –

2. From Computer to Brain: Foundations of Computational Neuroscience by William W. Lytton (Author)

SEMESTER II

CORE SUBJECTS

Course Title	MEDICAL IMAGING TECHNIQUES & SYSTEMS	Course Code	16MLBI2 CMI
Credits	4	L-T-P-S	3-0-1-1

CO1 Ability to acquire in-depth knowledge of Medical Imaging principles and their applications.

CO2 Ability to think laterally and originally, conceptualize and solve engineering problems, identify potential issues in an imaging system, evaluate a wide range of potential solutions for those issues and arrive at feasible, optimal solutions after considering public health and safety, societal and environmental factors in the core areas of expertise.

CO3 Use modern tools, apply appropriate techniques and modern engineering and programming tools, to understand the concepts of image acquisition, mathematical principles underlying the imaging system, acquisition and transformation of the signal to form the final image shown to the doctors.

CO4 Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective.

Introduction to Diagnostic Imaging Modalities: Basic Imaging Principles, Overview of the different modalities of diagnostic imaging, Axial, Coronal and Sagittal Views, Introduction to DICOM, Introduction to Image Viewing Software.

X-rays: Historical Overview, Fundamentals of X-rays, Electromagnetic Radiation, Interaction of X-rays with Matter, Intensity of an X-ray Beam, Attenuation and Factors affecting Attenuation, Generation of X-ray Radiation, X-Ray Generators, Filters, Beam Restrictors and Grids, X-ray Imaging Geometry, Film Radiography, Intensifying Screens and Image Intensifiers, Computed Radiography, Digital X-ray Detectors, X-ray Image Characteristics, Spatial Resolution, Noise and Contrast, Biological Effects of Ionizing Radiation, Units of Dose, Precautionary Measures while using X-rays, Fluoroscopy, Angiography, Digital Subtraction Angiography, Orthopantomography, Dual Energy X-ray Absorptiometry, Linear Accelerators, Some Clinical Applications.

Computed Tomography: Historical Overview, Conventional Tomography, Fundamentals of Computed Tomography, Generations of CT Machines from First to Seventh, Projection Function, Hounsfield Unit, Forward and Inverse Problems, Radon Transform, Sinogram, Algorithms for Image Reconstruction, Back Projection, Filtered Back Projection, Fourier Transform Methods, Fourier Slice Theorem, Algebraic Reconstruction Techniques, Parallel Beam Reconstruction, Fan Beam Reconstruction, Cone Beam Reconstruction, Helical CT, Maximum Intensity Projection Reconstruction, Volume Rendering, Artifacts in CT Images, Some Clinical Applications.

Ultrasound: Historical Overview, Fundamentals of Acoustic Propagation, Stress and Strain Relationships, Characteristic Impedance, Intensity, Radiation Force, Reflection, Refraction, Attenuation, Absorption, Scattering, Doppler Effect, Generation and Detection of Ultrasound,

Piezoelectric Effect, Ultrasonic Transducers, Transducer Beam Characteristics, Beam Profiles, Pulsed Ultrasound, Phased Arrays, Resolution – Axial and Lateral, Focussing of Ultrasound, Diagnostic Methods, Pulse Echo Systems, A-mode, B-mode, M-mode, C-mode, Ultrasound Image Characterization, Tissue Characterization, Colour Doppler Flow Imaging, Echocardiography, Biological Effects of Ultrasound, Ultrasound Safety, 3D Ultrasound, High Intensity Focussed Ultrasound (HIFU), Some Clinical Applications.

Nuclear Medicine: Historical Overview, Fundamentals of Radioactivity, Nuclear Activity and its Units, Half Life, Interaction of Nuclear Particles and Matter, Attenuation of Gamma Radiation, Radionuclides, Radiopharmaceuticals, Common Radioisotopes, Generation and Detection of Nuclear Emission, Radionuclide Generators, Cyclotrons, Nuclear Radiation Detectors, Rectilinear Scanners, Scintillation Camera, Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET), PET-CT and PET-MR Systems, PET Image Reconstruction, Attenuation Correction, Characteristics of Images, Contrast and Noise, Nuclear Radiation Safety, Some Clinical Applications.

Magnetic Resonance Imaging: Historical Overview, Fundamentals of Nuclear Magnetic Resonance, Angular Momentum, Dipole Moment, Magnetization, Larmor Frequency, Rotating Frame of Reference, RF Magnetic Field, Free Induction Decay, Relaxation Times, Pulse Sequences, Generation and Detection of NMR Signal, Main Magnetic Field, Gradient Magnetic Fields, Superconducting Magnets, Transmitter, Receiver, Slice Selection, Frequency Encoding, Phase Encoding, Spin-Echo Imaging, Gradient-Echo Imaging, Biological Effects of Magnetic Fields, Imaging Safety, Introduction to Functional MRI, Diffusion Weighted Imaging, Introduction to Image Registration in Multi-modal imaging, Some Clinical Applications

Thermal Imaging: Physics of Thermography, Thermal Imaging Systems, Liquid Crystal Thermography, Some Applications.

