DEPARTMENT OF
MEDICAL ELECTRONICS

SCHEME & SYLLABUS

M.TECH.
BIOMEDICAL SIGNAL PROCESSING
AND INSTRUMENTATION

I to IV SEMESTER
Batch Admitted 2016 onwards
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.
Program Outcome form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The POs of the PG programme are exemplars of the attributes expected of a graduate of an accredited programme. The POs of the PG programme of the NBA are as following:

1. **Scholarship of Knowledge** Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

2. **Critical Thinking** Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

3. **Problem Solving** Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

4. **Research Skill** Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

5. **Usage of modern tools** Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.
6. **Collaborative and Multidisciplinary work** Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

7. **Project Management and Finance** Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after considerisation of economical and financial factors.

8. **Communication** Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

9. **Life-long Learning** Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10. **Ethical Practices and Social Responsibility** Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11. **Independent and Reflective Learning** Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Course</th>
<th>Credits</th>
<th>Practical / Field Work / Assignment</th>
<th>Total Credits</th>
<th>CIE</th>
<th>SEE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MLBIPCPE</td>
<td>Physiology for Engineers</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16MLBIPCES</td>
<td>Electrophysiological Signal Acquisition and Analysis</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16MLBIPCIA</td>
<td>Biomedical Image Analysis</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16MLBIPCBI</td>
<td>Theory &amp; Design of Biomedical Instruments</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16APRDICRM</td>
<td>Research Methodologies</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16MLBIPEXX</td>
<td>Elective - 1</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16MLBIPEYY</td>
<td>Elective - 2</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>17</strong></td>
<td><strong>3</strong></td>
<td><strong>25</strong></td>
<td><strong>350</strong></td>
<td><strong>350</strong></td>
<td><strong>700</strong></td>
</tr>
</tbody>
</table>
# I Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Course</th>
<th>CIE</th>
<th>SEE</th>
<th>TOTAL</th>
<th>L</th>
<th>T</th>
<th>S</th>
<th>Practical / Field Work/ Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MLBPIPEEM</td>
<td>Embedded System Design for Biomedical Applications</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>16MLBPIPEBA</td>
<td>Bioinformatics and Applications</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>16MLBPIPER</td>
<td>Real Time Bio-signal Processing</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>16MLBPIPELA</td>
<td>Linear Algebra and Its Applications in Biomedical Engineering</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Electives (Group 1)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Course</th>
<th>CIE</th>
<th>SEE</th>
<th>TOTAL</th>
<th>L</th>
<th>T</th>
<th>S</th>
<th>Practical / Field Work/ Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MLBPIPEBR</td>
<td>Biomechanics and Rehabilitation</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>16MLBPIPEHM</td>
<td>Hospital Administration &amp; Management</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>16MLBPIPEHS</td>
<td>Hearing and Speech Processing</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>16MLBPIPECN</td>
<td>Computational Neuroscience</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**Electives (Group 2)**

- Course Code: 16MLBPIPEEM
- Name of the Course: Embedded System Design for Biomedical Applications
- Credits: 4
- Total Credits: 100
- Electives (Group 1):
  - Name of the Course: Biomechanics and Rehabilitation
  - Credits: 3
  - Total Credits: 100

