



National Commission for
Allied and Healthcare Professions
(NCAHP)



COMPETENCY BASED CURRICULUM
for
**DIPLOMA IN
MEDICAL EQUIPMENT TECHNOLOGY**



As per NCAHP Act 2021



EMPOWERING
TECHNOLOGY



SUPPORTING
CARE



ENSURING
RELIABILITY



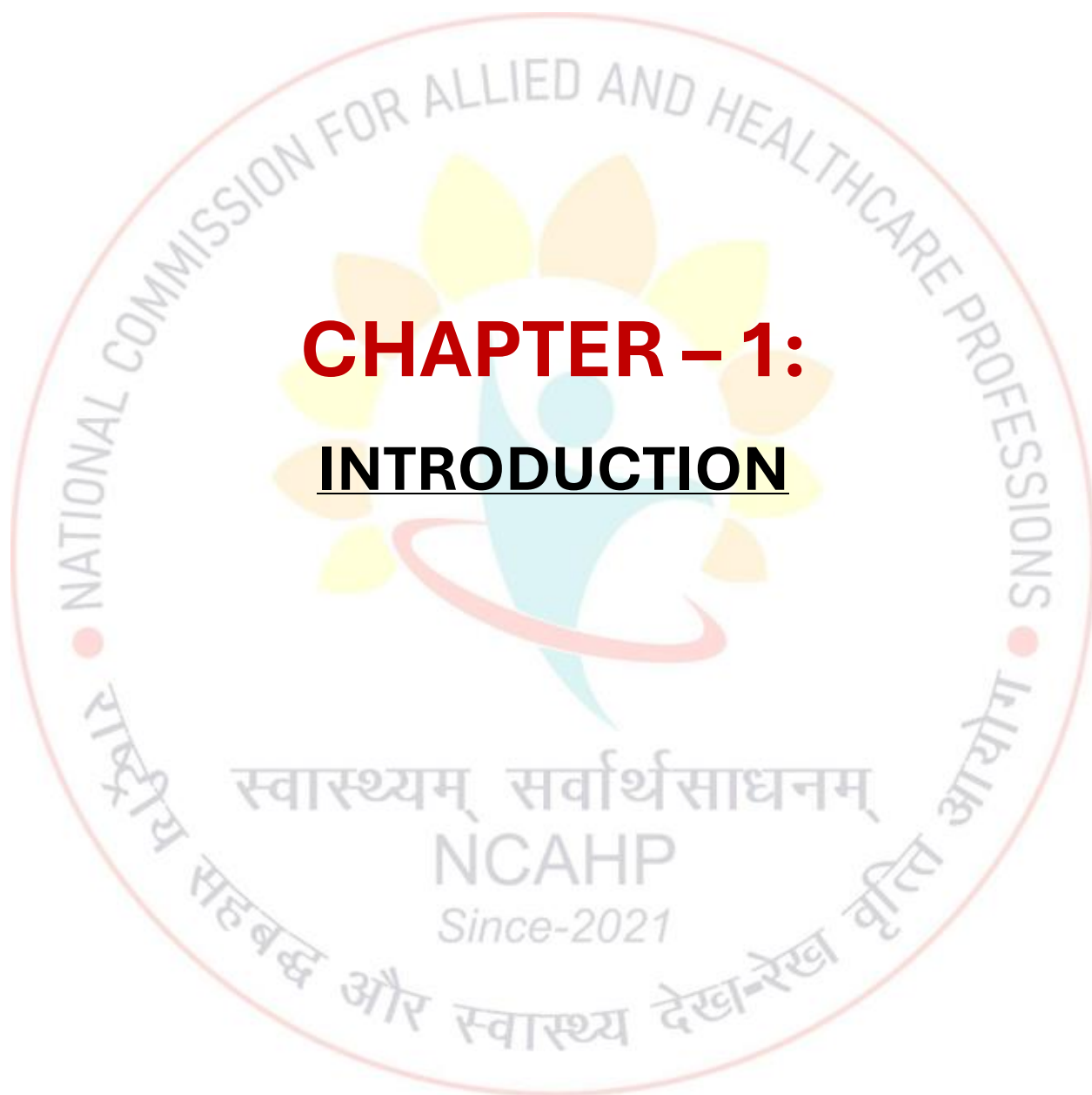
SHAPING THE FUTURE
OF HEALTHCARE



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CHAPTER – 1:

INTRODUCTION

1.1 Executive Summary

1.1.1 Introduction & Strategic Vision

Modern healthcare is an inextricable synthesis of clinical expertise and advanced engineering. Medical technology is now ubiquitous, forming the absolute foundation of safe, effective, and cost-optimized patient care. As hospitals evolve into highly complex, data-driven cyber-physical systems—incorporating robotics, AI diagnostics, and interconnected telemetry, the infrastructure required to sustain them has become phenomenally intricate.

Medical Equipment Technologists (METs) serve as the critical bridge between the physical laws of engineering and the biological realities of patient care. They are the unseen guardians of patient safety, complementing physicians and nurses by preventing mechanical, electrical, and digital failures. Because their responsibilities directly impact human survival and institutional liability, an under-trained technician is a severe clinical and legal liability. Therefore, this curriculum was designed with an uncompromising standard, aimed at producing a highly specialized, financially literate, and ethically grounded workforce capable of managing the healthcare breakthroughs of the future.

1.1.2 Academic Schedule Overview

The curriculum spans 5 Semesters (2 Years + 6 months of internship), structured to transition students progressively from foundational engineering principles to advanced clinical application, culminating in independent research and a formalized industry apprenticeship.

- **Semesters 1-2:** Focus on foundational electrical and electronics, devices, sensors, transducers, microprocessors, biomedical instrumentation, human anatomy & physiology, diagnostic equipment, healthcare IT, and professional ethics
- **Semester 3:** Focus on diagnostic, therapeutic, imaging, surgical, critical care, analytical and Lab equipment
- **Semester 4 (Major Project):** Focus on asset and facility management, regulatory compliance, facility management, safety and quality, advanced diagnostics and repair, and the Major Project.
- **Post-Academic Phase:** A mandatory 6-month clinical internship.

1.1.3 Pedagogical Thought Process & Curriculum Architecture

The architectural philosophy of this curriculum discards rote memorization in favor of competency-based execution, aligning academic milestones with strict real-world hospital demands.

- **Basis for Courses and Units:** The courses were selected to reflect the *actual* daily demands of a modern Clinical Engineering Director. Rather than limiting the scope to basic circuit repair, the curriculum includes mandatory units on Cybersecurity, Hospital Facility Management (HVAC/MGPS) & Healthcare IT. This ensures graduates can manage a hospital's entire technological footprint, not just individual bedside devices.
- **Design of Practical Experiments:** We shifted from passive "theoretical observation" to high-stakes "competency-based practical execution." Experiments are designed as forensic investigations, mass-casualty triage simulations, "white-hat" network hacking, and board-level micro-soldering. This forces students to operate under simulated clinical pressure and legal liability.
- **Provision of Laboratory Facilities:** Standard electronics benches are insufficient for this caliber of training. The curriculum mandates the creation of specialized hubs: an air-gapped *Medical Cyber-Range*, a *Biomedical Innovation & Prototyping Hub (Maker Space)*, a *Mock Ward* with active medical gas manifolds, and a *Clinical Ethics Boardroom* for legal deposition and procurement simulations.
- **Curation of Learning Resources:** To ensure global relevance, the required reading moves beyond outdated textbooks. The curriculum relies on open-source, gold-standard industry guidelines (FDA, WHO, AERB, HTM codes), OEM visual animations (Da Vinci, Tektronix), and active clinical engineering repositories. This teaches students how to source real-world technical data in the field.
- **Faculty Modeling & Ratios:** Teaching this curriculum requires a "Matrix Mentorship Model." Faculty must possess applied industry experience in corporate healthcare, IT security, and heavy mechatronics. To ensure absolute physical safety and academic rigor during high-stakes practicals, a strict 1:10 Faculty-to-Student ratio is mandated for all laboratory sessions.

1.1.4 The 6-Month Clinical Internship Framework

To bridge the gap between academic graduation and full-time employment, the curriculum concludes with a rigorous, 6-month (960-hour) clinical internship. This is divided into three strict operational parameters to ensure comprehensive training:

1. **The Rotational Matrix:** Students are not relegated to administrative tasks. They must complete a structured, 3-module internship: *General Equipment, Critical Care & Life Support, Heavy Infrastructure & Imaging and Quality Assurance & Administration*.
2. **Hospital Partnerships & Legal Frameworks:** Institutions must forge legally binding Memorandums of Understanding (MoUs) with Tier-1/Tier-2 preferably accredited hospitals (NABH/JCI) or OEM service centers. The MoU shall mandate a 1:3 Preceptor-to-Intern ratio, enforces the "Co-Sign Rule" (interns cannot independently clear equipment for patient use), and ensures comprehensive indemnity insurance.
3. **Legal Logging & Evaluation Requirements:** The traditional generic internship report is replaced by a formal 'Competency Portfolio'. Students must maintain a daily logbook (stripped of patient data), draft at least 20 legally compliant Service Reports, and execute a formal Root Cause Analysis case study. Final evaluation is a 360-degree assessment split evenly (50/50) between the Hospital Preceptor and University Faculty. The passing criterion for 6 month internship framework will be securing a minimum of **75% marks**.

1.2 Introduction to the Curriculum

Modern healthcare has transcended purely biological; it is now an inextricable synthesis of human clinical expertise and advanced engineering. Today, Medical Technology is ubiquitous, forming the absolute foundation of safe, effective, and cost-optimized patient care. From the simplest digital thermometer to multi-million-dollar robotic surgical suites, technology is the conduit through which modern medicine is delivered. A physician's diagnostic brilliance and a nurse's critical care are fundamentally dependent on the accuracy, availability, and safety of the equipment they utilize.

We stand on the precipice of a new era in clinical care. The technologies of the near future will advance at an exponential rate, resulting in healthcare breakthroughs that were previously unimaginable. Hyper-connected Intensive Care Units, autonomous logistics fleets, AI-driven diagnostic imaging, and zero-trust medical networks are no longer theoretical concepts—they are actively being deployed. As hospitals evolve into highly complex, data-driven cyber-physical systems, the infrastructure required to sustain them is becoming phenomenally intricate.

1.2.1 The Role of the Medical Equipment Technologist

Within this rapidly advancing ecosystem, Medical Equipment Technologists (METs) serve a role that is both critical and unique. They are the essential bridge between the physical laws of engineering and the biological realities of patient care.

Healthcare is delivered by a multidisciplinary team, and the MET complements every other professional within that hierarchy. While surgeons operate and physicians diagnose, the Medical Equipment Technologist ensures that the anesthesia workstation delivers the precise concentration of gas, that the surgical robot's master-slave kinematics operate with zero latency, and that the patient's electronic health records are shielded from catastrophic cyber-attacks. They are the unseen guardians of patient safety, operating in the background to prevent mechanical, electrical, and digital failures before they can impact human life.

Furthermore, their role has expanded far beyond the traditional workbench. Today's Medical Equipment Technologists are facility architects managing life-critical Medical Gas Pipeline Systems (MGPS) and high-voltage emergency power grids. They are financial stewards, utilizing health economics and total-cost-of-ownership modeling to protect hospital capital budgets. They are forensic investigators, utilizing advanced metrology to perform root-cause analyses on failed proprietary motherboards. In a modern hospital, the clinical engineering department is not merely a support service; it is a central pillar of hospital governance, legal compliance, and statutory accreditation.

1.2.2 The Case for Uncompromising Educational Standards

Because the responsibilities of the Medical Equipment Technologist directly impact human survival and institutional liability, the standard of education required to produce this workforce must be exceptionally high.

A curriculum cannot simply teach a student how to swap out a broken modular component; it must train them to be analytical, forensic, and ethically uncompromising. When a technician is pressured by hospital administration to clear a faulty life-support machine for use, or when supply chains collapse during a mass-casualty event, the technician must possess the deep moral framework and legal awareness to make defensible, life-saving decisions.

There is an urgent and undeniable imperative to elevate the training of this workforce. As medical equipment becomes more heavily integrated with IT networks, robotics, and complex fluid dynamics, the educational gap between standard electronics training and actual clinical engineering widens. An under-trained technician in a modern healthcare facility is not merely an operational inefficiency—they are a clinical and legal liability.

This 4-semester curriculum plus 6 months of internship has been meticulously designed to meet and exceed global academic and industrial standards. By synthesizing heavy mechanical infrastructure, advanced component-level diagnostics into a rigorous, competency-based framework, this program does more than grant a diploma. It produces highly specialized, and ethically grounded Medical Equipment Technologists.

The students who complete this rigorous academic and practical journey will not just be prepared to maintain the medical technology of the present. They will possess the elite systemic logic and multidisciplinary adaptability required to lead the healthcare engineering breakthroughs of the future.

This is an excellent operational structure. Moving to a 6-day workweek where mornings are dedicated to theoretical foundations (3 hours) and afternoons are dedicated to practical, hands-on application (3-4 hours) perfectly aligns with the intensive, skill-based requirements of Medical Equipment Technologist profession. By this design, each of the 6 courses gets one dedicated afternoon laboratory session per week.

1.3 Definition: Medical Equipment Technologist

A **Medical Equipment Technologist** (frequently also referred to internationally as a Biomedical Equipment Technician or Clinical Engineering Technologist) is an allied healthcare and engineering professional responsible for the installation, calibration, maintenance, troubleshooting, and safe operation of medical devices. Bridging the gap between clinical practice and engineering, they ensure that complex diagnostic, therapeutic, and life-support technologies are fully functional, safe for patient use, and compliant with international medical standards.

Under the **International Standard Classification of Occupations (ISCO-08)** published by the International Labour Organization (ILO), roles operating and maintaining medical technologies are primarily aligned with **Minor Group 321 (Medical and Pharmaceutical Technicians)**, specifically under **ISCO Code 3211**. Depending on the jurisdiction and the mechanical complexity of the role, they are also frequently associated with **ISCO Code 3114 (Electronics Engineering Technicians)** or work directly under **ISCO Code 2149 (Biomedical Engineers)**.

Scope of Practice: Medical Equipment Technology / Healthcare Technology Management

Job Title: Medical Equipment Technologist / Clinical Engineering Technologist

Department: Clinical Engineering / Biomedical Engineering

Reports To: Head of Clinical Engineering / Senior Biomedical Engineer

Core Objective:

To provide comprehensive technical support for healthcare technologies within a clinical environment, ensuring all medical equipment operates efficiently, accurately, and safely to support optimal patient care.

1.3.1 Installation and Commissioning

- Inspect, test, and commission newly procured medical equipment prior to clinical deployment.
- Ensure proper electrical grounding, network connectivity (IT/Telemetry), and environmental conditions (HVAC, MGPS) are met for heavy equipment installations (e.g., CT, MRI, Ventilators).
- Tag and register new assets into the hospital's Computerized Maintenance Management System (CMMS).

1.3.2 Preventive Maintenance (PM) and Calibration

- Execute routine, scheduled preventive maintenance on a wide array of medical devices according to Original Equipment Manufacturer (OEM) guidelines.
- Perform precise calibrations using specialized biomedical test equipment (e.g., Defibrillator Analyzers, Gas Flow Analyzers, Electrical Safety Analyzers).
- Document all PM activities, parameter adjustments, and parts replaced in the CMMS to maintain a complete audit trail.

1.3.3 Corrective Maintenance and Troubleshooting

- Respond rapidly to emergency breakdown calls in high-acuity environments (ICUs, Operation Theatres, Emergency Departments).
- Perform component-level and board-level troubleshooting to diagnose electrical, electronic, pneumatic, and mechanical faults.
- Repair or replace defective components, ensuring minimal downtime for critical life-support systems.

1.3.4 Quality Assurance and Patient Safety

- Conduct stringent electrical safety testing in accordance with international standards (e.g., IEC 60601).
- Perform Quality Assurance (QA) checks on diagnostic imaging equipment to ensure accurate outputs and compliance with radiation safety protocols (e.g., AERB, FDA).
- Participate in the investigation of adverse patient incidents involving medical equipment, performing Root Cause Analysis (RCA) and drafting technical incident reports.

1.3.5 Asset Management and Procurement Support

- Maintain an accurate, real-time inventory of all medical assets, spare parts, and biomedical consumables.
- Monitor equipment lifecycles and draft technical condemnation reports for obsolete or unrepairable devices.
- Evaluate vendor service reports to ensure compliance with Annual Maintenance Contracts (AMC) and Comprehensive Maintenance Contracts (CMC).

1.3.6 Clinical Staff Training and Support

- Act as the technical liaison between the engineering department and clinical staff (doctors, nurses, technicians).
- Conduct continuous in-service training for healthcare professionals on the safe operation, daily testing, and basic troubleshooting of complex medical devices.

Required Skills and Competencies

- Strong foundation in human anatomy/physiology and how biological signals interface with electronic sensors.
- Proficiency in reading schematic diagrams, clinical networking (HL7/DICOM), and operating diagnostic test analyzers.
- Ability to work under immense pressure in critical, life-or-death hospital environments.
- Strict adherence to ethical standards, patient privacy, and hospital infection control protocols.



1.4 Admissions and Academic Regulations

To ensure that this Diploma in Medical Equipment Technology programme remains accessible while maintaining the rigorous academic standards required for the healthcare sector, the admissions process and academic evaluations are strictly governed by the guidelines set forth by the All-India Council for Technical Education (AICTE) and the respective State Directorate of Technical Education (DTE).

1.4.1 Eligibility Criteria for Admission

Admission to the First Year of the 2.5-Year Diploma in Medical Equipment Technology is based on higher secondary school academic performance.

- **Basic Academic Qualification:** Candidates must have successfully passed the **12th Standard (Higher Secondary School Certificate - HSC)** examination or its equivalent from a recognized State or Central Board of Education (e.g., CBSE, ICSE, or State Boards).
- **Mandatory Subjects:** The candidate must have passed with Physics, Chemistry, Mathematics or Physics, Chemistry, Biology as mandatory subjects in their 12th-standard curriculum.
- **Minimum Qualifying Marks:** Candidates belonging to the General/Open category must have secured a minimum aggregate of **35% marks** in the qualifying examination.

1.4.2 Seat Reservation Policy

As per the state's reservation policy

1.4.3 Minimum Passing Marks and Academic Progression Criterion

Given that graduates of this program will be servicing life-critical medical equipment, the academic evaluation standard is rigorous. The grading methodology splits assessment into Continuous Internal Evaluation (Sessional) and End-Semester State Board Examinations.

To successfully clear a subject and the semester, students must meet the following minimum passing criteria:

- **Theory Examinations:** A student must secure a minimum of **40% marks** separately in end-semester written examination.
- **Practical/Laboratory Examinations:** A student must secure a minimum of **40% marks** separately in final practical examination and viva-voce.
- **Internal Sessional Assessment:** Sessional marks (derived separately from mid-term tests, assignments, and logbook maintenance) also require a minimum **40% threshold** separately to reflect consistent academic effort throughout the semester.

- **Project:** A student must secure a minimum of **75% marks** in final project examination and viva-voce.
- **Internship:** A student must secure a minimum of **75% marks** in final professional examination and viva-voce.

Note: A student must clear the theory, practical, and internal assessments **independently**. For instance, failing to secure 40% in the practical lab exam—even if the student scores 90% in the theory exam—results in failure for that specific course.

1.4.4 Evaluation Methodology

Here is the comprehensive grading methodology and the specific evaluation rubrics for the advanced subjects with a focus on **Competency-Based Practical Assessment**.

The Overall Grading Methodology

To produce field-ready engineers, the final grade for these courses should favor hands-on execution and continuous assessment. Following are five types of assessment templates and would be appropriately applicable to respective courses based on their L/T/P distribution.

Type A – Theory + Practical

- Internal Theory – 15%
- End-semester Theory – 25%
- Continuous Practical – 20%
- End-semester Practical – 40%

Type B – Theory + Tutorial

- Internal written / Problem solving – 20%
- End-semester Examination – 40%
- Tutorial/Case based Assessment – 20%
- Assignment / Presentation – 20%

Type C – Theory only

- Continuous Assessment – 40%
- End-semester examination – 60%

Type D – Project: 50% Internal + 50% External Assessment (Final Presentation + Viva-voce)

Type E – Internship: 50% Hospital Preceptor + 50 % University Faculty (Final Presentation + Viva-voce)

1.4.5 Intake of Students:

Minimum number of students = 20; Maximum number of students = 40

1.4.6 Institutional Infrastructural Requirements

Sl. No.	Facilities	Area required in sq ft per unit (except Sl.No. 9) (minimum desirable)
A	ACADEMIC BLOCK	
1	Department Offices	As per requirement
2	Administrative Office	As per requirement
3	Dean/Principal	300
4	Professor's Office	200
5	Associate Professor's Office	100
6	Assistant Professor's Office / Demonstrator	50
7	Common Room for Staff	500
8	Room For Visiting Faculty	Desirable
9	Seminar Room / Mini Auditorium / Multipurpose Hall	1000
10	Conference Room	Desirable
11	Classrooms With Lcd Projector / Smart Classrooms	12 sq. ft per student intake per year
12	Students Common Room (Girls)	08–10 sq ft per student intake per year
13	Students Common Room (Boys)	08–10 sq ft per student intake per year
14	Library With Reading Room	As per requirement

Furthermore, the institutions offering Diploma courses in engineering are regulated by All Indian Council for Technical Education (AICTE), which outlines the infrastructural for these Institutions in **“APPENDIX-4: Norms for Land and Built-up Area Requirements of the Technical Institutions”**

(<https://www.aicte.gov.in/sites/default/files/approval/2023-24/Appendix-4.pdf>).

