ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M.E. BIOMEDICAL ENGINEERING

REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES(PSOs):

PSO	Programme Specific Outcomes
PSO1	Ability to design and implement innovative solutions to solve complex problems in Biomedical Engineering.
PSO2	Competence to independently undertake research projects involving simulation, measurement, and product development in Biomedical Engineering -related fields.

ANNA UNIVERSITY, CHENNAI

POSTGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E., Biomedical Engineering **Regulations:** 2025

Abbreviations:

BS – Basic Science (Mathematics, Physics, Chemistry)

ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**)

SD – Skill Development

SL – Self Learning

OE – Open Elective

L – Laboratory Course

T – Theory

LIT – Laboratory Integrated Theory

PW – Project Work

TCP – Total Contact Period(s)

Semester I

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	BM25101	Diagnostic and Therapeutic Equipment	T	3	0	0	3	3	ES (PC)
2.	BM25102	Biomedical Sensors and Instrumentation	T	3	0	0	3	3	ES (PC)
3.	BM25103	Bio Signal Processing	LIT	3	0	2	5	4	ES (PC)
4.	BM25104	Human Anatomy and Physiology	T	3	0	0	3	3	ES (PC)
5.	BM25105	Medical Imaging Systems	T	3	0	0	3	3	ES (PC)
6.	BM25106	Clinical Instrumentation and Design Laboratory	L	0	0	4	4	2	ES (PC)
7.	BM25107	Technical Seminar	-	0	0	2	2	1	SD
						Total	**23**	**19**	

Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Medical Device Design	T	3	0	0	3	3	ES (PC)
2.		Biomaterials and Biomechanics	T	3	0	0	3	3	ES (PC)
3.		Applied Medical Image Processing	LIT	3	0	2	5	4	ES (PC)
4.		Soft Computing	T	3	0	0	3	3	ES (PC)
5.		Programme Elective I	T	3	0	0	3	3	ES(PE)
6.		Biomedical Design and Modeling Laboratory	L	0	0	4	2	2	ES (PC)
7.		Industry Oriented Course I	--	1	0	0	1	1	SD
8.		Industrial Training	-	-	--	-	---	1	SD
9.		Self-Learning Course	-	-	--	-	---	1	--
						Total	**20**	**21**	

Semester III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Programme Elective II	T	3	0	0	3	3	ES (PE)
2.		Programme Elective III	T	3	0	0	3	3	ES (PE)
3.		Programme Elective IV	T	3	0	0	3	3	ES (PE)
4.		Open Elective	T	3	0	0	3	3	ES (PE)
5.		Industry-Oriented Course II	--	1	0	0	1	1	SD
6.		Hospital Training	--	0	0	4	2	2	SD
7.		Project Work I	--	0	0	12	12	6	SD
						Total	**27**	**21**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Project Work II	--	0	0	24	24	12	SD
Total Credits							**24**	**12**	

PROGRAMME ELECTIVES COURSES (PE)

S. No.	Course Code	Course Title	Periods Per Week			Total Contact Periods	Credits
			L	T	P		
1.		Rehabilitation Engineering	3	0	0	3	3
2.		Medical Optics	3	0	0	3	3
3.		Human Assist Devices	3	0	0	3	3
4.		Micro and Nano Fluids	3	0	0	3	3
5.		Medical Device Standards and Regulation	3	0	0	3	3
6.		Tele Health Technology	3	0	0	3	3
7.		Medical Robotics	3	0	0	3	3
8.		Wearable Technologies	3	0	0	3	3
9.		Medical Ethics and Standards	3	0	0	3	3
10.		Brain Computer Interface	3	0	0	3	3
11.		Wavelet Transforms and Its Applications	3	0	0	3	3
12.		Hospital Planning, Organization and Management	3	0	0	3	3
13.		Human Resource Management in Hospitals	3	0	0	3	3
14.		Health Policy and Equipment Management	3	0	0	3	3
15.		Hospital Waste management	3	0	0	3	3
16.		Quality Assurance and Patient Safety standards in Hospitals	3	0	0	3	3
17.		Genetic Algorithms and Fuzzy Logics	3	0	0	3	3
18.		Tissue Engineering	3	0	0	3	3
19.		Embedded System and Internet of Things for Biomedical Applications	3	0	2	5	4
20.		Medical Informatics	3	0	2	5	4
21.		Pattern Recognition Techniques and Applications	3	0	2	5	4
22.		Data Analytics for Health Care Technologies	3	0	2	5	4
23.		Mixed Reality	3	0	2	5	4

Semester I

BM25101	Diagnostic and Therapeutic Equipments	L	T	P	C
		3	0	0	3

Course Objectives:

To study biomedical measurements, assist devices, and hospital electrical safety.