- Course Code: 16MLBPIPEBA
- Name of the Course: Bioinformatics and Applications
- Credits: 4
- Total Credits: 100
- Electives (Group 2):
  - Name of the Course: Hospital Administration & Management
  - Credits: 3
  - Total Credits: 100
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Course</th>
<th>CREDITS</th>
<th>TOTAL CREDITS</th>
<th>CIE</th>
<th>SEE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MLBIPCMII</td>
<td>Medical Imaging Techniques &amp; Systems</td>
<td>L: 3 T: 0 S: 1</td>
<td>5</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16MLBIPCBN</td>
<td>Biomaterials</td>
<td>L: 2 T: 0 S: 1</td>
<td>4</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16MLBIPCBP</td>
<td>Bio-Photonics</td>
<td>L: 3 T: 1 S: 0</td>
<td>4</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16MLBIPExx</td>
<td>Elective - 1</td>
<td>L: 3 T: 1 S: 0</td>
<td>4</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16MLBIPEyy</td>
<td>Elective - 2</td>
<td>L: 3 T: 1 S: 0</td>
<td>4</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>16xxxxIExx</td>
<td>Institutional Elective</td>
<td>L: - T: - S: -</td>
<td>4</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>L: 14 T: 2 S: 3</td>
<td>25</td>
<td>300</td>
<td>300</td>
<td>600</td>
</tr>
</tbody>
</table>
### II Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Course</th>
<th>CREDITS</th>
<th>TOTAL CREDITS</th>
<th>CIE</th>
<th>SEE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MLBIPEBS</td>
<td>Biosensors and Biosensor Networks</td>
<td>L: 3</td>
<td>T: 1</td>
<td>S: 0</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>16MLBIPEHT</td>
<td>Health Technology Assessment</td>
<td>L: 3</td>
<td>T: 1</td>
<td>S: 0</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>16MLBIPECS</td>
<td>Compressive Sensing in Biomedical Applications</td>
<td>L: 3</td>
<td>T: 1</td>
<td>S: 0</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>16MLBIPENM</td>
<td>Neuroimaging and Brain Mapping</td>
<td>L: 3</td>
<td>T: 1</td>
<td>S: 0</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
</tbody>
</table>

### Electives (Group 1)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Course</th>
<th>CREDITS</th>
<th>TOTAL CREDITS</th>
<th>CIE</th>
<th>SEE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MLBIPEBN</td>
<td>Bio-Nanotechnology</td>
<td>L: 3</td>
<td>T: 1</td>
<td>S: 0</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>16MLBIPETM</td>
<td>Telemedicine</td>
<td>L: 3</td>
<td>T: 1</td>
<td>S: 0</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>16MLBIPEOA</td>
<td>Optical Coherence Tomography and Adaptive optics</td>
<td>L: 3</td>
<td>T: 1</td>
<td>S: 0</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>16MLBIPES</td>
<td>Applied Statistics for Biomedical Research</td>
<td>L: 3</td>
<td>T: 1</td>
<td>S: 0</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
</tbody>
</table>
### III Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Course</th>
<th>CREDITS</th>
<th>TOTAL CREDITS</th>
<th>CIE</th>
<th>SEE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MLBIPCIN</td>
<td>Internship/Industrial Training</td>
<td>L 0 T 0</td>
<td>21</td>
<td>0</td>
<td>21</td>
<td>50</td>
</tr>
<tr>
<td>16MLBIPCP1</td>
<td>Project Phase- I</td>
<td>L 0 T 0</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>L 0 T 0</td>
<td>25</td>
<td>0</td>
<td>25</td>
<td>500</td>
</tr>
</tbody>
</table>

### IV Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Course</th>
<th>CREDITS</th>
<th>TOTAL CREDITS</th>
<th>CIE</th>
<th>SEE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MLBIPCP2</td>
<td>Project Phase-II</td>
<td>L 0 T 0</td>
<td>23</td>
<td>0</td>
<td>23</td>
<td>50</td>
</tr>
<tr>
<td>16MLBIPCTS</td>
<td>Technical Seminar</td>
<td>L 0 T 0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>L 0 T 0</td>
<td>25</td>
<td>0</td>
<td>25</td>
<td>500</td>
</tr>
</tbody>
</table>
CO1 Ability to apply basic concepts of physiology for engineering analysis of human physiological systems

CO2 Ability to translate the understanding of physiological functions into an engineering 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, Uroflow 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:**

**Reference Book:**
**Course Title**: ELECTROPHYSIOLOGICAL SIGNAL ACQUISITION AND ANALYSIS  
**Course Code**: L-T-P-S 2-0-1-1