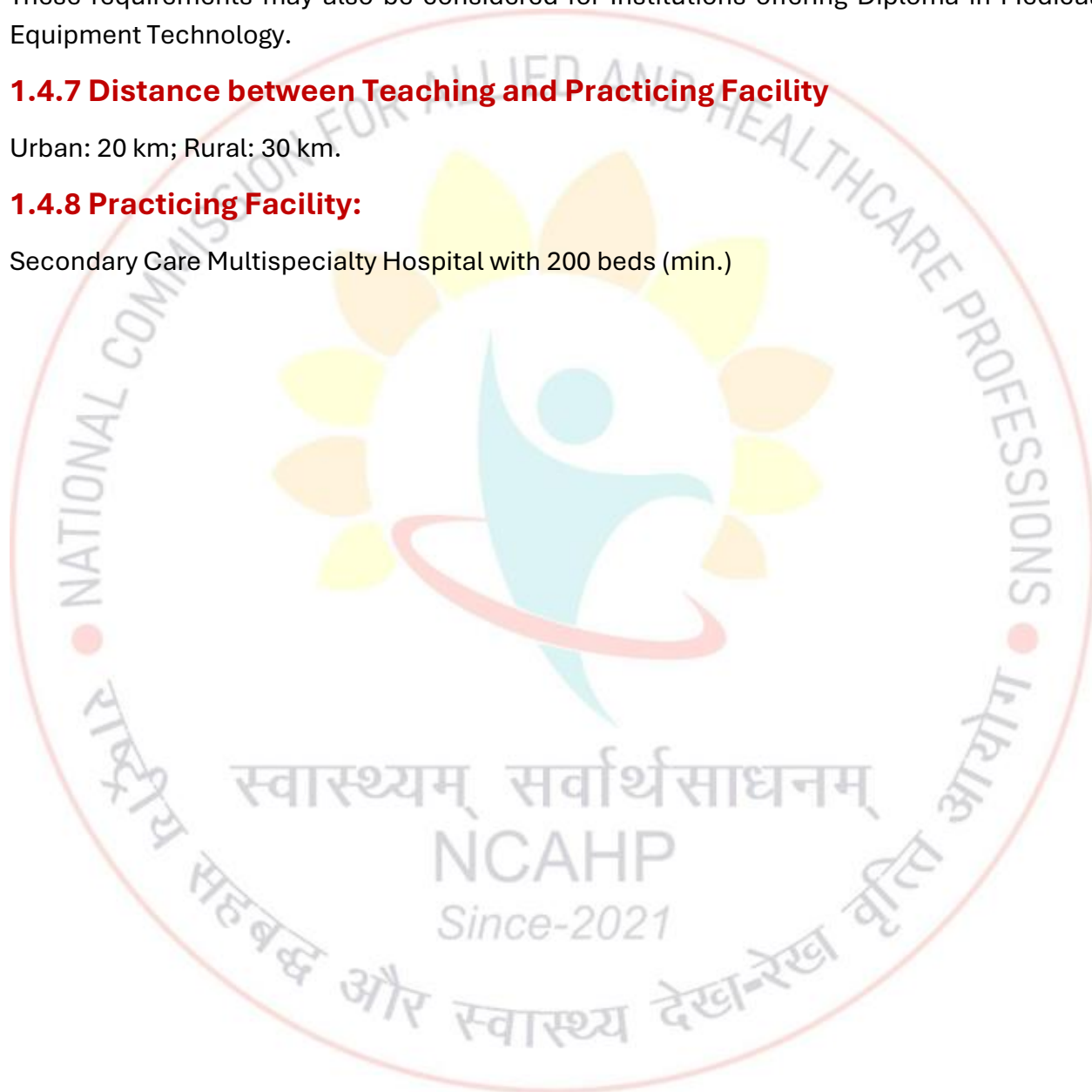
These requirements may also be considered for Institutions offering Diploma in Medical Equipment Technology.

1.4.7 Distance between Teaching and Practicing Facility

Urban: 20 km; Rural: 30 km.

1.4.8 Practicing Facility:

Secondary Care Multispecialty Hospital with 200 beds (min.)



1.5 Methodology and Basis of Curriculum Development

1.5.1 Statement of Original Synthesis

This curriculum is originally authored academic architecture. It was not reproduced or duplicated from any single proprietary university syllabus, textbook, or copyrighted institutional framework. Instead, it was developed through the systematic synthesis of contemporary clinical engineering demands, public-domain industrial protocols, and globally recognized healthcare technology standards. The structural flow, laboratory experiment designs, and evaluation rubrics were custom-engineered to address the evolving, high-stakes requirements of modern hospital environments.

1.5.2 Pedagogical Framework and Academic Alignment

The overarching structure of this 4-semester curriculum plus 6 months of internship was designed to provide progression from foundational applied sciences to macro-systems engineering and formal clinical apprenticeship, which reflects the competency frameworks promoted by major technical and allied healthcare accreditation bodies. Specific structural elements were informed by:

- **AICTE (All India Council for Technical Education) & Equivalent Global Engineering Boards:** Utilizing their mandates for progressive technical education, ensuring a rigorous balance between theoretical instruction and heavy practical laboratory hours.
- **NCAHP (National Commission for Allied and Healthcare Professions) & Clinical Competency Models:** Adopting their guidelines to ensure graduates possess the multidisciplinary adaptability, clinical hygiene, and patient-safety awareness required of modern allied healthcare workers.

1.5.3 Synthesis of Clinical and Industrial Standards

The selection of advanced subject matter—including Hospital Facility Management, and Healthcare IT—was derived directly from the operational realities of modern hospitals. The curriculum bridges the gap between traditional electronics repair and comprehensive health technology management by integrating the statutory frameworks of:

- **WHO (World Health Organization):** Utilizing frameworks such as the *Global Model Regulatory Framework for Medical Devices*, *Medical Device Procurement Guidelines*, and the *Blue Book* on biomedical waste management.

- **FDA CDRH & CDSCO:** Incorporating international and regional design controls, premarket notification standards, and medical device cybersecurity mandates.
- **AERB (Atomic Energy Regulatory Board) & NABH (National Accreditation Board for Hospitals):** Embedding statutory radiation safety codes and hospital quality assurance/infrastructure metrics directly into the academic grading rubrics.

1.5.4 Sourcing of Practical Experiments and Metrology

The 14-experiment structures within each module are designed by translating standard industry Preventive Maintenance (PM) schedules, Root Cause Analysis (RCA) protocols, and clinical triaging scenarios into a graded academic environment. The laboratory setups mimic the metrology standards (using patient simulators, mixed-signal oscilloscopes, and environmental manometers) dictated by Original Equipment Manufacturer (OEM) service guidelines and clinical engineering best practices.

1.5.5 Curated Learning Resources

To ensure the curriculum remains globally relevant and accessible, the recommended literature and reference materials rely exclusively on recognized, open-source, and peer-reviewed platforms. These include:

- **Government & Health Authority Guidelines:** Such as the UK NHS Health Technical Memorandums (e.g., HTM 02-01 for medical gases) and CDC/ASHRAE infection control metrics.
- **Open-Access Academic Platforms:** Leveraging specialized modules from NPTEL/Swayam, Coursera, and the Stanford Byers Center for Biodesign.
- **Industry & Advocacy Repositories:** Utilizing ethical and forensic databases such as the Online Ethics Center (OEC), the MITRE ATT&CK® framework for healthcare IT, and the American College of Clinical Engineering (ACCE) Code of Ethics.

1.6 List of Course Titles and Credits Table (Lecture, Tutorial & Practical):

The total number of hours are for 14 week teaching semester and the credit conversion table is as below

- Lectures (L): 1 hour per week= 1 Credit
- Tutorials (T): 1 hour per week= 1 Credit
- Practical / Lab (P): 1 hour per week = 0.5 Credits

Each Semester shall comprise of 14 instructional weeks, 2 examination weeks and other academic activities as prescribed by the academic calendar.

Semester 1

Code	Subject	L	T	P	Credit	Hours
DMET 101	Basic Electrical Engineering	3	0	2	4	70
DMET 102	Human Anatomy & Physiology I	3	0	4	5	98
DMET 103	Basic Electronics & Devices	3	0	2	4	70
DMET 104	Sensors & Transducers	3	0	2	4	70
DMET 105	Intro to Healthcare IT and Artificial Intelligence in Medicine	3	2	0	5	70
DMET 106	Eng. Workshop & Drawing	0	2	4	4	84
Total					26	462

Semester 2

Code	Subject	L	T	P	Credit	Hours
DMET 107	Human Anatomy & Physiology II	3	0	4	5	98
DMET 108	Diagnostic Equipment I (Vitals/NIBP)	3	0	4	5	98
DMET 109	Digital Logic Design	3	0	2	4	70
DMET 110	Microprocessors & Controllers	3	0	2	4	70
DMET 111	Power Electronics for Medical Equipment	3	0	2	4	70
DMET 112	Technical Communication and Professional Ethics	2	0	0	2	28
Total					26	434

Semester 3

Code	Subject	L	T	P	Credit	Hours
DMET 201	Diagnostic Equip. II (ECG/EEG)	3	0	4	5	98
DMET 202	Medical Imaging Systems	3	0	4	5	98
DMET 203	Respiratory & Therapeutic Tech	3	0	4	5	98
DMET 204	Analytical & Lab Instruments	3	0	2	4	70
DMET 205	Surgical & Critical Care Equip	2	0	4	4	84
DMET 206	Optical & Laser Systems	3	0	2	4	70
Total					27	518

Semester 4

Code	Subject	L	T	P	Credit	Hours
DMET 207	Clinical Eng. Asset Management	2	1	2	4	70
DMET 208	Hospital Facility Management	2	1	2	4	70
DMET 209	Hospital Safety & Standards	2	1	2	4	70
DMET 210	Regulatory & Quality Assurance	2	1	0	3	42
DMET 211	Advanced Diagnostics & Repair	2	0	2	3	56
DMET 212	Project	0	0	12	6	168
Total					24	476

Semester 5

Hospital Internship – 24 credits

Hospital Internship duration: 24 weeks; 40 hours /week; Total duration = 960 hours

Total Credits: 103 + 24= 127

Total Course Duration 2.5 years (462+434+518+476+960 = 2850)

1.7 Course-wise Learning Outcomes

Year 1: Semester 1 (Foundation in Basic Electrical, Electronics, Devices, Sensors, Transducers, IT Basics, Human Anatomy & Physiology)

DMET 101: Basic Electrical Engineering

- Analyze DC circuits using network theorems to troubleshoot medical device motherboards at the component level.
- Evaluate AC fundamentals and resonance to understand hospital mains power and bio-impedance measurements.
- Explain the operation of transformers and motors used in medical isolation systems and surgical drills.
- Implement strict electrical safety and grounding protocols to prevent patient macroshock and microshock in the ICU.
- Operate basic measuring instruments like digital multimeters and oscilloscopes for medical equipment calibration and repair.

DMET 102: Human Anatomy & Physiology I

- Describe cell biology and tissue classification to understand biocompatibility and pathology equipment requirements.
- Identify the structures of the skeletal system to interpret orthopaedic X-rays and support surgical power tool usage.
- Explain muscular system mechanics and electrical signal generation essential for Electromyography (EMG) monitoring.
- Analyze blood composition and coagulation mechanisms required for maintaining hemodialysis machines and cell counters.
- Detail the cardiovascular system's anatomy and electrical conduction to understand ECGs, pacemakers, and defibrillators.

DMET 103: Basic Electronics & Devices

- Explain semiconductor physics as the foundation for medical solid-state electronics, from simple probes to digital detectors.
- Analyze diode characteristics and rectifier circuits to troubleshoot medical AC-to-DC power supplies and voltage regulation.
- Evaluate Bipolar Junction Transistors (BJTs) to diagnose low-level signal amplification and electronic switching mechanisms.

- Utilize Field Effect Transistors (FETs) to repair Switched Mode Power Supplies (SMPS) and handle weak bio-signals.
- Apply operational amplifiers (Op-Amps) to design and troubleshoot biomedical instrumentation amplifiers for microvolt ECG/EEG signals.

DMET 104: Sensors & Transducers

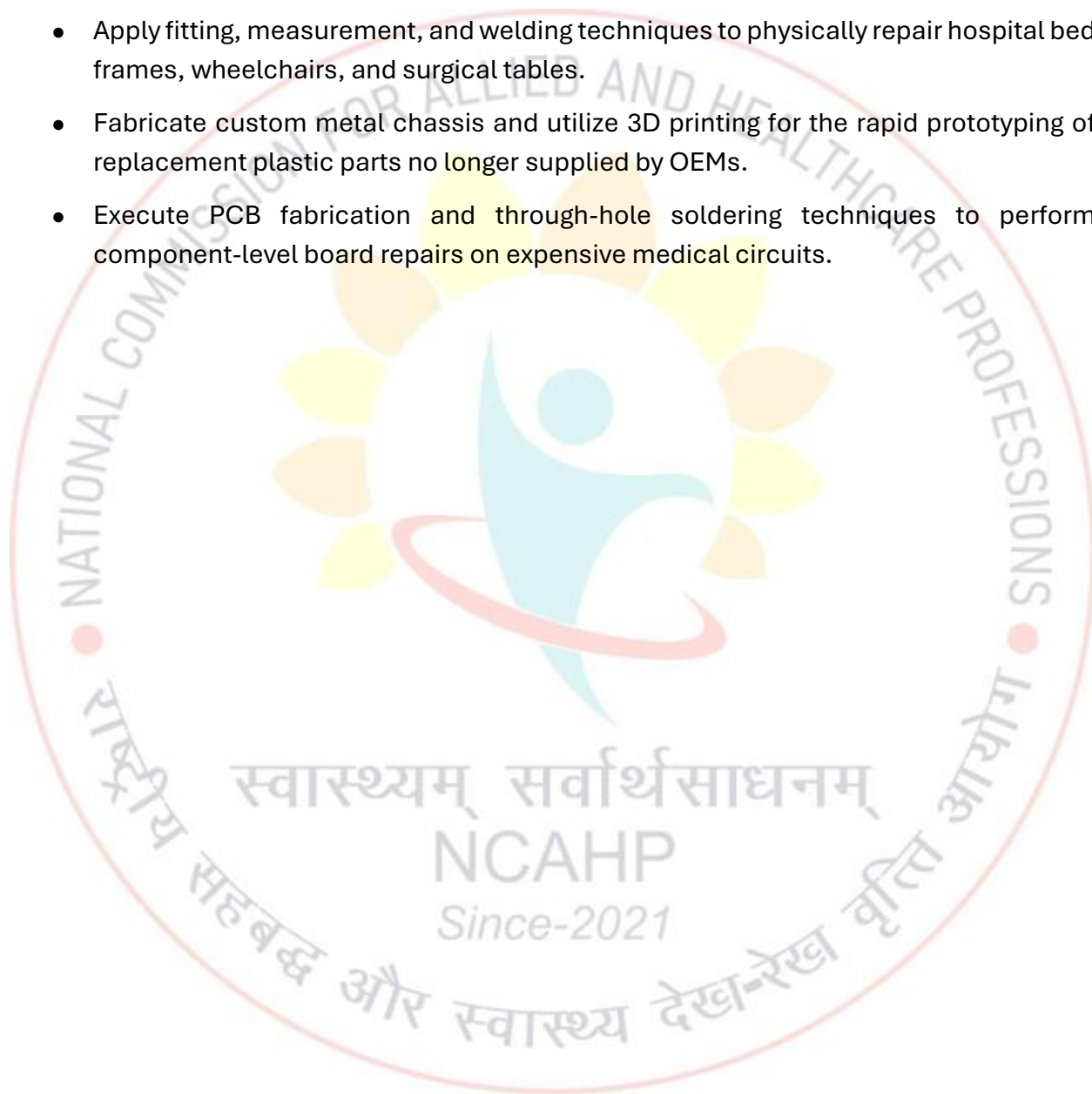
- Classify transducer characteristics to select appropriate medical sensors and accurately read calibration curves.
- Apply resistive and capacitive transducers in applications like hospital bed load cells and neonatal skin temperature probes.
- Explain the operation of piezoelectric and photoelectric sensors for use in diagnostic ultrasound probes and pulse oximetry.
- Analyze biopotential electrode interfaces to accurately acquire electrical signals like ECG, EEG, and EMG from the human body safely.
- Evaluate biochemical sensors to understand the operational foundation of Arterial Blood Gas (ABG) analyzers and capnography equipment.

DMET 105: Intro to Healthcare IT and Artificial Intelligence in Medicine

- Configure and secure local area networks (LAN/WLAN) for wireless patient telemetry and Central Nursing Station (CNS) hubs.
- Analyze Hospital Information Systems (HIS) to understand inter-departmental workflows and laboratory analyzer data integrations.
- Integrate bedside vital sign monitors with Electronic Medical Records (EMR) while maintaining role-based access controls and patient privacy.
- Manage Relational Database Management Systems (RDBMS) to audit clinical engineering CMMS tracking software and equipment repair histories.
- Implement HL7 and DICOM standards to successfully integrate diagnostic imaging scanners with hospital PACS servers.
- Setup coding environments using Python and SciKit-Learn to analyze and plot hospital equipment breakdown histories.
- Apply supervised and unsupervised machine learning algorithms to classify patient vital signs as normal or deteriorating.
- Evaluate the ethical responsibilities of auditing medical AI systems for algorithmic bias and compliance with Software as a Medical Device (SaMD) regulation.

DMET 106: Eng. Workshop & Drawing

- Interpret 2D orthographic projections to read complex mechanical service manuals and exploded-view diagrams of medical devices.
- Utilize CAD software to create isometric sketches and design custom mounting solutions for hospital equipment.
- Apply fitting, measurement, and welding techniques to physically repair hospital bed frames, wheelchairs, and surgical tables.
- Fabricate custom metal chassis and utilize 3D printing for the rapid prototyping of replacement plastic parts no longer supplied by OEMs.
- Execute PCB fabrication and through-hole soldering techniques to perform component-level board repairs on expensive medical circuits.



Year 1: Semester 2 (Digital Electronics, Microprocessors, Power Electronics, Diagnostic Devices, Medical Ethics)

DMET 107: Human Anatomy & Physiology II

- Explain respiratory mechanics and gas exchange to understand and service mechanical ventilators and capnography monitors.
- Detail nervous system anatomy and action potentials to support EEG, EMG, and neuromonitoring equipment.
- Describe digestive system physiology to maintain gastroenterology endoscopy tools and enteral feeding pumps.
- Outline excretory system functions and fluid balance to understand Hemodialysis machines and continuous renal replacement therapies.
- Identify endocrine and reproductive system functions to support infant incubators, fetal monitors, and IVF laboratory equipment.

DMET 108: Diagnostic Equip. I (Vitals/NIBP)

- Calibrate clinical thermometry devices, including IR tympanic thermometers and infant radiant warmer temperature probes.
- Explain the hemodynamics and physical mechanics of manual sphygmomanometers to calibrate and repair universally used triage blood pressure devices.
- Troubleshoot and repair the pneumatic components, micro-pumps, and proportional valves of automated Oscillo metric NIBP monitors.
- Diagnose faulty SpO₂ pulse oximetry probes and verify readings using functional analyzers based on Photoplethysmography (PPG).
- Execute preventive maintenance on ward diagnostic equipment using patient simulators and document tolerances against OEM service manuals.

DMET 109: Digital Logic Design

- Apply number systems and Boolean algebra to understand how patient data is encoded and how machine-level error codes are generated.
- Analyze logic gates and combinational circuits to troubleshoot hardware interlocks on medical device motherboards.
- Utilize multiplexers and decoders to understand how multi-parameter monitors route multiple sensor inputs to a main processor.

- Explain sequential circuits like flip-flops and counters to diagnose memory storage registers and precise timing circuits in infusion pumps.
- Evaluate A/D and D/A converters to digitize analog bio-signals for processing by computer arrays and display on LCD monitors.

DMET 110: Microprocessors & Controllers

- Describe 8085 microprocessor architecture to understand legacy computing logic in highly robust hospital laboratory equipment.
- Explain 8051 microcontroller basics to service single-function medical devices like digital thermometers and basic syringe pumps.
- Utilize the Arduino architecture and IDE to rapidly prototype customized clinical engineering solutions, such as OPD queue systems.
- Interface analog and digital physiological sensors with microcontrollers using ADC, I2C, and SPI communication protocols.
- Program microcontroller I/O to drive clinical alarms, control pump motors via PWM, and display patient vitals on LCDs.

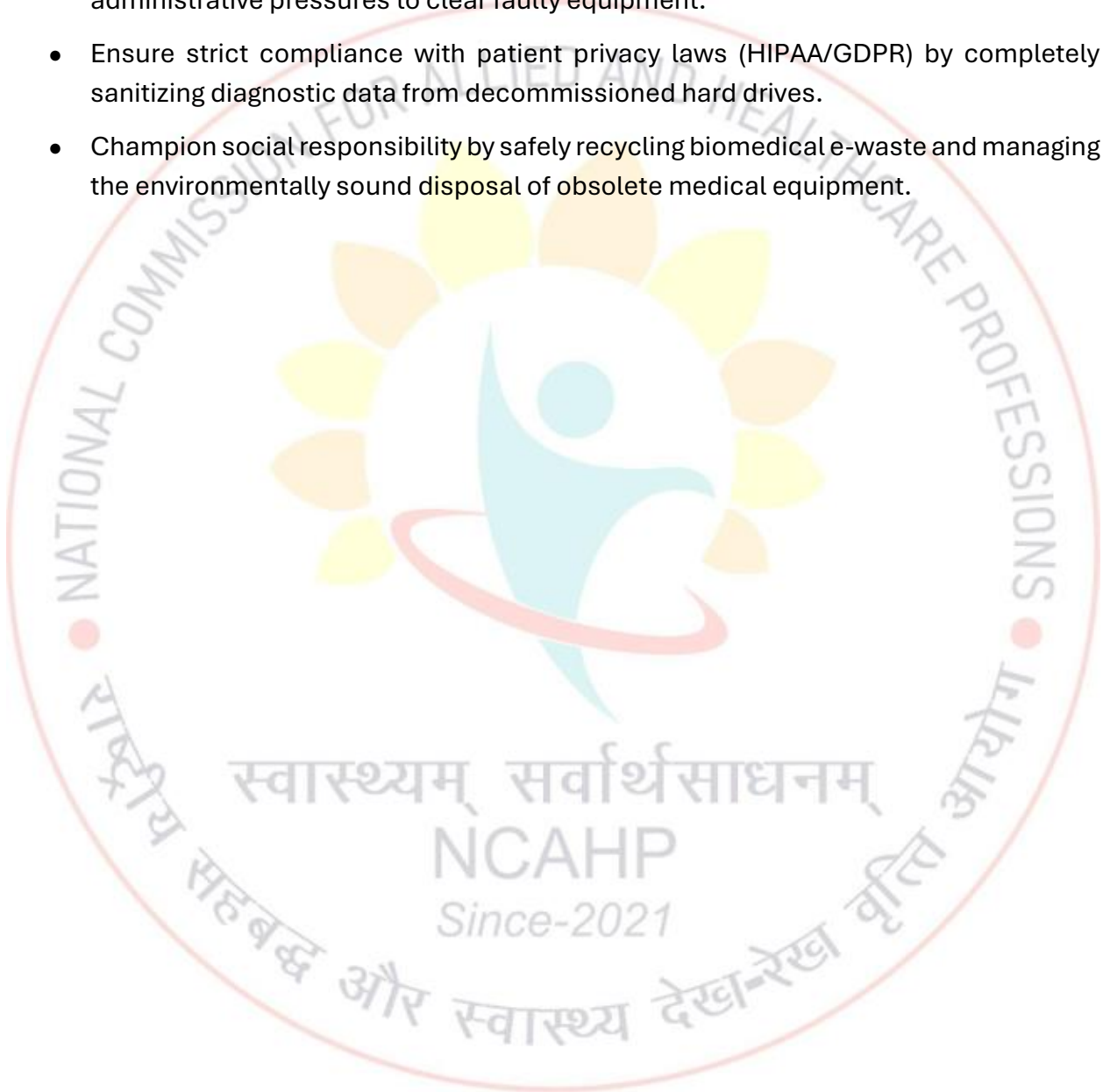
DMET 111: Power Electronics for Medical Equipments

- Troubleshoot high-voltage power drive boards incorporating SCRs, IGBTs, and Power MOSFETs in heavy medical machinery like X-ray generators.
- Repair DC-DC converters and DC-AC inverters in battery-operated portable medical devices and transport ventilators.
- Perform component-level repair on Switched Mode Power Supplies (SMPS) in patient monitors affected by hospital power surges.
- Maintain critical Uninterruptible Power Supplies (UPS) architectures and test battery chemistries to guarantee backup power for ICU life-support.
- Audit the electrical safety of Operation Theatre isolated power systems and Line Isolation Monitors to prevent patient macroshock.

