## DEPARTMENT OF MEDICAL ELECTRONICS AND ENGINEERING

### Vision

To be a leading force in the field of medical electronics in understanding medical equipment for health care.

### Mission

- To impart knowledge base and skill sets in the field of medical electronics.
- Inculcate managerial and entrepreneurial skills to work in multidisciplinary environment.
- To provide a best learning ambience for academics & research leading to global competence.
- To analyze and design latest life saving technologies to solve societal problems.

### Program Educational Objectives

**PEO 1:** To impart fundamental knowledge in science and technology to perform challenging roles in new trends of medical electronics.

**PEO2:** To develop professional attitude, good communication skill and to work in multidisciplinary teams with strong ethical, spiritual background.

**PEO3:** To excel in the field of research and innovation there by contributing to the evolving technology.

### Program Outcomes:

**Engineering Graduates will be able to:**

- **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

- **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**Program Specific Outcomes (PSOs)**

**PSO 1:** Investigate, Implement and demonstrate various applications of analog and digital electronic subsystems in designing and building biomedical instrumentation systems.

**PSO 2:** Specify, architect and prototype health-care solutions by applying signal and medical image processing techniques on modern hardware and software platforms

**PSO 3:** Design, develop and verify processes, algorithms and computer programs for medical purposes

# SRI SIDDHARTHA INSTITUTE OF TECHNOLOGY- TUMAKURU

**(A constituent College of Siddhartha Academy of Higher Education, Tumakuru)**

## DEPARTMENT OF MEDICAL ELECTRONICS

| **V Semester B.E. (Common to all UG programs: ML)** (Subjects and Syllabus as per AICTE-Model Curriculum for UG Course in Engg. & Tech.- Jan. 2018) | | | | | | **Teaching Hours/week** | | | | **Examination** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *SI No.* | *Course and Course Code* | | *Course Title* | *Teaching dept.* | *Board of Exam.* | *L* | *T* | *P* | *C* | *Duration in Hrs.* | *CIE* | *SEE* | *Total Marks* |
| 01 | PC | 18ML501 | Biomedical Instrumentation | ML | ML | 3 | 1 | - | 4 | 3 | 50 | 50 | 100 |
| 02 | PC | 18 MLI 502 | Digital Image Processing | ML | ML | 3 | - | 2 | 4 | 3 | 50 | 50 | 100 |
| 03 | PC | 18 ML 503 | Digital Signal Processing | ML | ML | 3 | 1 | - | 4 | 3 | 50 | 50 | 100 |
| 04 | PC | 18 ML 504 | Fibre Optics and Lasers in Medicine | ML | ML | 3 | - | - | 3 | 3 | 50 | 50 | 100 |
| 05 | PE | 18 ML5PE5x | Professional Elective-I | ML | ML | 3 | - | - | 3 | 3 | 50 | 50 | 100 |
| 06 | OE | 18 EC5OE6x | Open Elective-I | ML | ML | 3 | - | - | 3 | 3 | 50 | 50 | 100 |
| 07 | PC | 18 ML507 | Biomedical Instrumentation Lab-I | ML | ML | - | - | 2 | 1 | 3 | 50 | 50 | 100 |
| 08 | PC | 18 ML508 | DSP Lab | ML | ML | - | - | 2 | 1 | 3 | 50 | 50 | 100 |
| 09 | HS | 18SK501 | Skill Development-III | HS | HS | - | - | 2 | 1 | 3 | 50 | 50 | 100 |
| Total | | | | | | 18 | 2 | 08 | 24 | 27 | 450 | 450 | 900 |
| **Note: Open Elective are offered in V and VI sem; The students are encouraged take online courses (Swayam/Mooc / Nptel /MIT – Coursera ……) after IV sem SEE and before starting of VII Sem Classes (during Vacation time). The same is approved by concerned HEAD and DEAN(Academics) .** | | | | | | | | | | | | | |
| **Note: Open Elective : The strength should be Min of 25 and Max of 55 to 60. In Place of Open Elective at V Sem , the students are encouraged to take Online course (Swayam/Mooc / Nptel /MIT – Coursera ……). The same is approved by concerned HEAD and DEAN(Academics) .** | | | | | | | | | | | | | |

Professional Elective I: 18ML5PE51: Embedded System Design and ARM Processors
18ML5PE52: Computers in Medicine
18ML5PE53: Physiological Control Systems

Open Elective I: 18EC5OE63: Biomedical Instrumentation

Sri Siddhartha Institute of Technology, Tumkur

(A constituent College of Siddhartha Academy of Higher Education, Tumakuru)

Department of Medical Electronics

Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: V**

**Subject Name: Biomedical Instrumentation**

**Subject Code: 18ML501** **L-T-P-C: 3-1-0-4**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | Interpret technical aspects of medicine. |
| **2.** | Comprehend different bio signals and their measurement. |
| **3.** | Study the principles of various diagnostic and therapeutic equipment's. |
| **4.** | Distinguish the sub systems used in a typical man-machine system. |

| Unit | Course content | Teaching hrs |
|---|---|---|
| **I** | **Introduction to Biomedical Instrumentation:** Biometrics, Introduction to the man instrument system, components of the man instrument system, Physiological systems of the body, problems encountered in measuring living systems. Sources electric potentials: Resting and action potentials, propagation of action potentials. The bioelectric potentials. | **10** |
| **II** | **The Cardiovascular system:** The heart and cardiovascular system, the heart, electrocardiograph, blood pressure and its measurements, characteristics of blood flow, measurements of blood flow and cardiac output, Plethysmography, heart sounds and its measurements. | **10** |
| **III** | **Other Bio-electric signals & systems:** Electro-oculogram(EOG), Electro-encephalogram(EEG), Electro-myogram (EMG), Electro retinogram(ERG) Recording Electrodes: Electrode tissue interference polarization, Skin contact impedance , Silver-Silver chloride electrodes for ECG, Electrodes for EEG, EMG, Electrical conductivity of electrode jellies & creams, microelectrodes. | **10** |
| **IV** | **Measurements respiratory system:** The physiology of the Respiratory system test & Instrument for the | **10** |

| | | |
|---|---|---|
| | Mechanics of breathing. Gas exchange & distribution, respiratory therapy equipments. | |
| **V** | **Cardiac Pace Maker & Patient Safety:** Need for Cardiac Pacemaker, external pacemaker, Implantable pace maker, types of Implantable pacemakers. Patient Safety: Electric shock hazards, leakage currents, safety codes & analyzer, Biomedical telemetry, single channel telemetry, multi-patient telemetry, Implantable telemetry & telemedicine. | **12** |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Understand the need for engineering skills in medical applications |
| **CO2** | Understand the need & advantages of Sources of Bio-Electric potentials, Transducers, Biosensors and its type. |
| **CO3** | Record and analyze biological parameters like EEG, EMG and EC. |
| **CO4** | Understand Cardiac Pace Maker and patient safety measures. |

**Question paper Pattern:**

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|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Biomedical Instrumentation & Measurements, | Cromwell Et, AI | 2e, PHI/Pearson Education |
| 2 | Principles of Applied Biomedical Instrumentation | Geddes and Baker | 3e, John Wiley, 1989 |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Biomedical Instrumentation Technology and Applications | R. Khandpur | McGraw-Hill, 2nd e |
| 2 | Biomedical Instrumentation | M Armugam | Anuradha Publications, 2nd edition. 1994. |

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|---|---|---|---|
| 3 | Fundamentals of biomedical instrumentation | Dr. O N Pandey | Katson Books |
| 4 | Biomedical Instrumentation Systems | Shakthi Chatterji | Electronic Technical Assosiation |

Sri Siddhartha Institute of Technology, Tumkur

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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: V**