Self-Study Component: Individual Case Study on any one of the imaging modalities.

Text Books:

1. Kirk Shung, Michael Smith, Benjamin Tsui, Principles of Medical Imaging, Academic Press, 1992.

Reference Books:

1.Jerry Prince, Jonathan Links, Medical Imaging Signals and Systems, Pearson, 2008.

2. edX MOOC Course, Principles of Biomedical Imaging, online course.
3. Internet Text References and Videos.

Course Title	**BIOMATERIALS**	Course Code	16MLBI2CBM
Credits	**4**	**L-T-P-S**	**2-0-1-1**

CO1 Demonstrate an in-depth understanding to analyze and determine the material properties critically in order to select them for the required biocompatibility.

CO2 Work on multidisciplinary projects that involve extensive literature survey in the allied fields to arrive at optimal solutions considering patient safety

CO3 Utilize the acquired professional and intellectual integrity with the knowledge of ethical issues in the development of novel biomaterials

Biomaterials Science and Engineering: Multilevels of Structure and Categorization of Materials, Four Categories of Materials, Definitions of Biomaterials, Biomedical Materials and Biocompatibility

Toxicity and Corrosion : Elements in the Body, Biological Roles and Toxicities of Trace Elements, Selection of Metallic Elements in Medical-Grade Alloys, Corrosion of Metals, Environment inside the Body, Minimization of Toxicity of Metal Implants, Biological Roles of Alloying Elements

Mechanical Properties of Biomaterials: Role of Implant Biomaterials, Mechanical Properties of General Importance, Hardness, Elasticity: Resilience and Strechability, Mechanical Properties Terms Used in the Medical Community, Failure, Essential Mechanical Properties of Orthopedic Implant Biomaterials

Metallic Biomaterials in Orthopedic Implants: Development of Metallic Biomaterials, Stainless Steels, Cobalt-Based Alloys, Titanium Alloys, Comparison . Metallic Biomaterials: Dental Materials, NiTi Shape-Memory Alloys, Other Clinically Applied Metallic Materials, New Metallic Materials: Magnesium Alloys

Bioinert, Bioactive and Bioresorbable Ceramics: Overview of Bioceramics, Inert Bioceramics: Al_2O_3, ZrO_2, Types of Joints, Summary and Remarks, Dental Ceramics, Total Joint Replacement. Overview of Surface Bioactive and Bulk Degradable Ceramics, Calcium Phosphates and Hydroxyapatite, Bioactive Glasses, Bioactive Glass-Ceramics, Bone-Bonding Mechanisms, Biodegradable Ceramics, Bioceramic Scaffolds for Bone Tissue Engineering

Polymeric Biomaterials: Fundamentals, Basic Concepts on Polymers, Overview of Polymeric Biomaterials, Bioinert Polymers: Polyolefin, Poly (Ethylene Terephthalate), Acrylate Polymer, Fluorocarbon Polymers, Silicone, Polyurethane, Properties and Applications of Polyurethane as Biomaterials, Evolution of Biomaterials

Self Study Component: Individual case study on any one of the bio compatible material.

Text Book:

1. Biomaterials: A Basic Introduction, Qizhi Chen, George Thouas, CRC Press Textbook, 2014, ISBN 9781482227697 - CAT# K22550

Reference Books:

1. Ratner, B. D., Hoffman, A. S., Schoen, F. J., Lemons, J. E. (2004). Biomaterial science: an introduction to materials in medicine. (2nd ed.). New York: Academic Press.
2. Park, J. B., & Bronzino, J. D. (2003). Biomaterials: principles and applications. CRC Press.

Course Title	BIOPHOTONICS	Course Code	16MLBI2CBP
Credits	4	L-T-P-S	3-1-0-0

CO1: Ability to analyze the laser principles with safety regulations for biomedical applications.
CO2: Ability to utilize optical components for microscopes for biomedical imaging.
CO3: Ability to understand the optical biosensor for signal transduction.
CO4: Ability to utilize above for non-invasive physiological signal analysis.

Basic of Lasers: Principles of Lasers, Current Laser Technology, and Nonlinear Optics: Principles of Lasers, Principles of Laser Action, Classification of Lasers, Some Important Lasers for Bio-photonics,

Current Laser Technologies, Quantitative Description of Light: Radiometry, Nonlinear Optical Processes with Intense Laser Beam, Mechanism of Nonlinear Optical Processes, Frequency Conversion by a Second-Order Nonlinear Optical Process, Symmetry Requirement for a Second-Order Process, Frequency Conversion by a Third-Order, Nonlinear Optical Process, Multiphoton Absorption, Time-Resolved Studies, Laser Safety.