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Code</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTROPHYSIOLOGICAL SIGNAL ACQUISITION AND ANALYSIS</td>
<td>L-T-P-S</td>
<td>4</td>
</tr>
</tbody>
</table>

**CO1**: Understand the knowledge of acquiring the electrophysiological signals  
**CO2**: Know the signal patterns for analysis in medical diagnosis  
**CO3**: Identify the signal characteristics in normal and ailment conditions  
**CO4**: 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. Auto regressive (AR) and **ARMA (auto regressive 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:**

**Reference Books:**
1. Computer Analysis of Electrophysiological Signals, John Dempster,
2. [http://iitr.vlab.co.in/?sub=49&brch=267&sim=1305&cnt=1](http://iitr.vlab.co.in/?sub=49&brch=267&sim=1305&cnt=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 Understand the basic principles of medical image compression and communication

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 Book:**
1. Biomedical Image Analysis, Rangaraj. M Rangayyan, CRC 2005

**Reference Book:**

CO1 Demonstrate a comprehensive knowledge of the theory of biomedical equipment design components by applying appropriate technique to prototype and validate 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 with 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
Module 1:
Meaning, Objectives and Characteristics of research - Research methods Vs Methodology - Types of research - Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical - Research process - Criteria of good research - Developing a research plan.

Module 2:
Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem - Importance of literature review in defining a problem - Survey of literature - Primary and secondary sources - Reviews, treatise, monographs patents - web as a source - searching the web - Identifying gap areas from literature review - Development of working hypothesis.

Module 3:

Module 4:
Aim of this part of the course: is to strengthen students minds towards high quality research through publications, patents and also to learn research ethics. Publications (8-9 hours) Research concepts (2 hour) Research importance on economy, Research in India and abroad, Importance of publications, Why, where, when to publish? Publication ethics (2 hour), Plagiarism (how to use Turnitin effectively), International ethics on research, What and what not to publish, Ethical guidelines, Case studies

Quality vs quantity (2 hour) Searching literature with high quality, Impact factor, Citations (google scholar vs web of science), H-index, Case studies, How to write paper (2 hour),
In High quality journals, Conference Articles, Poster preparation, PhD thesis, Inclusion of References, Journal reviewing process (1 hour), Selection of the good journal, Knowledge bout journal template, Referee process, Research topic selection, Research today and tomorrow, Lab scale to Industry, Traditional research to Technology based research

**Module 5: Self study**

Interpretation and report writing - Techniques of interpretation - Structure and components of scientific reports - Different steps in the preparation - Layout, structure and language of the report - Illustrations and tables - Types of report - Technical reports and thesis

**REFERENCES:**

SEMESTER I
ELECTIVES (GROUP 1)

<table>
<thead>
<tr>
<th>Course Title</th>
<th>EMBEDDED SYSTEM DESIGN FOR BIOMEDICAL APPLICATIONS</th>
<th>Course Code</th>
<th>Credits</th>
<th>L-T-P-S</th>
<th>3-0-1-0</th>
</tr>
</thead>
</table>

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


**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:**
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
Course Title: BIOINFORMATICS AND APPLICATIONS

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credits</th>
<th>Course Code</th>
<th>16MLBIPEBA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>L-T-P-S</td>
<td>3-0-1-0</td>
</tr>
</tbody>
</table>

CO1: Interpret relationships among living things and analyze biological problems, from the molecular to ecosystem level using biological concepts

CO2: Demonstrate cognitive skills 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: Understand the contents and properties of bioinformatical databases, perform text- and sequence-based searches, and analyze the results with respect to molecular biological perspective

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 name spaces. 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 name spaces 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, Endfree-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:

Reference Books:
1. XML for Bioinformatics. CERAMI, Springer 2005
2. Beginning Perl for Bioinformatics, James D. Tisdall, O'Reilly 2001
CO1 Understand the architecture and basic operation of fixed-point and floating-point DSPs to perform timing analysis on real-time DSP systems.

CO2 Develop and realize computationally efficient algorithms on the DSP platform.