DMET 112: Technical Communication and Professional Ethics

- Apply correct grammar and technical vocabulary to clearly document equipment faults and write precise instructions.
- Draft professional emails and official correspondence to manage vendor service contracts and order spare parts from OEMs.
- Structure and write legally compliant technical reports, root cause analyses, and preventive maintenance records.

- Deliver effective presentations to conduct in-service training for clinical staff on the safe operation of new medical devices.
- Demonstrate professional hospital etiquette and conflict resolution while maintaining patient confidentiality in high-stress clinical environments.
- Uphold the clinical engineer's code of ethics by prioritizing patient safety over administrative pressures to clear faulty equipment.
- Ensure strict compliance with patient privacy laws (HIPAA/GDPR) by completely sanitizing diagnostic data from decommissioned hard drives.
- Champion social responsibility by safely recycling biomedical e-waste and managing the environmentally sound disposal of obsolete medical equipment.



Year 2: Semester 3 (Core Medical Modalities and Devices)

DMET 201: Diagnostic Equip. II (ECG/EEG)

- Explain the 12-lead ECG system and machine block diagrams to calibrate and repair standalone ECG and multi-parameter monitors.
- Troubleshoot common ECG artifacts, including somatic tremor and 50/60Hz interference, and correct grounding or patient cable faults.
- Maintain EEG systems and high-gain amplifiers used in neurology and intraoperative neuromonitoring during brain surgeries.
- Service Electromyography (EMG) diagnostic tools for physiotherapy by applying knowledge of motor unit action potentials.
- Test external pacemakers and the pacing functions of defibrillators utilizing specialized pacemaker analyzing equipment.

DMET 202: Medical Imaging Systems

- Perform Quality Assurance (QA) testing for kVp/mAs accuracy and interpret X-ray tube error codes based on bremsstrahlung radiation physics.
- Maintain the mechanical integrity of CT scanner gantries, slip-rings, and cooling chillers necessary for multi-slice tomography.
- Monitor MRI cryogenic helium levels and test the integrity of RF Faraday cages to prevent imaging artifacts.
- Test diagnostic ultrasound transducers for dead crystals using tissue-mimicking phantoms and perform cart preventive maintenance.
- Adhere to strict radiation safety, handling, and calibration protocols when servicing nuclear medicine PET/SPECT gamma cameras.

DMET 203: Respiratory & Therapeutic Tech

- Analyze respiratory mechanics and gas laws to safely configure mechanical ventilator pressure limits for diseased lungs.
- Calibrate spirometers and pulmonary function testing equipment using standard volume calibration syringes.
- Troubleshoot false apnea alarms on multi-parameter monitors caused by artifacts in high-frequency impedance pneumography.

- Perform preventive maintenance on ICU ventilators utilizing gas flow analyzers to verify tidal volume and pressure control modes.
- Execute mandatory daily and weekly high/low-pressure leak tests on anesthesia workstations to ensure Operation Theatre safety.

DMET 204: Analytical & Lab Instruments

- Maintain clinical centrifuges and incubators by verifying RPM, testing lid-interlocks, and mapping PID temperature stability.
- Calibrate colorimeters and spectrophotometers to ensure accurate optical density readings for blood biochemical concentrations.
- Troubleshoot automated fluidics, peristaltic pumps, and robotic sample arms in high-throughput biochemistry auto-analyzers.
- Maintain hematology cell counters by clearing micro-aperture clogs and running daily quality control calibration fluids.
- Ensure the strict cold chain for blood products by repairing refrigeration compressors and testing digital temperature backup alarms.

DMET 205: Surgical & Critical Care Equip

- Test electrosurgical unit power outputs and Return Electrode Monitoring (REM) safety circuits using an ESU Analyzer to prevent patient burns.
- Perform daily shift-checks and verify the delivered energy (Joules) of biphasic defibrillators using specialized defibrillator analyzers.
- Calibrate hemodialysis machine dialysate conductivity and temperature sensors, and troubleshoot complex hydraulic blocks and valves.
- Calibrate infusion pump flow rates and test occlusion pressure alarms using volumetric flow analyzers to ensure safe drug delivery.
- Map spatial temperature stability and verify critical over-temperature safety cut-offs on infant incubators and radiant warmers.

DMET 206: Optical & Laser Systems

- Test endoscope fiber-optic cables for attenuation and replace specialized cold light sources using optical power meters.
- Differentiate the tissue penetration and clinical applications of CO₂, Nd:YAG, Excimer, and Holmium medical lasers.
- Align therapeutic laser beams and calibrate output wattage using thermal power meters on surgical laser delivery systems.

- Perform mandatory pneumatic leak-tests on flexible endoscopes and troubleshoot camera interference in laparoscopy systems.
- Audit Operation Theatres for laser safety compliance, checking door interlocks, safety eyewear, and surgical smoke evacuator functionality.



Year 2: Semester 4 (Core Hospital Facilities & Management, Quality & Safety standards)

DMET 207: Clinical Engineering and Asset Management

- Navigate the clinical engineering department structure to prioritize equipment breakdown calls based on clinical acuity.
- Manage Computerized Maintenance Management Systems (CMMS) to track repair histories, calculate KPIs, and ensure regulatory compliance.
- Translate OEM service manuals into risk-based preventive maintenance schedules for high-risk equipment without disrupting workflows.
- Calculate equipment depreciation and draft financially justified condemnation reports to scrap obsolete medical devices.
- Optimize inventory and spare parts management to prevent ICU downtime and oversee Annual/Comprehensive Maintenance Contracts (AMC/CMC).

DMET 208: Hospital Facility Management

- Inspect Medical Gas Pipeline Systems (MGPS) manifolds, medical air compressors, and test high/low-pressure audio-visual alarms.
- Utilize differential pressure manometers to verify positive-pressure air cascades and HEPA filtration in sterile Operation Theatres.
- Monitor Total Dissolved Solids (TDS) and pH levels in Reverse Osmosis (RO) water plants designated for hemodialysis machines.
- Supervise the safe segregation and disposal of biohazardous waste, sharps, and electronic waste from the clinical engineering department.
- Coordinate backup power "black start" tests and load-bank testing on Diesel Generators and central UPS systems to guarantee ICU continuity.

DMET 209: Hospital Safety & Standards

- Evaluate the physiological risks of macroshock and microshock to justify stringent isolation in patient-connected devices.
- Perform electrical safety testing according to IEC 60601 standards to ensure earth leakage currents are within legal limits.
- Apply strict infection control and biohazardous waste protocols when decontaminating returned medical equipment for repair.
- Implement fire safety protocols and safe electrical setups in oxygen-enriched environments like the Operation Theatre to prevent sparks.

- Adhere to the ALARA principle and ergonomic lifting guidelines to protect staff health during radiation and heavy equipment maintenance.

DMET 210: Regulatory & Quality Assurance

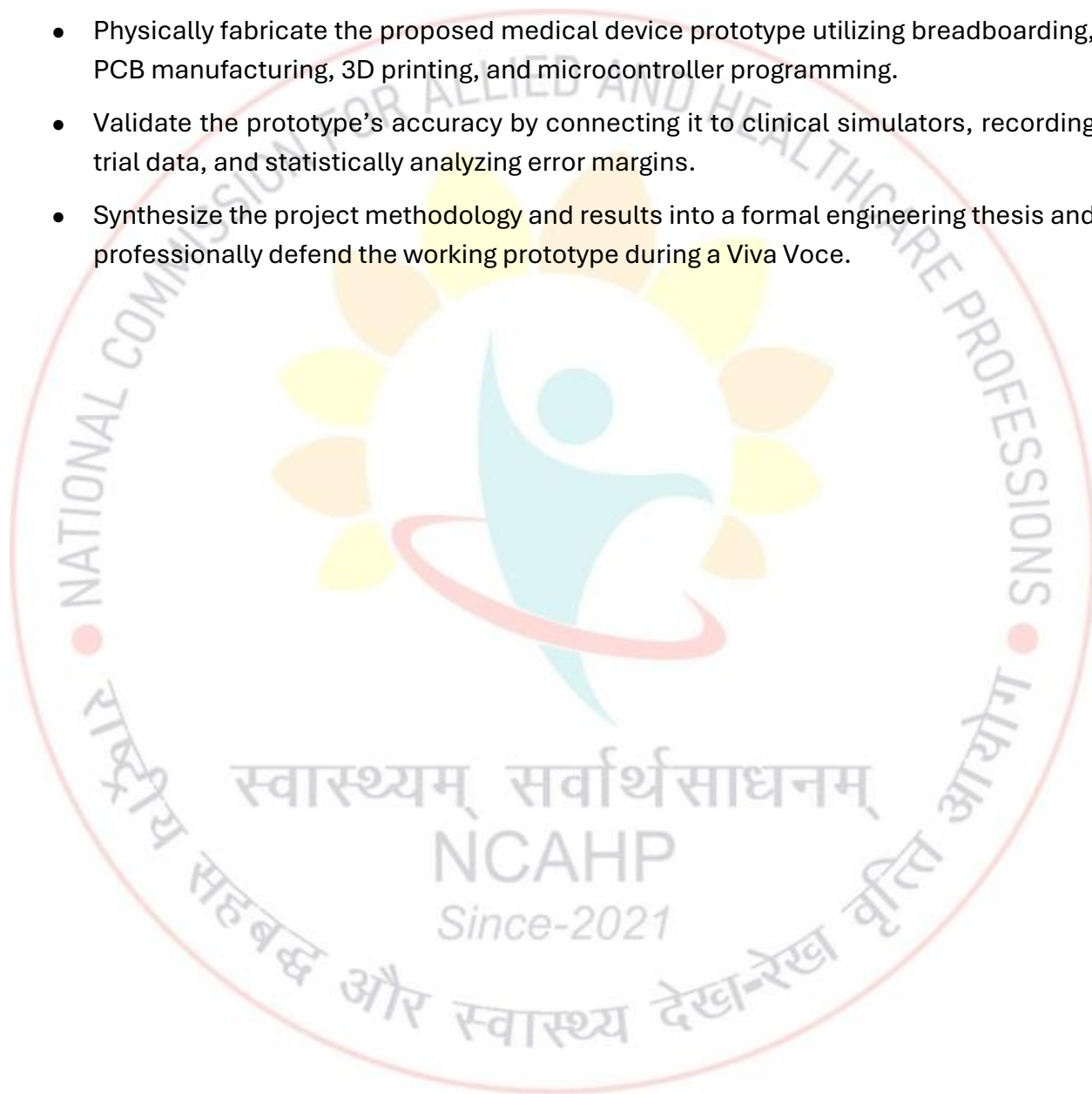
- Navigate global regulatory databases (FDA, CE) to correctly classify medical devices and verify their legal approval for clinical use.
- Write rigorous ISO 13485-compliant Standard Operating Procedures (SOPs) for the repair and calibration of hospital equipment.
- Lead technical hospital accreditation audits by presenting compliant PM logs, calibration certificates, and safety records to NABH auditors.
- Perform bi-annual QA tests on radiation equipment and manage layout approvals via the AERB e-LORA portal.
- Execute hospital-wide equipment recalls, manage safety alerts, and draft formal Corrective and Preventive Action (CAPA) plans.

DMET 211: Advanced Diagnostics & Repair

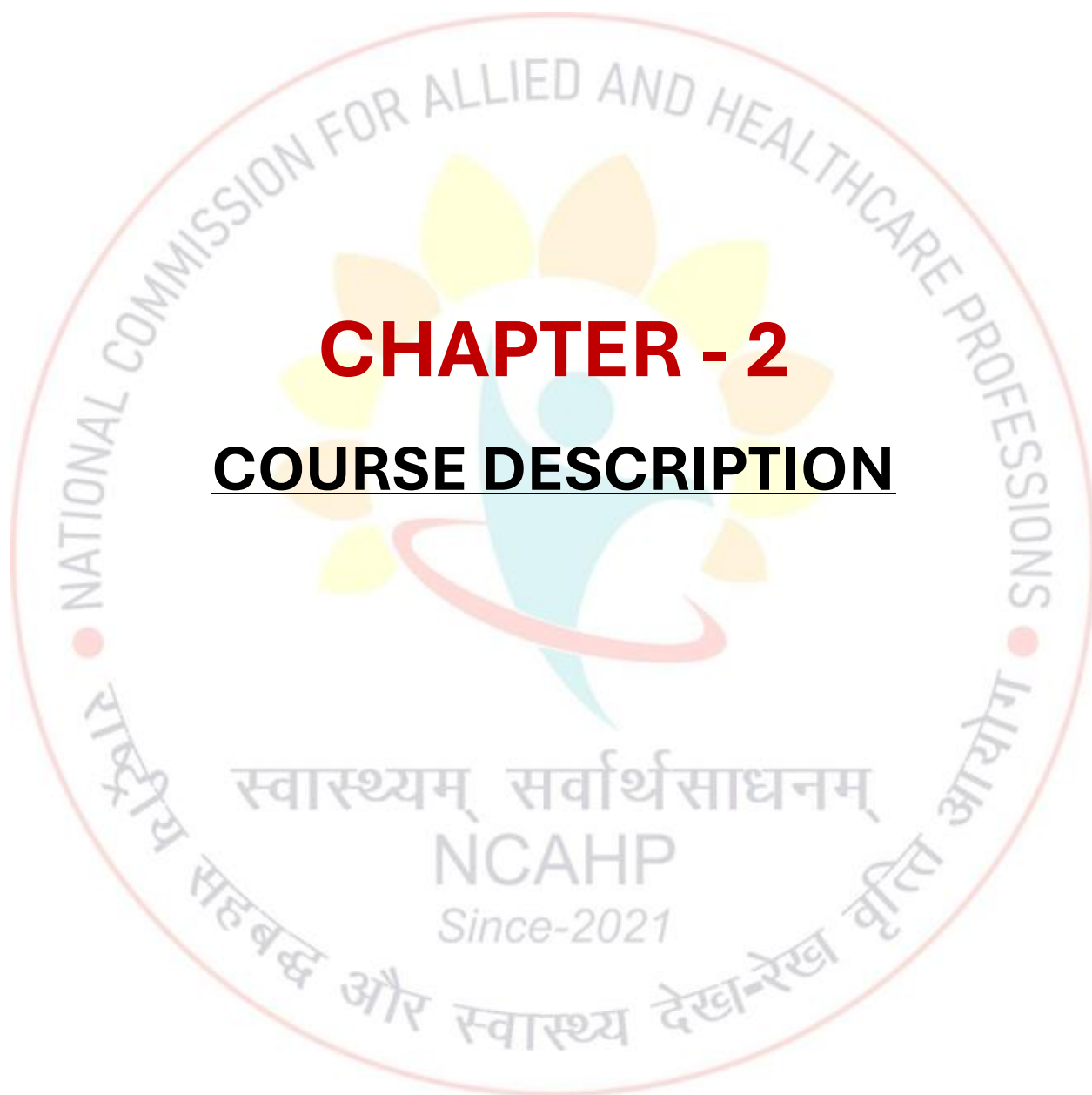
- Diagnose multi-layer PCB faults on expensive medical equipment using OEM schematics to avoid costly total-board replacements.
- Utilize oscilloscopes and spectrum analyzers to decode digital buses and pinpoint dangerous RF leakage or data corruption.
- Execute Surface Mount Technology (SMT) rework under stereomicroscopes to safely replace micro-controllers on high-value medical boards.
- Verify the calibration and legal traceability of multi-parameter patient simulators used daily by biomedical departments.
- Perform formal Root Cause Analysis (RCA) on failed medical devices using Ishikawa diagrams and the "5 Whys" methodology to prevent future occurrences.

DMET 212: Major Project

- Identify clinical pain points through observation and conduct literature reviews to define the scope of a real-world medical engineering solution.
- Draft technical block diagrams, create Bill of Materials (BOM), and present project budgets to defend technical feasibility.
- Physically fabricate the proposed medical device prototype utilizing breadboarding, PCB manufacturing, 3D printing, and microcontroller programming.
- Validate the prototype's accuracy by connecting it to clinical simulators, recording trial data, and statistically analyzing error margins.
- Synthesize the project methodology and results into a formal engineering thesis and professionally defend the working prototype during a Viva Voce.







CHAPTER - 2

COURSE DESCRIPTION

Each course is structured into 5 units, delivered over the 4-month academic semester, ensuring an in-depth, sequential learning process.

2.1 Year 1: Semester 1 (Foundation in Basic Electrical, Electronics, Devices, Sensors, Transducers, IT Basics, Human Anatomy & Physiology)

DMET 101: Basic Electrical Engineering

Objective: To build the foundational knowledge of electrical circuits and safety, which is paramount for any engineer touching hospital equipment.

- **Unit 1: DC Circuits & Network Theorems**

- *Topics:* Voltage, current, resistance, Ohm's law. Series and parallel circuits. Kirchhoff's Voltage and Current Laws (KVL/KCL). Thevenin's, Norton's, and Superposition theorems.
- *Medical Tech Application:* Component-level troubleshooting on medical device motherboards and understanding basic sensor circuits.

- **Unit 2: AC Fundamentals**

- *Topics:* Generation of alternating current, peak, average, and RMS values. Phase angle. R-L-C series and parallel circuits, resonance, and power factor.
- *Medical Tech Application:* Understanding hospital mains power, power conditioning, and the basic principles of electrical bio-impedance measurement.

- **Unit 3: Transformers & Machines**

- *Topics:* Faraday's laws of electromagnetic induction. Principle, construction, and types of transformers (step-up, step-down). Basic principles of DC and AC motors.
- *Medical Tech Application:* Understanding medical-grade isolation transformers used in OTs and the motor drives in infusion pumps and surgical drills.

- **Unit 4: Electrical Safety & Grounding**

- *Topics:* Concepts of electrical shock, macroshock vs. microshock. Leakage currents. Importance of earthing/grounding. Fuses, MCBs, and ELCBs.
- *Medical Tech Application:* Patient safety. Preventing electrocution in the ICU and understanding the basis of IEC 60601 medical electrical safety standards.

- **Unit 5: Measuring Instruments**

- *Topics:* Principles of moving coil and moving iron instruments. Operation of digital multimeters (DMMs), cathode-ray oscilloscopes (CROs), and Function Generators.
- *Medical Tech Application:* Mastery of the primary diagnostic tools used daily by Medical Equipment Technologists to test, calibrate, and repair equipment.

DMET 102: Human Anatomy & Physiology I

Objective: To understand the biological systems that medical equipment monitors, supports, or replaces.

- **Unit 1: Cell Biology & Tissues**

- *Topics:* Structure of the human cell, organelles, cell division. Classification and function of the four primary tissue types: epithelial, connective, muscle, and nervous.
- *Medical Tech Application:* The microscopic basis for pathology lab equipment, tissue processing, and understanding bio-compatibility of materials.

- **Unit 2: Skeletal System**

- *Topics:* Bone structure and formation. Axial and appendicular skeleton. Types of joints, articular cartilage, and synovial fluid.
- *Medical Tech Application:* Reading orthopaedic X-rays/CT scans, and understanding the physical requirements for surgical power tools and prosthetics.

- **Unit 3: Muscular System**

- *Topics:* Types of muscles (skeletal, smooth, cardiac). Microscopic structure of muscle fibers. The sliding filament theory of muscle contraction.
- *Medical Tech Application:* Understanding the generation of electrical signals for Electromyography (EMG) and the design of physical therapy/rehabilitation equipment.

- **Unit 4: Blood & Lymphatic System**

- *Topics:* Composition of blood (plasma, RBCs, WBCs, platelets). Blood grouping (ABO and Rh). Mechanism of blood coagulation. Functions of the lymphatic system.
- *Medical Tech Application:* Essential knowledge for maintaining blood bank refrigerators, hematology cell counters, and hemodialysis machines.

- **Unit 5: Cardiovascular System**

- *Topics:* Anatomy of the heart. The cardiac cycle. The electrical conduction system (SA node, AV node, Purkinje fibers). Blood vessels and systemic/pulmonary circulation.
- *Medical Tech Application:* The absolute foundation for understanding ECG machines, defibrillators, pacemakers, and non-invasive/invasive blood pressure monitors.

DMET 103: Basic Electronics & Devices

Objective: To build the foundational understanding of active electronic components used in signal amplification, switching, and power regulation within medical devices.

- **Unit 1: Semiconductor Physics**

- *Topics:* Intrinsic and extrinsic semiconductors. P-type and N-type doping. Majority and minority charge carriers. Energy band theory.
- *Medical Tech Application:* The basic science behind all solid-state electronics, from simple temperature probes to complex digital flat-panel X-ray detectors.

