Training Course on Biomedical Instrumentation and Bioelectronics

Professional Development Training Course Outline

Category	Engineering	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Introduction

Training course on Biomedical Instrumentation and Bioelectronics offers an immersive exploration into the interdisciplinary field that underpins modern healthcare diagnostics, monitoring, and therapy. Participants will gain a deep understanding of the fundamental principles of biomedical signals (ECG, EEG, EMG, PPG), bio-potential amplifiers, transducers, and signal processing techniques essential for extracting meaningful physiological information. The curriculum covers the design, operation, and application of a wide range of medical devices, from diagnostic instruments (e.g., electrocardiographs, electroencephalographs, pulse oximeters) to therapeutic devices (e.g., pacemakers, defibrillators, electrosurgical units). Attendees will acquire cutting-edge knowledge in areas such as medical device design, electrical safety, calibration, and regulatory compliance, critical for developing safe, accurate, and reliable healthcare technologies.

The program emphasizes practical considerations and addresses trending topics in bioelectronics and medical technology, including wearable biomedical devices, implantable electronics, neural interfaces, point-of-care diagnostics, telehealth solutions, and the integration of AI/ML for advanced signal analysis and personalized medicine. Participants will delve into the challenges of noise reduction, artifact removal, power efficiency in low-power biomedical devices, and the ethical considerations surrounding emerging bioelectronic technologies. By the end of this course, attendees will possess the expertise to innovate, develop, and apply biomedical instrumentation and bioelectronics concepts, driving advancements in preventive care, disease diagnosis, patient monitoring, and therapeutic interventions. This training is indispensable for engineers, scientists, and healthcare professionals seeking to be at the forefront of medical device innovation and digital health transformation.

Programme Curriculum

Training Course on Biomedical Instrumentation and Bioelectronics

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Course duration

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Course Objectives

1. Understand the sources and characteristics of various biomedical signals (e.g., ECG, EEG, EMG, PPG).
2. Design and analyze bio-potential amplifiers and signal conditioning circuits for medical applications.
3. Comprehend the principles and applications of biomedical transducers and sensors.
4. Apply digital signal processing techniques for noise reduction and feature extraction from biomedical data.
5. Analyze the operation and design of diagnostic medical instruments (e.g., ECG, EEG, pulse oximeters).
6. Understand the principles and safety aspects of therapeutic medical devices (e.g., pacemakers, defibrillators).
7. Design for electrical safety in medical environments (patient isolation, leakage currents, grounding).
8. Explore wearable and portable biomedical devices for continuous health monitoring.
9. Investigate implantable biomedical devices and neural interfaces.
10. Understand medical imaging modalities and their underlying electronic principles.
11. Apply AI/ML techniques for advanced biomedical signal analysis and diagnostics.
12. Comprehend regulatory pathways and quality standards (e.g., IEC 60601, ISO 13485) for medical devices.

13. Address biocompatibility and packaging challenges for implantable and body-worn electronics.

Organizational Benefits

1. Accelerated R&D and product development cycles for new medical devices.
2. Improved accuracy, reliability, and safety of their biomedical instrumentation.
3. Enhanced compliance with stringent medical device regulations and quality standards.
4. Creation of innovative diagnostic and therapeutic solutions for unmet medical needs.
5. Competitive advantage in the rapidly expanding healthcare technology market.
6. Development of in-house expertise in critical areas like bio-signal processing and sensor integration.
7. Reduced product recalls and warranty claims due to improved design and safety.
8. Exploration of new markets in digital health, wearables, and personalized medicine.
9. Optimized device performance leading to better patient outcomes.
10. Attraction and retention of top talent in biomedical engineering and bioelectronics.

Target Participants

- Biomedical Engineers
- Electrical Engineers
- Electronics Engineers
- Medical Device Design Engineers
- Clinical Engineers
- Researchers in Medical Technology and Bioelectronics
- Healthcare IT Professionals
- Product Development Managers in the Healthcare Industry

Course Outline

Module 1: Introduction to Biomedical Engineering and Bioelectronics

- **Interdisciplinary Nature:** Biology, medicine, engineering.
- **Physiological Systems Overview:** Nervous, cardiovascular, muscular.
- **Biomedical Signals:** Types (electrical, mechanical, chemical), origins, characteristics.
- **Role of Instrumentation:** Diagnostics, monitoring, therapy.
- **Case Study:** Discussing the evolution of electrocardiography (ECG) from early experiments to modern diagnostic tools.

Module 2: Bio-potential Electrodes and Transducers

- **Electrode-Skin Interface:** Equivalent circuit, half-cell potential.
- **Types of Electrodes:** Surface (Ag/AgCl), needle, microelectrodes, implantable.
- **Transducers:** Converting non-electrical physiological signals to electrical signals.
- **Common Transducers:** Pressure, temperature, flow, force, displacement.
- **Case Study:** Analyzing the selection criteria for electrodes used in long-term ECG monitoring.

Module 3: Bio-potential Amplifiers and Signal Conditioning

- **Challenges of Bio-signal Amplification:** Small amplitude, noise, common-mode interference.
- **Instrumentation Amplifiers:** High CMRR, high input impedance.
- **Isolation Amplifiers:** Patient safety, galvanic isolation.
- **Filtering and Shielding:** Noise reduction techniques.
- **Case Study:** Designing a differential amplifier circuit for amplifying a low-amplitude EEG signal while rejecting common-mode noise.

