

# **Bio-Medical Instrumentation**

## **Minor degree in “Bio-Medical Instrumentation”**

A minor degree program in biomedical instrumentation is an undergraduate-level program that provides students with a foundational understanding of the design, development, and application of medical devices and instruments. Biomedical instrumentation involves the use of electronics, mechanics, and computing to develop instruments that are used to diagnose, treat, and monitor medical conditions.

The program may also include a research component where students can work on projects under the supervision of faculty members. These research projects may involve developing new medical devices or improving existing ones, with the goal of making healthcare more accessible and effective.

One of the major benefits of pursuing a minor degree in biomedical instrumentation is the versatility of the skills learned. Graduates will have a broad understanding of electrical engineering, computer science, and biomedical engineering, which can be applied to a variety of industries. They may work in medical device companies or start-ups, research institutions, or government agencies.

Additionally, the demand for skilled professionals in this field is growing rapidly. With an aging population and increasing prevalence of chronic diseases, there is a need for innovative medical devices and technologies that can improve patient outcomes and quality of life. As a result, job opportunities in biomedical instrumentation are projected to continue to grow.

Overall, a minor degree program in biomedical instrumentation is an excellent choice for students interested in the intersection of healthcare and technology. The program provides a strong foundation for a variety of career paths and allows students to make a positive impact in the healthcare industry.

Course Structure						
S. No.	Course Code	Title	L	T	P	Credits
1.	BM-01	Anatomy and Human Physiology	3	-	-	3
2.	BM-02	Biomedical Instrumentation	3	-	-	3
3.	BM-03	Analytical & Diagnostic Equipments	3	-	-	3
4.	BM-04	Biomedical Imaging Techniques	3	-	-	3
5.	BM-05	Hospital Engineering & Management	3	-	-	3
6.	BM-06	Biomedical Instrumentation Laboratory	-	-	1.5	1.5
7.	BM-07	Medical Image Processing Laboratory	-	-	1.5	1.5
<b>Total=</b>			15	-	3	18

**Course Coding Nomenclature:**

- BM denotes that minor degree in “Bio-Medical Instrumentation”.
- 01, 02, 03, 04, 05, 06, 07 are courses in order students must be taken, if taken in different semesters. Multiple courses may also be taken in the same semester (if required).

**General Information:**

Eligibility/ Target Students	B.Tech.(To be enrolled from 5 <sup>th</sup> Semester)
Duration of program	5 <sup>th</sup> to 7 <sup>th</sup> Semester
Intake	20
Mode of Delivery (Classroom / MOOC)	(Classroom / Laboratory/ MOOC)
Proposed Fee	Rs. 10,000/-

## Syllabus

Course Code:	BM-01
Course Title:	Anatomy and Human Physiology
Number of Credits:	3(L: 3;T:0;P:0)
Course Category:	Bio-Medical Instrumentation
Offered By Department:	Electronics Engineering

**Course Objective:**The objective of this course is:

1. To identify all the organelles of an animal cell and their function.
2. To understand structure and functions of the various types of systems of human body.
3. To demonstrate their knowledge of importance of anatomical features and physiology of human systems

### Course Content

#### **Module1: Introduction to human body[05 Lectures]**

Levels of structural organization and Human body systems, basic life processes, homeostasis, basic anatomical terminology, structure and functions of hormones and glands, special senses: Structure and functions of eye, ear, nose and tongue and their disorders.

#### **Module 2: Skeletal, Muscular and Respiratory system[05 Lectures]**

Skeletal: Types of Bone and function, Division of Skeleton, Types of joints and function, Muscular system: Parts of Muscle and Movements of muscles, Respiratory System: Parts of Respiratory Systems, Types of respiration, Mechanisms of Breathing, Regulation of Respiration

#### **Module 3:Cardiovascular and Lymphatic Systems[05 Lectures]**

Cardiovascular: Components of Blood and its functions, Blood Groups and its importance, Structure of Heart, Conducting System of Heart, Properties of Cardiac Muscle, Cardiac Cycle, Heart Beat, Types of Blood vessel, Regulation of Heart rate and Blood pressure. Lymphatic: Parts and Functions of Lymphatic systems, Types of Lymphatic organs and vessels.