- **Unit 2: PN Junction Diodes & Rectifiers**

- *Topics:* Diode V-I characteristics (forward/reverse bias). Zener diodes for voltage regulation. LEDs. Half-wave, full-wave, and bridge rectifiers. Capacitor ripple filters.
- *Medical Tech Application:* Understanding the AC-to-DC power supply sections of medical equipment, voltage regulation for sensitive circuit boards, and LED light sources in pulse oximeters.

- **Unit 3: Bipolar Junction Transistors (BJTs)**

- *Topics:* NPN and PNP transistor structures. Operating regions (active, saturation, cutoff). Common Emitter (CE) configuration. Biasing and basic amplification principles.
- *Medical Tech Application:* Troubleshooting low-level signal amplification circuits and basic electronic switching mechanisms (e.g., turning on a relay for a hospital bed motor).

- **Unit 4: Field Effect Transistors (FETs)**

- *Topics:* Construction and characteristics of JFETs and MOSFETs. High input impedance properties. FETs acting as voltage-controlled resistors and fast switches.

- *Medical Tech Application:* Essential for repairing modern medical power supplies (Switched Mode Power Supplies - SMPS) and handling extremely weak bio-signals without loading the circuit.

- **Unit 5: Operational Amplifiers (Op-Amps)**

- *Topics:* Ideal Op-Amp characteristics. Inverting and non-inverting configurations. Voltage followers (buffers), summing amplifiers, integrators, and differentiators.
- *Medical Tech Application:* Op-Amps are the core building blocks of all biomedical instrumentation amplifiers (e.g., AD620) used to cleanly read microvolt ECG, EEG, and EMG signals.

DMET 104: Sensors & Transducers

Objective: To understand how physical and chemical physiological parameters are converted into measurable electrical signals by medical hardware.

- **Unit 1: Classification of Transducers**

- *Topics:* Definition of sensors vs. transducers. Active vs. passive transducers. Analog vs. digital outputs. Key sensor characteristics (sensitivity, linearity, hysteresis, range).
- *Medical Tech Application:* Selecting the appropriate medical sensor for a specific clinical requirement and understanding how to read calibration curves.

- **Unit 2: Resistive & Capacitive Transducers**

- *Topics:* Strain gauges and Wheatstone bridges. Potentiometers. Thermistors and RTDs (Resistance Temperature Detectors). Capacitive displacement sensors.
- *Medical Tech Application:* Using strain gauges in hospital bed load cells, thermistors in neonatal skin temperature probes, and capacitive sensors in IV fluid level detectors.

- **Unit 3: Piezoelectric & Photoelectric Sensors**

- *Topics:* Piezoelectric effect and ultrasonic crystals. LDRs, photodiodes, phototransistors, and photomultiplier tubes.
- *Medical Tech Application:* Piezo-crystals are the core of Ultrasound transducer probes; photoelectric sensors form the basis of Pulse Oximetry (SpO₂) and clinical lab colorimeters.

- **Unit 4: Biopotential Electrodes**

- *Topics:* The electrode-electrolyte interface, half-cell potentials, and polarization. Ag/AgCl surface electrodes, microelectrodes, and needle electrodes.

- *Medical Tech Application:* Understanding the direct physical interface required to acquire electrical signals (ECG, EEG, EMG) from the human body safely and accurately.

- **Unit 5: Biochemical Sensors (pH, pO₂, pCO₂)**

- *Topics:* Principles of ion-selective electrodes. Glass electrodes for pH measurement, the Clark electrode for oxygen, and the Severinghaus electrode for carbon dioxide.
- *Medical Tech Application:* The operational and chemical foundation of Arterial Blood Gas (ABG) analyzers and modern respiratory capnography equipment.

DMET 105: Intro to Healthcare IT and Artificial Intelligence in Medicine

Objective: To bridge the gap between standalone medical devices and hospital-wide information networks, ensuring data integrity, interoperability, and basic cybersecurity, while introducing modern data analytics and machine learning techniques to prepare engineers for the software-driven future of healthcare diagnostics.

- **Unit 1: Fundamentals of Computer Networks & Hospital Information Systems (HIS)**

- **Topics:** LAN, WAN, and WLAN concepts. Network topologies (Star, Ring, Bus). The OSI model, TCP/IP protocols, routers, switches, and MAC/IP addressing. Architecture of HIS. Core modules (Billing, Pharmacy, Radiology, Lab). Inter-departmental data flow and hospital workflows.
- **Medical Tech Application:** *Setting up, troubleshooting, and securing wireless patient telemetry networks and Central Nursing Station (CNS) hubs. Understanding how a device (like an auto-analyzer) receives patient demographics from admissions and sends test results back to the central server.*

- **Unit 2: Electronic Medical Records (EMR/EHR) & Database Management Basics**

- **Topics:** Evolution of EMR vs. EHR. Components of a digital patient record. Patient data privacy basics and role-based access controls. Introduction to Relational Databases (RDBMS). Tables, primary keys, foreign keys. Basic SQL queries (SELECT, INSERT, UPDATE, DELETE).
- **Medical Tech Application:** *Integrating bedside vital sign monitors directly into the EHR to eliminate manual charting errors by nurses and ensure real-time clinical data availability. Managing, querying, and auditing the Clinical Engineering department's CMMS software to track equipment repair histories and spare part inventories.*

- **Unit 3: Healthcare Data Standards (HL7, DICOM)**

- **Topics:** The purpose of *standardization* in healthcare. HL7 message structure (segments, fields) for text data. DICOM standard architecture for medical imaging.
- **Medical Tech Application:** The *essential* knowledge required to integrate an Ultrasound, MRI, or CT scanner with a hospital's PACS (Picture Archiving and Communication System).

- **Unit 4: Intro to AI, Machine Learning & Algorithms**

- **Topics:** Definitions and history of AI in healthcare. Logic-based expert systems vs. modern machine learning. Basic Python and *SciKit-Learn* libraries for data modeling. Classification and regression algorithms (Logistic Regression, Random Forest). Clustering algorithms (K-means). Training data, testing data, and the confusion matrix.
- **Medical Tech Application:** Setting up a basic coding environment to analyze and plot large datasets of hospital equipment breakdown histories. Understanding how an algorithm is trained to look at a patient's vital signs (e.g., heart rate and BP) and classify the data as "Normal" or "Deteriorating."

- **Unit 5: Ethical Considerations of AI in Health**

- **Topics:** Algorithmic bias and skewed *training* data. The "black box" problem in medical diagnostics. Data privacy and FDA regulations on Software as a Medical Device (SaMD).
- **Medical Tech Application:** Understanding the engineer's ethical responsibility to audit AI systems and ensure they do not *produce* biased results across different patient demographics.

DMET 106: Eng. Workshop & Drawing

Objective: To provide hands-on mechanical fabrication skills and spatial reasoning necessary for physical equipment repair and part creation.

- **Unit 1: Orthographic Projections**

- **Topics:** First-angle and third-angle projection methods. Drawing front, top, and side views of 3D objects. Standard dimensioning rules and line types.
- **Medical Tech Application:** Reading and interpreting complex mechanical service manuals and exploded-view diagrams of medical devices.

- **Unit 2: Isometric Projections & CAD Basics**

- *Topics:* Converting 2D orthographic views into 3D isometric sketches. Introduction to Computer-Aided Design (CAD) software interface and basic 2D drawing tools.
- *Medical Tech Application:* Modifying hospital infrastructure plans or designing custom mounting solutions for patient monitors.

- **Unit 3: Fitting & Welding Workshop**

- *Topics:* Proper use of hand tools: files, hacksaws, drills, and taps. Measurement using vernier calipers. Basics of arc and gas welding principles.
- *Medical Tech Application:* Physically repairing damaged hospital bed frames, IV poles, wheelchair chassis, and mechanical linkages in surgical tables.

- **Unit 4: Sheet Metal & 3D Printing**

- *Topics:* Cutting, bending, and riveting sheet metal. Introduction to additive manufacturing, slicing software, and operating a desktop 3D printer.
- *Medical Tech Application:* Fabricating custom metal chassis for prototype electronics or 3D printing replacement plastic knobs/gears that OEMs no longer supply.

- **Unit 5: PCB Fabrication & Soldering**

- *Topics:* Translating a schematic to a board layout. Etching and drilling printed circuit boards (PCBs). Techniques for through-hole soldering and de-soldering.
- *Medical Tech Application:* The foundational skill for component-level repair, allowing technicians to replace blown capacitors or ICs on expensive medical circuit boards.

2.2: Year 1: Semester 2 (Digital Electronics, Microprocessors, Power Electronics, Diagnostic Devices, Medical Ethics)

DMET 107: Human Anatomy & Physiology II

Objective: To understand the complex physiological systems that interact with life-support, diagnostic, and monitoring equipment.

- **Unit 1: Respiratory System**

- *Topics:* Anatomy of the respiratory tract (trachea, bronchi, alveoli). Mechanics of breathing. Lung volumes and capacities (tidal, vital, residual). Mechanism of gas exchange in the lungs.
- *Medical Tech Application:* The absolute physiological foundation for understanding mechanical ICU ventilators, CPAP/BiPAP machines, spirometers, and capnography (EtCO₂) monitors.

- **Unit 2: Nervous System**

- *Topics:* Central (CNS) and Peripheral (PNS) nervous system anatomy. Neuron structure, synapses, and the generation of action potentials. Brain lobes, spinal cord, and reflex arcs.
- *Medical Tech Application:* Forms the basis for EEG (Electroencephalography) monitoring, EMG (Electromyography) machines, neuro-navigation surgical tools, and deep brain stimulators.

- **Unit 3: Digestive System**

- *Topics:* Anatomy of the alimentary canal. Physiology of digestion, enzyme action, and nutrient absorption. The role of accessory organs (liver, pancreas, gallbladder).
- *Medical Tech Application:* Essential clinical knowledge for maintaining gastroenterology endoscopy equipment (gastrosopes, colonoscopes) and enteral feeding pumps.

- **Unit 4: Excretory System**

- *Topics:* Gross anatomy of the kidney. Microscopic structure of the nephron. Mechanisms of urine formation (filtration, reabsorption, secretion). Fluid and electrolyte balance.
- *Medical Tech Application:* The prerequisite biological knowledge required to understand the principles of Hemodialysis machines, CRRT (Continuous Renal Replacement Therapy), and uroflowmeters.

- **Unit 5: Endocrine & Reproductive Systems**

- *Topics:* Major endocrine glands (pituitary, thyroid, adrenal) and hormone regulation. Anatomy of male and female reproductive systems.
- *Medical Tech Application:* Understanding insulin pumps (pancreas), fetal monitors (CTG/NST), infant incubators, and the specialized microscopes and cryo-tanks used in IVF laboratories.

DMET 108: Diagnostic Equipment I (Vitals/NIBP)

Objective: To master the operating principles, calibration, and maintenance of the fundamental equipment used to monitor patient vital signs.

● **Unit 1: Clinical Thermometry**

- *Topics:* Physics of heat measurement. Thermistors vs. RTDs. Infrared (IR) tympanic and non-contact thermometers. Calibration methods using water baths.
- *Medical Tech Application:* Maintaining predictive digital ward thermometers and ensuring the temperature probes on infant radiant warmers are perfectly calibrated.

● **Unit 2: Principles of Sphygmomanometry**

- *Topics:* Hemodynamics of blood pressure. The auscultatory method, Korotkoff sounds, and the mechanics of aneroid and mercury pressure gauges.
- *Medical Tech Application:* The physiological baseline required to understand, calibrate, and repair manual blood pressure devices used universally in triage.

● **Unit 3: Automated NIBP Technologies**

- *Topics:* The oscillometric method of blood pressure measurement. Pneumatic pumps, proportional solenoid valves, pressure transducers, and deflation algorithms.
- *Medical Tech Application:* Troubleshooting pneumatic leaks, replacing micro-pumps, and using NIBP simulators to calibrate multi-parameter patient monitors in the ICU.

● **Unit 4: Pulse Oximetry (SpO₂)**

- *Topics:* The Beer-Lambert law of light absorption. Red and Infrared LED emission, photodiode reception, and the principles of Photoplethysmography (PPG).
- *Medical Tech Application:* Diagnosing faulty SpO₂ finger probes, understanding optical interference (ambient light, nail polish), and verifying readings using an SpO₂ functional analyzer.

● **Unit 5: Equipment Calibration & Testing**

- *Topics:* Metrology basics. Using patient simulators (vital sign generators). Documenting calibration tolerances and reading OEM service manuals.
- *Medical Tech Application:* Executing daily, weekly, and monthly Preventive Maintenance (PM) schedules to ensure all ward diagnostic equipment meets strict clinical accuracy standards.

DMET 109: Digital Logic Design

Objective: To master the digital building blocks that form the microprocessors, memory, and logic circuits inside all modern computerized medical equipment.

● Unit 1: Number Systems & Boolean Algebra

- *Topics:* Binary, octal, and hexadecimal conversions. Binary arithmetic. Boolean theorems, De Morgan's laws, and Karnaugh Maps (K-Maps) for logic simplification.
- *Medical Tech Application:* Understanding how patient data is encoded, stored, and processed at the machine level (e.g., interpreting hexadecimal error codes from a faulty ventilator).

● Unit 2: Logic Gates & Combinational Circuits

- *Topics:* AND, OR, NOT, NAND, NOR, XOR gates. Universal gate properties. Designing Half and Full adders/subtractors.
- *Medical Tech Application:* Tracing physical logic paths on a medical device motherboard to troubleshoot hardware interlocks (e.g., ensuring a surgical laser cannot fire if the door switch logic is open).

● Unit 3: Multiplexers & Decoders

- *Topics:* Multiplexers (MUX) and Demultiplexers (DEMUX). Encoders and Decoders. BCD to 7-segment display decoding.
- *Medical Tech Application:* Understanding how multi-parameter patient monitors route multiple sensor inputs (ECG, SpO2, NIBP) through a single data bus to the main processor.

● Unit 4: Sequential Circuits (Flip-flops, Counters)

- *Topics:* SR, D, JK, and T flip-flops. Shift registers (Serial/Parallel). Asynchronous and synchronous up/down counters.
- *Medical Tech Application:* Memory storage registers on circuit boards and precise timing circuits used to control the stepping motors in volumetric infusion pumps.

- **Unit 5: A/D and D/A Converters**

- *Topics:* The Sampling theorem and aliasing. Successive approximation and flash ADCs. R-2R ladder DACs. Resolution, step size, and quantization error.
- *Medical Tech Application:* The critical bridge for digitizing analog bio-signals (like a continuous ECG wave) so they can be displayed on an LCD monitor or processed by a computer array.

DMET 110: Microprocessors & Controllers

Objective: To transition from basic digital logic to programmable systems, enabling students to understand and prototype the "brains" of modern medical devices.

- **Unit 1: 8085 Microprocessor Architecture**

- *Topics:* ALU, registers, data and address buses. Fetch-execute cycle. Basic assembly language instructions, interrupts, and memory mapping.
- *Medical Tech Application:* Understanding the foundational computing logic and legacy architecture still found in older, highly robust hospital laboratory equipment.

- **Unit 2: 8051 Microcontroller Basics**

- *Topics:* Difference between microprocessors and microcontrollers. 8051 internal architecture, RAM/ROM, timers/counters, and serial communication ports.
- *Medical Tech Application:* The core processing unit for many simple, single-function medical devices like digital thermometers, basic syringe pumps, and motorized hospital beds.

- **Unit 3: Arduino Architecture & IDE**

- *Topics:* ATmega328P microcontroller architecture. Understanding the Arduino IDE, sketch structure (setup/loop), and digital/analog pin mapping.
- *Medical Tech Application:* Rapid prototyping of customized clinical engineering solutions, such as building a custom queue-management system for an OPD.

- **Unit 4: Interfacing Sensors with Arduino**

- *Topics:* Analog-to-Digital Conversion (ADC) resolution. Using analog Read. Communication protocols: I2C and SPI for digital sensors.
- *Medical Tech Application:* Connecting and reading physiological sensors—like thermistors (temperature), load cells (weight), and optical sensors (pulse)—directly into a microcontroller.

- **Unit 5: I/O Programming**

- *Topics:* Digital output, Pulse Width Modulation (PWM), handling switch debouncing, and interfacing relays and LCD displays.
- *Medical Tech Application:* Programming the outputs of a medical device, such as driving a buzzer for a clinical alarm, controlling the speed of a pump motor via PWM, or displaying vitals on an LCD.

DMET 111: Power Electronics for Medical

Objective: To understand the high-power electronic components and systems that drive heavy medical machinery and ensure uninterrupted power.

- **Unit 1: Power Diodes & Thyristors**

- *Topics:* High-power diodes, SCRs (Silicon Controlled Rectifiers), TRIACs, IGBTs, and Power MOSFETs. Switching characteristics and thermal management (heat sinks).
- *Medical Tech Application:* Troubleshooting the high-voltage power drive boards of heavy surgical tables, medical centrifuges, and X-ray generators.

- **Unit 2: Inverters & Converters**

- *Topics:* DC-DC converters (Buck, Boost). DC-AC inverters. Pulse Width Modulation (PWM) techniques for motor control.
- *Medical Tech Application:* Repairing battery-operated portable medical devices, ambulance transport ventilators, and portable X-ray motor drives.

- **Unit 3: Switched Mode Power Supplies (SMPS)**

- *Topics:* Flyback and forward converter topologies. High-frequency transformers, opto-isolators, and EMI (Electromagnetic Interference) filtering.
- *Medical Tech Application:* Performing component-level repair on blown power supplies inside patient monitors, which frequently fail due to hospital power surges.

- **Unit 4: Uninterruptible Power Supplies (UPS)**

- *Topics:* Offline vs. Line-Interactive vs. Online (Double Conversion) UPS topologies. Battery chemistries (VRLA, Li-ion) and transfer times.
- *Medical Tech Application:* Maintaining the massive, critical power backups required to keep ICU life-support and OT lighting running during a total hospital blackout.

- **Unit 5: Medical Grade Isolation Transformers**

- *Topics:* Principle of isolated power systems (IPS). Line Isolation Monitors (LIM). Reducing leakage currents in wet environments.
- *Medical Tech Application:* Auditing the electrical safety of an Operation Theatre's isolated power panel to ensure surgeons and patients are safe from macroshock.

DMET 112: Technical Communication and Professional Ethics

Objective: To develop the professional language skills required to interact with clinical staff, document repairs legally, and deal with corporate vendors, while cultivating the moral framework and legal awareness necessary to navigate the life-and-death responsibilities of clinical engineering.

- **Unit 1: Grammar, Syntax & Professional Code of Ethics**

- **Topics:** Parts of speech, sentence structures, correct usage of tenses, active vs. passive voice. Technical vocabulary building. Integrity, honesty, prioritizing patient safety over hospital profit, and maintaining professional competence.
- **Medical Tech Application:** Ensuring absolute clarity when writing instructions or documenting equipment faults. Refusing to sign off on a faulty anesthesia machine as "ready for use" even if pressured by hospital administration or a senior surgeon to save time.

- **Unit 2: Professional Writing, Emails & Patient Privacy**

- **Topics:** Formatting official emails, drafting memorandums, circulars, and professional letters (inquiry, complaint, quotation requests). Legal frameworks (HIPAA/GDPR), Protected Health Information (PHI), and the engineer's absolute duty of confidentiality.
- **Medical Tech Application:** Communicating effectively with OEMs (Original Equipment Manufacturers) for spare parts, service manuals, and managing vendor service contracts. Ensuring that patient names and diagnostic data are completely wiped (anonymized) from a hard drive before sending a broken ultrasound machine back to the vendor for repairs.

- **Unit 3: Technical Report Writing**

- **Topics:** Structure of a technical report (Abstract, Introduction, Methodology, Results, Conclusion). Drafting incident reports and root cause analyses.
- **Medical Tech Application:** Legally documenting preventive maintenance (PM) records and writing critical breakdown reports after a device failure in the ICU.

- **Unit 4: Presentation Skills**

- **Topics:** Slide design, public speaking techniques, managing audience Q&A, and non-verbal communication (body language).
- **Medical Tech Application:** Conducting effective in-service training sessions for doctors and nurses on how to safely operate newly installed medical devices.

- **Unit 5: Hospital Etiquette, Interpersonal Communication & Social Responsibility**

- **Topics:** Conflict resolution, active listening, bedside manners, and understanding patient privacy/confidentiality. Sustainable engineering, reducing biomedical/e-waste, and designing accessible healthcare solutions for low-resource environments.
- **Medical Tech Application:** Working calmly in high-stress environments (like active Operation Theatres) without disrupting clinical workflows or distressing patients. Championing the safe recycling of hospital lead-acid batteries and ensuring obsolete medical equipment is donated or disposed of in an environmentally sound manner.



2.3 Year 2: Semester 3 (Core Medical Modalities and Devices)

DMET 201: Diagnostic Equipment II (ECG/EEG)

Objective: To understand the acquisition, analysis, and troubleshooting of complex cardiac and neurological diagnostic equipment.

- **Unit 1: Electrocardiography (ECG) Principles**

- *Topics:* Einthoven's triangle, the standard 12-lead system. Block diagram of an ECG machine: pre-amplifiers, isolation amplifiers, and driven-right-leg (DRL) circuits.
- *Medical Tech Application:* The foundational knowledge required to calibrate and repair standalone ECG machines and multi-parameter patient monitors in the ICU.

- **Unit 2: ECG Artifacts & Troubleshooting**

- *Topics:* Types of artifacts: somatic tremor, baseline wander, 50/60Hz AC powerline interference. Faulty lead detection and electrode-skin impedance issues.
- *Medical Tech Application:* Diagnosing noisy ECG traces at the patient's bedside, correcting grounding faults, and replacing broken patient cables.

- **Unit 3: Electroencephalography (EEG) Systems**

- *Topics:* The international 10-20 electrode placement system. Brain wave classifications (Alpha, Beta, Delta, Theta). High-gain, low-noise EEG amplifiers.
- *Medical Tech Application:* Maintaining neurology department equipment and setting up intraoperative neuromonitoring systems during brain surgeries.