CO3 Explore filter structures for bio-signal analysis.

CO4 Implement real-time filter structures and identify the sources of performance discrepancies using modern tools.

**Overview on Hardware and Software Tools:** The ARM Cortex M4 Architecture or DSP Platform C6x family processor, Android or iOS development tools, ARM core on Smart phone.

**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 of optimum signal processing, Wiener filters adaptive structures, LMS algorithms and simple variations. RLS algorithms, Basic Kalman Filters with implementations.

Text Books:
1. Modern Digital Signal Processing by Roberto Cristi, Cengage Learning, 2004

Reference Book:
1. Digital Signal Processing and Applications with the OMAP - L138 eXperimenter, Wiley 2012
<table>
<thead>
<tr>
<th>Course Title</th>
<th>LINEAR ALGEBRA AND ITS APPLICATIONS IN BIOMEDICAL ENGINEERING</th>
<th>Course Code</th>
<th>16MLBIIPELA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits</td>
<td>4</td>
<td>L-T-P-S</td>
<td>3-0-1-0</td>
</tr>
</tbody>
</table>

CO1: Identify, evaluate, analyze and synthesize solutions using linear algebra concepts.
CO2: Conceptualize hypothesis and develop computational algorithms using modern tools.
CO3: Research the concepts of Linear algebra to manage projects efficiently by working as an individual, document and present the conceptualized work concepts.
CO4: 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 Book:**

**Reference Book:**
CO1: Apply knowledge of mathematics, science and engineering to analyze moving systems in relation to human anatomy.

CO2: Comprehend biomechanical principles that relate to movement and communication disabilities.

CO3: Develop and apply the principles of biomechanics to a range of rehabilitation strategies and problem solving.


**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:**

**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
CO1 Demonstrate the organizational elements and structure, delivery modalities, barriers to system and process improvement.

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

CO3 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


**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


**Text Books:**

**Reference Book:**
1. Hospital Management: Text & Cases by K. V. Ramani,
CO1: Analyze the sound and speech data with mathematical foundations.

CO2: Use various speech parameters associated with multiple sources for Bi-aural hearing to design speech ailment devices.

CO3: 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 Books:
1. Textbook of Hearing Aid Amplification, Robert E. Sandlinion

Reference Books:
## Course Title: Computational Neuroscience

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Code</th>
<th>Credits</th>
<th>L-T-P-S</th>
<th>16MLBIPECN</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPUTATIONAL NEUROSCIENCE</td>
<td></td>
<td>4</td>
<td></td>
<td>3-1-0-0</td>
</tr>
</tbody>
</table>

CO1 Interpret cellular compositions of the nervous system and the process of communication between cells.

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

CO3 Emphasize on the interdisciplinary nature of modern neuroscience and opportunities to contribute.

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.

Text Book:
1. Computational Neuroscience and Cognitive Modelling by Britt Anderson –
   SAGE, 2014

Reference Book:
1. From Computer to Brain:Foundations of Computational Neuroscience by William
   W. Lytton, Springer, 2002
MEDICAL IMAGING TECHNIQUES & SYSTEMS

<table>
<thead>
<tr>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquire in-depth knowledge of Medical Imaging principles and their applications.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

**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


**Nuclear Medicine:** Historical Overview, Fundamentals of Radioactivity, Nuclear Activity and its Units, Half Life, Interaction of Nuclear Particles and Matter, Attenuation of Gamma


**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 Book:**

**Reference Books:**
2. edX MOOC Course, Principles of Biomedical Imaging, online course.
3. Internet Text References and Videos.
<table>
<thead>
<tr>
<th>Course Title</th>
<th>BIOMATERIALS</th>
<th>Course Code</th>
<th>16MLBIPCBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits</td>
<td>4</td>
<td>L-T-P-S</td>
<td>2-0-1-1</td>
</tr>
</tbody>
</table>

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 multi disciplinary 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:** Multi levels 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 Stretchability, 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: Al₂O₃, ZrO₂, 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:

Reference Books:
BIO-PHOTONICS

CO1: Analyze the laser principles with safety regulations for biomedical applications.
CO2: Utilize optical components for microscopes in biomedical imaging.
CO3: Understand the optical biosensor for image transduction.