#### **Module4: Brain and Nervous System[05 Lectures]**

Brain: Structure and functions of brain (cerebrum, brain stem, cerebellum), Ventricles of brain and cerebrospinal fluid, Nervous System: Classification of peripheral nervous system, Structure and functions of sympathetic and parasympathetic nervous system, Origin and functions of spinal and cranial nerves.

#### **Module5: Digestive and Kidney Systems[05 Lectures]**

Digestive: Organs of Digestive system, Digestion and Absorption. Structure of Kidney and Nephron, Regulation of Blood pressure by Urinary System, Urinary reflex

**Course Outcome:**At end of the course

1. Students would be able to explain basic structure and functions of cell
2. Students would be learnt about anatomy and physiology of various systems of human body
3. Students would be able to explain interconnect of various systems

**Text Books:**

1. Prabhjot Kaur. Text Book of Anatomy and Physiology. Lotus Publishers. 2014
2. Elaine.N. Marieb , Essential of Human Anatomy and Physiology, Eight Edition, Pearson Education, New Delhi, 2007

**Reference Books:**

1. Frederic H. Martini, Judi L. Nath, Edwin F. Bartholomew, Fundamentals of Anatomy and Physiology. Pearson Publishers, 2014
2. Gillian Pocock, Christopher D. Richards, The human Body – An introduction for Biomedical and Health Sciences, Oxford University Press, USA, 2013
3. William F.Ganong, Review of Medical Physiology, 22nd Edition, Mc Graw Hill, New Delhi, 2010
4. Eldra Pearl Solomon, Introduction to Human Anatomy and Physiology, W.B. Saunders Company, 2015
5. Guyton and Hall, Medical Physiology, 13th Edition, Elsevier Saunders, 2015

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Course Code:	BM-02
Course Title:	Biomedical Instrumentation
Number of Credits:	3(L: 3;T:0;P:0)
Course Category:	Bio-Medical Instrumentation
Offered By Department:	Electronics Engineering

**Course Objective:**The objective of this course is:

1. To define commonly used technical terms from Medicine and Biomedical Engineering.
2. To describe bio-signals that emanate from the body.
3. To learn the working principles of blood flow meters and Physiological assist devices.
4. To describe the engineering principles of commonly used medical devices and medical imaging systems.
5. To realize safety requirements of biomedical instrumentation.

### **Course Content**

#### **Module 1: Components of Medical Instrumentation Systems [03 Lectures]**

Basic Medical Instrumentation System, Static and dynamic characteristics of medical instruments, Bio-signals and characteristics. Problems encountered with measurements from human beings.

#### **Module 2: Bio-Signal Acquisition [06 Lectures]**

Electrical Conduction system of the heart, Block diagram Of Electrocardiograph , ECG leads, Einthoven triangle, ECG amplifier, EEG 10-20 lead system, Specifications and Interpretation of ECG,EEG,EMG.

#### **Module 3: Bio-Signal Measurements[ 06 Lectures]**

Blood flow meters- Electromagnetic blood flow meter, Ultrasonic Doppler blood flow meter. Blood pressure measurement- Ultrasonic blood pressure monitoring, physiological assist devices & therapeutic equipment: Pacemakers- External & internal, Defibrillators- External & internal, dialysis machine.

#### **Module 4: Operation Theatre Equipment[06 Lectures]**

Spirometry, Pnemuotachograph, Ventilators, MONITORING EQUIPMENT: Arrhythmia Monitor, Foetal Monitor, and Incubator.

#### **Module 5: Medical Imaging Equipment[03 Lectures]**

X-ray generation, X-ray tube, X-ray machine, Computed Tomography (CT), Ultrasound Imaging system

**Course Outcomes:** At the end of the course the student able to

1. define commonly used technical terms from Medicine and Biomedical Engineering.
2. describe bio-signals that emanate from the body
3. learn the working principles of blood flow meters and Physiological assist devices
4. describe the engineering principles of commonly used medical devices and medical imaging systems
5. realize safety requirements of biomedical instrumentation.

**Text Books:**

1. R.S. Khandpur, “Hand-book of Biomedical Instrumentation”, TMH, 2<sup>nd</sup> Ed., 2003.
2. Leslie Cromwell and F.J. Weibell, E.A. Pfeiffer, “Biomedical Instrumentation and Measurements”, PHI, 2<sup>nd</sup> ed, 1980.
3. “Bio-Medical Electronics and Instrumentation”, Onkar N. Pandey, Rakesh Kumar, Katson Books.