**Subject Name: Fundamentals of Digital Image Processing**

**Subject Code: 18MLI502** **L-T-P-C: 3-0-2-4**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | Understand and analyze the representation of a digital image. |
| **2.** | To realize algorithms to solve image processing problems and meet design specifications. |
| **3.** | To comprehend the techniques of image processing to enhance the image resolution. |
| **4.** | To grasp various transformations and restoration techniques to gain knowledge with respect to different types of noise. |

| Unit | Course content | Teaching hours |
|---|---|---|
| **I** | **Introduction:** Background, digital image representation, examples of field that use DIP, fundamental steps in digital image processing, elements of digital image processing system.<br>Digital image fundamentals: Simple image model, Sampling and quantization, some basic relationships between pixels, some basic transformations | **8** |
| **II** | **Image enhancement** in the spatial domain: Background, Basic gray level transformations, histogram processing, enhancement using arithmetic/logic operations, basics of spatial filtering, smoothing and | **8** |

| | | |
|---|---|---|
| | sharpening spatial filters, combining spatial enhancement methods. | |
| **III** | **Image enhancement in the frequency domain:** introduction to the frequency domain, smoothing and sharpening frequency domain filters, homomorphic filtering, implementation, generation of spatial masks from frequency domain specifications, color image processing | **7** |
| **IV** | **Image Transforms**: unitary transform- DFT, DCT, Wavelet, Haar, Hadamard, sine transforms with their properties and applications. | **8** |
| **V** | **Image Restoration:** Degradation model, Noise models, restoration in the presence of noise only (Spatial and frequency domain filters), linear position invariant degradations, wiener filters, Inverse filtering, LMS filtering. | **8** |

**Course Outcomes:**

| **Sl. No.** | **Course Outcomes** |
|---|---|
| **CO1** | Understand the relevant aspects of digital image representation and their practical implications, components required in digital image processing. |
| **CO2** | Foster on different techniques employed for the enhancement of images in both spatial and frequency. |
| **CO3** | Emphasize the need for image transforms different types of image transforms and their properties and applications. |
| **CO4** | learn different causes for image degradation and implement various filtering techniques to enhance quality of the image. |

**Question paper Pattern:**

From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice.

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Digital Image Processing | by R C Gonzalez & R E Woods | Pearson Education, 2nd Edition. |
| 2. | Fundamentals of Digital Image Processing | Anil K Jain | Eastern Economy Edition, Prentice Hall of India Private Limited, 2003. |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Digital Image Processing | Sid Ahmed | McGraw Hill |
| 2. | Digital Image Processing | S Jayaraman and Esakirajan | Tata McGraw Hill Publications |
| 3. | Introduction to Digital Image Processing | William J Pratt | CRC Press |
| 4. | Fundamentals of Digital Image Processing | Annadurai | Pearson Publications |

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Department of Medical Electronics

Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: V**

**Subject Name: Digital Signal Processing**

**Subject Code: 18ML503** **L-T-P-C: 3-1-0-4**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1** | To study about discrete Fourier transform and to learn about FFT algorithms. |
| **2** | To study the design techniques and realization methods for FIR and IIR digital filters |
| **3** | To study the applications of DSP |

| Unit | Course content | Teaching hrs |
|---|---|---|
| **I** | **Introduction to Digital Signal Processing:** Basic elements of Digital Signal Processing system, advantages of digital over analog signal processing, Applications of DSP. **Discrete Fourier transform**: Introduction, Fourier representations of finite-duration sequences, properties of DFT, Linear convolution using DFT, computation of Circular convolution and correlation, | **12** |

| | | |
|---|---|---|
| | discrete cosine transform (DCT). | |
| **II** | **Computation of DFT:** Filtering of long sequences: Overlap-Save and Overlap-add method, Decimation-in-time and decimation-in-frequency radix-2 FFT, Linear filtering approach to computation of the DFT. | **10** |
| **III** | **Filter design techniques:** Ideal filter characteristics, low-pass, high-pass and band-pass filters; digital resonators, notch filters. Design of FIR filters: Issues in filter design, importance of linear phase, frequency response of linear phase FIR filters, locations of zeros of FIR filters, Design techniques of FIR filters, windowing, frequency sampling method, design of Hilbert transformer. | **10** |
| **IV** | **Design of IIR filters:** Analog filter design- Butterworth and Chebyshev filter, frequency transformations in analog domain, Elementary properties of IIR filters, Design of digital filters from analog filters, impulse invariant transformation and bilinear transformation methods, comparison of FIR and IIR filters. | **10** |
| **V** | **Implementation of discrete-time systems:** Basic structures for FIR systems: Direct, Cascade, Linear Phase and frequency sampling structures. Structures for IIR systems: Direct, Cascade and Parallel structures. Factors to be considered in choosing a structure: coefficient quantization, finite word length effects, memory requirements.<br>**Applications:** Dual Tone Multi Frequency signal detection, Spectral analysis using DFT, Musical sound processing. | **10** |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Incorporate the knowledge about signals and systems and hence appreciate the methods involved to realize discrete Fourier transforms Discrete Fourier Transforms and hence appreciate the efficient methods involved to solve engineering problems |
| **CO2** | Recognize the importance of techniques to solve discrete Fourier transforms faster using FFT |
| **CO3** | Comprehend and interpret the various techniques involved in the design and implementation of IIR and FIR filters |
| **CO4** | Realize various types of IIR and FIR filters using various approaches |

**Question paper Pattern:**

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|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year |
|---|---|---|---|

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|---|---|---|---|
| | | | of Edition |
| 1. | Digital Signal Processing: Principles, Algorithms and Applications | J.G. Proakis and D. G. Manolakis. | 1997, PHI |
| 2. | Digital Signal Processing: A computer-Based Approach | S. K. Mitra | 2nd Edition, 2001, TMH. |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Fundamentals of Digital Signal Processing, | John Wiley & sons. Lonnie C. Ludeman | 1st Edition, 1986, |
| 2 | Digital Signal Processing | Hussain, Zahir M., Sadik, Amin Z., O'Shea, Peter | Springer publications. 2011 |
| 3 | Digital Signal Processing: Principles, Algorithm and Applications | John G Prokias, Dimitris Manolakis | Pearson Publications |
| 4 | Digital Signal Processing | Nagoor Kani | Tata McGraw Hill Publications |

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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: V**

**Subject Name: Fiber Optics and Lasers in Medicine**

**Subject Code: 18ML504** **L-T-P-C: 3-0-0-3**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | To expose the students to the basic concepts of optical fibers and their properties |
| **2.** | To provide adequate knowledge about the Industrial applications of optical fibers |

| | |
|---|---|
| **3.** | To expose the students to the Laser fundamentals |
| **4.** | To provide adequate knowledge about Medical applications of lasers. |

| Unit | Course content | Teaching hours |
|---|---|---|
| **Unit I** | **Optical Fibers:** Introduction, electromagnetic spectrum, fiber optic transmission link, nature of light, basic optical laws with definitions, quantum nature of light, optical fiber modes, ray optics representation, optical couplers, fiber joints, fiber splices, fiber connectors. | **8** |
| **Unit II** | **Fiber Structures and Fabrication:** optical fibers- fundamentals, light transmission in optical fibers-principles, types of fabrication methods, power transmission through optical fibers, fiber ends and tips, attenuation. | **8** |
| **Unit III** | **Lasers:** Historical background. Medical Lasers: Introduction, Laser physics-fundamentals, principles, Medical Lasers-fundamentals, principles( co2, Nd-YAG, helium, eximer, dye - lasers), advances( semiconductor laser, free electron laser). Medical Laser Systems-fundamentals, principles. Laser safety-fundamentals. | **8** |
| **Unit IV** | **Applications of Lasers in Therapy & Diagnosis:** Introduction, laser assisted diagnosis and therapy-fundamentals, interaction of laser beams and materials-principles, laser interaction with tissue-principles, laser assisted diagnostics-principles, applications of lasers in diagnosis and imaging-advances, Laser surgery and therapy- principles: photo thermal, photo mechanical mechanism, thermal interaction between laser and tissue. | **8** |
| **Unit V** | **Clinical Applications of Lasers:** Fiber optic laser systems in gastroenterology, general surgery and thoracic surgery, gynecology, neurosurgery, oncology, ophthalmology, orthopedics, urology, flow diagram for laser angioplasty, flow diagram for photo dynamic therapy. | **7** |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Understand the basics of optical fibers, fiber joints & fiber couplers. |
| **CO2** | Comprehend fiber structure & different fabrication technology. |
| **CO3** | Realize different types of laser and its applications. |
| **CO4** | Gain the knowledge about application of laser technology in clinical field. |

