

Dr. Babasaheb Ambedkar Technological University, Lonere

Dr. Babasaheb Ambedkar Technological University
(Established as a University of Technology in the State of Maharashtra)
(Under Maharashtra Act No. XXIX of 2014)
P.O. Lonere, Dist. Raigad, Pin 402 103, Maharashtra
Telephone and Fax. 02140 - 275142
www.dbatu.ac.in



Course Structure and Detailed Syllabus

of

B. Tech Programme

for

Minor in Biomedical Engineering

from

Second to Final Year Engineering

In line with National Education Policy 2020

Effective from Academic year 2025-26 for affiliated colleges

List of Courses for Minor in Biomedical Engineering

Multidisciplinary Minor (MDM) Bucket in Biomedical Engineering

Course Code	Course	Credit	Disciplines involved
25AF1461MD306	Network Theory	2	Electronics, Electrical, E&TC
25AF1461MD406	Data Science & Machine Learning	2	Computer Science and Engineering, Electronics, Electrical, E&TC
25AF1461MD506	Neuroscience	3	Biology, Psychology, Cognitive Science
25AF1461MD606	Healthcare Informatics	3	Electrical Engineering, , Computer Science and Engineering
25AF1461MD706	Robotics and Control Systems	2	Electrical Engineering, Mechanical Engineering, Computer Science and Engineering
25AF1461MD804	Biomedical Product Development	2	Electrical Engineering, Mechanical Engineering, Computer Science and Engineering

Student can complete the online courses for minor in Biomedical Engineering through online platform NPTEL / SWAYAM/ Sector Skill council of India and other online platforms identified by the University time to time. At least 80% contents (including applications of Biomedical Engineering) of the NPTEL / SWAYAM/ Sector Skill council of India course should match with syllabus contents of the subject prescribed by the university.

SECOND YEAR

SEMESTER III

25AF1461MD306	MDM Bucket	02 Credits
25AF1461MD306	Network Theory	02 Credits

Course Objectives

1. To introduce the fundamentals of electrical networks and circuit laws
2. To analyze the behavior of linear circuits using various theorems and techniques
3. To understand transient and steady-state analysis for RLC circuits
4. To apply Laplace transform for circuit analysis in the frequency domain
5. To provide a foundation for analog electronics and biomedical signal pathways

Course Outcomes (COs)

After successful completion of this course, the student will be able to:

- CO1:** Apply network laws to analyze resistive circuits
- CO2:** Solve electrical networks using mesh, nodal, and network theorems
- CO3:** Analyze the transient behaviour of RLC circuits
- CO4:** Use Laplace transforms to solve electrical circuits in the s-domain
- CO5:** Understand resonance, coupled circuits, and two-port network parameters for practical applications

Unit 1: Basic Circuit Concepts

Ohm's law, Kirchhoff's laws, Series and parallel circuits, source transformation, Power and energy in electrical elements, Star-delta transformations, Network reduction techniques

Unit 2: Network Theorems and Analysis Techniques

Mesh and nodal analysis, Superposition theorem, Thevenin's and Norton's theorems
Maximum power transfer theorem

Unit 3: Transient Analysis of First and Second Order Circuits

RC, RL, and RLC circuits with step and impulse inputs, Natural and forced response of circuits
Time constants, damping, and resonance, Application to biomedical capacitive/resistive sensors

Unit 4: Laplace Transform and Frequency Domain Analysis

Laplace transform of basic signals and circuit elements, Initial and final value theorems
Circuit analysis using Laplace transforms, Transfer function, poles and zeros

Unit 5: Resonance and Two-Port Networks

Series and parallel resonance in RLC circuits, Quality factor, bandwidth, selectivity
Coupled circuits and dot convention, Two-port network parameters: Z, Y, h, parameters

Textbooks

1. Sudhakar, A., & Shyam Mohan, S. P. – *Circuits and Networks: Analysis and Synthesis*, McGraw Hill
2. Hayt, W. H., Kemmerly, J. E., & Durbin, S. M. – *Engineering Circuit Analysis*, McGraw Hill