Module 4: Digital Signal Processing for Biomedical Signals

- **Sampling and Quantization:** Nyquist theorem, aliasing.
- **Digital Filters:** FIR, IIR for noise removal (e.g., power line interference).
- **Feature Extraction:** P-QRS-T detection (ECG), alpha/beta/theta rhythms (EEG).
- **Time-Frequency Analysis:** Wavelets, spectrograms for non-stationary signals.
- **Case Study:** Applying a digital notch filter to remove 50/60 Hz power line noise from an ECG recording.

Module 5: Electrocardiography (ECG)

- **Cardiac Electrical Activity:** Myocardial depolarization/repolarization.
- **ECG Lead Systems:** 12-lead, Einthoven's Triangle.
- **ECG Waveforms and Intervals:** P, QRS, T waves, PR, QT intervals.
- **Common Arrhythmias Detection:** Atrial fibrillation, tachycardia, bradycardia.
- **Case Study:** Interpreting a 12-lead ECG recording to identify signs of a myocardial infarction.

Module 6: Electroencephalography (EEG) and Electromyography (EMG)

- **EEG Principles:** Brain electrical activity, brain waves (alpha, beta, delta, theta).
- **EEG Electrodes and Montages:** 10-20 system.
- **EMG Principles:** Muscle electrical activity, motor unit action potentials.
- **EMG Applications:** Muscle fatigue, prosthetic control.
- **Case Study:** Analyzing EEG signals during different sleep stages and identifying characteristic brainwave patterns.

Module 7: Biometric and Physiological Monitoring Devices

- **Pulse Oximetry:** Principles (Beer-Lambert Law), SpO2 measurement.
- **Blood Pressure Measurement:** Oscillometric, auscultatory methods.
- **Respiratory Rate and Flow Measurement:** Thermistors, pneumotachometers.
- **Body Temperature Measurement:** Thermistors, IR sensors.
- **Case Study:** Explaining the operation of a pulse oximeter and factors affecting its accuracy.

Module 8: Therapeutic Medical Devices

- **Pacemakers:** Types, pacing modes, lead placement.
- **Defibrillators:** External, implantable (ICD), biphasic waveforms.
- **Electrosurgical Units (ESU):** Cut and coagulation modes, safety.
- **Infusion Pumps:** Controlled drug delivery.
- **Case Study:** Discussing the design considerations for a dual-chamber implantable pacemaker.

Module 9: Medical Imaging Systems (Overview)

- **X-Ray Imaging:** Principles, components, CT scans.

- **Magnetic Resonance Imaging (MRI):** NMR principles, strong magnetic fields.
- **Ultrasound Imaging:** Transducers, A-mode, B-mode, Doppler.
- **Nuclear Medicine:** PET, SPECT principles.
- **Case Study:** Comparing the diagnostic capabilities of X-ray and MRI for visualizing bone and soft tissue structures.

Module 10: Electrical Safety in Medical Environments

- **Physiological Effects of Electric Current:** Macroshock, microshock.
- **Grounding and Isolation:** Patient isolation, insulated power systems.
- **Leakage Currents:** Allowable limits, measurement.
- **Safety Standards: IEC 60601 series**, AAMI, UL.
- **Case Study:** Analyzing a medical device circuit for potential leakage current paths and proposing safety improvements.

Module 11: Wearable and Portable Biomedical Devices

- **Trends in Wearable Health:** Continuous monitoring, preventative care.
- **Sensor Integration:** PPG, accelerometer, gyroscope, temperature.
- **Power Management:** Low-power design, energy harvesting.
- **Connectivity:** Bluetooth Low Energy (BLE), Wi-Fi, cellular.
- **Case Study:** Designing a functional block diagram for a smart wearable patch for continuous vital signs monitoring.

Module 12: Implantable Devices and Neural Interfaces

- **Biocompatibility of Materials:** Host response, long-term stability.
- **Packaging and Encapsulation:** Hermetic sealing, preventing fluid ingress.
- **Powering Implantable Devices:** Inductive charging, micro-batteries.
- **Neural Interfaces:** Brain-Computer Interfaces (BCI), cochlear implants.
- **Case Study:** Discussing the engineering challenges in developing a deep brain stimulation (DBS) device for Parkinson's disease.

Module 13: AI/ML in Biomedical Signal Analysis and Diagnostics

- **Machine Learning for Classification:** Disease detection (e.g., arrhythmia classification).
- **Deep Learning for Signal Processing:** Denoising, feature learning.
- **Predictive Analytics:** Early disease onset prediction.
- **Explainable AI (XAI) in Healthcare:** Trust and interpretability.
- **Case Study:** Training a convolutional neural network (CNN) to classify different types of heartbeats from ECG data.

Module 14: Medical Device Regulatory and Quality Systems

- **Regulatory Bodies:** FDA (US), CE Mark (EU), PMDA (Japan).
- **Design Controls:** Requirements for medical device development.
- **Quality Management Systems: ISO 13485** standard.
- **Risk Management:** ISO 14971 for medical devices.
- **Case Study:** Outlining the key steps in the regulatory approval process for a new diagnostic medical device in the EU or US.

Module 15: Future Trends in Biomedical Instrumentation and Bioelectronics

- **Miniaturization and Nanobioelectronics:** Lab-on-a-chip, in-vivo sensing.
- **Personalized Medicine:** Data-driven diagnostics and therapies.

- **Telehealth and Remote Monitoring:** Expanding access to care.
- **Digital Therapeutics:** Software as a medical device.
- **Case Study:** Discussing the potential impact of advanced nanotechnology on the future of implantable biosensors.

Training Methodology

This course employs a participatory and hands-on approach to ensure practical learning, including:

- Interactive lectures and presentations.
- Group discussions and brainstorming sessions.
- Hands-on exercises using real-world datasets.
- Role-playing and scenario-based simulations.
- Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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