**Reference Books:**

1. John G. Webster, “Medical Instrumentation, Application and Design”, John Wiley, 3<sup>rd</sup> ed., 2009.
2. Dr. M. Arumugam, “Biomedical Instrumentation”, Anuradha publications, 2<sup>nd</sup> ed., 19

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Course Code:	BM-03
Course Title:	Analytical & Diagnostic Equipment
Number of Credits:	3(L: 3;T:0;P:0)
Course Category:	Bio-Medical Instrumentation
Offered By Department:	Electronics Engineering

### **Course Objective:**

This course is intended to impart the fundamental knowledge of versatile analytical & diagnostic equipment used in the health care system.

### **Course Content**

#### **Module 1: Clinical equipment [ 07 Lectures ]**

Principles of photometric measurement, Radiation sources, Optical filters, Colorimeter, Spectrometer, Design of Monochromators, Flame photometer, atomic absorption spectrophotometer, Automated biochemical analyzer- Auto analyzer, Electromechanical analyzer Chromatographs, Microscopes, Scanning Electron Microscope, Transmission Electron Microscope.

#### **Module 2: Blood gas analyzers and Oximeters [ 06 Lectures ]**

Blood pH measurement, Blood pCO<sub>2</sub> measurement, Blood pO<sub>2</sub> measurement, a complete blood gas analyzer, Fiber optic-based blood gas sensors, Oximetry, Principles of oximetric measurements, Ear oximeter, Pulse oximeter, Intravascular oximeter.

#### **Module 3: Blood cell counters and Blood pressure apparatus [ 04 Lectures ]**

Methods of cell counting, Flow cytometry, Coulter Counters, automatic recognition and differential counting of cells, Sphygmomanometer, Automated indirect and specific direct method of B.P. monitor.

#### **Module 4: Blood Flow meters [ 03 Lectures ]**

Electromagnetic blood flow meter, Ultrasonic blood flow meter-Transit time and Doppler blood flow meter, Cardiac output measurement-Dye dilution method and Impedance technique.

#### **Module 5: Endoscopy [ 06 Lectures ]**

Basic endoscopic equipment, Fiberoptic instruments and video-endoscopes, Accessories-illumination, instrument tips, instrument channels, tissue sampling devices, suction traps and fluid-flushing devices, Various endoscopic applications. Maintenance and Storage



**Course Outcome:**

After completion of this course the students will be able to identify, understand and explain the working principle of basic analytical & diagnostic equipments used in biomedical engineering domain

1. Understand and explain the working principle of Blood gas analyzers and Oximeters
2. Understand and explain the working principle of Blood cell counters and Blood pressure apparatus
3. Understand and explain the working principle of Blood Flow meters
4. Understand and explain the working principle of Pulmonary function analyzers
5. Understand and explain the working principle of Endoscopy

**Text Books:**

1. R.S.Khandpur “Handbook of Bio-Medical Instrumentation”,2<sup>nd</sup> Edition, Tata McGraw Hill.
2. J.J.Carr&J.M.Brown,“IntroductiontoBiomedicalEquipmentTechnology”PearsonEducation,Asia.
3. Cromwell,Weibell&Pfeiffer,“BiomedicalInstrumentation&Measurement”,PrenticeHall,India

**ReferenceBooks:**

1. Joseph Bronzino, “Biomedical Engineering and Instrumentation”, PWS Engg . , Boston.
2. J.Webster,“Bioinstrumentation”,Wiley&Sons.
3. Joseph D. Bronzino,“The Biomedical Engineering handbook”, CRC Press.

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Course Code :	BM-04
Course Title :	Biomedical Imaging Techniques
Number of Credits:	3(L: 3;T:0;P:0)
Course Category :	Bio-Medical Instrumentation
Offered By Department:	Electronics Engineering

### **Course Objective:**

The objective of this course is to provide students:

1. To impart in-depth knowledge and understanding of imaging technology for disease diagnosis.
2. To understand the principle & working of various imaging equipment for diagnosis and therapeutics.

### **Course Content**

#### **Module1 :Basic Image Processing[ 07 Lectures]**

Objectives of Biomedical Image Analysis, Computer Aided Diagnosis, Spatial Transformations, Fourier Series, Fourier Transform, Convolution, Sampling Theory, Aliasing, Interpolation.