**Question paper Pattern:**

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|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Lasers and Optical fibers in Medicine | Abraham Katzir | Academic Press |
| 2. | Optical Fiber Communication | Gred Keiser | McGraw-Hill Education (India) Pvt Limited |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Optical Fiber Communication | P Chakrabarti | McGraw-Hill Education (India) Pvt Limited |
| 2. | Optical Fiber Communication | Sr. Kakani and Shubhadra Kakani | CBS Publications and Distributors |
| 3. | Optical Fiber Communication: Principles and Applications | T L Singhal | Cambridge University. |
| 4. | Lasers for Medical Applications | Helena Jelínková | Woodhead Publishing |

**Department: Medical Electronics** **Semester: V**

**Subject Name: Embedded System Design and ARM Processors**

**Subject Code: 18ML5PE51** **L-T-P-C: 3-0-0-3**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | To emphasize on the major components that constitute an embedded system and provide experience to integrate hardware and software for microcontroller applications systems. |
| **2.** | Implement small programs to solve well-defined problems on an embedded platform. |
| **3.** | Develop familiarity with tools used to develop an embedded environment. |
| **4.** | To learn various communication protocols applicable in embedded system applications. |

| Unit | Course content | Teaching hours |
|---|---|---|
| **I** | **Introduction:** Overview of embedded systems, embedded system design challenges, common design metrics and optimizing them. Survey of different embedded system design technologies, trade-offs. Custom Single- Purpose Processors, Design of custom single purpose processors.<br><br>**Single-Purpose Processors:** Hardware, Combinational Logic, Sequential Logic, RT level Combinational and Sequential Components | **8** |
| **II** | **General Processors-Software:** Basic Architecture, Operation, Programmer's View, Development Environment, ASIPS.Standard **Single-Purpose Peripheral:** Timers, Counters, UART, PWM, LCD Controllers, Keypad controllers, Stepper Motor Controller, A to D Converters, Examples | **8** |
| **III** | **Memory and communication:** Introduction, Common memory Types, Composing memory, Memory Hierarchy and Cache, Advanced RAM.<br>**Interfacing:** Communication Basics, Microprocessor Interfacing, Arbitration, Advanced Communication Principles, Protocols – Serial, Parallel and Wireless. | **6** |
| **IV** | **ARM Embedded Systems:** The RISC Design Philosophy, The ARM Design Philosophy, Embedded System Hardware, Embedded System Software.<br>**ARM processor fundamentals:** Registers, Current Program Status Register, Pipeline, Exceptions, Interrupts, and Vector Table, Core | **8** |

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|---|---|---|
| | Extensions, Architecture Revisions, ARM Processor Families. | |
| **V** | **Introduction to the Arm Instructions Set:**<br>Data Processing Instructions, Branch Instructions, Load-Store Instructions, Software Interrupt Instructions, Program Status Register Instruction, Loading Constants, ARMv5E Extensions, Conditional Execution, and Example Programs. | **9** |

Course Outcomes:

| **Sl. No.** | **Course Outcomes** |
|---|---|
| **CO1** | Foster to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, Manufacturability and sustainability. |
| **CO2** | Identify and analyze the formal design methodologies to optimize various aspects in the design of embedded systems for industrial applications. |
| **CO3** | Apply Knowledge of various embedded processor architectures in real time applications to perform the real time processing. |
| **CO4** | Emphasizes on ARM family of microcontrollers that are widely used in design of real time sophisticated embedded systems like tablets, hand held devices, automation and industrial control systems. |

**Question paper Pattern:**

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|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Embedded System Design: A unified hardware and software: introduction | Frank Vahid/ Tony Givrgis | Wiley India Edition, 2002. |
| 2. | ARM Systems Developer's Guide Designing and Optimizing System Software | Andrew N. Sloss, Dominic Symes, Chris Wright, | Morgan Kaufmann Publishers, ElseveirInc, 2004 |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Introduction to Embedded Systems | Shibu K V | Tata McGraw Hill |

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|---|---|---|---|
| | | | Education Private Limited, 2017. |
| 2. | Embedded systems | Raj Kamal | Tata McGraw Hill publishing companies 2nd edition. |
| 3. | Embedded Systems: Hardware, Design and Implementation | Krzysztof Iniewski | Wiley Publications |
| 4. | Embedded System Design | Santanu Chattopadhyay | PHI Publications |

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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: V**

**Subject Name: 18ML5PE52**

**Subject Code: Computers in Medicine** **L-T-P-C: 3-0-0-3**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | Understand the importance of hospital information systems. |
| **2.** | Realize the use of database in clinical laboratory and computer aided diagnosis. |
| **3.** | Analyze the case studies using in clinical data analysis. |
| **4.** | Know the used of internet and Ethernet in medical data. |

| Unit | Course content | Teaching hours |
|---|---|---|
| **I** | **Introduction:** Historical review of computers & their use in Medical field, Hospital information, system –need for computerization in hospitals-cost effectiveness –Help of computerization to physicians.<br>Computerized patient data base management: History taking by computer-computerized medical records-security. | **8** |
| **II** | **Computers in clinical laboratory:** Data base approach –Automated clinical laboratories and analysis-Analysis of computerized ECG, EMG, and EEG results. Computer assisted medical imaging – Nuclear medicine –Digital subtraction radiography-computerized ultrasonography-x-ray CT –Nuclear magnetic resonance. | **8** |
| **III** | **Computer assisted medical decision making:** General model, algorithms-Fuzzy set theory - Production role systems-Cognitive models-QMR,KESandTIA. Computers in intensive care units- Fluid and metabolic Balance -Pulmonary function evaluation, cardiovascular Physiologic evaluation. | **8** |
| **IV** | **Computer assisted therapy- Introduction:** Digitalis therapy-Illustrative cases-computers for care of renal disorders-other examples | **7** |

| | | |
|---|---|---|
| **V** | **Computer aids for the handicapped-Introduction:** Mobility, computer aids for the deaf, blind and visually handicapped-computer speech generation and recognition. Introduction to computer assisted instruction Medicine --Telemetrics, ISDN and INDONET in medicine. | **8** |

Course Outcomes:

| **Sl. No.** | **Course Outcomes** |
|---|---|
| **CO1** | Apply the concepts of hospital information systems in managing data base. |
| **CO2** | Examine the concepts of data base using computers. |
| **CO3** | Evaluate computer data in ICU's for diagnosis and therapy. |
| **CO4** | Utilize data base in computers in telemetry, ISDN. |

**Question paper Pattern:**

From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice.

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Computer in Medicine | R.D Lele | TATA McGraw Hill Publications |

**Reference Book:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Visual Computing for Medicine | Bernhard Preim Charl Botha | Morgan Kaufmann Publications |
| 2. | Computers in Medicine: Applications and | Jonathan Javitt MD MPH | Saunders Publications; 1st |

| | | | |
|---|---|---|---|
| | Possibilities 1st Edition | | Edition |
| 3 | Use and Impact of Computers in Clinical Medicine | James G. Anderson, Stephen J. Jay | Springer Publications |

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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: V**