Bio-imaging: Principles and Techniques: An Overview of Optical Imaging, Transmission Microscopy, Simple Microscope, Compound Microscope, Kohler Illumination, Numerical Aperture and Resolution.

Optical Bio-microscopic Imaging: Optical Aberrations and Different Types of Objectives, Phase Contrast Microscopy, Dark-Field Microscopy, Differential Interference Contrast Microscopy, Fluorescence Microscopy, Scanning Microscopy, Confocal Microscopy, Multiphoton Microscopy. Optical Coherence Tomography, Total Internal Reflection Fluorescence Microscopy, Near-Field Optical Microscopy, Spectral and Time-Resolved Imaging, Spectral Imaging , Bandpass Filters, Excitation Wavelength Selection, Acousto-Optic Tunable Filters, Localized Spectroscopy, Fluorescence Resonance Energy Transfer (FRET) Imaging, Fluorescence Lifetime Imaging Microscopy (FLIM), Nonlinear Optical Imaging, Second-Harmonic Microscopy, Third-Harmonic Microscopy, Coherent Anti-Stokes Raman Scattering (CARS) Microscopy, Multifunctional Imaging, Pi Imaging, Combination Microscopes, Miniaturized Microscopes, Some Commercial Sources of Imaging Instruments,

Applications of Bio-photonics: Fluorophores as Bio-imaging Probes, Endogenous Fluorophores, Exogenous Fluorophores, Organometallic Complex Fluorophores, Near-IR and IR Fluorophore, Two-Photon Fluorophores, Inorganic Nanoparticles, Green Fluorescent Protein, Imaging of Organelles, Imaging of Microbes, Confocal Microscopy, Near-Field Imaging, Cellular Imaging, Probing Cellular Ionic Environment, Intracellular pH Measurements, Optical Tracking of Drug-Cell Interactions, Imaging of Nucleic Acids, Cellular Interactions Probed by FRET/FLIM
Imaging, Tissue Imaging, *In Vivo* Imaging, Commercially Available Optical Imaging Accessories,

Optical Biosensors: Principles of Optical Bio-sensing, Bio-recognition, Optical Transduction, Fluorescence Sensing, Fluorescence Energy Transfer Sensors, Molecular Beacons, Optical Geometries of Biosensing, Support for and Immobilization of Bio-recognition Elements.
Immobilization

Fiber-Optic Biosensors: Planar Waveguide Biosensors, Evanescent Wave Biosensors, Interferometric Biosensors, Surface Plasmon Resonance Biosensors, Some Recent Novel Sensing Methods, Commercially available sensors.

Text/Reference Books:

1. Introduction to Bio-photonics, Paras N Prasad, A John Wiley & Sons, Inc., Publication. 2003.
2. Biomedical Optics: Principles and Imaging, Lihong V Wang, Hsin-I Wu, ISBN: 978-0-471-74304-0, May 2007.

SEMESTER II

ELECTIVES (GROUP 1)

Course Title	BIOSENSORS AND BIOSENSOR NETWORKS	Course Code	16MLBI2EBS
Credits	4	L-T-P-S	3-1-0-0

CO1 Apply the fundamental concepts to differentiate and interpret the data related to performance characteristics of biosensors.

CO2 Select, learn and deploy suitable sensors for a wide range of potential problems related to health monitoring domain for the analytes – Glucose, Cholesterol, nitrite, nitrate and urea.

CO3 Work with multidisciplinary teams consisting of biologists, doctors, pathologists and electronic communication engineers to analyze and understand issues related to wireless biosensor networks

Introduction to Biosensors: Components, Classification, Generations of biosensors, Molecular recognition, Biosensor electrode fabrication, Applications of biosensors.

Amperimetric Biosensor Based on Carbon Nanotube and Plasma Polymers: Introduction, Plasma polymerization for biosensor design, Optimization, for device fabrication, comparison between single- and multi-walled CNT, mechanism of sensor response, sensor performance.

Enzymatic and Immunosensors: History, Biomarkers, Glucose sensors, Cholestrol biosensors, Nitrite and nitrate sensors. Antibody as biorecognition element, Types of immunosensors.

Urea Biosensor based on Conducting Polymer Transducers : Various electrochemical techniques, Comparison, Effect of enzyme loading on urea biosensor response, Stability of the urea biosensor: Estimation of urea in biological sample

Intelligent Communication Module for Wireless Biosensor Networks: Wireless biosensor networks- Introduction and applications, Ultra wideband radio as a communication module for WBSN, UWB Transmitter & Receiver, Real time reconfigurability algorithm, RTRA design and implementation, Translation And Control Algorithms.