#### **Module2 :Medical Imaging Modalities[ 06 Lectures]**

X-ray imaging, Computed Tomography, Nuclear Medicine Imaging, SPECT Imaging, Positron Imaging Tomography, Ultrasonography/Ultrasound – Magnetic Resonance Imaging,

#### **Module3 :Image Enhancement[ 08 Lectures]**

Gray level transforms, Histogram transformation, Convolution mask operators, Contrast enhancement, Denoising, Deblurring, Detection of regions of interest, Thresholding and binarization, Detection of isolated lines and points- Edge detection – Region growing, Removal of Artifacts, Space Domain Filters, Frequency Domain Filters, Optimal Filtering, Adaptive Filters.

#### **Module4 :Image Registration[ 06 Lectures]**

Correlation, Least Squares, Transform based Registration, Joint Entropy, Mutual Information, Binning Discontinuities, Registration Optimization, Registration By Clustering, Ensemble Registration, Gaussian Mixture Models.

#### **Module5 :Image Segmentation:[ 05 Lectures]**

Region Growing, K-Means Clustering, Analysis of shape and texture, Representation of shapes and contours, Statistical analysis of texture, Fractal analysis, Fourier domain analysis of texture, Segmentation and structural analysis of texture.

#### **Module6 :Medical Image Reconstruction and diagnostic decision[ 04 Lectures]**

Theory of MRI Reconstruction, MRI Motion Compensation, Algebraic CT Reconstruction, CT Filtered Back-Projection, Measures of diagnostic accuracy.

**Course Outcome:**

After studying this course is to provide students:

1. An overview of the computational methods in medical imaging.
2. The main sources of medical imaging data (X-Ray, CT, MRI, PET and ultrasound).
3. Various clinical applications and Which also provides hands-on experience on various medical imaging Software tools.
4. Many of the current methods used to enhance and extract useful information from medical images are also introduced.

**Text Books:**

1. Prince J L and Links J M, Medical Imaging Signals and Systems, Pearson (2015).
2. Suetens P, Fundamentals of Medical Imaging, Cambridge University Press (2009).

**ReferenceBooks:**

1. Sinha G. R, Patel, B. C., “Medical Image Processing: Concepts and Applications”, Prentice Hall, 2014.
2. Gonzalez R C, Woods R E, “Digital Image Processing”, Third Edition, Prentice Hall, 2007
3. Rangayyan R M, “Biomedical Image Analysis”, Fifth Edition, CRC Press, 2005
4. KayvanNajarian, Robert Splinter, “Biomedical Signal and Image Processing”, Second Edition, CRC Press, 2014.
5. Deserno T M, “Biomedical Image Processing”, Springer, 2011.

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Course Code:	BM-05
Course Title:	Hospital Engineering & Management
Number of Credits:	3(L: 3;T:0;P:0)
Course Category:	Bio-Medical Instrumentation
Offered By Department:	Electronics Engineering

### **Course Objectives:**

1. Identify various areas of hospitals.
2. Identify various activities of departments like out/in patient and nursing.
3. Discuss about critical care departments of hospital like iccu, icu and activities of central sterile supply department.
4. Discuss about effective hospital management.
5. Maintain various medical records and waste management.
6. Develop knowledge of hospital building maintenance, equipment and systems for health care.
7. Students shall be well trained to solve the rising challenges and specific necessities of modern day hospitals.

### **Course Content**

#### **Module 1: Healthcare System[ 04 Lectures]**

Health organization of the country, health technology and challenges in maintaining normal health, Indian hospitals- challenges and strategies, modern techniques of hospital management.

#### **Module 2: Hospital Organization[ 03 Lectures]**

Classification of hospital, Hospital- social system, location of hospital, site selection of new hospital, Line services, Supportive services and Auxiliary services of hospital.

#### **Module3: Engineering Services of hospital [ 05 Lectures]**

Biomedical engineer's role in hospital, Maintenance department, MRO, Clinical engineering preventive maintenance of equipment, Electrical system, Power supply system, Electrical safety, Centralized gas supply system, Air conditioning system, Hospital waste management system, Fire safety and threat alarm system.