Reference Books

1. Van Valkenburg, M. E. – *Network Analysis*, PHI
2. Joseph Edminister – *Schaum's Outline of Electric Circuits*, McGraw Hill
3. Charles K. Alexander & Matthew N. O. Sadiku – *Fundamentals of Electric Circuits*, McGraw Hill
4. William D. Stanley – *Network Analysis with Applications*, Pearson

SEMESTER IV

25AF1461MD406	MDM Bucket	02 Credits
25AF1461MD406	Data Science and Machine Learning	02 Credits

Course Objectives

1. To introduce fundamental concepts of data science and machine learning relevant to biomedical applications
2. To understand data preprocessing, visualization, and exploratory data analysis techniques
3. To learn supervised and unsupervised machine learning algorithms and their biomedical use cases
4. To develop skills to implement machine learning models using Python or relevant tools
5. To explore real-world biomedical datasets for predictive modeling and decision making

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Understand and apply data preprocessing and exploratory data analysis techniques

CO2: Implement supervised learning algorithms such as regression, decision trees, and SVM

CO3: Apply unsupervised learning methods including clustering and dimensionality reduction

CO4: Evaluate machine learning models using performance metrics and validation techniques

CO5: Analyze biomedical datasets using data science and machine learning tools for predictive insights

Unit 1: Introduction to Data Science and Data Preprocessing

Overview of data science, machine learning, and their applications in biomedical engineering, Data types, data collection, and data quality issues, Data cleaning, handling missing data, data transformation, and normalization, Exploratory Data Analysis (EDA) and visualization techniques (using Python libraries like matplotlib, seaborn)

Unit 2: Supervised Learning – Regression and Classification

Linear regression and multiple regression analysis, Logistic regression for binary classification, Decision trees and random forests, Support Vector Machines (SVM), Model training, testing, and cross-validation

Unit 3: Unsupervised Learning

Clustering techniques: K-means, hierarchical clustering, DBSCAN, Dimensionality reduction methods: PCA, t-SNE, Applications in pattern recognition and data segmentation in biomedical data

Unit 4: Model Evaluation and Optimization

Performance metrics: accuracy, precision, recall, F1-score, ROC and AUC, Overfitting and underfitting, Model tuning using grid search and hyperparameter optimization, Introduction to ensemble methods: bagging and boosting

Unit 5: Biomedical Applications and Tools

Case studies on biomedical data analysis: disease prediction, medical image analysis, Introduction to Python libraries: scikit-learn, pandas, numpy, Hands-on project: Implementing machine learning models on biomedical datasets, Ethical considerations and data privacy in biomedical data science

Textbooks

1. Aurélien Géron – *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly
2. Agrawal, Charu Gupta, Anand Sharma, Vishu Madaan, Nisheeth Joshi. – *Machine Learning and Data Science: Fundamentals and Applications*, Wiley

Reference Books

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville – *Deep Learning*, MIT Press
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman – *The Elements of Statistical Learning*, Springer
3. Jason Bell – *Machine Learning: Hands-On for Developers and Technical Professionals*, Wiley
4. Sebastian Raschka – *Python Machine Learning*, Packt Publishing

SEMESTER V

25AF1461MD506	MDM Bucket	03 Credits
25AF1461MD506	Neuroscience	03 Credits

Course Objectives (COB)

The course aims to:

1. Understand the structure and function of the human nervous system.
2. Explain neuronal communication and electrophysiology.
3. Study sensory and motor systems of the brain.
4. Introduce neurological disorders and diagnostic techniques.
5. Familiarize students with neuroengineering, brain-computer interfaces, and emerging biomedical applications.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the anatomy and physiology of the nervous system.

CO2: Describe neuronal signaling, synaptic transmission, and electrophysiological mechanisms.

CO3: Analyze the organization and functions of sensory and motor pathways.

CO4: Interpret neurological disorders and modern neurodiagnostic techniques.

CO5: Evaluate biomedical engineering applications in neuroscience including EEG, EMG, Brain-Computer Interface (BCI), and neural prostheses.

UNIT 1: Introduction to Neuroscience.