**Subject Name: Physiological Control Systems**

**Subject Code: 18ML5PE53** **L-T-P-C: 3-0-0-3**

| Sl. No. | Course Objectives |
|---|---|
| **1** | This course provides undergraduate engineering students with an introduction to the physiological concepts and mathematical tools that they will need to understand, analyse and interpret the data from different physiological control systems of human body by various compartmental models. |
| **2** | The physiological control theory, system analysis, model identification techniques helps to understand process involved in regulation of different physiological systems. |

| Unit | Course content | Teaching hours |
|---|---|---|
| **I** | **Dynamic Systems and their control:** Introduction, some system definitions, man machine example, modelling and block diagram, the pupil control system, the generic structure of control systems, the dynamic response characteristics of the pupil-control system, open-and closed-loop systems, automatic aperture control in camera. | **08** |

| | | |
|---|---|---|
| **II** | **The Human thermal system:** Heat production, Brief description of the biochemistry of digestion, Loss of heat to the environment, heat transfer within the body.<br>Mathematical modelling of the system: Thermoregulation: Introduction thermoregulation of cold-bloodedness and warm bloodedness, an anatomy of thermoregulation, lumping and partial differential equations and heat transfer examples. | **08** |
| **III** | **An Introduction to physiological control system:** Differences between the technological and physiological control systems, Regulation of electrolyte concentrations, Regulation of acid-basebalance, Regulation of red blood cell production, Regulation of arterial pressure, Regulation of blood volume, Regulation of respiration, Reflex functions of nervous system, Regulation of body temperature, Regulation of blood glucose. | **08** |
| **IV** | **Modelling the body as compartments:**<br>Process flow sheet models, Examples of photokinetic models, modelling of large multicompartment systems, dissolution of drugs in solid form, distribution and accessibility of body water and tissue compartments. | **08** |
| **V** | **Biological receptors:**<br>Introduction, receptor characteristics, transfer function models of receptors, preceptors and perceived intensity. Respiratory control system and cardiovascular system. | **07** |

Course Outcomes:

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | To understand the basics of Biological control Systems, difference between active and passive control system, steady-state and dynamic responses of pupil control system. |
| **CO2** | Understand the different modes of heat transfer from the human body, anatomy and physiology of human thermal system and its different models. |
| **CO3** | Understand the processes involved in regulation of different physiological systems. |
| **CO4** | Understand human body by various compartmental models. To study characteristics of biological receptors, Respiratory and cardiovascular control system models. |

**Question paper Pattern:**

| |
|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Biological control system | John H Milsum | McGraw Hill |
| 2 | Biomedical Engg Principles | David O Cooney | Michael Deckker |
| 3 | The Application of control theory to physiological systems | Howard T Milhorn | Tata McGraw Hill |
| | | | |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Physiological Control Systems: Analysis, Simulation, and Estimation | Michael C. K. Khoo | IEEE Press |
| 2 | Endogenous and Exogenous Regulation and Control of Physiological Systems | Robert B. Northrop | The Biomedical Engineering Sereis |

Sri Siddhartha Institute of Technology, Tumkur
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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: V**

**Subject Name: Biomedical Instrumentation**

**Subject Code: 18EC5OE63** **L-T-P-C: 3-0-0–3**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1** | The students will be able to:<br>Interpret technical aspects of medicine. |
| **2** | Comprehend different bio signals and their measurement. |

| | |
|---|---|
| **3** | Study the principles of various diagnostic and therapeutic equipment's. |
| **4** | Distinguish the sub systems used in a typical man-machine system. |

| Unit | Course content | Teaching hours |
|---|---|---|
| **I** | **Introduction to Biomedical Instrumentation:** Biometrics, Introduction to the man instrument system, components of the man instrument system, Physiological systems of the body, problems encountered in measuring living systems.<br>**Sources electric potentials:** Resting and action potentials, propagation of action potentials, the bioelectric potentials. | 8 |
| **II** | **Other Bioelectric signals & systems:**<br>Electrocardiogram (ECG), Electrooculogram (EOG), Electroencephalogram (EEG), Electromyogram (EMG), Electroretinogram (ERG). | 8 |
| **III** | **The Cardiovascular system:**<br>The heart and cardiovascular system, the heart, electrocardiograph, blood pressure and its measurements, characteristics of blood flow, measurements of blood flow and cardiac output, Plethysmography, heart sounds and its measurements. | 8 |
| **IV** | **Cardiac Pace Maker & Defibrillators:**<br>Need for Cardiac Pacemaker, external pacemaker, Implantable pace maker, types of implantable, Defibrillators. | 8 |
| **V** | **Biotelemetry and patient Safety:**<br>Biomedical telemetry, single channel telemetry, multi-patient telemetry, Implantable telemetry & telemedicine.<br>**Patient Safety:** Electric shock hazards, leakage currents, safety codes & analyzer. | 7 |

Course Outcomes:

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Understand the sources of biomedical signals; design a medical instrumentation system taking into account the general constraints. |
| **CO2** | Record and analyse Bioelectric signals & systems, cardiovascular system and its parameters measurement characteristics. |

| | |
|---|---|
| **CO3** | Understand Cardiac Pace Makers and Defibrillators |
| **CO4** | Understand Biotelemetry and measures taken with respect to patient Safety |

**Question paper Pattern:**

| |
|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Biomedical Instrumentation & Measurements | Cromwell Et, AI | PHI/Pearson Education, 2nd e |
| 2 | Principles of Applied Biomedical Instrumentation | Geddes and Baker | John Wiley, 3rd e |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Biomedical Instrumentation Technology and Applications | R. Khandpur | McGraw-Hill, 2nd e |
| 2 | Biomedical Instrumentation | M Armugam | Anuradha Publications, 2nd edition. 1994. |
| 3 | Fundamentals of biomedical instrumentation | Dr. O N Pandey | Katson Books |
| 4 | Biomedical Instrumentation Systems | Shakthi Chatterji | Electronic Technical Assosiation |

Sri Siddhartha Institute of Technology, Tumkur
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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: V**

**Subject Name: Biomedical Instrumentation Lab-I**

**Subject Code: 18ML507** **L-T-P-C: 0-0-2-1**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | Interpret technical aspects of medicine. |
| **2.** | Comprehend different bio signals and their measurement. |
| **3.** | Study the principles of various diagnostic and therapeutic equipment's. |

| Sl no. | Course Contents |
|---|---|
| 1 | Measurement of Blood Pressure using Sphygmomanometer & Digital meter. |
| 2 | Measurement of pH of a given solution using pH meter. |
| 3 | Plotting the characteristics & determination of parameters of Temperature transducer RTD. |
| 4 | Design of simple circuit for Electronic Thermometer and study of its characteristic. |
| 5 | Plotting the characteristics of Strain Gauge. |
| 6 | Determination of solution concentration using Colorimeter. |
| 7 | Determination of solution concentration using Spectrophotometer. |
| 8 | Calculate the Skin contact impedance of Multi point electrodes |
| 9 | Design & determine the characteristics of ,<br><br>(A) (i) Inverting Amplifier<br>(ii) Non-Inverting Amplifier<br>(iii) Summing Amplifier<br><br>(B) (i) Difference Amplifier |

| | |
|---|---|
| | (ii) Isolation Amplifier<br>(iii) Instrumentation Amplifier |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Reminisce the basics of measurements and the generic sensors used. (PO 1, 2, 4). |
| **CO2** | Accent the determination of characteristics of sensors used to measure various variables (PO 3, 12). |
| **CO3** | Illustrate the usage of various sensors for signal acquisition. (PO 9, 12). |
| **CO4** | Implement linear ICs for signal amplification. (PO 1,2) |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Biomedical Instrumentation & Measurements | Cromwell Et, AI | PHI/Pearson Education, 2nd e |
| 2 | Principles of Applied Biomedical Instrumentation | Geddes and Baker | John Wiley, 3rd e |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Biomedical Instrumentation Technology and Applications | R. Khandpur | McGraw-Hill, 2nd e |
| 2 | Biomedical Instrumentation | M Armugam | Anuradha Publications, 2nd edition. 1994. |
| 3 | Fundamentals of biomedical instrumentation | Dr. O N Pandey | Katson Books |
| 4 | Biomedical Instrumentation Systems | Shakthi Chatterji | Electronic Technical Assosiation |

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Department of Medical Electronics

Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: V**

**Subject Name: Digital Signal Processing Lab**

**Subject Code: 18ML508** **L-T-P-C: 0-0-2-1**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1** | To study about discrete Fourier transform and to learn about FFT algorithms. |
| **2** | To study the design techniques and realization methods for FIR and IIR digital filters |
| **3** | To study the applications of DSP |

| Sl.No | Course content | Teaching hrs |
|---|---|---|
| 1 | Verification of sampling theorem. | 3 Hrs/ Week |
| 2 | Impulse response of a given system | |
| 3 | Linear convolution of two given sequences. | |
| 4 | Circular convolution of two given sequences | |
| 5 | Autocorrelation of a given sequence and verification of its properties. | |
| 6 | Cross correlation of given sequences and verification of its properties. | |
| 7 | Solving a given difference equation. | |
| 8 | Computation of N point DFT of a given sequence and to plot magnitude and phase spectrum. | |
| 9 | Linear convolution of two sequences using DFT and IDFT. | |
| 10 | Circular convolution of two given sequences using DFT and IDFT | |

| | | |
|---|---|---|
| 11 | Design and implementation of FIR filter to meet given specifications. | |
| 12 | Design and implementation of IIR filter to meet given specifications | |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Compute the convolution and correlation of given signals. |
| **CO2** | Compute the strength of different frequency components of the discrete-time signal. |
| **CO3** | Design an infinite impulse response filter to remove noise from a noisy signal given the pass band and stop band specifications using Butterworth and Chebyshev approximation and implement the same on a digital signal processor. |
| **CO4** | Implement basic DSP operations (eg. Linear convolution, Circular convolution, Discrete Fourier Transform) on a digital signal processor. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Digital Signal Processing: Principles, Algorithms and Applications | J.G. Proakis and D. G. Manolakis. | 1997, PHI |
| 2. | Digital Signal Processing: A computer-Based Approach | S. K. Mitra | 2nd Edition, 2001, TMH. |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Fundamentals of Digital Signal Processing, | John Wiley & sons. Lonnie C. Ludeman | 1st Edition, 1986, |
| 2 | Digital Signal Processing | Hussain, Zahir M., Sadik, Amin Z., O'Shea, Peter | Springer publications. 2011 |
| 3 | Digital Signal Processing: Principles, Algorithm and Applications | John G Prokias, Dimitris Manolakis | Pearson Publications |
| 4 | Digital Signal Processing | Nagoor Kani | Tata McGraw Hill Publications |

# SRI SIDDHARTHA INSTITUTE OF TECHNOLOGY- TUMAKURU

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## DEPARTMENT OF MEDICAL ELECTRONICS

| **VI Semester B.E. (Common to all UG programs: EE/ EC/TC/ML/CS/IS/ ME/IM/CV)** (Subjects and Syllabus as per AICTE-Model Curriculum for UG Course in Engg. & Tech.- Jan. 2018) | | | | | | **Teaching Hours/week** | | | | **Examination** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *SI No.* | *Course and Course Code* | | *Course Title* | *Teaching dept.* | *Board of Exam.* | *L* | *T* | *P* | *C* | *Duration in Hrs.* | *CIE* | *SEE* | *Total Marks* |
| 01 | PC | 18ML601 | Patient Monitoring Systems | ML | ML | 3 | 1 | - | 4 | 3 | 50 | 50 | 100 |
| 02 | PC | 18 MLI602 | OOPS with C++ for medical applications | ML | ML | 3 | - | 2 | 4 | 3 | 50 | 50 | 100 |
| 03 | PC | 18 ML603 | Medical Image Analysis | ML | ML | 3 | 1 | - | 4 | 3 | 50 | 50 | 100 |
| 04 | PE | 18 ML6PE4x | Professional Elective-II | ML | ML | 3 | - | - | 3 | 3 | 50 | 50 | 100 |
| 05 | OE | 18ML6OE5x | Open Elective-II | ML | ML | 3 | - | - | 3 | 3 | 50 | 50 | 100 |
| 06 | PC | 18ML6MP01 | Mini Project | ML | ML | - | - | 4 | 2 | 3 | 50 | 50 | 100 |
| 07 | PC | 18 ML607 | Medical Image Processing Lab | ML | ML | - | - | 2 | 1 | 3 | 50 | 50 | 100 |
| 08 | PC | 18 ML608 | Biomedical Instrumentation Lab-II | ML | ML | - | - | 2 | 1 | 3 | 50 | 50 | 100 |
| 09 | HS | 18HS601 | Skill Development-IV | HS | HS | - | - | 2 | 1 | 3 | 50 | 50 | 100 |
| Total | | | | | | 14 | 2 | 12 | 23 | 27 | 450 | 450 | 900 |
| BS-Basic Science=26 Credits, ES-Engineering Science=19 Credits, HS-Humanities and Social sciences=09+1=10 Credits<br>PC-Professional core=55+18=73 Credits, PE-Professional Elective =3+3=6 Credits, OE-Open Elective = 3+3=6 Credits. | | | | | | | | | | | | | |
| L-Lecture, T-Tutorial, P-Practical, CIE-Continuous Internal Evaluation, SEE-Semester End Examination | | | | | | | | | | | | | |

Professional Elective II: 18ML6PE41: VLSI Circuits and Applications in Medicine
18ML6PE42: Sensors and Transducers
18ML6PE43: Speech Signal Processing

Open Elective II: 18EC6OE53: Digital Image Processing

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Department of Medical Electronics

Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: VI**

**Subject Name: Patient Monitoring system**

**Subject Code: 18ML601** **L-T-P-C: 3-1-0-4**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | To have a quantitative assessment of the important physiological variables of the patients during critical periods of their biological functions. |
| **2.** | To understand diagnostic and research requirements. |
| **3.** | To be acquainted with the necessity of various critical bedside monitoring systems. |
| **4.** | To identify the trends and prospects in the area of PMS. |

| Unit | Course content | Teaching hrs |
|---|---|---|
| **I** | **Patient Monitoring system:** System concepts, measurements of heart rate, blood pressure measurements, measurement of temperature, measurement of respiratory rate, apnoea detectors.<br>Arrhythmia and ambulatory monitoring systems:cardiac arrthymia, ambulatory- monitoring instruments. | **10** |
| **II** | **Foetal monitoring instruments:** Cardiotachograph, methods of monitoring Foetal heart rate, foetal heart rate measurement, monitoring labour activity, continous monitoring foetal scalp pH, use of computers for data processing.<br>Blood flow meters: Electromagnetic blood flow meter, ultrasonic blood flow meter, NMR blood flow meter, laser Doppler flowmetry. | **10** |
| **III** | **Cardiac output measurements:** Indicator dilution method , impedance method, measurement of continuous cardiac output.<br>Pulmonary function analyzers: Pulmonary function measurement, spirometry, pulmonary function analyzers, respiratory gas analyzers. | **10** |
| **IV** | **Blood gas Analyzers:** Blood pH measurement, measurement of | **12** |

| | | |
|---|---|---|
| | blood pCO2, blood pO2 measurement, a complete blood gas analysers. | |
| **V** | **Audiometers:** Basic Audiometers, pure tone audiometer, speech audiometer, Bekasy audiometer system, Evoked response audiometry system. | **10** |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | The learners will be in a condition to measure the basic physiological parameters of human body and to display in a meaningful way to the external world, also to analyze and compare the safe range of these parameters like heart rate, temperature, pulse, etc….. |
| **CO2** | It is able to design suitable instrument using sensors and transducers to measure accurate fetal heart rate, labor activity, pH etc….. and to give out automatic readouts memory facilities. |
| **CO3** | Comfortable to use and apply the techniques of electromagnetic principles for blood flow meters. |
| **CO4** | To design basic audiometers like pure tone audiometer, speech audiometer and to draw the audiogram of a person's hearing level and to calibrate the quality of hearing. |

**Question paper Pattern:**

| |
|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Hand Book of Biomedical Instrumentation | R.S.Khandpur | McGraw Hill, 2014, 3rd edition |
| 2 | Biomedical Instrumentation & Measurements, | Cromwell Et, AI | 2e, PHI/Pearson Education |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Patient-Monitoring Systems | Reed M. Gardner And | Springer Publications |

| | | | |
|---|---|---|---|
| | | M. Michael Shabot | |
| 2. | Computer-based patient monitoring systems. | Arthur D Little | University of Michigan Library |
| 3. | Patient Monitoring Systems. | Richa Guptha | Lambert Publications. |
| 4. | IP Based Patient Monitoring Systems | Syed Mohammed Yasir Jafri | Lambert Publications. |