Anti-Stokes Raman Scattering (CARS) Microscopy, Multifunctional Imaging, Pi Imaging, Combination Microscopes, Miniaturized Microscopes, Some Commercial Sources of Imaging Instruments,


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

**Text Book:**

**Reference Book:**
SEMESTER II
ELECTIVES (GROUP 1)

<table>
<thead>
<tr>
<th>Course Title</th>
<th>BIOSENSORS AND BIOSENSOR NETWORKS</th>
<th>Course Code</th>
<th>16MLBIPEBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits</td>
<td>4</td>
<td>L-T-P-S</td>
<td>3-1-0-0</td>
</tr>
</tbody>
</table>

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.

**Amperometric 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

Reference Books
<table>
<thead>
<tr>
<th>Course Title</th>
<th>HEALTH TECHNOLOGY ASSESSMENT</th>
<th>Course Code</th>
<th>16MLBIPEHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits</td>
<td>4</td>
<td>L-T-P-S</td>
<td>3-1-0-0</td>
</tr>
</tbody>
</table>

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:** Monitor Impact of Health technology Assessment, Barriers and Issues related to Health Technology Assessment.

**Text Book:**

**Reference Book:**
**Course Title**: COMPRESSIVE SENSING IN BIOMEDICAL APPLICATIONS  
**Course Code**: 16MLBIPECS  
**Credits**: 4  

CO1 To reason and select sparse or nearly sparse signals from under-sampled data for reconstruction.  
CO2 Use recent ideas in modern convex optimization allowing rapid signal recovery or parameter estimation.  
CO3 To produce optimal representation of signals that are suited for internet of medical signal acquisition devices as things.  

**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.  


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

Text Book:

Reference Books:
1. http://dsp.rice.edu/courses/elec631
2. Compressed Sensing (Eldar, Kutyniok), CUP 2012
**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

**Text Book:**

**Reference Books:**
2. Learning Neuroimaging: 100 Essential Cases (Learning Imaging)by Francisco de Asís Bravo-Rodríguez and Francisco de Asís Bravo-Rodríguez, Springer 2011
CO1 Understand the essential features of biology and nanotechnology that are converging to create the new area of bio-nanotechnology
CO2 Recognize the structural and functional principles of bio-nanotechnology
CO3 Employ bio-nanomaterials for biomedical sensing 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 Book:

Reference Books:
CO1 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


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


Text Book

Reference Book:
1. Telemedicine: Medicine and Communication by Thorsten M. Buzug (Editor), Heinz Handels (Editor), Dietrich Holz (Editor), Publisher: Springer; ISBN-10: 1461354633
<table>
<thead>
<tr>
<th>Course Title</th>
<th>OPTICAL COHERENCE TOMOGRAPHY AND ADAPTIVE OPTICS</th>
<th>Course Code</th>
<th>16MLBIPEOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits</td>
<td>4</td>
<td>L-T-P-S</td>
<td>3-0-1-0</td>
</tr>
</tbody>
</table>

CO1 Understand the fundamentals of optical sources and system integration concept

CO2 Apply the principles of optical coherence tomography and components of adaptive optics to 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, gynaecology, 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 Post processing 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 Books:**


**Reference Book:**
Course Title: APPLIED STATISTICS FOR BIOMEDICAL RESEARCH
Course Code: 16MLBIPEAS
Credits: 4

CO1: Apply knowledge of mathematics, science and engineering to understand the basic statistical concepts
CO2: Analyze and select a methodology of statistical testing correctly along with study design
CO3: Implement and demonstrate uni-variate analysis using statistical software
CO4: Interpret results of statistical analysis to be used in real-life applications

**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:**

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