#### **Module4 :Hospital Management and Information System:[ 06 Lectures]**

Role of HMIS, Functional areas, Modules forming HMIS, HMIS and Internet, Centralized data record system, computerized patient record system, Health information system.

## **Module5 :Regulation and planning of new hospital:[ 06 Lectures]**

FDA regulation, ISO certification, Fire protection standard, Planning and designing of new hospital.

### **Course outcome:**

1. To understand the criteria regarding assessment, management, administration and regulation of healthcare technology.
2. To understand the clinical effectiveness, efficiency and safety of technology use, considering the importance and impact of technology on patient care.
3. To identify the better management of information regarding identification of biomedical and hospital technology planning, procurement and operation requirements.
4. To understand environmental considerations and sustainable engineering solutions in hospital engineering and management.
5. Develop an ability to understand professional ethics and legal issues related to hospital engineering and healthcare system.

### **TextBooks:**

1. R.C. Goyal, Handbook of Hospital Personal Management, Prentice Hall of India, 1993
2. Hans Pfeiff, Vera Dammann (Ed.), Hospital Engineering in Developing Countries, Z report Eschbom, 1986

### **Reference Books:**

1. Cesar A. Caceres and Albert Zara, The practice of clinical engineering, Academic Press, 1977.
2. Webster, J. G and Albert M. Cook, Clinical Engineering Principles and Practices, Prentice Hall Inc. Englewood Cliffs, 1979
3. Jacob Kline, Handbook of Bio Medical Engineering, Academic Press, San Diego 1988

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Course Code :	BM-06
Course Title :	Biomedical Instrumentation Laboratory
Number ofCredits :	1.5(L: 0;T:0;P:2)
Course Category :	Bio-Medical Instrumentation
Offered By Department:	Electronics Engineering

### **Course Objective**

1. To familiarize students with the operation of DC-to-DC converter & its application.
2. To introduce students with timer circuits & heart-rate meter.
3. To emphasis on the study of EMG, ECG, EEG & PCG waveform & analysis.
4. To familiarize students with the design of biopotential amplifiers.
5. To introduce students with basic operation of X-ray system.
6. To introduce students on the study of isolation of biosignals.

### **List of experiments:**

1. Timer circuits: ON delay and OFF delay study
2. Measurement of heart rate using F-V converter
3. ECG processing and analysis
4. EMG processing and analysis
5. EEG processing and analysis
6. Detection of QRS component from ECG signals
7. Study on Instrumentation Amplifier-Design
8. Study on X-ray radiography systems / X-ray simulator
9. Characterization of biopotential amplifier for ECG & EMG signals
10. PCG processing and analysis / electronic stethoscope
11. Isolation of bio-signal (EMG / ECG)

### **Course Outcome**

After completion of this course the students will be able to

1. Understand and implement isolation techniques in designing biomedical instruments.
2. Measure and Analyze EMG, ECG, EEG and PCG waveforms in diagnostic point of views
3. Measure and Analyze QRS components from diagnostic point of view.
4. Design and analyze the characteristics of Biopotential amplifiers.
5. Understand & describe the basic operation of an X-ray system.

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Course Code:	BM-07
Course Title:	Medical Image Processing Laboratory
Number of Credits:	1.5(L: 0;T:0;P:2)
Course Category:	Bio-Medical Instrumentation
Offered By Department:	Electronics Engineering

**Course Objectives:**

1. To gain the practical knowledge about the processing of medical images,
2. To understand the fundamentals of digital image and its properties.
3. To enhance the medical images by applying various filters and segment the region of interest using various image processing Algorithms.

**List of experiments:**

1. Display of Gray scale Images.
2. To understand Image enhancement procedure -Histogram Equalization.
3. Image smoothing.
4. Image sharpening
5. Point detection
6. Line detection
7. Edge detection
8. Image data compression
9. Vector & Matrix Indexing
10. Image Transformation

**Course Outcome**

1. After completion of the course the students will gain
2. To understand about medical images and image processing, including mathematical transforms.
3. To gain better understanding of Digital Image Processing, including Image Enhancement in the Spatial and Frequency Domain, Compression, Morphology and Segmentation.
4. To apply the knowledge in science and technological practice in society requirement and industry purpose.
5. To analyse the medical image of patients and finding the procedure to better enhancement for quick diagnosis.