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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: VI**

**Subject Name: OOPS with C++ for Medical Applications**

**Subject Code: 18MLI602** **L-T-P-C: 3-0-2-4**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | To understand the difference between top-down and bottom-up approach. |
| **2.** | To learn writing inline functions for efficiency and performance and the syntax and semantics of the C++ programming language. |
| **3.** | To learn the design of C++ classes for code reuse and to implement copy constructors and class member functions. |
| **4.** | To learn the use of overload functions and operators in C++ and to use inheritance and virtual functions implementation and use of exception handling in C++ programs |

| Unit | Course content | Teaching hours |
|---|---|---|
| **I** | **Introduction:** OOPS paradigm-Programming language, Object-Oriented Programming, Object-Oriented Languages, Basic concept of oops-Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Brief History of C++, Applications of OOPS concepts in Medicine. Data types & Variables- Structure of a C++ program, Comments, Variables, Identifiers, Data types. Declaration of variables, Initialization of variables, Scope of variables, Constants, Operators | **8** |

| | | |
|---|---|---|
| | and Control Structures -Types of Operators. Priority of Operators. | |
| **II** | **Classes and Objects**- Introduction to class, Class Definition, Classes and Objects, Access specifiers – Private, Public and Protected. Member functions of the class, Object as data types constructor. Object as function arguments. The default copy constructor, returning object from function. Structures and classes. Classes objects and memory static class data. Const and classes, Applications of classes and objects in Medicine | **8** |
| **III** | **Function Overloading-** Precautions to be taken while overloading functions. Static Class Members, Static Member Functions, Friend Functions Operator Overloading- Introduction to Operator Overloading, Operator Overloading fundamentals, implementing the operator functions. | **8** |
| **IV** | **Inheritance**- Reusability, Inheritance concept-single inheritance. Using the derived class, Constructor and destructor in derived class, Object initialization and conversion, Types of Inheritance, Nested classes, Virtual base class, Applications of Inheritance in Medicine. | **8** |
| **V** | **Virtual Function** - friend function, Static function, Assignment and copy initialization, this pointer, dynamic type information<br>**Streams and Files** - Streams classes, Stream Errors, Disk File I/O with streams, file pointers, error handling in file I/O with member function, overloading the extraction and insertion operators, memory as a stream object, command line arguments, and printer output.<br>**Templates and Exceptions** - Function templates, Class templates Exceptions The Standard Template Library - Introduction algorithms, sequence containers, iterators, specialized iterators, associative containers, strong user-defined object, function objects. Applications in Medicine. | **7** |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Differentiate between structure oriented programming and object oriented programming and use object oriented programming language like C++ and associated libraries to develop object oriented programs for handling Medical data. |
| **CO2** | Identify, analyze and apply the concepts of classes, Objects and other advanced OOPs concepts like inheritance, data abstraction, encapsulation, operator overloading, functions, polymorphism. |
| **CO3** | Implement the algorithms using standard libraries and templates and exception handling for Medical data management. |
| **CO4** | Implement, analyze, demonstrate, document and present the concepts as application to healthcare implemented in groups or individual. |

**Question paper Pattern:**

From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice.

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| **1.** | Object Oriented Programming with C++ | E Balaguruswamy | TMH 2006, 3rd edition |
| **2.** | Object Oriented Programming in C++ | Robert Lafore | Golgotia Publications Pvt. Ltd. |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| **1.** | C++ and Object Oriented Programming paradgim | Debasish Jana | PHI Publications |
| **2.** | The complete reference C | Herbert shieldt | Tata McGraw Hill Publication. |
| **3.** | OOPS with C++ | Sourav Sahay | Oxford Publications |
| **4.** | Object Oriented Programming in C++ | Nicolai M Josuttis | Wiley Pubulication |

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Department of Medical Electronics

Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: VI**

**Subject Name: Medical Image Analysis**

**Subject Code: 18ML603** **L-T-P-C: 3-1-0-4**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | To provide students with an overview of the computational and mathematical methods in medical image processing. |
| **2.** | To study many of the current methods used to enhance and extract useful information from medical images. |
| **3.** | Understand different image segmentation techniques used on medical images. |
| **4.** | Know various application of medical image processing. |

| Unit | Course content | Teaching hrs |
|---|---|---|
| **I** | **Introduction to biomedical images:** introduction, block diagram of computer aided diagnosis (CAD), objectives of biomedical image analysis, nature of biomedical images, body temperature as an image, transillumination, medical imaging types and modalities: X-ray imaging, Computed Tomography (CT), nuclear medicine imaging, ultrasound imaging, magnetic resonance imaging. | **10** |
| **II** | **Image quality and information content:** difficulties in biomedical image acquisition and analysis, characterization of image quality, review of concept of sampling and quantization, spatial and gray level resolution, optical density, dynamic range, contrast, histogram, entropy, blur and spread functions with reference to medical images, Fourier spectra of biomedical images. | **12** |
| **III** | **Medical image segmentation:** introduction to image segmentation, edge detection, thresholding, region based methods, boundary based methods, active contrast method, watershed segmentation. | **10** |
| **IV** | **Morphological Image Processing:** Basic concepts of set theory, Logical operations involving binary images, Dilation and erosion, Opening and closing, The hit-or-miss transformation, Basic | **10** |

| | | |
|---|---|---|
| | morphological algorithms. | |
| **V** | **Medical Image Application:** computer aided diagnosis in mammography, tumor imaging and treatment, angiography, bone strength and osteoporosis. | **10** |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Acquire a basic understanding of the important concepts related to medical image processing. |
| **CO2** | Identify and formulate the various difficulties associated with medical images and eliminate the same |
| **CO3** | Recognize and apply various segmentation techniques for medical images and apply the techniques of set theory and logical operations. |
| **CO4** | Apply image processing algorithms on various medical images to diagonize tumors of various organs. |

**Question paper Pattern:**

| |
|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Biomedical Image Analysis | Rangaraj M Rangayyan | CRC press |
| 2. | Digital Image Processing for Medical Applications | Geoff Dougherty | Cambridge University Press, 2009 |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Digital Image Processing | Sid Ahmed | McGraw Hill |
| 2. | Digital Image Processing | S Jayaraman and Esakirajan | Tata McGraw Hill Publications |
| 3. | Introduction to Digital Image Processing | William J Pratt | CRC Press |
| 4. | Fundamentals of Digital Image Processing | Annadurai | Pearson |

| | | | |
|---|---|---|---|
| | | | Publications |

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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: VI**

**Subject Name: VLSI Circuits and Applications in Medicine**

**Subject Code: 18ML6PE41** **L-T-P-C: 3-0-0-3**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | To understand the fabrication process of CMOS technology |
| **2.** | To teach fundamentals of VLSI circuit design and implementation using circuit simulators and layout editors |
| **3.** | To study digital circuits using various logic methods and their limitations. |
| **4.** | To gain knowledge of VLSI design applied in various biomedical applications. |

| Unit | Course content | Teaching hrs |
|---|---|---|
| **I** | **An Overview of VLSI:** Complexity and design. Basic concepts, Physical structure CMOS integrated circuits: Integrated circuit layers, MOSFETS. Ideal switches and Boolean operation, MOSFETS and switches, Basic logic gates in CMOS, Complex logic gates in CMOS, Transmission gate circuits, CMOS layers, Designing FET array. | **9** |
| **II** | **Electronic analysis of CMOS:** Logic gates, DC characteristics of the CMOS Inverter, Inverter Switching characteristics, Power dissipation, DC characteristics of NAND and NOR gates, NAND and NOR transient response, Analysis of complex logic gates. | **8** |
| **III** | **Fabrication of CMOS integrated circuits:** Overview of silicon processing, material growth and deposition, lithography, CMOS | **6** |

| | | |
|---|---|---|
| | process flow. | |
| **IV** | **Self-Powered Sensors and circuits for biomechanical Implants:** Introduction, Fundamentals of Piezoelectric Transduction and power Delivery. Design and Calibration of a Complete Floating Gate Sensor Array. | **6** |
| **V** | **Micro needles:** Introduction, Categories of Micro needles and Probes, Fabrication of Metal Micro needles, Fabrication of Silicon Micro needles, Fabrication of Polymer Micro needles, Drug Delivery through Micro needles, Bio sensing using Micro needles. | **10** |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Apply the knowledge of mathematics and engineering fundamentals to understand MOSFET's. |
| **CO2** | Analyze VLSI circuits and arrive at suitable conclusions. |
| **CO3** | Design VLSI circuits for given specifications. |
| **CO4** | Design VLSI circuits for biomedical applications. |