- **Unit 4: Electromyography (EMG)**

- *Topics:* Motor unit action potentials (MUAP). Surface vs. needle electrodes. Nerve conduction velocity (NCV) testing principles.
- *Medical Tech Application:* Servicing EMG diagnostic tools used in physiotherapy, rehabilitation clinics, and sports medicine departments.

- **Unit 5: Pacemakers**

- *Topics:* Anatomy of pacing: asynchronous vs. synchronous modes. Internal (implanted) vs. external pacemakers. Pacing leads, thresholds, and energy requirements.
- *Medical Tech Application:* Testing external pacemakers and the transcutaneous pacing functions of defibrillators using specialized pacemaker analyzers.

DMET 202: Medical Imaging Systems

Objective: To master the physics, operation, and maintenance of heavy diagnostic imaging modalities that form the core of a hospital's radiology department.

- **Unit 1: Physics of X-Rays**

- *Topics:* Bremsstrahlung and characteristic radiation. Components of an X-ray tube (rotating anode, cathode filament, stator coils). Heel effect and tube cooling charts.
- *Medical Tech Application:* Understanding how to safely warm up X-ray tubes, interpret error codes related to tube arcing, and perform Quality Assurance (QA) testing for kVp/mAs accuracy.

- **Unit 2: Computed Tomography (CT)**

- *Topics:* Principles of tomography, pitch, and Hounsfield units. Slip-ring technology, multi-slice detector arrays, and basic image reconstruction algorithms.
- *Medical Tech Application:* Maintaining the mechanical integrity of the fast-spinning CT gantry, replacing slip-ring brushes, and monitoring the critical chiller systems that prevent tube overheating.

- **Unit 3: Magnetic Resonance Imaging (MRI)**

- *Topics:* Spin physics, Larmor frequency, and T1/T2 relaxation times. Superconducting magnets, liquid helium cryogenics, gradient coils, and RF (Radio Frequency) coils.
- *Medical Tech Application:* Understanding the absolute necessity of MRI safety zones. Monitoring helium boil-off levels and testing the integrity of the RF cabin (Faraday cage) to prevent image artifacts.

- **Unit 4: Diagnostic Ultrasound**

- *Topics:* Advanced piezoelectric effect, acoustic impedance, and the Doppler effect (Color/Pulsed Wave). Linear, convex, and phased array transducer design.
- *Medical Tech Application:* Using tissue-mimicking phantoms to test transducers for dead crystals (dropouts) and performing basic preventive maintenance on the ultrasound cart.

- **Unit 5: Nuclear Medicine (PET/SPECT)**

- *Topics:* Radioactive decay, half-life, and radiopharmaceuticals (e.g., FDG). Gamma camera architecture, collimators, coincidence detection, and photomultiplier tubes.
- *Medical Tech Application:* Understanding the strict radiation safety, handling, and calibration protocols required when servicing equipment that detects internally administered isotopes.

DMET 203: Respiratory & Therapeutic Technology

Objective: To master the pneumatics, mechanics, and maintenance of critical life-support and respiratory therapy devices.

- **Unit 1: Respiratory Mechanics**

- *Topics:* Lung compliance and airway resistance. The work of breathing. Application of gas laws (Boyle's, Charles's) to alveolar pressures.
- *Medical Tech Application:* Understanding how a mechanical ventilator interacts with a patient's diseased lung (e.g., stiff lungs in ARDS) to set safe pressure limits.

- **Unit 2: Spirometry & PFT**

- *Topics:* Volume and flow measurement techniques: pneumotachometers, rotating turbines, and hot-wire anemometers. Forced Vital Capacity (FVC) and FEV1.
- *Medical Tech Application:* Calibrating Pulmonary Function Test (PFT) equipment using standard 3-Liter calibration syringes.

- **Unit 3: Impedance Pneumography**

- *Topics:* Measuring respiration rate using ECG chest electrodes. Injecting high-frequency carrier waves to measure thoracic impedance changes. Artifact rejection.
- *Medical Tech Application:* Troubleshooting false "Apnea" (no breathing) alarms on multi-parameter monitors caused by patient movement or shallow breathing.

- **Unit 4: Mechanical Ventilators**

- *Topics:* Volume control vs. pressure control modes. PEEP and CPAP. Pneumatic block diagrams: proportional solenoid valves, exhalation blocks, and oxygen blenders.
- *Medical Tech Application:* Performing preventive maintenance and calibration on ICU ventilators using Gas Flow Analyzers to ensure accurate Tidal Volume delivery.

- **Unit 5: Anesthesia Workstations**

- *Topics:* Vaporizer principles, circle breathing systems, CO₂ absorbers (soda lime), and active/passive anesthetic gas scavenging systems (AGSS).
- *Medical Tech Application:* Performing mandatory daily/weekly high-pressure and low-pressure leak tests on anesthesia machines to ensure OT safety.

DMET 204: Analytical & Lab Instruments

Objective: To explore the electro-mechanical and optical technologies used in pathology and biochemistry laboratories for diagnostic testing.

- **Unit 1: Centrifuges & Incubators**

- *Topics:* Principles of sedimentation and Relative Centrifugal Force (RCF). Brushless DC motors and lid-interlock safety. PID temperature control in incubators.
- *Medical Tech Application:* Routine maintenance of the pathology lab; replacing centrifuge carbon brushes, verifying RPM with tachometers, and mapping incubator temperature stability.

- **Unit 2: Colorimeters & Spectrophotometers**

- *Topics:* The Beer-Lambert law in chemistry. Light sources, monochromators (prisms/gratings), cuvettes, and photomultiplier tubes. Optical Density (OD).
- *Medical Tech Application:* Calibrating optical laboratory equipment to ensure accurate concentration readings of glucose, cholesterol, and other blood biochemicals.

- **Unit 3: Auto-analyzers (Biochemistry)**

- *Topics:* Continuous flow vs. discrete analyzers. Automated fluidics, peristaltic pumps, robotic sample arms, and automated cuvette washing systems.
- *Medical Tech Application:* Troubleshooting fluid blockages, replacing worn pump tubings, and aligning robotic dispensing arms in high-throughput automated laboratory machines.

- **Unit 4: Blood Cell Counters**

- *Topics:* The Coulter Principle (electrical impedance) for cell counting. Basics of laser flow cytometry and hydrodynamic focusing. Hemoglobin measurement channels.
- *Medical Tech Application:* Maintaining hematology analyzers, clearing micro-aperture clogs, and running daily quality control (QC) calibration fluids.

- **Unit 5: Blood Bank Equipment (Refrigeration)**

- *Topics:* Vapor-compression refrigeration cycles. Deep freezers (-80°C) and platelet agitators. Chart recorders, digital data loggers, and independent temperature alarms.
- *Medical Tech Application:* Ensuring the strict "cold chain" is maintained for life-saving blood products by repairing compressors and testing backup battery alarms on blood bank refrigerators.

DMET 205: Surgical & Critical Care Equip

Objective: To understand the mechanics, fluidics, and safety testing of high-risk, life-saving therapeutic devices used in critical care and operating rooms.

- **Unit 1: Electrosurgical Units (Diathermy)**

- *Topics:* High-frequency alternating current and tissue interaction (cutting, fulguration, desiccation). Monopolar vs. bipolar circuits. Crest factors and waveforms.
- *Medical Tech Application:* Using an ESU Analyzer to measure power output (Watts) and rigorously testing the Return Electrode Monitoring (REM) safety circuit to prevent severe patient burns.

- **Unit 2: Defibrillators**

- *Topics:* Biphasic truncated exponential waveforms. High-voltage energy storage capacitors, charge/discharge circuits. Synchronized cardioversion vs. unsynchronized shocks.
- *Medical Tech Application:* Performing daily shift-checks, replacing depleted internal batteries, and using a Defibrillator Analyzer to verify delivered energy (in Joules).

- **Unit 3: Hemodialysis Machines**

- *Topics:* Principles of diffusion, osmosis, and ultrafiltration. Dialyzer clearance. Proportioning pumps, conductivity sensors, heaters, and air-in-line detectors.
- *Medical Tech Application:* Calibrating dialysate conductivity and temperature sensors, and troubleshooting complex hydraulic blocks, valves, and fluid leaks.

- **Unit 4: Infusion & Syringe Pumps**

- *Topics:* Stepper motors, lead screws, and linear peristaltic mechanisms. Ultrasonic air-in-line sensors and downstream pressure transducers.
- *Medical Tech Application:* Using volumetric flow analyzers to precisely calibrate flow rates (ml/hr) and testing occlusion pressure alarms to ensure safe drug delivery.

- **Unit 5: Infant Incubators & Warmers**

- *Topics:* Modes of heat loss in neonates. Servo-controlled radiant heating vs. forced convective heating. Humidity control and oxygen blending.
- *Medical Tech Application:* Performing spatial temperature mapping using multi-channel thermocouples and verifying critical fan-failure and over-temperature safety cut-offs.

DMET 206: Optical & Laser Systems

Objective: To explore the physics, maintenance, and rigid safety protocols of optical visualization tools and high-energy surgical lasers.

- **Unit 1: Physics of Light & Fiber Optics**

- *Topics:* Total internal reflection, numerical aperture, light attenuation, and chromatic aberration. Xenon, Halogen, and LED cold light sources.
- *Medical Tech Application:* Testing endoscope fiber-optic cables for broken glass fibers using optical power meters and replacing specialized high-intensity light bulbs.

- **Unit 2: Types of Medical Lasers**

- *Topics:* Spontaneous vs. stimulated emission, population inversion. Physics of CO₂, Nd:YAG, Excimer, and Holmium lasers. Tissue penetration based on wavelength.
- *Medical Tech Application:* Knowing which laser hardware is required for specific surgeries (e.g., Holmium lasers for kidney stones vs. CO₂ lasers for dermatology).

- **Unit 3: Surgical Applications of Lasers**

- *Topics:* Photocoagulation, photoablation, and lithotripsy. Laser delivery systems (articulated arms with mirrors vs. flexible optical fibers).
- *Medical Tech Application:* Aligning the visible aiming beam (HeNe) with the invisible therapeutic beam, and calibrating the output wattage using thermal power meters.

- **Unit 4: Endoscopy & Laparoscopy Systems**

- *Topics:* Rigid vs. flexible endoscope anatomy. The Hopkins rod-lens system. Camera Control Units (CCU), white balancing, and video signal processing.
- *Medical Tech Application:* Performing mandatory pneumatic leak-tests on flexible colonoscopes to prevent fluid invasion, and troubleshooting camera interference.

- **Unit 5: Laser Safety Guidelines**

- *Topics:* Laser hazard classifications (Class 1 to 4). Maximum Permissible Exposure (MPE), Nominal Hazard Zones, and Optical Density (OD) for safety eyewear.

Medical Tech Application: Auditing an Operation Theatre for laser safety compliance, testing door interlocks, and ensuring surgical smoke evacuators are functioning.



2.4 Year 2: Semester 4 (Core Hospital Facilities & Management, Quality & Safety standards)

DMET 207: Clinical Engineering Asset Management

Objective: To develop the administrative, financial, and logistical skills required to run a hospital's Clinical Engineering Department.

- **Unit 1: Role of Clinical Engineering**

- *Topics:* Evolution of the profession. Departmental structure, interfacing with clinical heads, and the engineer's code of ethics.
- *Medical Tech Application:* Navigating the professional landscape of a multispecialty hospital and prioritizing breakdown calls based on clinical acuity.

- **Unit 2: Computerized Maintenance Management Systems (CMMS)**

- *Topics:* Database structures for asset tracking. Generating work orders. Calculating Key Performance Indicators (KPIs) like MTBF (Mean Time Between Failures) and MTTR (Mean Time To Repair).
- *Medical Tech Application:* The daily digital tracking of repair histories, logging technician hours, and ensuring regulatory compliance through meticulous records.

- **Unit 3: Preventive Maintenance Planning**

- *Topics:* Translating OEM service manuals into PM checklists. Risk-based maintenance scheduling (critical vs. non-critical devices).
- *Medical Tech Application:* Planning the annual maintenance calendar to ensure 100% compliance for high-risk equipment like defibrillators without disrupting OT schedules.

- **Unit 4: Equipment Lifecycle & Condemnation**

- *Topics:* Calculating depreciation (straight-line vs. declining balance). Managing obsolescence, trade-ins, and local e-waste disposal regulations.
- *Medical Tech Application:* Drafting a formal, financially justified condemnation report to scrap a 15-year-old X-ray machine rather than paying for expensive repairs.

- **Unit 5: Inventory & Spares Management**

- *Topics:* Reorder points, ABC inventory analysis. Managing Annual/Comprehensive Maintenance Contracts (AMC/CMC) and vendor SLA negotiations.
- *Medical Tech Application:* Preventing ICU downtime by ensuring critical, high-turnover spare parts (like SpO2 cables and BP cuffs) are always in stock.

DMET 208: Hospital Facility Management

Objective: To manage the critical background infrastructure that supports the hospital, ensuring medical gases, clean air, and emergency power are never interrupted.

- **Unit 1: Medical Gas Pipeline Systems (MGPS)**

- *Topics:* Liquid Medical Oxygen (LMO) tanks, cylinder manifolds, automatic changeover valves. Medical air compressors, vacuum plants, and color-coding standards.
- *Medical Tech Application:* Inspecting the central gas plant, testing ward-level Area Valve Service Units (AVSU), and verifying high/low-pressure audio-visual alarms.

- **Unit 2: Hospital HVAC & Infection Control**

- *Topics:* Air Changes per Hour (ACH), HEPA filtration, and laminar airflow. Designing positive pressure (Operating Theatres) vs. negative pressure (Isolation Wards) rooms.
- *Medical Tech Application:* Using differential pressure manometers and anemometers to verify that an operating theatre is maintaining sterile, positive-pressure air cascades.

- **Unit 3: RO Water Systems for Dialysis**

- *Topics:* City water pre-treatment (multimedia, carbon, softeners). Reverse Osmosis (RO) membranes, UV sterilization, and endotoxin limits for hemodialysis.
- *Medical Tech Application:* Monitoring the Total Dissolved Solids (TDS) and pH of the dialysis water plant, and executing backwash/disinfection cycles.

- **Unit 4: Biomedical Waste Management**

- *Topics:* Statutory rules for BMW segregation. Color-coded bin systems (Yellow, Red, White, Blue). Safe disposal of sharps, chemical waste, and electronic waste (e-waste).
- *Medical Tech Application:* Ensuring the Clinical Engineering department safely disposes of biohazard-contaminated spare parts, lead-acid batteries, and obsolete PCBs.

- **Unit 5: Backup Power & Generators**

- *Topics:* Diesel Generator (DG) sets, Automatic Transfer Switches (ATS), and hospital-wide central UPS architectures. Load shedding and critical vs. non-critical power panels.
- *Medical Tech Application:* Coordinating with electrical teams to conduct routine "black start" tests and load-bank testing on UPS batteries to guarantee backup times for the ICU.

DMET 209: Hospital Safety & Standards

Objective: To instill a rigorous culture of safety, focusing on international standards that protect patients and staff from electrical, biological, and physical harm.

- **Unit 1: Macro & Micro-shock Hazards**

- *Topics:* Physiological effects of electrical current on the human body. Let-go current, ventricular fibrillation thresholds. Macroshock vs. internally applied Microshock.
- *Medical Tech Application:* Understanding why medical devices require such extreme isolation; a microampere leakage current harmless on the skin can be fatal if applied directly to the heart via a catheter.

- **Unit 2: IEC 60601 Standard Overview**

- *Topics:* Introduction to the global standard for medical electrical equipment. Class I, II, and III power configurations. Type B, BF, and CF applied parts.
- *Medical Tech Application:* Testing hospital equipment using an Electrical Safety Analyzer to ensure earth leakage and patient auxiliary currents are strictly within legal IEC 60601 limits.

- **Unit 3: Biological & Chemical Hazards**

- *Topics:* Chain of infection, standard precautions, and biohazardous waste segregation. Handling equipment exposed to bloodborne pathogens. Chemical sterilants (e.g., Ethylene Oxide).
- *Medical Tech Application:* Safely decontaminating a returned surgical device or laboratory analyzer before opening the chassis to perform internal electronic repairs.

- **Unit 4: Fire Safety in Hospitals**

- *Topics:* The fire triangle. Risks of oxygen-enriched environments (ICU/OT). Types of fire extinguishers and evacuation protocols (RACE/PASS).
- *Medical Tech Application:* Designing safe electrical setups in operating theatres to prevent sparks near anesthesia gases, and understanding hospital fire alarm integrations.

- **Unit 5: Ergonomics & Radiation Safety Basics**

- *Topics:* Biomechanics of safe lifting. ALARA principle (As Low As Reasonably Achievable) for radiation. Time, distance, and shielding (lead aprons).
- *Medical Tech Application:* Protecting the clinical engineer's physical health when lifting heavy equipment, and ensuring safety when repairing or testing mobile X-ray and C-arm machines.

DMET 210: Regulatory & Quality Assurance

Objective: To navigate the complex legal, regulatory, and quality frameworks that govern medical device safety, procurement, and hospital accreditation.

- **Unit 1: FDA & CE Marking Overview**

- *Topics:* Global regulatory bodies. Device risk classification (Class I, II, III). The 510(k)-clearance process vs. Pre-Market Approval (PMA). The CE marking technical file.
- *Medical Tech Application:* Researching regulatory databases to ensure a new piece of equipment the hospital intends to purchase is legally approved and safe for clinical use.

- **Unit 2: ISO 13485 (Medical Devices QMS)**

- *Topics:* Core principles of a Quality Management System (QMS). Document control, traceability, and ISO 14971 (Risk Management for medical devices).
- *Medical Tech Application:* Standardizing the Clinical Engineering workshop by writing rigorous Standard Operating Procedures (SOPs) for equipment repair and calibration.

- **Unit 3: NABH Accreditation for Hospitals**

- *Topics:* National Accreditation Board for Hospitals & Healthcare Providers. Facility management chapters, patient safety goals, and equipment management indices.
- *Medical Tech Application:* Acting as the key technical lead during a hospital accreditation audit, presenting PM logs, calibration certificates, and safety records to the auditors.

- **Unit 4: AERB Regulations (Radiation)**

- *Topics:* Atomic Energy Regulatory Board guidelines. The e-LORA registration portal. Shielding calculations, layout approvals, and mandatory Quality Assurance testing.
- *Medical Tech Application:* Performing the bi-annual QA tests on X-ray and CT machines required to maintain the hospital's legal license to operate radiation equipment.

- **Unit 5: Post-Market Surveillance**

- *Topics:* Adverse event reporting (FDA MAUDE database). Corrective and Preventive Action (CAPA) plans. Managing equipment recalls and safety alerts.
- *Medical Tech Application:* Executing a hospital-wide recall response (e.g., locating all infusion pumps of a specific model, updating their firmware as mandated by the manufacturer, and filing the CAPA report).

DMET 211: Advanced Diagnostics & Repair

Objective: To equip students with advanced, component-level repair skills and analytical troubleshooting methodologies to salvage complex, high-value medical systems.

- **Unit 1: Advanced PCB Troubleshooting**

- *Topics:* Multi-layer PCB architecture, tracing power and signal rails, reading complex OEM schematics, and identifying short/open circuits.
- *Medical Tech Application:* Diagnosing a dead motherboard on an expensive ICU ventilator without relying solely on the manufacturer's costly "swap the whole board" recommendations.

- **Unit 2: Oscilloscope & Spectrum Analyzer Mastery**

- *Topics:* Advanced triggering, digital bus decoding (I2C, SPI, UART), and analyzing Electromagnetic Interference (EMI) using spectrum analyzers and near-field probes.
- *Medical Tech Application:* Identifying data corruption in a medical device's internal communication lines or pinpointing dangerous RF leakage from a faulty electrosurgical unit in the OT.

- **Unit 3: Surface Mount Technology (SMT) Rework**

- *Topics:* SMT component identification, using hot air rework stations, micro-soldering under stereomicroscopes, flux chemistry, and thermal profiles.
- *Medical Tech Application:* Safely desoldering and replacing a burnt micro-controller or blown SMD fuse on a high-value ultrasound probe connector board.

- **Unit 4: Testing Patient Simulators**

- *Topics:* Architecture of multi-parameter simulators, calibration traceability (NABL/NIST), simulating rare arrhythmias, and testing device alarm thresholds.
- *Medical Tech Application:* Verifying that the vital-signs simulator used daily by the biomedical department to calibrate life-support machines is itself accurate and legally traceable.

- **Unit 5: Root Cause Analysis (RCA)**

- *Topics:* The "5 Whys" methodology, Ishikawa (Fishbone) diagrams, Fault Tree Analysis (FTA), and Failure Mode and Effects Analysis (FMEA).
- *Medical Tech Application:* Systematically investigating *why* a medical device failed during a procedure to prevent future occurrences, rather than just patching the immediate symptom.

DMET 212: Major Project

Objective: To synthesize two years of academic and clinical knowledge into a functional, real-world engineering project or comprehensive research study.

- **Unit 1: Problem Identification & Lit Review**

- *Topics:* Identifying a clinical pain point, conducting a literature review, performing market analysis of existing solutions, and defining the project scope.
- *Medical Tech Application:* Observing nurses struggling with tangled ECG wires in the ICU and deciding to design a low-cost, organized telemetry harness as the final diploma project.

- **Unit 2: Design Proposal & Budgeting**

- *Topics:* Drafting block diagrams, CAD models, and software flowcharts. Creating a Bill of Materials (BOM) and presenting a project budget.
- *Medical Tech Application:* Pitching the prototype idea to a faculty panel, defending the technical feasibility, and justifying the requested funds for components.

- **Unit 3: Implementation/Prototyping Phase**

- *Topics:* Breadboarding, PCB fabrication, 3D printing, writing firmware (C/Python), and integrating sensors with microcontrollers.
- *Medical Tech Application:* The hands-on engineering phase where the student physically builds the proposed device (e.g., soldering the components of a neonatal jaundice detector).

- **Unit 4: Testing & Data Collection**

- *Topics:* System verification and validation. Testing against clinical simulators, statistical analysis of results, and debugging software/hardware.
- *Medical Tech Application:* Connecting the prototype to a patient simulator, recording its accuracy over 100 trials, and tweaking the algorithms to reduce error margins.

- **Unit 5: Final Report & Viva Voce**

- *Topics:* Writing a formal engineering thesis (Methodology, Results, Conclusion), creating a poster presentation, and defending the work orally.
- *Medical Tech Application:* Presenting the final, working prototype to industry experts, demonstrating the ability to communicate complex technical work clearly and professionally.