Cardiac Care Units: Pacemakers, DC defibrillators (asynchronous & synchronous), patient monitoring systems, principles of bio-telemetry, echocardiography.

Activities:

1. Virtual demonstration on pacemaker design and battery longevity.
2. Simulation of patient monitoring and telemetry systems.

Neurological Equipment: Multi-channel EEG recording, clinical EEG (sleep patterns, epilepsy), evoked potentials (visual, auditory, somatosensory), EEG biofeedback, psychophysiological measurements, MEG principles.

Activities:

1. EEG waveform analysis for epilepsy and sleep stages.
2. Virtual demonstration on MEG applications in neurology.

Muscular Equipment: EMG (recording, waveform analysis, fatigue characteristics), muscle and nerve stimulators, nerve conduction velocity, EMG biofeedback, EGG (Electro-gastrograph), MMG (Magneto-myograph).

Activities:

1. Lab experiment: EMG recording during muscle activity.
2. Case discussion on clinical use of nerve conduction studies.

Respiratory Measurement and Assist Systems: Lung Volume and vital capacity, Spirometer, measurements of residual volume. pneumotachometer – Airway resistance measurement, Whole body plethysmography. Intra- Alveolar and Thoracic pressure measurements, Apnea Monitor. Types of Ventilators – Pressure, Volume, and Time controlled. Flow, Patient Cycle Ventilators, Humidifiers, Nebulizers, Inhalators.

Activities:

1. Spirometry practical: measurement of lung capacity.
2. Design-based assignment on ventilator control systems.

Diathermy, Stimulator and Patient Safety: Diathermy-Physiological effects of high frequency radiation, Depth of Penetration, short wave, Ultrasonic and microwave diathermy, Surgical diathermy, Hazards and safety procedures.

Activities:

1. Demonstration of diathermy equipment with safety considerations.
2. Simulation/Case study on electrical safety hazards in hospitals.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References:

1. Geddes, L. A., & Baker, L. E. (2008). Principles of applied biomedical instrumentation (3rd ed.). John Wiley & Sons.

2. Webster, J. G. (2009). Medical instrumentation: Application and design (4th ed.). John Wiley & Sons.
3. Khandpur, R. S. (2014). Handbook of biomedical instrumentation (3rd ed.). Tata McGraw-Hill.
4. Carr, J. J., & Brown, J. M. (2014). Introduction to biomedical equipment technology. Pearson Education.
5. Cobbold, R. S. C. (1992). Transducers for biomedical measurements: Principles and applications. John Wiley & Sons.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the principles, working, and clinical significance of biomedical equipment.	-	-	-
CO2	Apply appropriate methods to measure bio potentials, physiological parameters, and therapeutic responses	PO1(3) PO3(3)	2	2
CO3	Analyze biomedical signals and equipment performance for diagnosis, safety, and effective patient monitoring.	PO3(3)	3	3
CO4	Design and evaluate biomedical instruments with safety protocols	PO1(3)	3	3

BM25102	Biomedical Sensors and Instrumentation	L	T	P	C
		3	0	0	3

Course Objectives:

To study measurement principles, errors, and biosensors in medicine, and to understand biopotentials and bioamplifiers

Biomedical Sensors & Transducers: Resistive transducers (strain gauge – gauge factor, configuration, displacement & pressure sensing, biomedical applications), RTDs, thermistors, temperature sensors, capacitive and inductive transducers, LVDT, thermocouples.

Activities:

1. Case study on strain gauge applications in biomedical measurement.
2. Demonstration/assignment on temperature sensors in medical devices.

Biopotential and Its Measurements: Origin and propagation of biopotentials, electrode–electrolyte and electrode–skin interface, half-cell potential, polarization, surface/needle/micro electrodes & equivalent circuits, non-polarizable electrodes.

Activities:

1. Simulation/lab: Measuring skin–electrode impedance.
2. Comparative study of electrode types and their biomedical uses.

Measurement of Non-Electrical Parameter: Measurements of Respiration Rate, Temperature, Pulse rate, Blood pressure Measurements- Direct, Indirect. Blood flow Measurements – In vitro, In vivo, Gas flow measurements. Blood cell counter.