Text Books

1) Biosensors and Bioelectronics: Chandran Karunakaran, Kalpana Bhargava, Bosson Benjamin, Elsevier, 2015
2) Biosensors, Edited by Pier Andrea Serra, InTech, ISBN 978-953-7619-99-2

Reference Books

1. Handbook of Biosensors and Biosensor Kinetics, Sadana & Sadana, 1st Edition Elsevier Science Print Book ISBN :9780444532626, eBook ISBN :9780080932859
2. Biosensors, Elizabeth A.H. Hall, Open university press, 1990
3. Electrochemical Biosensors - Review Paper-Sensor Principles and Architectures, Dorothee Grieshaber et al., , Sensors 2008, 8, 1400-1458

Course Title	HEALTH TECHNOLOGY ASSESSMENT	Course Code	16MLBI2EHT
Credits	4	L-T-P-S	3-1-0-0

CO1 Ability to apply the knowledge of health technology assessment (HTA) in the decision processes of the medicare.

CO2 Analyze the structure, the methods, and the typical content of HTA

CO3 Evaluate the scientific quality of HTA-reports and design a record for a HTA

Introduction: Fundamental concepts, History of Technology Assessment, primary data methods, integrative methods, International Developments and Collaborations

Basics of Epidemiology; prototypic description of diseases: severity, course, outcomes; determination of the "burden of illness"; examples

Description of technologies: technical characteristics and functioning; requirements for its use; "Life cycle" of technologies (e.g. diffusion, patterns of use, regulatory status)

Safety: Assessing safety, efficacy, effectiveness of diagnostic technologies, Assessing safety, efficacy, effectiveness of therapeutic and / or preventive interventions

Health Economics: Basics of Health economics; Social and ethical implications of technology use

Case Studies: Montior Impact of Health technology Assessment, Barriers and Issues related to Health Technology Assessment.

TEXT BOOKS:

1. Clifford S. Goodman: Introduction to Health Technology Assessment. The Lewin Group; January 2004

Course Title	COMPRESSIVE SENSING IN BIOMEDICAL APPLICATIONS	Course Code	16MLBI2ECS
Credits	4	L-T-P-S	3-1-0-0

CO1 To get the basic theory and ideas showing when it is possible to reconstruct sparse or nearly sparse signals from under sampled data.
CO2 Ability to use recent ideas in modern convex optimization allowing rapid signal recovery or parameter estimation.
CO3 To get a sense of real applications that might benefit from compressive sensing ideas.
CO4 To be able to produce optimal representation of signal that are suited to internet of thing medical signal acquisition devices for future.

Introduction to compressed or sparse sensing: Review of Basics of matrix algebra, Fourier transform, convex optimization and statistics. Sparse signal models: from Fourier to *-lets transforms (wavelets, curvelets.) How to make the world sparse: Wavelets, curvelets, contourlets and shearlets. Beyond sparsity: grouped sparsity and low-rank priors.

Signal models: Shannon-Whitaker Sampling Theory. Introduction to vector spaces. Normed vector spaces. Bases and frames. Low-dimensional signal models. Sparse representations. Compressible signals. Unions of subspaces.

Sensing matrices: Sensing matrix design. Null space conditions. Restricted isometry property (RIP). Sensing matrix constructions. Coherence. Matrices that satisfy the RIP. Sub-Gaussian random variables.

Recovery Algorithms: ℓ_1 -norm minimization. Noise-free signal recovery. Signal recovery in noise. Instance-optimal guarantees revisited. The cross-polytope and phase transitions. Convex optimization. Linear and quadratic programming. Alternatives to convex optimization. Greedy algorithms. Combinatorial algorithms. Bayesian methods.
Emerging Topics: Compressive sensing acquisition hardware. Multiple measurement vectors. Structured measurement matrices. Structured sparsity. Random projections and Johnson-Lindenstrauss lemma

Compressed sensing applications: ECG and EEG signal sensing, Magnetic Resonance Imaging and the art of discretizing analog problems.

Text Books:

1. Simon Foucart, Holger Rauhut, "A Mathematical Introduction to Compressive Sensing", ISBN 978-0-8176-4948-7
2. http://dsp.rice.edu/courses/elec631
3. Compressed Sensing (Eldar, Kutyniok), CUP 2012

Course Title	Neuroimaging and Brain Mapping	Course Code	16MLBI2ENI
Credits	**4**	**L-T-P-S**	**3-1-0-0**

CO1 Ability to describe neuroimaging techniques, including the basic underlying physics principles, benefits and drawbacks of each technique, and applications clinically and in research.

CO2 Ability to understand the principles and main technical aspects of neuroimaging instrumentation and data acquisition and image analysis techniques.

CO3 Ability to apply the knowledge of modern methods for scientific and clinical investigation of the human nervous system using neuroimaging.