2.5 Text/Reference Books

Category 1: Foundational Sciences & Electronics

These books build the essential bridge between human biology and fundamental engineering physics.

1. **Handbook of Biomedical Instrumentation** by R.S. Khandpur (McGraw Hill India)
 - *Relevance:* The absolute "Bible" for biomedical engineering in India. It covers almost every device from a foundational level.
2. **Ross & Wilson Anatomy and Physiology in Health and Illness** by Anne Waugh & Allison Grant (Elsevier India)
 - *Relevance:* The gold standard for teaching human anatomy to non-medical professionals and engineers.
3. **Guyton and Hall Textbook of Medical Physiology** by John E. Hall (Elsevier - South Asia Edition)
 - *Relevance:* Deeper physiological concepts necessary for understanding hemodynamics and respiratory mechanics.
4. **Basic Electronics and Linear Circuits** by N.N. Bhargava, D.C. Kulshreshtha (McGraw Hill India / TTTI Chandigarh)
 - *Relevance:* The classic Indian text for foundational circuit theory, diodes, and basic amplification.
5. **Engineering Circuit Analysis** by William H. Hayt, Jack Kemmerly (McGraw Hill India)
 - *Relevance:* Essential for advanced AC/DC network theorems and electrical safety.

Category 2: Core Biomedical Instrumentation

The heavy-lifting texts covering diagnostic, analytical, and therapeutic equipment.

6. **Biomedical Instrumentation and Measurements** by Leslie Cromwell, Fred J. Weibell (Pearson India LPE)
 - *Relevance:* Excellent breakdowns of ECG, EEG, and EMG signal acquisition and electrode theory.
7. **Introduction to Biomedical Equipment Technology** by Joseph J. Carr, John M. Brown (Pearson India LPE)
 - *Relevance:* Highly practical; bridges the gap between theoretical electronics and actual hospital repair manuals.

8. **Medical Instrumentation: Application and Design** by John G. Webster (Wiley India LPE)

- *Relevance:* The premier text for the engineering design controls and signal processing behind medical sensors.

9. **Principles of Applied Biomedical Instrumentation** by L.A. Geddes, L.E. Baker (Wiley India)

- *Relevance:* Exceptional for understanding the underlying physics of transducers and physical sensors.

10. **Measurement Systems: Application and Design** by Ernest O. Doebelin (McGraw Hill India)

- *Relevance:* Vital for teaching metrology, calibration, and error analysis in measuring instruments.

Category 3: Embedded Systems & Prototyping

For the firmware, microcontrollers, and hardware design elements of the curriculum.

11. **The 8051 Microcontroller and Embedded Systems** by Muhammad Ali Mazidi (Pearson India LPE)

- *Relevance:* The foundational text for understanding how microcontrollers interface with physical sensors.

12. **Op-Amps and Linear Integrated Circuits** by Ramakant A. Gayakwad (Pearson India LPE)

- *Relevance:* Mandatory for learning how to design noise-free medical amplifiers and active filters.

13. **Make: Electronics** by Charles Platt (Shroff Publishers India)

- *Relevance:* A highly visual, hands-on guide perfect for the early stages of the Maker Space / Major prototyping lab.

Category 4: Medical Imaging & Radiation

Focusing on the heavy infrastructure of Radiology and diagnostic imaging.

14. **Christensen's Physics of Diagnostic Radiology** by Thomas S. Curry (Lippincott Williams & Wilkins - Indian Reprint)

- *Relevance:* The definitive guide to X-ray generation, fluoroscopy, and radiation safety (AERB compliance).

15. **Medical Imaging Signals and Systems** by Jerry L. Prince, Jonathan Links (Pearson LPE)

- *Relevance:* Covers the mathematical and computational reconstruction of CT, MRI, and Ultrasound images.

16. Farr's Physics for Medical Imaging by Penelope J. Allisy-Roberts (Elsevier India)

- *Relevance:* A concise, highly accessible text for understanding the clinical application of imaging physics.

Category 5: Critical Care & Facility Management

Covering life support, medical gases, and the physical hospital environment.

17. Mosby's Respiratory Care Equipment by J.M. Cairo (Elsevier India)

- *Relevance:* An incredibly detailed breakdown of the pneumatics, valves, and operating modes of ICU ventilators.

18. Clinical Engineering Handbook by Ernesto Iadanza (Academic Press - Asian editions available)

- *Relevance:* A massive reference volume detailing the exact operational roles of a clinical engineering department.

19. Hospital Facilities Planning and Management by G.D. Kunders (McGraw Hill India)

- *Relevance:* Essential for the Facility Management unit, covering Medical Gas Pipeline Systems (MGPS), HVAC, and hospital power grids.

20. Biomedical Device Technology: Principles and Design by Anthony Y. K. Chan (Charles C Thomas Pub - Check local availability)

- *Relevance:* Excellent chapters on defibrillators, electrosurgery, and infusion pumps.

Category 6: Medical IT, Cybersecurity & Telemetry

Addressing the digital evolution and networking of hospital infrastructure.

21. Data Communications and Networking by Behrouz A. Forouzan (McGraw Hill India)

- *Relevance:* The standard text for understanding TCP/IP, VLANs, and the networking architecture required for medical telemetry.

22. Practical Internet of Things Security by Brian Russell, Drew Van Duren (Packt Publishing - widely printed in India)

- *Relevance:* Directly applicable to the Cybersecurity unit, focusing on securing embedded IoT sensors and preventing network exploits.

23. PACS and Imaging Informatics by H.K. Huang (Wiley India)

- *Relevance:* The authoritative text on DICOM standards, HL7 routing, and securely managing digital medical imaging servers.

Category 7: Health Economics, Procurement & Management

For the boardroom skills: purchasing, SLAs, and negotiation.

24. Materials Management: An Integrated Approach by P. Gopalakrishnan (PHI Learning India)

- *Relevance:* An Indian classic on supply chain, inventory control, and navigating local tendering/procurement laws.

25. Health Economics by Jay Bhattacharya (Palgrave Macmillan - Local prints available)

- *Relevance:* Teaches the macro-economics of healthcare, essential for Total Cost of Ownership (TCO) and ROI modeling.

26. Negotiation by Roy J. Lewicki (McGraw Hill India)

- *Relevance:* The premier business text for the "Vendor Negotiation Strategies" unit, covering BATNA and contract leverage.

Category 8: Professional Ethics & Major Research

Legal liability, design frameworks, and moral philosophy.

27. Engineering Ethics by Charles B. Fleddermann (Pearson India LPE)

- *Relevance:* Provides case studies on engineering disasters, whistleblowing, and the legal liability of a technical signature.

28. Biodesign: The Process of Innovating Medical Technologies by Paul Yock, Stefanos Zenios (Cambridge University Press - Indian Edition)

- *Relevance:* The ultimate roadmap for the Major Project. It guides students through clinical needs-finding, FDA/CDSCO regulations, and prototyping.

29. Design of Medical Electronic Devices by Reinaldo Perez (Academic Press / Elsevier India)

- *Relevance:* Focuses heavily on EMI/EMC shielding, bio-compatibility, and packaging—crucial for making a Capstone prototype legally safe.

30. Biomedical Ethics by Walter Glannon (Oxford University Press India)

- *Relevance:* Explores the moral dilemmas of resource allocation (triage), patient privacy, and end-of-life technological support.





APPENDIX - I

CLINICAL INTERNSHIP

Diploma in Medical Equipment Technology

Medical Equipment Technology Internship Structure (Weekly Schedule)

Duration: 6 Months (divided into 3 modules, 8 weeks for each module) at the end of year 2.

Setting: 200+ Bed Multispecialty Tertiary Care Hospital.

Module I: Foundation, Wards, and Laboratory Facilities

- **Week 1: Orientation & Safety.** Hospital tour, introduction to the Clinical Engineering Dept (CED), infection control protocols, and hand-hygiene training.
- **Week 2: Asset Management System.** Learning the CMMS software. Tagging new equipment, understanding inventory logs, and tracking maintenance schedules.
- **Week 3: General Wards PM (Preventive Maintenance).** Shadowing technicians to perform PM on weighing scales, digital thermometers, and suction apparatus.
- **Week 4: Basic Diagnostic Checking.** Hands-on checking and calibration of standard NIBP monitors and pulse oximeters in Outpatient Departments (OPD).
- **Week 5: Laboratory Instrumentation.** Familiarization with the Pathology lab. Observing the daily calibration of centrifuges, incubators, and cell counters.
- **Week 6: Sterilization & CSSD.** Understanding the Central Sterile Services Department (CSSD). Assisting in the validation and maintenance of autoclaves.
- **Week 7: Electrical Safety Testing.** Performing electrical leakage and grounding tests on ward equipment using electrical safety analyzers.
- **Week 8: Minor Fault Resolution.** Addressing Tier-1 mechanical breakdown calls (e.g., replacing broken cables, fixing wheels on IV stands) under strict supervision.

Here is the detailed competency and evaluation framework for the 8-week Internship I (Foundation, Wards, and Laboratory Facilities). This framework ensures that the theoretical knowledge gained in the first three semesters is rigorously assessed through practical application.

Week 1: Orientation & Safety

Hospital tour, introduction to CED, infection control, and hand-hygiene.

- **Competencies Acquired:**

- Ability to navigate the physical layout of a 200+ bed hospital and identify critical vs. non-critical zones.
- Understanding of the Clinical Engineering Department (CED) hierarchy and reporting structure.
- Mastery of standard infection control protocols, including proper donning/doffing of Personal Protective Equipment (PPE).
- Mastery of the WHO standard steps for hand hygiene in a clinical setting.

- **Evaluation Methodology:**

- **Practical Demonstration:** Intern must correctly demonstrate the standard hand-washing technique and PPE donning/doffing sequence to the Infection Control Nurse or CED Supervisor.
- **Written Quiz:** A short multiple-choice test on hospital zones, emergency codes, and basic workplace safety hazards.

Week 2: Asset Management System

Learning CMMS software, tagging equipment, and tracking logs.

- **Competencies Acquired:**

- Proficiency in navigating the hospital's Computerized Maintenance Management System (CMMS).
- Ability to properly classify, assign asset IDs, and physically tag new medical equipment.
- Capability to retrieve historical maintenance logs and identify upcoming Preventive Maintenance (PM) schedules.

- **Evaluation Methodology:**

- **System Task:** The intern is provided with details of three "dummy" medical devices. They must successfully enter these devices into the CMMS, generate asset tags, and correctly schedule their first PM cycle.
- **Logbook Verification:** Supervisor checks that the intern has correctly documented their daily activities using standard engineering terminology.

Week 3: General Wards PM (Preventive Maintenance)

Shadowing and performing PM on weighing scales, thermometers, and suction apparatus.

- **Competencies Acquired:**

- Ability to execute a standard visual and physical inspection checklist for basic ward equipment.
- Competence in performing span calibration on digital weighing scales using standard weights.
- Ability to test suction apparatus for vacuum leaks, clean overflow jars, and replace bacterial filters.

- **Evaluation Methodology:**

- **Direct Observation (Checklist):** The supervising technician observes the intern performing a complete PM on a suction apparatus on the ward. The intern is graded on a rubric including safety checks, proper use of tools, and bedside etiquette.
- **Documentation Audit:** Evaluation of the PM reports filled out by the intern for accuracy and completeness.

Week 4: Basic Diagnostic Checking

Checking and calibration of standard NIBP monitors and pulse oximeters in OPD.

- **Competencies Acquired:**

- Ability to test pneumatic circuits in NIBP monitors for air leaks and verify pressure limits.
- Understanding of how to inspect SpO₂ probes for cable wear and optical integrity.
- Ability to use a vital signs simulator to verify the accuracy of SpO₂ and Heart Rate readings.

- **Evaluation Methodology:**

- **Practical Viva Voce:** The intern is handed an NIBP monitor and an SpO₂ cable. They must physically demonstrate the pneumatic leak test and explain the operating principle of the optical sensor while testing it.

Week 5: Laboratory Instrumentation

Familiarization with the Pathology lab, checking centrifuges, incubators, etc.

- **Competencies Acquired:**

- Understanding the strict biological safety protocols required inside a pathology laboratory.

- Ability to verify the RPM of a clinical centrifuge using a digital photo-tachometer and check lid-lock safety mechanisms.
- Capability to perform temperature mapping and verify the stability of laboratory incubators.

- **Evaluation Methodology:**

- **On-Site Assessment:** The intern must independently verify the RPM of a centrifuge and explain the procedure for balancing a rotor load to the supervisor.
- **Oral Q&A:** A brief question-and-answer session on handling equipment that may be contaminated with biohazardous materials.

Week 6: Sterilization & CSSD

Understanding CSSD workflow and assisting in autoclave validation.

- **Competencies Acquired:**

- Clear understanding of the directional workflow in CSSD (Dirty → Clean → Sterile zones).
- Familiarity with the operational cycles of a hospital autoclave (pre-vacuum, sterilization, drying).
- Ability to identify and read chemical indicator tapes and biological indicator vials used to validate sterilization.

- **Evaluation Methodology:**

- **Process Mapping:** The intern must draw and correctly label the physical workflow of instruments through the CSSD.
- **Scenario Test:** The intern is shown various chemical/biological indicators (both passed and failed) and must correctly interpret them and state the required corrective action.

Week 7: Electrical Safety Testing

Performing electrical leakage and grounding tests on ward equipment.

- **Competencies Acquired:**

- Proficiency in operating a standard Electrical Safety Analyzer (e.g., Fluke).
- Ability to measure protective earth resistance, enclosure leakage current, and earth leakage current.
- Understanding of IEC 60601 basic parameters to determine if a device passes or fails safety standards.

- **Evaluation Methodology:**

Competency Based Curriculum for “Diploma in Medical Equipment Technology”

(Intellectual property of National Commission for Allied and Healthcare Professions, Ministry of Health and Family Welfare)

- **Hands-On Exam:** The intern is given an Electrical Safety Analyzer and a Class I medical device (e.g., an infusion pump). They must perform a full safety test, record the values, and correctly declare the device as "Pass" or "Fail" based on the readings.

Week 8: Minor Fault Resolution

Addressing Tier-1 mechanical breakdown calls under strict supervision.

- **Competencies Acquired:**

- Ability to safely perform basic mechanical repairs (e.g., replacing castor wheels, tightening chassis screws, replacing broken knobs).
- Competence in safely stripping wires and replacing damaged mains power plugs and fuses.
- Capability to independently close a breakdown work order in the CMMS after resolving a minor fault.

- **Evaluation Methodology:**

- **Mock Breakdown Challenge:** The intern is dispatched to a simulated breakdown (e.g., an IV pole with a damaged wheel and a monitor with a blown fuse). They are evaluated on response time, diagnostic approach, repair quality, and safety.
- **Final Logbook Sign-Off:** Comprehensive review of the 8-week logbook by the Head of Clinical Engineering to ensure all competencies have been documented and signed.

Module II: Critical Care, Cardiology, and Respiratory

- **Week 1: ICU/NICU Orientation.** Familiarization with high-acuity environments. Understanding the setup and cabling of multi-parameter patient monitors.
- **Week 2: ECG & Signal Artifacts.** Checking 12-lead ECG machines. Practical troubleshooting of baseline wander, lead faults, and grounding issues on live machines.
- **Week 3: Defibrillators & Resuscitation Tech.** Routine safety testing of defibrillators using energy analyzers. Checking crash cart readiness.
- **Week 4: Respiratory Therapies.** Routine testing and sterilization protocols for BiPAP/CPAP machines and oxygen concentrators.

- **Week 5: Impedance Pneumography & Ventilators.** Assisting in the calibration of mechanical ventilators. Observing real-time respiratory data and recognizing movement artifacts.
- **Week 6: Infusion Technologies.** Using flow analyzers to calibrate and test volumetric infusion pumps and syringe pumps used in critical care.
- **Week 7: Telemetry Troubleshooting.** Mapping and diagnosing the hospital's WiFi-based patient monitoring networks. Fixing connectivity drops between beds and central stations.
- **Week 8: Independent Night/Shift Shadowing.** Shadowing the on-call Biomedical Engineer or Medical Equipment Technologist during an evening shift to experience emergency breakdown responses in the ICU.

Here is the detailed competency and evaluation framework for the 8-week **Internship II (Critical Care, Cardiology, and Respiratory)**. This phase shifts the intern from general wards into high-acuity, life-support environments, requiring a higher level of technical precision and clinical awareness.

Week 1: ICU/NICU Orientation

Familiarization with high-acuity environments. Understanding the setup and cabling of multi-parameter patient monitors.

- **Competencies Acquired:**
 - Ability to navigate high-acuity zones (ICU/NICU/CCU) without disrupting critical clinical workflows.
 - Proficiency in the proper setup, routing, and cable management for ECG, SpO₂, NIBP, IBP (Invasive Blood Pressure), and Temperature probes.
 - Understanding the difference between critical physiological alarms (e.g., Asystole) and technical alerts (e.g., Sensor Off), and how to configure alarm limits.
- **Evaluation Methodology:**
 - **Practical Demonstration:** Intern must independently set up a multi-parameter monitor on a patient simulator, connect all five vital sign cables correctly without tangling, and configure a customized alarm profile.
 - **Ward Etiquette Observation:** Supervising engineer assesses the intern's bedside manners, situational awareness, and adherence to ICU sterile boundary protocols.

Week 2: ECG & Signal Artifacts

Checking 12-lead ECG machines. Practical troubleshooting of baseline wander, lead faults, and grounding issues on live machines.

- **Competencies Acquired:**

- Mastery of the correct anatomical placement for all 10 electrodes in a standard 12-lead ECG setup.
- Ability to differentiate between physiological artifacts (e.g., somatic tremor/muscle noise) and technical artifacts (e.g., 50/60Hz AC interference, baseline wander, cable faults).
- Competence in applying correct diagnostic vs. monitoring hardware filters to clean a noisy signal.

- **Evaluation Methodology:**

- **Scenario Test:** The intern is presented with a live, noisy ECG trace on a monitor (induced via simulator or poor grounding). They must correctly identify the type of artifact and successfully eliminate it within 3 minutes.
- **Oral Viva:** A brief explanation of the Driven-Right-Leg (DRL) circuit and how it reduces common-mode noise.

Week 3: Defibrillators & Resuscitation Tech

Routine safety testing of defibrillators using energy analyzers. Checking crash cart readiness.

- **Competencies Acquired:**

- Ability to safely handle, operate, and discharge a biphasic defibrillator without posing a risk to self or others.
- Proficiency in using a Defibrillator Analyzer to measure delivered energy (Joules), charge time, and synchronized cardioversion delay.
- Understanding the audit process for certifying a clinical "Crash Cart" for immediate emergency readiness.

- **Evaluation Methodology:**

- **Hands-On Exam:** The intern must perform a complete daily shift-check and a full analyzer PM (Preventive Maintenance) test on a defibrillator, adhering to all high-voltage safety rules.

- **Documentation Audit:** Supervisor verifies the intern's completion of a mock Crash Cart checklist, ensuring all expired pads and depleted batteries were caught.

Week 4: Respiratory Therapies

Routine testing and sterilization protocols for BiPAP/CPAP machines and oxygen concentrators.

- **Competencies Acquired:**

- Ability to measure and verify delivered IPAP (Inspiratory) and EPAP (Expiratory) pressures using a digital pressure manometer.
- Competence in assessing the oxygen purity (FiO₂) output and flow rate of an oxygen concentrator using an Oxygen Analyzer.
- Mastery of the specific high-level disinfection and sterilization workflows required for reusable respiratory tubing and masks.

- **Evaluation Methodology:**

- **Practical Calibration:** The intern must connect a BiPAP machine to a test lung and manometer, verify the pressures against the machine's display, and adjust if necessary.
- **Protocol Verification:** The intern must verbally outline the step-by-step infection control process for decontaminating a biohazard-exposed CPAP circuit.

Week 5: Impedance Pneumography & Ventilators

Assisting in the calibration of mechanical ventilators. Observing real-time respiratory data and recognizing movement artifacts.

- **Competencies Acquired:**

- Understanding the basic pneumatic block, proportional solenoids, and flow sensors inside an ICU ventilator.
- Ability to assist in verifying Tidal Volume (V_t), Peak Inspiratory Pressure (PIP), and PEEP using a Gas Flow Analyzer and test lungs.
- Capability to recognize the limitations of Impedance Pneumography (ECG-based respiration counting) and differentiate true breathing from cardiac/movement artifacts.

- **Evaluation Methodology:**

- **Guided Calibration Task:** The intern assists a senior engineer with a ventilator PM, tasked with accurately connecting the flow analyzer, reading the measurements, and recording the data into the CMMS.
- **Trace Interpretation Test:** Intern is shown various multi-parameter monitor screens and must correctly identify false respiration triggers caused by patient movement.

Week 6: Infusion Technologies

Using flow analyzers to calibrate and test volumetric infusion pumps and syringe pumps used in critical care.

- **Competencies Acquired:**

- Proficiency in setting up and running tests on an automated Infusion Device Analyzer (IDA).
- Ability to verify flow rate accuracy (mL/hr) and volume-to-be-infused (VTBI) against strict clinical tolerances (usually $\pm 5\%$).
- Competence in testing and calibrating the downstream occlusion pressure alarm thresholds to prevent patient harm.

- **Evaluation Methodology:**

- **Independent Assessment:** The intern is assigned one syringe pump and one volumetric pump. They must independently run a flow and occlusion test on the analyzer, calculate the percentage of error, and officially pass or fail the devices.

Week 7: Telemetry Troubleshooting

Mapping and diagnosing the hospital's WiFi-based patient monitoring networks. Fixing connectivity drops between beds and central stations.

- **Competencies Acquired:**

- Ability to map MAC/IP addresses and pair bedside monitors/telemetry packs to a Central Nursing Station (CNS).
- Competence in using basic IT tools (ping, checking signal strength, viewing network logs) to diagnose connectivity issues.
- Understanding of RF interference, identifying WiFi "blind spots" in the ward, and resolving IP address conflicts.

- **Evaluation Methodology:**

- **System Tracing Task:** The intern must successfully add a new, unregistered telemetry transmitter to the hospital network and assign it to a specific bed on the central station.
- **Mock Troubleshooting:** The supervisor unplugs a network switch or alters an IP address; the intern must diagnose the "loss of central monitoring" alarm and restore the connection.