Activities:

1. Practical measurement of pulse rate and respiration using available sensors.
2. Assignment on methods of blood pressure measurement and comparison.

Biosignals & Measurement Systems: Characteristics of biosignals (frequency, amplitude), ECG (Einthoven's triangle, 12-lead system), EEG (10–20 system, recording modes), EMG (recording modes), PCG, ERG, EOG, EGG – recording methods, waveform analysis, abnormal signals, evoked responses.

Activities:

1. Lab experiment: ECG or EEG signal recording and waveform analysis.
2. Case study on clinical use of EMG or PCG signals.

Bioamplifiers & Signal Conditioning: Need for bioamplifiers, single-ended & differential bioamplifiers, impedance matching, isolation amplifiers (transformer & optical isolation), isolated DC & AC carrier amplifiers, power-line interference removal, right-leg driven ECG amplifier, band-pass filtering, recording systems.

Activities:

1. Design exercise: Differential bioamplifier for ECG.
2. Simulation of noise removal techniques (band-pass filtering, right-leg drive).

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References:

1. Aston, R. (2002). Principles of biomedical instrumentation and measurement. Merrill Publishing Company.
2. Carr, J. J., & Brown, J. M. (2000). Introduction to biomedical equipment technology. Pearson.
3. Cromwell, L. (2015). Biomedical instrumentation and measurement. Prentice Hall of India.

4. Geddes, L. A., & Baker, L. E. (1989). Principles of applied biomedical instrumentation. John Wiley & Sons.
5. Khandpur, R. S. (2014). Handbook of biomedical instrumentation. McGraw Hill Education India.
6. Webster, J. G. (2009). Medical instrumentation: Application and design. John Wiley & Sons.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the working principles of biomedical sensors, electrodes, bio potentials, and signal acquisition systems.	-	-	-
CO2	Apply appropriate methods to measure bio potentials, physiological parameters, and therapeutic responses	PO1(3) PO3(3)	2	2
CO3	Analyze biomedical signals and equipment performance for diagnosis, safety, and effective patient monitoring.	PO3(3)	3	3
CO4	Design and evaluate biomedical instruments with safety protocols	PO1(3)	3	3

BM25103	Bio Signal Processing	L	T	P	C
		3	0	2	4

Course Objectives:

To study biosignal characteristics, apply filtering techniques, and demonstrate wavelet-based feature extraction in biosignal processing.

Signal, System and Spectrum: Characteristics of biomedical signals, types of noise (random, structured, physiological), IIR and FIR filters, spectrum analysis (PSD, cross-spectral density, coherence function, cepstrum, homomorphic filtering), estimation of mean in finite time signals.

Activities:

1. Lab experiment: FIR filter design for ECG noise removal.
2. Assignment on power spectral density estimation of EEG signals.

Practicals:

1. Design and implementation of FIR & IIR filters **for ECG noise removal.**
2. Power Spectral Density (PSD) estimation **of EEG signals using Welch's method.**

Time Series Analysis and Spectral Estimation: Time series models, linear prediction, process order estimation, non-stationary processes, fixed/adaptive segmentation, applications in EEG, PCG, HRV, model-based ECG simulator. Spectral estimation (Blackman–Tukey, periodogram, model-based).

Activities:

1. MATLAB/Python implementation of periodogram method for HRV.
2. Case study on adaptive segmentation in EEG signals.

Practicals:

1. Time series modeling of ECG signals using linear prediction (AR model).
2. Spectral estimation using Periodogram & Blackman-Tukey methods on HRV signals.

Adaptive Filtering and Wavelet Detection Adaptive filtering, LMS adaptive filter, adaptive noise cancellation in ECG, FECG, EEG; wavelet detection in ECG, structural features, matched filtering, adaptive wavelet detection, overlapping wavelets.

Activities:

1. Implementation of LMS adaptive filter for ECG denoising.
2. Mini-project: QRS detection using wavelet transform.

Practicals:

1. Biosignal analysis in virtual instrumentation platform

Analysis of Biosignal: Artifact removal, event detection in ECG, P wave, QRS complex, T wave detection, correlation analysis of ECG, averaging of PCG/ECG/EMG signals.

Activities:

1. ECG signal event detection using correlation analysis.
2. Group project: Noise artifact removal from EMG recordings.

Biosignal Classification: Statistical signal classification, linear discriminant function, feature selection, backpropagation neural network, biosignal classification using CNN & LSTM.