Introduction to Neuroimaging and Brain Mapping Terminology Review of Neuroanatomy . The Physics of Neuroimaging (invasive and non-invasive, structural vs. functional, digital data representation).

The Normal Brain: The Developing Brain, Matured Brain, Aging Brain Diseases: Depression, Schizophrenia, Autism, Bipolar disorder, Neurodegeneration and dementia (AD), Epilepsy, Multiple Sclerosis, Methamphetamine, Fetal Alcohol Syndrome, Head Trauma, Tumors.

Challenges in computational neuroscience and brain imaging Preprocessing methods in Neuroimaging (intensity modulation, spatial normalization, filtering

Volumetric and Surface modeling, representation and analysis . Statistical methods in structural and functional neuroimaging

The LONI Grid-Compute Pipeline Environment . Imaging in Psychology and Psychiatry . Behavior, Memory, Language and Cognition

Textbooks:

1. Brain Mapping: The Methods Arthur W. Toga & John Mazziotta, University of California, Los Angeles, U.S.A. ISBN-9780126930191

Reference Books:

1 Handbook of Functional Neuroimaging of Cognition, Second Edition
Edited by Roberto Cabeza and Alan Kingstone, MIT press 2006

2 Learning Neuroimaging: 100 Essential Cases (Learning Imaging)
by Francisco de Asís Bravo-Rodríguez and Francisco de Asís Bravo-Rodríguez, Springer 2011

SEMESTER II

ELECTIVES (GROUP 2)

Course Title	BIO-NANOTECHNOLOGY	Course Code	16MLBI2EBN
Credits	4	L-T-P-S	3-0-1-0

CO1 To understand the essential features of biology and nanotechnology that are converging to create the new area of bionanotechnology
CO2 To recognize the structural and functional principles of bionanotechnology
CO3 To employ bionanomaterials for analysis and sensing techniques
CO4 To apprehend and explain the biomedical applications of nanotechnology

NANOBIOMATERIALS AND BIOCOMPATIBILITY: Surface and Bulk Properties of Bio materials – Nanobiomaterials –NanoCeramics – Nanopolymers – Nano Silica – Hydroxy apatite - Carbon Based nanomaterials -Surface modification – Textured and Porous Materials – Surface immobilized biomolecules – Cell-biomaterial interactions – immune response – In Vitro and In Vivo assessment of tissue compatibility

STRUCTURAL & FUNCTIONAL PRINCIPLES OF BIONANOTECHNOLOGY: Lipid Bilayers – liposomes – neosomes- Polysacharides - Peptides –Nucleic acids – DNA scaffolds – Enzymes- Biomolecular motors: linear, rotary mortors – Immunotoxins – Membrane transporters and pumps – Antibodies – monoclonal Antibodies – immunoconjugates - limitations of natural biomolecules

PROTEIN AND DNA BASED NANOSTRUCTURES: Nanocircuitry - S-layer proteins: structure, chemistry and assembly – lipid chips –S - Layers as Templates – engineered nanopores - DNA–Protein Nanostructures - DNA-templated Electronics - DNA-based Metallic Nanowires and Networks - DNA–Gold-Nanoparticle Conjugates – DNA -templated Electronics – DNA Nanostructures for Mechanics and Computing

NANOBIO-ANALYTICS: Luminescent Quantum Dots for Biological Labeling - Nanoparticle Molecular Labels - Surface Biology: Analysis of Biomolecular Structure by Atomic Force Microscopy and Molecular Pulling - Force Spectroscopy – Bio-functionalized Nanoparticles for Surface - Enhanced Raman Scattering and Surface Plasmon Resonance – Bio-conjugated Silica Nanoparticles for Bioanalytical Applications

NANOTECHNOLOGY IN FOOD, MEDICINE AND HEALTH SCIENCE: Nano particle Based Drug delivery systems - Ultra sound triggered Nano/Microbubbles - Regenerative Medicine – Nanoimmuno conjugates- Biosensors - Optical Biosensors Based on Nanoplasmonics – Nanobiosesors - Nano-Biosensors for Mimicking Gustatory and Olfactory Senses -Cyclodextrin in Nanomedicinal Foods and Cosmetics - Bioavailability and Delivery of Nutraceuticals and Functional Foods Using Nanotechnology - Polymer-Based Nanocomposites for Food Packaging - Nanocomposites for Food Packaging - Toxicity and Environmental Risks of Nanomaterials

TEXT BOOKS

1. Niemeyer C. M., "*Nanobiotechnology: Concepts, Applications and Perspectives*", Wiley – VCH, 2006.

REFERENCE BOOKS

1. David S Goodsell, "*Bionanotechnology*", John Wiley & Sons, 2004.
2. Debasis Bagchi, Manashi Bagchi, Hiroyoshi Moriyama, Fereidoon Shahidi, "*Bio-Nanotechnology: A Revolution in Food, Biomedical and Health Sciences"* Wiley-Blackwell, 2013.