**Question paper Pattern:**

| |
|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | 1. "Introduction to VLSI circuits andSystems" For Unit: 1, 2, and 3. | JOHN P. UYEMURA, John Wiley, | Wiley2001 edition. |
| 2 | VLSI circuits for Biomedical Applications For Unit 4 and 5 | KrzysztofIniewski. | Artech House 2008 edition |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Basic VLSI Design | Douglas A. Pucknell and Kamran Eshranghian | PHI third edition,2005 |
| 2 | VLSI Design: Circuits, Systems and Applications | Jie Li (Editor), A Ravi | Springer Publications |

| | | | |
|---|---|---|---|
| | | Sankar (Editor), & P Augusta Sophy Beulet | |
| 3 | Design of CMOS Analog Integrated Fractional-Order Circuits<br>Applications in Medicine and Biology | Tsirimokou, Georgia, Psychalinos, Costas, Elwakil, Ahmed | Springer Publications |
| 4 | 3D Integration in VLSI Circuits: Implementation Technologies and Applications (Devices, Circuits, and Systems) | Katsuyuki Sakuma | CRC Press |

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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: VI**

**Subject Name: Sensors and Transducers**

**Subject Code: 18ML6PE42** **L-T-P-C: 3-0-0-3**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | Make students familiar with the constructions, working principle, parameters and classifications of different types of sensors and transducers, |
| **2.** | Be aware of the measuring instruments and the methods of measurement and the use of different transducers. |
| **3.** | Be aware of the characteristics of sensors and uses of it. |
| **4.** | Know various applications of sensors in all the fields. |

| Unit | Course content | Teaching hours |
|---|---|---|
| **I** | **Introduction to sensors and transducers:** Principles, classification, parameters, characterization, types of sensors- resistive potentiometer, inductive sensors, capacitive sensors, stress sensors, ultrasonic sensors. | 7 |
| **II** | **Thermal sensors:** Gas thermometric sensors, Acoustic temperature sensor, magnetic thermometer, resistance change type thermometric sensors, thermal radiation sensor.<br><br>**Magnetic sensor:** introduction, principle behind, magneto resistive sensors, hall effect and sensors, electromagnetic flow meter. | 8 |
| **III** | **Radiation sensors:** introduction, basic characteristics, types of photo detectors, X-ray and Nuclear radiation sensors, and fiber optic sensors. | 7 |
| **IV** | **Smart Sensors:** introduction, primary sensors, compensation, information coding and processing, data communication and automation.<br><br>**Recent trends in sensor technology and applications:** Film sensors, semiconductor IC technology- standard methods, MEMS, Nano-sensors, automotive sensors, home appliance sensors, sensors for medical diagnosis. | 8 |
| **V** | **Bio Sensors for Health Applications:** introduction, Biorecognition elements and transduction technology, Biosensors for diabetes applications, Biosensors for cardiovascular diseases applications, Biosensors for cancer applications, conclusion. | 9 |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Identify the classifications and principles of working of a sensor and a transducer. |
| **CO2** | Be acquainted with different types of sensors, its structure and functioning. |
| **CO3** | Realize the working of various smart sensors and their applications in various fields. |
| **CO4** | Know the importance of biosensors and its use in solving various health issues. |

**Question paper Pattern:**

| |
|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Sensors and Transducers | D. Patranabis | PHI publications, 2018 |
| 2. | Biosensors for health applications | Cibele Marli Cação Paiva Gouvêa | PHI publications, 2018 |

**Reference Books**:

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Sensors and Transducers | Ian R Sinchlair | Newnes, 2001 |
| 2. | Sensors and Transducers | Dr. A. D. Shaligram | Chittan Publications. |
| 3. | Sensors and Transducers | C. R. Balamurugan and D.Periazhaagar | Sruthi Publishers |
| 4. | Sensors and Transducers | M.J. Usher | Palgrave Macmillan Publications |

Sri Siddhartha Institute of Technology, Tumkur

(A constituent College of Siddhartha Academy of Higher Education, Tumakuru)

Department of Medical Electronics

Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: VI**

**Subject Name: Speech Signal Processing**

**Subject Code: 18ML6PE43** **L-T-P-C: 3-0-0-3**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1** | To study the characteristics of speech signal and realize the Speech signal and its representations using MATLAB. |
| **2** | To apply signal processing concepts to speech signaland to understand the classification of speech signals in time domain. Examine the properties inPractice using MATLAB. |
| **3** | To get an insight into a few applications of speech processing |

| Unit | Course content | Teaching hours |
|---|---|---|
| **I** | **Digital Models for Speech Signals:** Process of speech production, Lossless tube models, digital models for speech signals. | **07** |
| **II** | **Time Domain Models for Speech Processing:** Time dependent speech processing, short time energy & average magnitude, short time averaging zero crossing rate, speech v/s silence discrimination using energy & zero crossing.<br>**Short Time Fourier Analysis:** Linear filtering interpretation, Filter bank summation method, design of digital filter banks, implementation using FFT, Spectrographic display. | **09** |
| **III** | **Digital Representation of Speech Waveform**: Sampling speech signals, statistical speech model, instantaneous quantization, adaptive quantization, differential quantization, delta modulation. | **08** |
| **IV** | **Linear Predictive Coding of Speech:** Basic principles of linear predictive analysis, solution of LPC equations & predictive error signal, frequency domain interpretation, relation between the various speech parameters, applications of LPC parameters. | **08** |
| **V** | **Speech Synthesis:** Principles of Speech synthesis, Synthesis based on waveform coding, Synthesis based on analysis synthesis method, Synthesis based on speech production mechanism, Synthesis by rule, Text to speech conversion.<br>**Speech Recognition:** Principles of Speech recognition, Speech period detection, Spectral distance measures, Structure of word recognition systems, Dynamic time warping (DTW), Word recognition using phoneme units. | **07** |

Course Outcomes:

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Understand the production of speech and the phonemes of speechsignal. |
| **CO2** | Design of filter bank and its implementation, analyse spectrographic displayand Demonstrate the speech representation and its Fourier analysis. |

| | |
|---|---|
| **CO3** | Digital representation of speech signal using different quantization techniques. |
| **CO4** | Analyse processing and illustrate the methods of speech enhancement and speech synthesis and explain the working of speech recognition techniques. |

**Question paper Pattern:**

| |
|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books**:

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Digital Processing of speech signals | L R Rabiner, R W Schafer | Pearson Education 2004 |
| 2 | Digital Speech Processing-Synthesis & Recognition | SadoakiFurui | Mercel Dekker 2002, 2nd edition |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Introduction to data compression | Khalid Sayood, | 3rd edition, Elsevier Publications |
| 2 | Digital Speech | A M Kondoz | Wiley Publications, 2nd edition |
| 3 | Discrete-Time Speech Signal Processing: Principles and Practice | Quatieri Thomas F. | Pearson Publications |
| 4 | Speech and Audio Signal Processing | Ben Gold, Nelson Morgan, Dan Ellis | Wiley Publication, 2nd Edition. |

Sri Siddhartha Institute of Technology, Tumkur

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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: VI**