Scope of Neuroscience, Organization of the nervous system, Central Nervous System, Peripheral Nervous System, Autonomic Nervous System, Structure of neurons, Neuroglia and their functions, Neurotransmitters, Cerebrospinal fluid (CSF), Blood-Brain Barrier.

UNIT 2: Neurophysiology and Electrophysiology.

Resting membrane potential, Action potential, Ion channels, Sodium-Potassium pump, Synaptic transmission, Excitatory and inhibitory synapses, Synaptic plasticity, Neural coding, Signal propagation, Introduction to electrophysiological recording.

UNIT 3: Functional Organization of the Brain.

Cerebral cortex, Functional localization, Limbic system, Basal ganglia, Cerebellum, Thalamus, Hypothalamus, Cranial nerves, Sensory pathways, Motor pathways, Reflex mechanism.

UNIT 4: Neurological Disorders and Neurodiagnostics

Stroke, Epilepsy, Parkinson's disease, Alzheimer's disease, Multiple sclerosis, Brain tumors, Spinal cord injury, EEG, EMG, Evoked potentials, CT, MRI, fMRI, PET, SPECT, Clinical applications.

UNIT 5: Neuroengineering and Biomedical Applications

Brain-Computer Interface (BCI), Neural prostheses, Cochlear implants, Deep Brain Stimulation (DBS), Functional Electrical Stimulation (FES), Neural signal processing, Machine Learning in neuroscience, Neuroinformatics, Wearable neurotechnology, Ethical issues in neurotechnology, Future trends in neuroscience.

Text Books

1. Bear, Connors & Paradiso – **Neuroscience: Exploring the Brain**, 4th Edition.
2. Purves et al. – **Neuroscience**, Oxford University Press.
3. Kandel, Schwartz & Jessell – **Principles of Neural Science**, 6th Edition.
4. Guyton & Hall – **Textbook of Medical Physiology**.
5. Ganong – **Review of Medical Physiology**.

Reference Books

1. Eric Kandel – *Principles of Neural Science*
2. Nolte – *The Human Brain*
3. Robert Plonsey – *Bioelectric Phenomena*
4. Rangayyan – *Biomedical Signal Analysis*
5. He et al. – *Neural Engineering*

THIRD YEAR

SEMESTER VI

25AF1461MD606	MDM Bucket	03 Credits
25AF1461MD606	Healthcare Informatics	03 Credits

Course Objectives (COs)

The course aims to enable students to:

1. Understand healthcare information systems and digital transformation in healthcare.
2. Learn healthcare data standards, interoperability, and clinical information management.
3. Explore electronic health records, clinical decision support systems, and telemedicine.
4. Apply health informatics concepts for data analytics and biomedical applications.
5. Understand emerging technologies such as AI, IoMT, cloud computing, and cybersecurity in healthcare.

Course Outcomes

After successful completion of the course, students will be able to:

CO1: Explain the architecture and components of healthcare information systems.

CO2: Apply healthcare data standards and interoperability protocols for clinical information exchange.

CO3: Analyze Electronic Health Records (EHRs), Clinical Decision Support Systems (CDSS), and healthcare databases.

CO4: Evaluate digital healthcare technologies including telemedicine, IoMT, AI, and healthcare analytics.

CO5: Assess cybersecurity, privacy, ethical, and regulatory issues in healthcare informatics.

UNIT 1: Fundamentals of Healthcare Informatics

Introduction to Healthcare Informatics, Evolution of Digital Healthcare, Hospital Information System (HIS), Clinical Information System (CIS) , Laboratory Information System (LIS), Radiology Information System (RIS), Pharmacy Information System (PIS), Health Information Exchange (HIE), Role of Biomedical Engineers in Healthcare Informatics.

UNIT 2: Electronic Health Records and Healthcare Data Standards

Electronic Medical Record (EMR), Electronic Health Record (EHR), Personal Health Record (PHR), Clinical Documentation, Medical Coding (ICD-10, CPT, SNOMED CT), Healthcare Data Standards, HL7, DICOM, FHIR, LOINC.

UNIT 3: Clinical Decision Support and Health Data Analytics

Clinical Decision Support Systems (CDSS), Evidence-Based Medicine, Healthcare Databases, Data Warehousing, Data Mining in Healthcare, Predictive Analytics, Biomedical Data Visualization, Introduction to Population Health Analytics.