Course Title	TELEMEDICINE	Course Code	16MLBI2ETM
Credits	4	L-T-P-S	3-0-1-0

CO1 Ability to apply the knowledge of clinical applications, standards, and guidelines in telehealth and analyze the impact of model telehealth programs on patient care outcomes.

CO2 Identify the issues surrounding credentialing and licensure of healthcare providers using telehealth. Recognize current status of reimbursements, legal, regulatory and policy issues related to implementation of telehealth.

CO3 Demonstrate utilization of telehealth technologies to explore the nursing role as telepresenter, to provide nursing care, patient education, and patient monitoring, thus gaining the skills and knowledge to integrate telehealth knowledge into practice

Introduction, Signal Processing for Telemedicine Applications: Introduction to Signal Processing, Signal Processing Applications, Electrocardiography, Electroencephalography, Medical Image Processing

Medical Data Encoding for Transmission: Introduction, Data Compression, Wavelet Compression

Clinical Decision Support Systems for Remote and Commuting Clinicians: Introduction, Classification Systems, k-Nearest Neighbours, Artificial Neural Networks, Decision Trees, Ensemble Machines, Fuzzy Logic and Fuzzy Rule Systems, Evaluation, Conclusions

Medical Data Coding and Standards: Introduction, The Major Medical Informatics Coding Standards, Health Level 7 (HL7), International Classification of Diseases–(ICD), Digital Imaging and Communications in Medicine (DICOM), Other Standards, Biosignal Coding Standards, SCP-ECG Standard Description

Web Technologies for Networked E-Health Applications: Introduction, The World Wide Web, XML Data Representation, Web Services and Mobile Agents, Security Issues

Distributed Collaborative Platforms for Medical Diagnosis over the Internet: Introduction, State of the Art Review, Collaborative Architectural Aspects, Collaborative Platform—Main Functions and Modules, Users' Registration, On-Line Calls, Patient Record and Medical Image Transfer, Video–Audio Communication, Workspace Management, Image Compression, Security Issues, Conclusions and Challenges for the Future.

Distributed Telemedicine based on Wireless and Ad Hoc Networking: Introduction, Emerging Mobile Telemedicine Technologies, Distributed Mobile Telemedicine Requirements, Ad Hoc Networks in Distributed Mobile Telemedicine Applications

Ambient Intelligence and Pervasive Computing for Distributed Networked E-Health Applications: Introduction, Enabling Technologies in Pervasive Healthcare, Networking Technologies, Positioning Technologies, Pervasive Healthcare Applications in Controlled Environments, Pervasive Healthcare in Distributed Nonhospital Settings—Home Care Applications, Conclusions and Future Challenges

Telemedicine and Virtual Reality: Introduction, Overview of Virtual Reality Technology, Medical Applications of Virtual Reality Technology, Conclusions.

Text Book

1. Ilias G. Maglogiannis, Kostas Karpouzis and ManolisWallace "Image and Signal Processing for Networked E-Health Applications" Morgan & Claypool Publishers, 2006

Course Title	OPTICAL COHERENCE TOMOGRAPHY AND ADAPTIVE OPTICS	Course Code	16MLBI2EAO
Credits	**4**	**L-T-P-S**	**3-0-1-0**

CO1 To understand the fundamentals of optical sources and system integration concept

CO2 To understand the principle of optical coherence tomography, components, working and applications to different medical fields.

Optical sources: optical delay scanning system integration and signal/image processing. Speckle reduction techniques, Doppler optical coherence microscopy. Spectral radar.

Optical coherence tomography (OCT): in Fourier domain, OCT for high density data storage, OCT for study of polymer components, OCT in laryngology, urology, gynecology, gastrointestinal applications, cardiology, cardiology, study of eye

Modelling Light–Tissue Interaction: Optical Coherence Tomography Systems, Inverse Scattering, Dispersion, and Speckle in Optical Coherence Tomography, Spectral/Fourier Domain Optical Coherence Tomography

Data Analysis and Signal Postprocessing for Optical Coherence Tomography: Full-Field Optical Coherence Tomography, Holographic Optical Coherence Imaging.