Week 8: Independent Night/Shift Shadowing

Shadowing the on-call Biomedical Engineer or Medical Equipment Technologist during an evening shift to experience emergency breakdown responses in the ICU.

- **Competencies Acquired:**

- Ability to triage and prioritize multiple concurrent equipment breakdown calls based on clinical acuity (e.g., a broken ventilator takes precedence over a broken weighing scale).
- Rapid, stress-resilient problem solving in life-or-death clinical environments.
- Effective, calm communication with highly stressed intensivists and critical care nurses during equipment failures.

- **Evaluation Methodology:**

- **Shift Report Review:** At the end of the rotation, the intern must write and present a detailed case study of the most critical or complex breakdown they assisted with during their night shifts.
- **Mid-Term Logbook Sign-Off:** Comprehensive review of the Internship II logbook by the Head of Clinical Engineering to ensure readiness for the final Phase III (Advanced Systems).

Module III: Imaging, Surgery, and Advanced Systems

- **Week 1: Operation Theatre (OT) Protocols.** Scrubbing in. Testing OT tables, surgical LED lights, and setting up electrosurgical units (cautery) before surgeries.
- **Week 2: Anesthesia & Endoscopy.** Assisting in the leak-testing of anesthesia workstations and checking cold-light sources/camera systems for endoscopy towers.
- **Week 3: Radiology (X-Ray & Ultrasound).** Assisting in Quality Assurance (QA) checks of mobile X-ray units, C-arms, and Ultrasound machines.

- **Week 4: Heavy Imaging (CT/MRI) Observation.** Learning radiation safety protocols (AERB). Observing the maintenance environment for CT and MRI (chiller monitoring, RF room integrity).
- **Week 5: Medical Gas Pipeline Systems (MGPS).** Inspecting oxygen manifolds, vacuum pumps, and ward-level gas alarm panels for the whole hospital.
- **Week 6: IT & AI Integration.** Shadowing the IT department to see how radiological images (PACS) and AI-assisted diagnostic software integrate with hospital servers.
- **Week 7: Administrative Workflows.** Processing AMC/CMC renewals, drafting condemnation reports for obsolete equipment, and attending vendor negotiation meetings.
- **Week 8: Independent Operations.** Taking the lead on standard breakdown calls across the hospital. Diagnosing faults independently and proposing the solution to the senior engineer for approval before execution.

Here is the detailed competency and evaluation framework for the final 8-week **Internship III: Imaging, Surgery, and Advanced Systems**. This phase is the culmination of the diploma program, shifting the intern from routine maintenance into high-risk surgical environments, heavy imaging facilities, and departmental management.

Week 1: Operation Theatre (OT) Protocols

Scrubbing in. Testing OT tables, surgical LED lights, and setting up electrosurgical units (cautery) before surgeries.

- **Competencies Acquired:**
 - Mastery of strict aseptic techniques, sterile boundaries, and proper "scrubbing in" protocols required for functioning inside active surgical suites.
 - Ability to functionally test and troubleshoot motorized/hydraulic OT tables and adjust the lux and focal lengths of surgical LED lights.
 - Competence in setting up Electrosurgical Units (ESU), selecting correct monopolar/bipolar accessories, and verifying the Return Electrode Monitoring (REM) safety alarms.
- **Evaluation Methodology:**
 - **Practical Demonstration:** The intern must independently prep an OT suite for a mock surgery, ensuring the table functions, lights are focused, and the ESU is safely configured.
 - **OT Etiquette Observation:** The OT Matron or Senior Engineer observes the intern's movement and behavior to ensure they do not break the sterile field.

Week 2: Anesthesia & Endoscopy

Assisting in the leak-testing of anesthesia workstations and checking cold-light sources/camera systems for endoscopy towers.

- **Competencies Acquired:**

- Ability to perform the mandatory preoperative automated and manual leak tests on an anesthesia workstation, checking vaporizers and soda lime canisters.
- Proficiency in connecting and white-balancing endoscopy camera control units (CCU) and rigid/flexible scopes.
- Competence in testing fiber-optic cold-light sources (Xenon/LED) and measuring light transmission loss.

- **Evaluation Methodology:**

- **Scenario Test:** The intern is tasked with performing a complete morning safety checklist on an anesthesia machine, exactly as required before a patient is wheeled in.
- **Oral Viva:** A brief explanation of the optical path in an endoscopy tower and how to safely handle and clean fiber-optic cables.

Week 3: Radiology (X-Ray & Ultrasound)

Assisting in Quality Assurance (QA) checks of mobile X-ray units, C-arms, and Ultrasound machines.

- **Competencies Acquired:**

- Understanding of how to use a non-invasive X-ray multimeter to verify kVp, mAs, and exposure time accuracy on mobile X-ray and C-arm units.
- Ability to perform basic Quality Assurance (QA) on ultrasound machines, including checking transducer arrays for dead crystals using a tissue-mimicking phantom.
- Competence in inspecting and logging the integrity of lead aprons and thyroid shields.

- **Evaluation Methodology:**

- **Hands-On Assessment:** The intern must safely set up a radiation multimeter, make a test exposure on a mobile X-ray unit (following all scatter protocols), and record the QA data.
- **Image Quality Check:** The intern must identify simulated dead elements or artifacts on an ultrasound display using a test phantom.

Week 4: Heavy Imaging (CT/MRI) Observation

Learning radiation safety protocols (AERB). Observing the maintenance environment for CT and MRI (chiller monitoring, RF room integrity).

- **Competencies Acquired:**

- Deep understanding of statutory radiation safety protocols (AERB guidelines) and MRI magnetic safety zones.
- Familiarity with the facility infrastructure required for heavy imaging, including monitoring helium cryogen levels, HVAC humidity, and dedicated chiller plants.
- Understanding of the purpose and testing methods for the MRI Faraday cage (RF shielding).

- **Evaluation Methodology:**

- **Facility Audit Report:** The intern must conduct an infrastructure audit of the MRI suite, logging chiller temperatures, checking emergency quench button statuses, and verifying the 5-Gauss line markings.
- **Safety Quiz:** A stringent written quiz on AERB radiation safety guidelines and MRI contraindications.

Week 5: Medical Gas Pipeline Systems (MGPS)

Inspecting oxygen manifolds, vacuum pumps, and ward-level gas alarm panels for the whole hospital.

- **Competencies Acquired:**

- Ability to inspect central oxygen manifolds, read primary/secondary regulators, and understand automatic changeover mechanisms.
- Competence in checking vacuum plant reservoirs, bacterial filters, and medical air compressors.
- Capability to test ward-level Area Valve Service Units (AVSU) and verify the auditory/visual triggers of high and low-pressure gas alarms.

- **Evaluation Methodology:**

- **Practical Inspection:** The intern conducts a routine daily check of the central manifold room and logs the line pressures accurately.
- **Alarm Response Test:** The supervisor simulates a pressure drop at a ward-level manifold; the intern must identify the alarm, isolate the correct valve, and explain the emergency cylinder backup procedure.

Week 6: IT & AI Integration

Shadowing the IT department to see how radiological images (PACS) and AI-assisted diagnostic software integrate with hospital servers.

- **Competencies Acquired:**

- Clear understanding of how DICOM images are generated at the modality (e.g., CT scanner), pushed over the network, and archived on the PACS server.
- Basic IT troubleshooting skills for medical networks, including pinging IP addresses and checking HL7 port configurations.
- Familiarization with the data flow of AI-diagnostic nodes (e.g., how an X-ray is routed to an AI server for triage and sent back to the radiologist).

- **Evaluation Methodology:**

- **System Tracing Task:** The intern must draw a complete, accurate network block diagram tracing an image from a specific Ultrasound machine to a specific doctor's viewing station via the PACS server.
- **Network Viva:** Oral questioning on the difference between DICOM and HL7 standards.

Week 7: Administrative Workflows

Processing AMC/CMC renewals, drafting condemnation reports for obsolete equipment, and attending vendor negotiation meetings.

- **Competencies Acquired:**

- Ability to evaluate vendor service reports and ensure compliance with the Service Level Agreements (SLAs) defined in AMC/CMC contracts.
- Competence in performing a Total Cost of Ownership (TCO) or depreciation analysis to justify the condemnation of obsolete equipment.
- Professional communication and negotiation skills required when interacting with third-party biomedical service vendors.

- **Evaluation Methodology:**

- **Documentation Task:** The intern is given historical breakdown data for an aging defibrillator. They must draft a formal, legally sound condemnation report justifying why the device should be scrapped rather than repaired.
- **Roleplay:** The intern acts as the Hospital Medical Equipment Technologist in a mock meeting, questioning a "Vendor" about missed preventive maintenance schedules.

Week 8: Independent Operations

Taking the lead on standard breakdown calls across the hospital. Diagnosing faults independently and proposing the solution to the senior engineer for approval before execution.

- **Competencies Acquired:**

- Confidence and autonomy in conducting Tier-2 Root Cause Analysis (RCA) on complex equipment failures across the entire hospital.
- Ability to formulate a complete repair strategy, identify the necessary spare parts, and communicate the technical solution clearly to clinical staff and engineering management.
- Full readiness to transition from an intern to a fully employed Medical Equipment Technologist.

- **Evaluation Methodology:**

- **Capstone Breakdown Challenge:** The intern is assigned a live, complex breakdown call (e.g., an anesthesia ventilator that won't pass its leak test). They must independently diagnose the fault, propose the solution, and execute the repair while the Senior Engineer strictly observes without intervening.
- **Final Viva & Logbook Sign-Off:** A comprehensive, final interview with the Head of Clinical Engineering to review the entire 6-month internship logbook, assess overall clinical maturity, and grant the final internship completion sign-off.



APPENDIX - II

EXPERIMENTAL LIST & INFRASTRUCTURE FOR EXPERIMENTS

Diploma in Medical Equipment Technology

Year 1: Semester 1

DMET 101: Basic Electrical Engineering

List of 14 Practical Experiments

Unit 1: DC Circuits & Network Theorems

1. Component Familiarization & Multimeter Basics:

- *Description:* Identifying passive components, reading resistor color codes, and using a Digital Multimeter (DMM) to measure voltage, current, and continuity.
- *Medical Tech Application:* The absolute baseline skill for any Medical Equipment Technologist diagnosing a dead medical device motherboard.

2. Verification of Ohm's Law and Kirchhoff's Laws (KVL/KCL):

- *Description:* Constructing series and parallel resistive circuits on a breadboard and using meters to verify current and voltage drops.
- *Medical Tech Application:* Tracing power distribution across different sub-circuits within a multi-parameter patient monitor.

3. Verification of Network Theorems (Thevenin & Superposition):

- *Description:* Simplifying complex multi-loop circuits to find the equivalent voltage and resistance across a specific load.
- *Medical Tech Application:* Analyzing complex power supply boards and determining how a failure in one section impacts the voltage delivered to the main processor.

4. Wheatstone Bridge & Voltage Dividers (Sensor Simulation):

- *Description:* Building a bridge circuit to measure unknown resistance changes accurately.
- *Medical Tech Application:* Understanding how thermistors (temperature probes) and strain gauges (hospital bed weighing scales) convert physical changes into readable millivolt signals.

Unit 2: AC Fundamentals

5. AC Waveform Measurement using an Oscilloscope (CRO):

- *Description:* Measuring peak-to-peak voltage, RMS values, time period, and frequency of various AC waveforms.
- *Medical Tech Application:* Diagnosing AC power rail ripples and understanding the raw sinusoidal nature of biological signals.

6. R-L-C Series Resonance:

- *Description:* Finding the resonant frequency of a circuit containing resistors, inductors, and capacitors, and plotting the frequency response curve.
- *Medical Tech Application:* Understanding analog filter circuits used to clean up noisy ECG signals.

7. Power Factor Measurement:

- *Description:* Measuring real power, apparent power, and the power factor in a single-phase AC circuit.
- *Medical Tech Application:* Understanding the power efficiency and electrical load that heavy medical equipment (like CT scanners) places on a hospital's electrical grid.

Unit 3: Transformers & Machines

8. Step-Down Transformer Turns Ratio & Efficiency:

- *Description:* Measuring primary and secondary voltages/currents to determine the turns ratio and efficiency of a standard step-down transformer.
- *Medical Tech Application:* Understanding the linear power supplies that convert 220V/110V wall power to the 12V/5V DC required by medical device logic boards.

9. Medical-Grade Isolation Transformer Demonstration:

- *Description:* Comparing the grounding and leakage characteristics of a standard transformer versus a medical-grade isolation transformer.
- *Medical Tech Application:* A critical concept for understanding how Operation Theatres use isolated power systems to prevent microshocks to patients with internal catheters.

10. DC Motor Speed Control:

- *Description:* Operating a fractional horsepower DC motor and varying its speed using a rheostat or basic voltage regulation.
- *Medical Tech Application:* The mechanical foundation for troubleshooting syringe pumps, volumetric infusion pumps, and surgical power drills.

Unit 4: Electrical Safety & Grounding

11. Earth Pit Resistance Testing:

- *Description:* Using a dedicated Earth Tester instrument to measure the resistance of the laboratory's ground connection.
- *Medical Tech Application:* Auditing a hospital ward to ensure the grounding resistance is below 1 ohm, which is legally required to safely operate Class I medical electrical equipment.

12. Simulating and Measuring Leakage Current:

- *Description:* Using a microammeter to measure enclosure and earth leakage currents under simulated normal and single-fault conditions.
- *Medical Tech Application:* Practical introduction to IEC 60601 safety standards to ensure a device will not electrocute a patient.

13. Testing Protective Devices (MCB, ELCB, Fuses):

- *Description:* Simulating overload and short-circuit conditions to test the tripping time of Miniature Circuit Breakers (MCBs) and Earth Leakage Circuit Breakers (ELCBs/RCCBs).
- *Medical Tech Application:* Ensuring hospital electrical panels are correctly configured to cut power instantly during an equipment malfunction.

Unit 5: Measuring Instruments

14. Advanced Function Generator & Lissajous Figures:

- *Description:* Using a function generator to inject specific frequencies into a circuit and using a CRO in X-Y mode to measure phase differences (Lissajous figures).
- *Medical Tech Application:* Mastery of signal injection, a primary technique used to simulate a patient's heartbeat when repairing ECG machines and patient monitors.

Laboratory, Computing, and Special Facilities Required

To conduct these experiments safely and effectively, a dedicated **Basic Electrical & Biomedical Safety Laboratory** must be established. Because students will be working with live AC mains voltage in later experiments, safety infrastructure is the absolute highest priority.

1. Physical Laboratory Infrastructure

- **Workstations:** 10 to 15 insulated, anti-static workbenches (accommodating 2-3 students per bench).
- **Power Supply:** Each workbench must have an isolated, regulated AC power supply (Variac) and a variable DC regulated power supply (e.g., 0-30V, 2A).
- **Safety Breakers: Crucial:** Every individual workbench *must* be equipped with its own highly sensitive Residual Current Circuit Breaker (RCCB/ELCB) set to trip at 30mA, alongside an emergency "Kill Switch" for immediate power cutoff.
- **ESD Protection:** Electrostatic Discharge (ESD) wrist straps and grounding mats at every station to instill proper habits for handling sensitive medical electronics.

2. Hardware & Instrumentation

- **Measurement Tools:** * Digital Multimeters (DMMs) (e.g., Fluke 100 series or equivalent).
 - Dual-Channel Cathode Ray Oscilloscopes (CROs) or Digital Storage Oscilloscopes (DSOs) (minimum 50 MHz bandwidth).
 - Digital Function/Signal Generators (capable of sine, square, and triangular waves).
- **Components & Breadboards:** High-quality solderless breadboards, connecting jumper wire kits, and bins of assorted resistors, capacitors, inductors, diodes, and LEDs.
- **Machines & Safety Testers:** * Step-down transformers, variable auto-transformers, and medical isolation transformers.
 - Fractional horsepower DC motors with built-in tachometers.
 - Earth resistance testers (Megger).
 - Basic electrical safety analyzers or custom-built leakage current simulation boards.

3. Computing Facilities

- **Simulation Workstations:** A dedicated computing area within the lab, or laptops integrated into the workbenches (ratio of 1 computer per 3 students).
- **Circuit Simulation Software:** Software such as **NI Multisim**, **LTspice** (Open Source), or **Proteus**.
 - *Rationale:* Before students physically wire a live circuit (especially AC and transformer circuits), they should build and simulate it in software to verify their calculations and prevent hardware damage or blown fuses.

4. Safety & Special Provisions

- **First Aid & Fire:** A fully stocked electrical burns first-aid kit and CO2/Dry Powder fire extinguishers prominently mounted and regularly inspected.
- **Signage:** Clear, color-coded wall charts displaying standard electrical symbols, resistor color codes, and emergency electrocution response protocols (CPR).

DMET 102: Human Anatomy & Physiology I

List of 14 Practical Experiments

Unit 1: Cell Biology & Tissues

1. Microscopy Fundamentals & Calibration:

- *Description:* Operating a binocular compound light microscope, understanding magnification, and performing basic optical calibration using a stage micrometer.
- *Medical Tech Application:* Foundational skill for maintaining clinical pathology microscopes and understanding optical limits.

2. Histological Slide Examination:

- *Description:* Examining and identifying prepared slides of the four primary tissue types (epithelial, connective, muscle, nervous).
- *Medical Tech Application:* Understanding what automated tissue processors and slide stainers in a pathology lab are actually preparing for clinical review.

Unit 2: Skeletal System

3. Skeletal Topography & Biomechanics:

- *Description:* Identifying major bones, landmarks, and joint types using an articulated human skeletal model, and analyzing basic joint levers (Class 1, 2, 3).

- *Medical Tech Application:* The mechanical foundation required to understand continuous passive motion (CPM) machines, traction beds, and orthopedic surgical drills.

4. Radiological Anatomy (Bone Imaging):

- *Description:* Viewing and identifying skeletal structures, fractures, and joint spaces on standard X-ray films and basic CT cross-sections.
- *Medical Tech Application:* Teaching engineers how to determine if an X-ray or C-arm machine is producing clinically diagnostic, high-resolution images.

Unit 3: Muscular System

5. Muscular System Mapping:

- *Description:* Identifying major muscle groups, origin/insertion points, and their anatomical actions using 3D anatomical models and charts.
- *Medical Tech Application:* Knowing anatomical locations for applying physical therapy equipment (e.g., TENS units) and rehabilitation robotics.

6. Muscle Fatigue & Dynamometry:

- *Description:* Using a hand-grip dynamometer to measure maximum voluntary contraction (MVC) and logging the rate of muscle fatigue over time.
- *Medical Tech Application:* Understanding the physiological mechanics measured by rehabilitation equipment and sports medicine diagnostics.

Unit 4: Blood & Lymphatic System

7. Simulated Blood Typing (ABO & Rh):

- *Description:* Performing a slide agglutination test to determine blood groups using safe, synthetic simulated blood kits.
- *Medical Tech Application:* Understanding the strict biological protocols driving the design and alarm systems of blood bank refrigerators and freezers.

8. Hemoglobin Estimation (Colorimetry):

- *Description:* Estimating hemoglobin concentration using a basic clinical colorimeter or spectrophotometer on simulated blood samples.
- *Medical Tech Application:* Learning the optical density principles used inside expensive, automated hematology cell counters.

9. Blood Smear Preparation & Analysis:

- *Description:* Preparing a basic smear on a glass slide (using safe synthetic fluids or animal blood) and identifying RBCs/WBCs under the microscope.
- *Medical Tech Application:* Understanding the fluidic mechanics of automated slide makers and how flow cytometers count cells.

Unit 5: Cardiovascular System

10. Cardiac Anatomy & Dissection Model:

- *Description:* Identifying the internal chambers, valves, coronary arteries, and the conduction pathway on a dissectible mammalian heart model.
- *Medical Tech Application:* The absolute physical baseline required to understand how a pacemaker connects to the heart or how a defibrillator current travels through it.

11. Blood Pressure Measurement (Auscultatory):

- *Description:* Using a manual aneroid sphygmomanometer and a stethoscope to measure systolic and diastolic pressures via Korotkoff sounds.
- *Medical Tech Application:* The manual gold standard that engineers must master to properly calibrate automated NIBP (Non-Invasive Blood Pressure) patient monitors.

12. Pulse Palpation vs. Photoplethysmography:

- *Description:* Manually palpating the radial/carotid pulse to calculate heart rate, and comparing the results to a clinical pulse oximeter reading in real-time.
- *Medical Tech Application:* Differentiating between actual mechanical pulse (perfusion) and optical SpO2 readings on a patient monitor.

13. Heart Sounds Auscultation:

- *Description:* Using a clinical stethoscope to listen to, identify, and time S1 (lub) and S2 (dub) heart sounds on a volunteer or a cardiopulmonary simulator.
- *Medical Tech Application:* Understanding cardiac acoustics, which is necessary for repairing electronic stethoscopes and fetal Doppler monitors.

14. Electrocardiogram (ECG) Surface Anatomy:

- *Description:* Correctly identifying the anatomical placement for standard 3-lead and 12-lead ECG electrodes on the human chest and limbs.
- *Medical Tech Application:* Engineers cannot troubleshoot "noisy" ECG monitors in the ICU without first knowing if the clinical staff placed the electrodes in the correct anatomical positions.

Laboratory, Computing, and Special Facilities Required

To conduct these experiments safely and effectively, a dedicated **Clinical Physiology & Anatomy Laboratory** must be established. Unlike a purely medical lab, this space should merge biological observation with basic diagnostic instrumentation.

1. Physical Laboratory Infrastructure

- **Workstations:** Sturdy, chemical-resistant laboratory benches with integrated sinks and biohazard disposal bins (even for simulated kits, instilling strict clinical hygiene habits is critical).
- **Observation Areas:** Central tables for examining large anatomical models and skeletons.
- **Lighting:** High-quality, shadow-free LED ceiling lighting, critical for slide examination and reading diagnostic gauges.

2. Anatomical Models & Biological Simulators

- **3D Models:** High-fidelity articulated human skeletons, dissectible multi-part human torsos, and life-size dissectible heart/brain models (e.g., from 3B Scientific or Somso).
- **Simulators:** Cardiopulmonary patient simulators (manikins that generate artificial heart and lung sounds) for auscultation practice.
- **Consumables:** Synthetic blood typing kits, simulated urinalysis/hemoglobin kits, and sets of professionally prepared human histology tissue slides.