UNIT 4: Digital Health and Emerging Technologies

Telemedicine and Telehealth, Mobile Health (mHealth), Internet of Medical Things (IoMT), Wearable Healthcare Devices, Artificial Intelligence in Healthcare, Machine Learning Applications, Precision Medicine, Smart Hospitals, Digital Twin in Healthcare (Introduction).

UNIT 5: Healthcare Security, Ethics, and Regulations

Healthcare Data Security, Cybersecurity in Healthcare, Privacy and Confidentiality, Electronic Consent, Ethical Issues in Digital Healthcare, Healthcare Regulations and Standards, Cloud Computing in Healthcare, Blockchain in Healthcare (Introduction), Future Trends in Healthcare Informatics.

Text Books

1. Edward H. Shortliffe & James J. Cimino, **Biomedical Informatics**, Springer.
2. Marion J. Ball et al., **Healthcare Information Management Systems**, Springer.
3. Robert E. Hoyt & Ann Yoshihashi, **Health Informatics: Practical Guide**.
4. Charlotte Weaver, **Healthcare Information Management Systems**.

Reference Books

1. Raghupathi & Raghupathi, **Healthcare Analytics and Informatics**.
2. HIMSS, **Introduction to Healthcare Informatics**.

3. R. D. Lele, **Computers in Medicine.**
4. Karen Wager, Frances Lee & John Glaser, **Health Care Information Systems: A Practical Approach for Health Care Management.**

FINAL YEAR

SEMESTER VII

25AF1461MD706	MDM Bucket	02 Credits
25AF1461MD706	Robotics and Control Systems	02 Credits

Course Objectives

The course aims to:

1. Understand the fundamentals of robotics and control systems used in biomedical applications.
2. Learn the components, kinematics, and control of robotic systems.
3. Explore medical and rehabilitation robotics for healthcare.
4. Study intelligent control techniques used in robotic systems.
5. Understand emerging trends in surgical robotics, AI, and human–robot interaction.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

- CO1:** Explain the fundamentals of robotic systems and control principles.
CO2: Analyze robotic components, sensors, actuators, and robotic manipulators.
CO3: Apply control strategies in medical and rehabilitation robotic systems.
CO4: Evaluate robotic applications in surgery, diagnosis, and patient rehabilitation.
CO5: Assess emerging technologies including AI-enabled robotics, collaborative robots, and autonomous healthcare systems.

UNIT 1: Fundamentals of Robotics

Introduction to Robotics, History and Evolution of Robotics, Classification of Robots, Components of Robotic Systems, Degrees of Freedom (DOF), Coordinate Systems, Robot Configurations, Sensors and Actuators used in Robotics, Applications of Robotics in Biomedical Engineering.

UNIT 2: Robot Kinematics and Control Systems

Basic Robot Kinematics, Forward and Inverse Kinematics (Concepts), Motion Control, Open-loop and Closed-loop Control Systems, PID Controller, Position and Velocity Control, Feedback Sensors, Servo Systems.

UNIT 3: Medical and Rehabilitation Robotics

Surgical Robotics, Rehabilitation Robots, Prosthetic and Orthotic Robotics, Robotic Exoskeletons, Robot-assisted Physiotherapy, Assistive Robots for Elderly and Disabled, Medical Robot Safety.

UNIT 4: Intelligent Control and Human–Robot Interaction

Intelligent Control Systems, Fuzzy Logic Control (Introduction), Neural Network-based Control, Human–Robot Interaction (HRI), Vision-based Robotics, Haptic Feedback Systems, Collaborative Robots (Cobots).

UNIT 5: Emerging Trends in Healthcare Robotics

Artificial Intelligence in Robotics, Autonomous Medical Robots, Internet of Robotic Things (IoRT), Digital Twin in Robotics (Introduction), Robot-assisted Diagnostics, Robotic Drug Delivery Systems, Future Trends and Ethical Considerations .