**Subject Name: Digital Image Processing**

**Subject Code: 18EC6OE53** **L-T-P-C: 3-0-0-3**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | Understand and analyze the representation of a digital image. |
| **2.** | To realize algorithms to solve image processing problems and meet design specifications. |
| **3.** | To comprehend the techniques of image processing to enhance the image resolution. |
| **4.** | To grasp various transformations and restoration techniques to gain knowledge with respect to different types of noise. |

| Unit | Course content | Teaching hours |
|---|---|---|
| **I** | **Introduction:** Background, digital image representation, examples of field that use DIP, fundamental steps in digital image processing, elements of digital image processing system. | **8** |
| **II** | **Digital image fundamentals:** Simple image model, Sampling and quantization, some basic relationships between pixels, some basic transformations | **7** |
| **III** | **Image enhancement in the spatial domain:** Background, Basic gray level transformations, histogram processing, enhancement using arithmetic/logic operations, basics of spatial filtering, smoothing and sharpening spatial filters, combining spatial enhancement methods | **8** |
| **IV** | **Image enhancement in the frequency domain:** introduction to the frequency domain, smoothing and sharpening frequency domain filters, homomorphic filtering, implementation, generation of spatial masks from frequency domain specifications, color image processing | **8** |
| **V** | **Image Restoration:** Degradation model, Noise models, restoration in the presence of noise only (Spatial and frequency domain filters), linear position invariant degradations, wiener filters, algebraic | **8** |

| | | |
|---|---|---|
| | approach to restoration, Inverse filtering, LMS filtering. | |

Course Outcomes:

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Understand the relevant aspects of digital image representation and their practical implications, components required in digital image processing. |
| **CO2** | Foster on different techniques employed for the enhancement of images in both spatial and frequency. |
| **CO3** | Emphasize the need for image transforms different types of image transforms and their properties and applications. |
| **CO4** | learn different causes for image degradation and implement various filtering techniques to enhance quality of the image. |

**Question paper Pattern:**

| |
|---|
| From each unit, two questions of 20 marks each have to be prepared, the student has to answer one full question of his/her choice. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Digital Image Processing | R C Gonzalez & R E Woods | 2e, Pearson Education |
| 2. | Fundamentals of Digital Image processing | A K Jain | PHI / Pearson Education, 1989 |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Digital Image Processing | Sid Ahmed | McGraw Hill |
| 2. | Digital Image Processing | S Jayaraman and Esakirajan | Tata McGraw Hill Publications |
| 3. | Introduction to Digital Image Processing | William J Pratt | CRC Press |
| 4. | Fundamentals of Digital Image Processing | Annadurai | Pearson Publications |

Sri Siddhartha Institute of Technology, Tumkur

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Syllabus for the Academic Year – 2020 – 2021

**Department: Medical Electronics** **Semester: VI**

**Subject Name: Medical Image Processing Lab**

**Subject Code: 18ML607** **L-T-P-C:0-0-2-1**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | To provide students with an overview of the computational and mathematical methods in medical image processing. |
| **2.** | To study many of the current methods used to enhance and extract useful information from medical images. |
| **3.** | Understand different image segmentation techniques used on medical images. |
| **4.** | Know various application of medical image processing. |

| No. of Experiments | Course content | Teaching hours |
|---|---|---|
| **1.** | Histogram processing and spectra in understanding the information content of medical images. | 3 Hrs/ Week |
| **2.** | Error measures using MSE and NMSE | |
| **3.** | Effect of blurring and noise on the error measure 2-D convolution. | |
| **4.** | Image Segmentation using edge/ boundary detection | |
| **5.** | Image Segmentation using Binary/global Thresholding | |
| **6.** | Medical Image smoothing and sharpening. | |
| **7.** | Image Segmentation using region-oriented segmentation techniques | |
| **8.** | Arithmetic and logical operations | |
| **9.** | Basic Morphological operations: Erosion and dilation | |
| **10.** | Applications- blood vessel detection in retinal images, tumor detection in MRI images, lung nodules detection in CT images. | |

**Course Outcomes:**

| Sl. No. | Course Outcomes |
|---|---|

| | |
|---|---|
| **CO1** | Estimate various errors in medical images. |
| **CO2** | Apply various morphological image processing operations and logical operations on binary images. |
| **CO3** | Implement image enhancement and segmentation algorithms on medical images. |
| **CO4** | Apply image processing algorithms for various organs of the body. |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Biomedical Image Analysis | Rangaraj M Rangayyan | CRC press |
| 2. | Digital Image Processing for Medical Applications | Geoff Dougherty | Cambridge University Press, 2009 |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1. | Digital Image Processing | Sid Ahmed | McGraw Hill |
| 2. | Digital Image Processing | S Jayaraman and Esakirajan | Tata McGraw Hill Publications |
| 3. | Introduction to Digital Image Processing | William J Pratt | CRC Press |
| 4. | Fundamentals of Digital Image Processing | Annadurai | Pearson Publications |

**Department: Medical Electronics** **Semester: VI**

**Subject Name: Biomedical Instrumentation Lab-II**

**Subject Code: 18ML608** **L-T-P-C: 0-0-2-1**

**Course Objectives:**

| Sl. No. | Course Objectives |
|---|---|
| **1.** | Interpret technical aspects of medicine. |
| **2.** | Comprehend different bio signals and their measurement. |
| **3.** | Study the principles of various diagnostic and therapeutic equipment's. |

| Sl no. | Course Contents |
|---|---|
| **1** | To Analyze ECG pattern of a Subject & determine amplitude & timings of P, QRS & T waveforms. |
| **2** | Using ECG waveform determine electrical axis/Einthoven triangle of the Heart. |
| **3** | Using ECG waveform analyze PQ, ST Segments. |
| **4** | To Observe the following parameters of a subject using EOG.<br>a. To observe movements used while watching a moving object using Electro Oculography.<br>b. To observe Electro Oculography of a subject while reading |
| **5** | To observe & analyze the characteristics of EEG parameters. |
| **6** | To Observe and Analyze the characteristics of EMG parameters. |
| **7** | To Observe and Measure Respiratory parameters. |
| **8** | To plot audiogram of the subject using air conduction pure tone audiometer. |
| **9** | To Study Blood grouping of a subject. |
| **10** | To Study the Applications of suction operator. |
| **11** | To Design following second order Filters using Op amp.<br>a. Low pass filter<br>b. High pass filter<br>c. Band pass filter<br>d. Band elimination filter. |

| | |
|---|---|

Course Outcomes:

| Sl. No. | Course Outcomes |
|---|---|
| **CO1** | Accent the basics of biomedical instruments as well as the components of various biomedical instruments (PO 1, 2, 4) |
| **CO2** | Comprehend the usage of hardware and simulation-based approaches in biomedical instrumentation (PO 3, 12) |
| **CO3** | Analyze the results obtained using various Biomedical instruments. (PO 9, 12) |
| **CO4** | Implement linear ICs for signal conditioning. (PO 1,2) |

Text Books:

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Biomedical Instrumentation Technology and Applications | R. Khandpur | McGraw-Hill, 2nd e |
| 2 | Biomedical Instrumentation | M Armugam | Anuradha Publications, 2nd edition. 1994. |
| 3 | Fundamentals of biomedical instrumentation | Dr. O N Pandey | Katson Books |
| 4 | Biomedical Instrumentation Systems | Shakthi Chatterji | Electronic Technical Assosiation |

**Text Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Biomedical Instrumentation & Measurements, | Cromwell Et, AI | 2e, PHI/Pearson Education |
| 2 | Principles of Applied Biomedical Instrumentation | Geddes and Baker | 3e, John Wiley, 1989 |

**Reference Books:**

| SI No | Text Book title | Author | Volume and Year of Edition |
|---|---|---|---|
| 1 | Biomedical Instrumentation Technology and Applications | R. Khandpur | McGraw-Hill, 2nd e |
| 2 | Biomedical Instrumentation | M Armugam | Anuradha Publications, 2nd edition. 1994. |
| 3 | Fundamentals of biomedical instrumentation | Dr. O N Pandey | Katson Books |
| 4 | Biomedical Instrumentation Systems | Shakthi Chatterji | Electronic Technical Assosiation |