Adaptive optics in vision science: Brief history of aberration correction in human eye, application of ocular adaptive optics

Text Book:

1. Optical Coherence Tomography Technology and Applications Editors: Professor Dr. Wolfgang Drexler, Professor Dr. James G. Fujimoto, Springer, ISBN: 978-3-540-77549-2 (Print) 978-3-540-77550-8 (Online).
2. Adaptive optics for vision science, Ed by Jason Porter et al, Wiley Interscience, 2006

Reference Book:

1. Optical Coherence Tomography, Edited by Masanori Kawasaki, ISBN 978-953-51-1032-3, Publisher: InTech, Chapters published March 06, 2013

Course Title	APPLIED STATISTICS FOR BIOMEDICAL RESEARCH	Course Code	16MLBI2EAS
Credits	4	L-T-P-S	3-0-1-0

CO1: Ability to apply knowledge of mathematics, science and engineering to understand the basic statistical concepts

CO2: Ability to analyze and select a methodology of statistical testing correctly along with study design

CO3: Ability to implement and demonstrate uni-variate analysis with using statistical software

CO4: Ability to interpret results of statistical analysis to be used in a real-life application

Basic Statistical Concepts: Introduction to basic statistical concepts such as descriptive statistics including mean, standard deviation, median, inter-quartile range, hypothesis testing, concepts of p-values and confidence intervals, how to enter data in to statistical software, and how to use R commander.

Basic Epidemiological Concepts Difference between experimental studies vs. observational studies, cohort studies, case-control, and cross-sectional studies. Concepts of randomization in clinical trials with biases introduced in non-randomized studies.
Selecting Proper Statistical Tests: Proper statistical test defined by the following conditions (1) randomized vs observational studies, (2) detecting difference or correlation, (3) data dependence or independence, (4) outcome data type, (5) distribution of outcome data, (6) number of comparison groups in detecting differences (7) sample size.

Student's t-test, Mann-Whitney U test, Paired t-test, Wilcoxon signed-rank test: Compare means of continuous outcome variables between two independent groups by using Student's t-test and comparing medians of continuous outcome variables by using Mann-Whitney U test. Paired t-test and Wilcoxon signed-rank test will be also covered to compare means (or medians) of continuous outcome variable between two related groups.

Risk, Rate and Chi-square tests: Compare a proportion of having an event in two groups of patients, ratio of two proportions provides relative risk (RR) as a measure of association between an exposure and an outcome. A similar matrix includes odds ratio (OR). How to compute and interpret Risk Ratio and Odds Ratio with a hands-on computation?

Sample Size and Power Analysis: Importance of estimation of how many numbers of subjects/participants for the study are needed in order to reach an estimated effect of an exposure of interest. Basic concepts in computing sample sizes using a software.

Text Books

1. BIOSTATISTICS-A Foundation for analysis in the Health Sciences by Warne W Daniel, 7th Edition, John Wiley & Sons Publication.
2. Fundamentals of Biostatistics by Khan and Khanum, 2nd Edition, Ukaaz Publications, 2004.

Online Course

OsakaUx: MED101x Introduction to Applied Biostatistics: Statistics for Medical Research https://courses.edx.org/courses/course-v1:OsakaUx+MED101x+1T2016/info

SEMESTER II

ELECTIVES (INSTITUTIONAL)

Course Title	MEDICAL DEVICE DEVELOPMENT	Course Code	16MLBI2EMD
Credits	4	L-T-P-S	3-0-1-0

CO1 Identify and analyse unmet clinical need and its requirements to solve the identified need.
CO2 Search, analyse and document clinical practice, engineering science and relevant literature in order to determine the need for further research and development in a chosen clinical area.
CO3 Develop a sustainable business plan, including market overview, regulation strategies for health & safety of individuals and intellectual property (IP) strategies.
CO4 Understand medical device design engineering and manufacturing process by avoiding common quality pitfalls in turn learning project management.
CO5 Present the findings of the research in a team to peer audience.

MedTech Invention: Needs finding through Observation and Problem Identification. Need Statement Development. Need Screening & Selection through Stakeholder Analysis, Market Analysis & Needs Filtering. Concept Generation, Screening and selection

Product Requirements: Define MedTech Device. Classification of Device. Role of Requirements in MedTech Product Development. Market Requirements, Customer Requirements, Clinical Workflow. Design Input. ISO 13485. Intended use, Functional / performance requirements, safety, usability requirements etc

Design Engineering: Design and Development Plan. Design Process. Design Outputs, Intermediate deliverables - System Architecture, Subsystem requirements, Prototype, System Integration. Design Review. Design Verification

Validation: System Validation. Usability Validation. Safety Validation. Clinical Validation, Regulatory Submission

Program Management: Program Planning, Stage Gate Process, Milestones. Budgeting, Development Strategy, Risk identification and Mitigation process

Text Books:

1. "Biodesign: The Process of Innovating Medical Technologies", by Stefanos Zenios , Josh Makower, Paul Yock, Todd J. Brinton, Uday N. Kumar, Lyn Denend, Thomas M. Krummel published by Cambridge University Press; 2nd edition

Reference Books:

1. "Inventing medical devices: A perspective from India", by Dr Jagdish Chaturvedi, CreateSpace Independent Publishing Platform; 1st edition, 2015.
2. "The Medical Device R&D Handbook", by Theodore R. Kucklick, Second Edition, CRC Press, 2012.