Text Books

1. **M. P. Groover**, *Industrial Robotics: Technology, Programming and Applications*, McGraw-Hill.
2. **John J. Craig**, *Introduction to Robotics: Mechanics and Control*, Pearson.
- K. S. Fu, R. C. Gonzalez & C. S. G. Lee**, *Robotics: Control, Sensing, Vision and Intelligence*, McGraw-Hill.
3. **Richard C. Dorf & Robert H. Bishop**, *Modern Control Systems*, Pearson.

Reference Books

1. Siciliano, Sciavicco, Villani & Oriolo, *Robotics: Modelling, Planning and Control*.
2. Bruno Siciliano & Oussama Khatib, *Springer Handbook of Robotics*.
3. Webster J.G., *Medical Instrumentation: Application and Design*.
4. Niku S.B., *Introduction to Robotics: Analysis, Control and Applications*.
5. Corke P., *Robotics, Vision and Control*.

SEMESTER VIII

25AF1461MD806	MDM Bucket	02 Credits
25AF1461MD806	Biomedical Product Development	02 Credits

Course Objectives

The course aims to:

1. Understand the complete biomedical product development lifecycle from concept to commercialization.
2. Learn design thinking, user-centered design, and regulatory requirements for medical devices.

3. Apply engineering principles to prototype, test, and validate biomedical products.
4. Understand quality management systems, intellectual property, and risk management.
5. Explore entrepreneurship, innovation, and commercialization strategies in the medical device industry.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the biomedical product development process and identify clinical needs.

CO2: Apply design thinking, engineering design, and prototyping techniques for medical devices.

CO3: Evaluate medical devices using quality assurance, verification, validation, and risk management principles.

CO4: Interpret regulatory requirements, intellectual property rights, and quality management systems applicable to biomedical products.

CO5: Develop a roadmap for commercialization, entrepreneurship, and innovation in biomedical product development.

UNIT 1: Introduction to Biomedical Product Development

Introduction to Medical Devices, Biomedical Product Development Lifecycle, Clinical Need Identification, Problem Definition, User-Centered Design, Design Thinking in Healthcare, Product Design Requirements, Market Analysis, Product Development Case Studies.

UNIT 2: Biomedical Product Design and Prototyping

Engineering Design Process, Concept Generation and Selection, Computer-Aided Design (CAD), Rapid Prototyping, 3D Printing for Medical Devices, Biomaterials Selection, Sensor and Electronics Integration, Prototype Development, Design Documentation.

UNIT 3: Verification, Validation, and Risk Management

Design Verification and Validation, Product Testing, Clinical Evaluation (Overview), Human Factors Engineering, Usability Engineering, Risk Management (ISO 14971 – Overview), Failure Mode and Effects Analysis (FMEA), Product Reliability and Safety.

UNIT 4: Regulatory Affairs and Quality Management

Medical Device Classification, Regulatory Approval Process, CDSCO Medical Device Rules (India), FDA and CE Marking (Overview), ISO 13485 Quality Management System, Good Manufacturing Practices (GMP), Documentation and Technical File, Intellectual Property Rights (IPR) and Patents.

UNIT 5: Commercialization and Entrepreneurship

Product Commercialization, Technology Transfer, Medical Device Start-ups, Business

Model Canvas, Funding Opportunities, Biomedical Innovation Ecosystem, Product Launch Strategy, Post-Market Surveillance, Future Trends in Biomedical Product Development.

Text Books

1. Peter J. Ogrodnik, **Medical Device Design: Innovation from Concept to Market**, Academic Press.
2. Richard C. Fries, **Reliable Design of Medical Devices**, CRC Press.
3. Joseph D. Bronzino, **Biomedical Engineering Handbook**, CRC Press.
4. R. S. Khandpur, **Handbook of Biomedical Instrumentation**, McGraw-Hill.

Reference Books

1. Jonathan S. Kahan, **Medical Device Development: A Regulatory Overview**.
2. FDA, **Design Control Guidance for Medical Device Manufacturers**.
3. ISO 13485: Medical Devices – Quality Management Systems (Overview).
4. ISO 14971: Medical Devices – Risk Management (Overview).
5. BIS and CDSCO Medical Device Regulations (India).