Activities:

1. Simulation of statistical classification for EMG/EEG signals.
2. Deep learning project: ECG classification using CNN/LSTM.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%
Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).
References: 1. Babu, P. R. (2014). Digital signal processing. SciTech Publications. 2. Ifeachor, E. C., & Jervis, B. W. (2002). Digital signal processing: A practical approach Pearson Education. 3. Rao, R. M., & Bopardikar, A. S.(2000). Wavelet transforms: Introduction to theory and its applications. Pearson Education. 4. Rangaraj, M. R. M. (2015). Biomedical signal analysis: A case‐study approach. Wiley‐IEEE Press. 5. Tompkins, W. J. (2006). Biomedical digital signal processing. Prentice Hall of India.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the characteristics of biomedical signals, noise sources, and spectrum analysis methods.	-	-	-
CO2	Apply time series and spectral estimation techniques to analyze biosignals.	PO1(3) PO3(3)	2	2
CO3	Analyze biosignals using adaptive filtering, wavelet-based detection, and artifact removal methods.	PO3(3)	3	3
CO4	Design and implement signal classification models	PO1(3)	3	3

BM25104	Human Anatomy and Physiology	L	T	P	C
		3	0	0	3

Course Objectives:

To study animal cell organelles, human body systems, sensory and accessory organs, and understand the anatomy, physiology, and regulatory mechanisms of the human body.

Organization of the Human Body: Levels of organization, anatomical planes, cell structure & functions, plasma membrane, cell transport, cell signaling, cell cycle regulation, action potential, homeostasis, specialized tissues.

Activities:

1. Microscopy lab – identification of cell structures and tissues.
2. Case study on disorders related to cell cycle regulation.

Integumentary, Skeletal, Muscular and Respiratory Systems: Skin (structure & functions), bones (types, formation, joints, cartilage), muscular system (parts, movement), respiratory system (structure, types, breathing, regulation).

Activities:

1. Skeleton model demonstration – identification of major bones & joints.
2. Spirometry experiment – measurement of lung volumes & capacities

Cardiovascular, Lymphatic and Endocrine Systems: Heart structure & conduction system, cardiac cycle, cardiac muscle properties, heart rate regulation, blood vessels, blood composition, blood groups. Lymphatic organs, functions. Endocrine glands (pituitary, thyroid).

Activities:

1. ECG recording and analysis of heart rate.
2. Blood group determination practical.

Nervous, Sense Organs and Reproductive Systems: Neuron structure, properties, nerve impulse, CNS & PNS, brain parts, reflex mechanism. Sensory systems (eye, ear). Reproductive system (male & female anatomy).

Activities:

1. Reflex activity demonstration (e.g., knee-jerk reflex).
2. Model/diagram study of brain, eye, and ear structures.

Digestive and Urinary Systems : Digestive organs, digestion & absorption, kidney & nephron structure, urine formation, urinary reflex, blood pressure regulation by urinary system.

Activities:

1. Urine analysis (physical and chemical tests).
2. Chart/animation-based activity on digestive processes.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References:

1. Ganong, W. F. (2010). Review of medical physiology. McGraw Hill.
2. Guyton, A. C., & Hall, J. E. (2015). Medical physiology. Elsevier Saunders.
3. Martini, F. H., Nath, J. L., & Bartholomew, E. F. (2014). Fundamentals of anatomy and physiology). Pearson Publishers.

4. Marieb, *E. N. (2015).* Essentials of human anatomy and physiology*. Pearson Education.*
5. *Pocock, G., & Richards, C. D. (2017).* The human body: An introduction for biomedical and health sciences*.* Oxford University Press.
6. Solomon, *E. P. (2015).* Introduction to human anatomy and physiology*. W. B.* Saunders Company.

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Explain the structural organization of the human body from cells to organ systems.	**-**	**-**	**-**
CO2	Apply anatomical and physiological knowledge to measure, record, and interpret basic body functions.	PO1(3) PO3(3)	2	2
CO3	Analyze the integration of various systems in maintaining homeostasis.	PO3(3)	3	3
CO4	Design activities to explore structure–function relationships of human organ systems	PO1(3)	3	3

BM25105	Medical Imaging Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To study the principles of Medical Imaging Systems

X-ray Imaging Modalities: Principle and production of soft X – Rays, X- ray machine and digital radiography, principles of Angiography and Fluoroscopic Techniques, digital subtraction angiography, mammography.