Course Title	NEURAL NETWORKS & FUZZY LOGIC APPLICATIONS	Course Code	16MLBI2ENN
Credits	4	L-T-P-S	3-0-1-0

CO1: Learn the knowledge representation and reasoning techniques in rule-based systems, case-based systems, and model-based systems

CO2: ability to specify, analyse, design and train feedforward neural networks, recurrent neural networks, and self-organising neural networks and fuzzy logic control systems.

CO3: Acquire knowledge and systematic understanding of essential facts, concepts, principles and theories relating biomedical applications of neural networks and fuzzy systems

CO4: Critically analyze and deploy appropriate theory, practices and tools for the specification, design and implementation of neural networks and fuzzy systems

CO5: Ability to perform designs with various intelligent control tools using MATLAB simulation toolboxes.

Introduction to neural networks: Properties of Single neurons, Neuronal Electrical behavior, The membrane potential, The action potential. Synaptic Integration in neural models, Slow potential theory of the neuron. Theoretical models of the neuron: Two-state neuron, Integrators, The generic Neural Network Neuron.

Mathematics for neural networks: Essential vector operations, Linear algebra, State vectors. Vector arithmetic, Linear independence. Simple Matrix operations: Matrix arithmetic, Transpose, Eigenvectors and eigenvalues, Linear systems.

Lateral Inhibition & Sensory Processing: Simple lateral inhibition, Winner-take-all networks The Linear Associator: Background & foundations: Synaptic learning: Hebbian rules, Multiple associations The Linear Associator: Simulations.

Early network models: the perceptron, Supervised and unsupervised learning, pattern recognition, The perceptron, The perceptron convergence theorem, Connectedness. Energy & neural networks: Hopfield networks & Boltzmann Machines: Analysis of Hopfield net, Optimization using neural networks. Boltzmann Machines: Finding minima

Representation of information: Distribution versus specificity, Distributed representation, Motor output, layered structures, Arrangements of units within cortical regions, local circuitry, connectivity, maps, Visual systems, Auditory systems, Motor output distribution, Other structures with topographic organization. Cognitive representations, similarity, reciprocity, Natural Data representations.

TEXTBOOKS:-

1. James A. Anderson - An Introduction To Neural Networks. 2e, PHI, 1995
2. Simon Haykin - Neural Networks, Pearson Edcation/PHI,2001.

REFERENCE BOOKS:-

1. Introduction To Artificial Neural Systems- Jacek M Zurada, Jaico publishing
2. Artificial Neural Networks- B Yegnanarayana, PHI, 2001
3. Fundamentals of Artificial Neural Networks- Mohammad Hassan,PHI,1999

Course Title	PATTERN RECOGNITION AND APPLICATIONS	Course Code	16MLBI2EPR
Credits	4	L-T-P-S	3-0-1-0

CO1: Ability to describe why a particular model is appropriate in a given situations, formulate the model and use it appropriately.
CO2: Ability to analytically demonstrate how different models and different algorithms are related to one another.
CO3: Ability to implement a set of practical methods and program solutions to some given real world machine learning problems.
CO4: Ability to justify why a given model is appropriate for the situation and develop an algorithm from a given model
CO5: Ability to design and compare machine learning methods, and discuss how different methods relate to one another and will be able to develop new and appropriate machine learning methods appropriate for particular problems.

Introduction: Applications of pattern recognition, statistical decision theory, image processing and analysis, the internet, pointers to literature.

Probability: Introduction, Probability of events, random variables, joint distribution & densities, moments of random variables, estimation of parameters from samples, minimizing risk estimators.

Statistical decision making: Introduction, bayes theorem, multiple feature, conditionally independent feature, decision foundries, unequal costs of error, estimation of error rates the living one out technique characteristics curves estimating the composition of populations.

Nonparametric decision making: introduction, histogram, kernel & window estimators, nearest neighbor classification techniques, adaptive decision foundries, adaptive.

Clustering: Introduction, hierarchical clustering and partitional clustering.

Artificial neural networks: Introduction, nets without hidden layers, nets with hidden layers, and the back propagation algorithm hop filed nets, an application classifying sex form facial images

Text books:

1. Pattern recognition & image analysis (chapter 1 to Chapter 6) Earl Gose, Richard Johnson Baugh & Steve Jost, PHI.
2. Pattern Recognition Statistical structural & neural approaches, Robert J Schalkof, John Wiley, 1992.

Reference Books:

1. Richard O. Duda, Peter E. Hart, and David G.Stork: Pattern Classification, 2nd Edition, Wiley-Interscience, 2001.
2. K. Jain, R. Bolle, S. Pankanti: Biometrics: Personal Identification in Networked Society, Kluwer Academic, 1999.