Activities:

1. Lab demo/visit: Digital radiography machine and image acquisition.
2. Case study on mammography in breast cancer screening.

CT and Computer Aided Tomography: Principle, multisection radiography, computerized axial tomography, detectors, image reconstruction, spiral CT, transverse tomography, 3D imaging, convolution and back-projection, multislice CT, artifacts.

Activities:

1. MATLAB/Python simulation of back-projection for CT image reconstruction.
2. Assignment on types of CT artifacts with clinical examples.

MRI and Emission Computed Tomography: Principle of MRI, MRI instrumentation, tissue characterization, MR spectroscopy, functional MRI, radiation detectors, gamma camera, PET, SPECT, PET/CT, PET/MRI.

Activities:

1. Mini-project: MRI pulse sequence simulation.
2. Case study on PET/CT in oncology imaging.

Ultrasound Imaging: Ultrasonic frequency for medical application, display modes (A, B, M), ultrasonic probes, real-time echo, 2D scanner.

Activities:

1. Practical demo: Ultrasound scanning for abdominal imaging.
2. Assignment on probe design and applications of Doppler ultrasound.

Quality Metrics in Medical Imaging: Global parameter assessment, spatial and frequency assessment, image processing assessment, observer assessment, image discrimination models, figure of merit, AI in imaging systems.

Activities:

1. Project: Comparative analysis of image quality across CT/MRI/Ultrasound.
2. Seminar: AI applications in medical imaging and diagnostics.

Specific Activity: Case Study: Applications of Imaging Methods

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References:

1. Richard L. Van Metter, Jacob Beutel, Harold L. Kundel, Handbook of Medical Imaging,
2. Volume 1. Physics and Psychophysics, SPIE, 2000
3. Chesney D. N., Chesney M. O. Radio graphic imaging, CBS Publications, New Delhi, 1989
4. Donald W. McRobbice, Elizabeth A. Moore, Martin J. Grave and Martin R. Prince MRI

5. from Picture to proton, Cambridge University press, second edition, New York 2007.
6. Frederick W Kremkau, Diagnostic Ultrasound Principles & Instruments, Saunders Elsevier,2005.
7. Jerry L. Prince, Jnathan M. Links, Medical Imaging Signals and Systems- Pearson Education Inc. 2014.
8. Peggy, W., Roger D. Ferimarch, MRI for Technologists, McGraw Hill, New York, second edition, 2000.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the principles of X-ray and ultrasound imaging systems and their clinical applications.	-	-	-
CO2	Apply reconstruction techniques in CT and MRI to generate sectional images.	PO1(3) PO3(3)	2	2
CO3	Analyze different medical imaging modalities (MRI, PET, SPECT) for tissue characterization and functional studies..	PO3(3)	3	3
CO4	Evaluate and design imaging quality metrics and AI-based methods for medical image assessment.	PO1(3)	3	3

BM25106	Clinical Instrumentation and Design Laboratory	L	T	P	C
		0	0	4	2

Course Objectives:

To design the the design of bio medical instrumentation Circuits. And the critical care equipment in medical field.

List of Experiments:

1. Design and analysis of bio amplifier using circuit simulation.
2. Design of instrumentation amplifier using Opamp and single IC
3. Design of bio amplifier for acquiring bio signals.
4. Recording and analysis of Electromyogram signals.
5. Recording of EEG signal.
6. Measurement of respiratory parameters using spirometer
7. Plotting of human auditory response using audiometer.
8. Performance and testing of surgical diathermy unit using diathermy Analyser.
9. Measurement of Vital parameters using patient monitoring system and biotelemetry.
10. Electrical safety testing of medical equipment.
11. Study of different types of muscle stimulator waveforms.
12. Study the working of Defibrillator and pacemakers
13. Study of ventilators
14. Develop prototype using 3D printing for Biomedical applications.

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Project (30%), Assignment (10%), Practical (30%), Internal Examinations (30%)

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the role of preamplifiers and isolation circuits in biomedical applications.	-	-	-
CO2	Apply amplifier design techniques for bio-signal acquisition..	PO1(3) PO3(3)	2	2
CO3	Analyze the operation of medical and critical care equipment..	PO3(3)	3	3
CO4	Design 3D printing models for biomedical applications.	PO1(3)	3	3