3. Basic Medical & Diagnostic Equipment

- Binocular compound light microscopes (1 per 2 students).
- Manual aneroid sphygmomanometers (blood pressure cuffs) of various sizes.
- Clinical dual-head stethoscopes.
- Basic handheld pulse oximeters and digital/infrared thermometers.
- Hand-grip dynamometers.

4. Computing Facilities

- **DICOM Viewing Stations:** 2 to 4 high-resolution computer workstations loaded with an open-source DICOM viewer (like RadiAnt or Horos). These are loaded with a library of anonymized clinical X-rays, CT scans, and MRIs for anatomical identification.
- **Interactive Anatomy Software:** Subscriptions to 3D interactive anatomy platforms (e.g., *Complete Anatomy* by Elsevier or *Biodigital Human*) displayed on a large smartboard. This allows the instructor to digitally "dissect" the heart or skeletal system in 3D while explaining the origin points of bio-signals.

DMET 103: Basic Electronics & Devices

Here is the comprehensive list of 14 practical experiments for the **Basic Electronics & Devices** course. This curriculum is designed to move students from abstract semiconductor physics into the practical reality of building, testing, and troubleshooting the active circuits found in modern medical hardware.

Following the list, you will find the detailed specifications for the required laboratory, computing, and specialized electronics facilities.

List of 14 Practical Experiments

Unit 1: Semiconductor Physics

1. Semiconductor Temperature Sensors (Thermistors):

- *Description:* Characterizing an NTC (Negative Temperature Coefficient) thermistor by plotting its resistance against varying temperatures in a controlled water bath.
- *Medical Tech Application:* Understanding the solid-state physics behind the reusable and disposable temperature probes used in multi-parameter patient monitors.

Unit 2: PN Junction Diodes & Rectifiers

2. V-I Characteristics of PN and Zener Diodes:

- *Description:* Plotting the forward and reverse bias voltage-current curves for standard silicon diodes and Zener diodes.
- *Medical Tech Application:* The foundational step for understanding current flow in logic boards and sensor arrays.

3. Medical Power Supply Rectification & Filtering:

- *Description:* Building half-wave, full-wave, and bridge rectifiers on a breadboard, then adding capacitor filters to observe the reduction of AC ripple on an oscilloscope.
- *Medical Tech Application:* Visualizing how hospital AC wall power is converted into the raw DC power required by all medical equipment.

4. Zener Voltage Regulation:

- *Description:* Designing a Zener diode circuit to maintain a constant DC output voltage despite fluctuations in the input load or power supply.
- *Medical Tech Application:* Simulating the protection of highly sensitive microcontroller logic boards from voltage spikes.

5. LED Biasing and Driver Circuits:

- *Description:* Calculating series current-limiting resistors and testing the forward voltage drops of various LED colors (Red, IR, Green).
- *Medical Tech Application:* Troubleshooting the specific light-emitting diodes used in pulse oximeter finger probes, as well as diagnosing component-level faults in the LED backlight driver arrays of medical display screens.

Unit 3: Bipolar Junction Transistors (BJTs)

6. BJT Input and Output Characteristics:

- *Description:* Mapping the active, saturation, and cutoff operating regions of an NPN transistor in a Common Emitter (CE) configuration.
- *Medical Tech Application:* Understanding the boundaries of when a transistor acts as a linear amplifier versus a hard digital switch.

7. The Transistor as an Electronic Switch:

- *Description:* Wiring a BJT to drive a 12V electromechanical relay using a low-voltage (5V) control signal.
- *Medical Tech Application:* Creating the interface circuits used to drive heavy loads, such as engaging motorized ICU bed actuators or triggering audible buzzers in automated clinic queue management systems.

8. BJT Single-Stage Signal Amplification:

- *Description:* Constructing a basic Common Emitter audio-frequency amplifier and measuring its voltage gain using a function generator and oscilloscope.

- *Medical Tech Application:* Boosting low-amplitude simulated biological signals before they are sent to an analog-to-digital converter.

Unit 4: Field Effect Transistors (FETs)

9. JFET Characteristics and High Impedance:

- *Description:* Plotting the drain and transfer characteristics of a Junction Field Effect Transistor (JFET) to demonstrate its extremely high input impedance.
- *Medical Tech Application:* Learning how to handle delicate, high-impedance bio-signals without loading or draining the sensor circuit.

10. MOSFET High-Speed Switching:

- *Description:* Testing a power MOSFET to observe its fast switching capabilities and low ON-resistance.
- *Medical Tech Application:* Analyzing the primary driving components inside the Switched-Mode Power Supplies (SMPS) that run modern medical imaging and diagnostic systems.

Unit 5: Operational Amplifiers (Op-Amps)

11. Op-Amp Basics (Inverting & Non-Inverting):

- *Description:* Wiring a standard Op-Amp (e.g., 741 or TL071) in both inverting and non-inverting configurations and verifying the theoretical voltage gain equations.
- *Medical Tech Application:* The absolute core building blocks of all biomedical instrumentation circuitry.

12. The Voltage Follower (Impedance Buffering):

- *Description:* Building a unity-gain buffer circuit to match a high-impedance source to a low-impedance load without signal distortion.
- *Medical Tech Application:* An essential intermediate stage when interfacing human skin electrodes to medical processing boards.

13. Op-Amp Difference Amplifier:

- *Description:* Constructing a differential amplifier circuit to amplify the difference between two inputs while rejecting shared noise (Common Mode Rejection).
- *Medical Tech Application:* The fundamental first step required to extract clean, microvolt-level ECG morphology waveforms from a sea of ambient electrical noise.

14. Active Signal Filtering (Integrator & Differentiator):

- *Description:* Using Op-Amps, resistors, and capacitors to build active low-pass and high-pass filters, observing their frequency response curves.
- *Medical Tech Application:* Conditioning raw analog signals to strip away high-frequency artifacts (like 50Hz/60Hz mains interference) or baseline wander before diagnostic analysis.

Laboratory, Computing, and Special Facilities Required

To conduct these fundamental electronics experiments safely and rigorously, the institution must establish an **Active Devices & Circuits Laboratory**. This lab requires a strict 1-to-1 or 1-to-2 equipment ratio to ensure every student actively builds and measures circuits.

1. Physical Laboratory Infrastructure

- **Workstations:** 15 robust laboratory workbenches (accommodating 2 students each).
- **ESD Protection:** Because students will be handling static-sensitive components (like MOSFETs and CMOS Op-Amps), every workbench must be fitted with an Electrostatic Discharge (ESD) grounding mat and individual ESD wrist straps.
- **Power Distribution:** Clean, stable, and isolated AC power at each bench to prevent ground loops that can corrupt sensitive oscilloscope readings.

2. Hardware & Bench Instrumentation

- **Digital Storage Oscilloscopes (DSOs):** Dual-channel, minimum 50 MHz bandwidth DSOs at every bench. The ability to freeze, capture, and measure waveforms using cursors is critical for analyzing Op-Amp performance and rectifier ripple.
- **Function/Arbitrary Waveform Generators:** To inject precise sine, square, and triangular waves (simulating bio-signals) into the amplifier circuits.
- **DC Power Supplies:** Dual-channel, variable, regulated DC power supplies (e.g., 0-30V, 2A) to provide the separate biasing voltages needed for transistors and the dual-rail power (+12V/-12V) required for Op-Amps.
- **Digital Multimeters (DMMs):** High-precision handheld or benchtop multimeters for verifying resistor values and measuring DC bias points.
- **Component Inventory:** Large stocks of high-quality solderless breadboards, jumper wire kits, resistors, capacitors, various diodes (1N4007, Zener, LEDs), BJTs (e.g., 2N2222, BC547), FETs, and standard Op-Amp ICs (LM741, TL071, LM358).

3. Computing & Simulation Facilities

- **Simulation Workstations:** A computing zone within the lab, or laptops at each bench.
- **SPICE Software:** Access to circuit simulation software such as **LTspice** (free and highly robust), **NI Multisim**, or **Proteus**.
- **Pre-Lab Workflow:** Before physically placing components on a breadboard (where a misplaced wire could destroy an IC), students must digitally draft their schematic, run a SPICE simulation, and verify the expected voltage gains and transient responses. This builds the exact analytical workflow required when designing secure digital bridges or complex diagnostic hardware interfaces.

DMET 104: Sensors & Transducers

Here is the comprehensive list of 14 practical experiments for the **Sensors & Transducers** course. This laboratory sequence is designed to bridge the gap between raw physical phenomena and the electrical signals that medical diagnostic equipment relies on.

Following the list, you will find the detailed specifications for the required laboratory, computing, and specialized calibration facilities.

List of 14 Practical Experiments

Unit 1: Classification of Transducers

1. Sensor Static Characteristics:

- *Description:* Loading a standard linear displacement transducer and plotting its input-output curve to calculate its sensitivity, linearity error, and hysteresis loop.
- *Medical Tech Application:* Understanding how to interpret the calibration sheets provided by Original Equipment Manufacturers (OEMs) when replacing sensors in medical drives.

2. Dynamic Response (Time Constants):

- *Description:* Subjecting a bare thermistor and a heavily sheathed temperature probe to a sudden step-change in temperature (plunging into a hot water bath) to calculate and compare their thermal time constants.
- *Medical Tech Application:* Understanding why some patient temperature monitors react instantly while others take minutes to stabilize.

Unit 2: Resistive & Capacitive Transducers

3. Strain Gauge and Wheatstone Bridge:

- *Description:* Bonding a resistive strain gauge to a cantilever beam, wiring it into a quarter-bridge configuration, and measuring the microvolt output as calibrated weights are applied.
- *Medical Tech Application:* The core mechanical principle behind hospital bed weighing scales and mechanical ventilator pressure sensors.

4. Thermistor Calibration & Linearization:

- *Description:* Plotting the non-linear resistance-temperature curve of an NTC thermistor in a controlled thermal bath, and designing a resistor network to linearize its output.
- *Medical Tech Application:* Calibrating the disposable and reusable skin temperature probes used in neonatal incubators.

5. Capacitive Fluid Level Sensing:

- *Description:* Measuring the change in capacitance between two parallel plates as a dielectric fluid (simulating saline or blood) fills the space between them.
- *Medical Tech Application:* The foundational technology behind non-contact IV fluid level detectors and blood reservoir alarms in dialysis machines.

Unit 3: Piezoelectric & Photoelectric Sensors

6. Piezoelectric Resonance:

- *Description:* Applying a variable frequency AC signal to a piezoelectric ceramic disc and using an oscilloscope to identify its resonant frequency and maximum acoustic output.
- *Medical Tech Application:* Understanding the acoustic physics required to maintain and test diagnostic ultrasound transducer arrays.

7. Photoplethysmography (PPG) Setup:

- *Description:* Aligning an Infrared (IR) LED and a matched photodiode across a finger to detect the pulsatile volumetric changes in local blood flow, viewing the raw analog waveform on an oscilloscope.
- *Medical Tech Application:* Building the raw optical foundation of a clinical SpO₂ (Pulse Oximetry) sensor.

8. Optical Absorbance (Colorimetry):

- *Description:* Using a light-dependent resistor (LDR) or phototransistor to measure the varying optical density of simulated chemical solutions at specific wavelengths.
- *Medical Tech Application:* The operational basis for automated clinical chemistry analyzers and blood sample hemoglobinometers.

Unit 4: Biopotential Electrodes

9. Half-Cell Potential & Polarization:

- *Description:* Placing two identical Ag/AgCl surface electrodes in a saline bath and measuring the DC offset voltage (half-cell potential) and observing polarization when a small DC current is applied.
- *Medical Tech Application:* Diagnosing baseline wander in ECG machines caused by degraded electrode gel or improper skin preparation.

10. Skin-Electrode Impedance Measurement:

- *Description:* Using a precision LCR meter to measure the contact impedance of disposable ECG electrodes on human skin before and after proper abrasive skin preparation.
- *Medical Tech Application:* Ensuring absolute signal fidelity when preparing patients for sensitive EEG or Holter monitor recordings.

11. Multi-Frequency Tissue Impedance Sweep:

- *Description:* Applying a safe, constant-current AC signal across electrodes on a simulated tissue phantom and sweeping the frequency from 50 kHz to 800 kHz to observe changes in measured impedance.
- *Medical Tech Application:* The advanced diagnostic foundation required for developing and troubleshooting impedance pneumography systems (like those used for Obstructive Sleep Apnea screening) and body composition analyzers.

Unit 5: Biochemical Sensors (pH, pO₂, pCO₂)

12. Glass pH Electrode Calibration:

- *Description:* Standardizing a clinical glass pH electrode using precise chemical buffer solutions (pH 4.0, 7.0, and 10.0) and calculating the millivolt slope per pH unit.
- *Medical Tech Application:* The mandatory daily maintenance routine for Arterial Blood Gas (ABG) analyzers in the ICU.

13. Dissolved Oxygen (Clark Electrode) Basics:

- *Description:* Using a polarographic dissolved oxygen sensor to measure the partial pressure of oxygen in aerated and nitrogen-purged water samples.
- *Medical Tech Application:* Understanding the electrochemical cell that directly measures a patient's pO₂ during critical care blood analysis.

14. Severinghaus CO₂ Simulation:

- *Description:* Demonstrating the principle of the Severinghaus electrode by placing a pH sensor in a bicarbonate buffer solution separated by a gas-permeable membrane, observing the pH change as CO₂ gas diffuses across the barrier.
- *Medical Tech Application:* Grasping the indirect chemical measurement techniques used in transcutaneous CO₂ monitors and capnography.

Laboratory, Computing, and Special Facilities Required

To conduct these experiments with industrial precision, the institution must establish a **Medical Transducers & Instrumentation Laboratory**. This space must integrate heavy mechanical test rigs with highly sensitive microvolt electronics and secure wet-chemistry zones.

1. Physical Laboratory Infrastructure

- **Workstations:** 10 to 15 highly stable, vibration-dampened laboratory workbenches.
- **Zoning:** * *Dry Electronics Zone:* For breadboarding, piezoelectric testing, and strain gauge calibration.
 - *Wet Chemistry Zone:* Chemical-resistant benches with distilled water access, required for the safe handling of pH buffers, saline solutions, and simulated blood parameters.
- **Environmental Control:** The lab must have stable ambient temperature and humidity control, as thermal drift heavily impacts bare thermistor and chemical electrode calibrations.

2. Hardware & Bench Instrumentation

- **Signal Acquisition:** Dual-channel Digital Storage Oscilloscopes (DSOs), Digital Function Generators, and high-precision benchtop multimeters (minimum 5.5 digit resolution) to measure the microvolt outputs of unbalanced Wheatstone bridges.
- **Data Acquisition (DAQ):** Microcontroller development boards (e.g., Arduino Nano ESP32 or similar high-speed MCUs) and standard DAQ modules (like NI MyDAQ) at

each bench to allow students to log sensor data directly to their computers for analysis.

- **Test Rigs & Simulators:**

- Precision, circulating, temperature-controlled water baths for thermal sensor calibration.
- Mechanical cantilever beam rigs with calibrated brass weight sets for strain gauge loading.
- Dark-boxes or opaque enclosures for testing photoelectric sensors without ambient room-light interference.

3. Medical Consumables & Chemical Supplies

- **Electrodes:** Bulk supplies of disposable Ag/AgCl ECG electrodes, reusable EEG cups, and conductive electrode paste.
- **Biochemical Sensors:** Educational-grade glass pH electrodes, dissolved oxygen probes, and standard calibration buffer solutions.
- **Phantoms:** Conductive hydrogel phantoms or saline baths to simulate human tissue for impedance and half-cell potential experiments.

4. Computing Facilities

- **Workstations:** Desktop PCs equipped with software capable of real-time data logging and visualization.
- **Software:** Licenses for graphical programming environments (like NI LabVIEW) or open-source Python environments (using Pandas and Matplotlib) to automate the plotting of sensor calibration curves, linearity errors, and frequency response graphs.

DMET 105: Intro to Healthcare IT and Artificial Intelligence in Medicine

List of 14 Practical Experiments

Unit 1: Fundamentals of Computer Networks & HIS

1. Wireless Telemetry Network Scanning

- **Description:** Students write and execute a network scanning script to map hospital WLAN access points designated for patient telemetry. They must formulate precise regular expressions to accurately extract and separate the SSID and BSSID fields without generating identical outputs.
- **Medical Tech Application:** Mapping wireless coverage zones to prevent dropped signals from ambulatory patient monitors in cardiac wards.

2. TCP/IP Subnetting & MAC Filtering

- **Description:** Using managed network switches and routers, students create a segmented Local Area Network (LAN). They must configure static IP addresses and apply MAC filtering to restrict network access to a specific list of simulated medical devices.
- **Medical Tech Application:** Securing critical life-support equipment on an isolated hospital subnet, preventing unauthorized devices from consuming bandwidth or introducing malware.

3. HIS Workflow Simulation (Admissions to Lab)

- **Description:** Navigating an open-source Hospital Information System (HIS), students simulate a patient pathway: registering a patient, ordering a lab test from the ward, and viewing the simulated results routed back from the pathology module.
- **Medical Tech Application:** Understanding the digital handoffs required so that an auto-analyzer physically processing a blood sample can automatically attach the result to the correct patient's billing and clinical file.

Unit 2: Electronic Medical Records (EMR/EHR) & Database Management Basics

4. Basic SQL Querying for CMMS

- **Description:** Students connect to a simulated Relational Database Management System (RDBMS) populated with equipment repair data. They execute SQL SELECT, INSERT, and UPDATE queries to filter records by "Device Type," "Failure Code," and "Date."
- **Medical Tech Application:** Managing the Clinical Engineering department's asset tracking software to instantly locate which infusion pumps are overdue for preventive maintenance.

5. Real-Time Clinical Dashboard Integration

- **Description:** Students design the logic for an EHR dashboard displaying incoming bedside vital signs. They must implement event-triggered updates utilizing "Version" or "Timestamp" checks to refresh data immediately upon receiving new values, strictly avoiding legacy 1-second polling intervals.
- **Medical Tech Application:** Ensuring nursing staff see critical vital sign drops the millisecond they occur without crashing the hospital's central server via excessive, redundant polling requests.

6. Role-Based Access Control (RBAC) in EHR

- **Description:** Within a sandbox EHR system, students configure user profiles with distinct permission tiers (e.g., Physician, Nurse, Clinical Engineer). They

must test the system to verify that engineering accounts can view equipment connection statuses but are blocked from reading physician clinical notes.

- **Medical Tech Application:** Enforcing strict patient data privacy and complying with legal frameworks (like HIPAA) by ensuring staff only access the minimum data required for their role.

Unit 3: Healthcare Data Standards (HL7, DICOM)

7. Parsing HL7 Text Messages

- **Description:** Students are provided with raw HL7 v2.x message strings (e.g., ADT - Admit/Discharge/Transfer). Using a text editor and basic scripting, they must manually decode the segments and fields to extract patient demographics and attending physician details.
- **Medical Tech Application:** Troubleshooting communication errors between a patient monitor and the central server by reading the raw text logs to see exactly where the data handoff failed.

8. DICOM Metadata Extraction

- **Description:** Using a free DICOM viewer (e.g., RadiAnt or Horos), students open a sample MRI dataset. They must navigate the DICOM header tags to extract specific metadata, including the scanner manufacturer, slice thickness, and patient anonymization status.
- **Medical Tech Application:** Verifying that a diagnostic imaging scanner is correctly formatting its output files before authorizing its connection to the hospital's main PACS server.

9. PACS Server Push/Pull Simulation

- **Description:** Students configure a local workstation to act as an imaging modality (like a portable X-ray) and successfully execute a DICOM "C-ECHO" and "C-STORE" command to push an image to a simulated centralized PACS server.
- **Medical Tech Application:** The daily IT task of ensuring that images captured in the Emergency Department are instantly viewable by radiologists on the other side of the hospital.

Unit 4: Intro to AI, Machine Learning & Algorithms

10. Python Environment Setup & Data Plotting

- **Description:** Students install Python, Jupyter Notebooks, and the Pandas/Matplotlib libraries. They load a large CSV dataset containing 5 years of hospital equipment breakdown histories and generate scatter plots and histograms to visualize failure trends over time.
- **Medical Tech Application:** Moving beyond basic spreadsheets to handle massive clinical datasets, allowing engineers to visualize which specific ventilator models fail most often during peak summer months.

11. Equipment Calibration Optimization using Python

- **Description:** Students write a Python script to optimize the calibration curves of a simulated medical tracking system. They utilize optimization functions (such as `scipy.optimize.least_squares`) and structure the code to pass data arrays explicitly through the `args` parameter to calculate spatial trilateration accurately.
- **Medical Tech Application:** Mathematically calibrating Real-Time Location Systems (RTLS) used to track the exact physical coordinates of mobile medical assets (like defibrillators) within a hospital ward.

12. Machine Learning for Vital Sign Classification

- **Description:** Using SciKit-Learn, students train a Random Forest classifier algorithm using a provided dataset of historical patient vitals (Heart Rate, SpO2, Blood Pressure). They must generate a confusion matrix to evaluate the algorithm's accuracy in classifying the data as "Normal" or "Deteriorating."
- **Medical Tech Application:** Understanding the underlying logic of modern "smart" patient monitors that automatically generate early warning scores before a patient enters cardiac arrest.

Unit 5: Ethical Considerations of AI in Health

13. Identifying Algorithmic Bias in Medical Datasets

- **Description:** Students are given a pre-trained diagnostic algorithm and two distinct testing datasets representing different patient demographics. They execute the model on both sets and calculate the discrepancy in false-positive rates to identify skewed training bias.
- **Medical Tech Application:** Fulfilling the engineer's ethical responsibility to mathematically prove that a newly purchased AI triage system works equally well for all patient populations before deploying it in the hospital.

14. SaMD (Software as a Medical Device) FDA Audit

- **Description:** Students review the software architecture and training documentation for a hypothetical AI-driven ECG analysis tool. Using a checklist derived from FDA SaMD guidelines, they must perform a mock regulatory audit to identify compliance gaps in data privacy and software validation.
- **Medical Tech Application:** Ensuring that locally developed hospital software scripts used for clinical diagnostics meet the strict legal requirements necessary to avoid regulatory penalties and ensure patient safety.

Laboratory, Computing, and Special Facilities Required

To effectively conduct these IT and AI experiments, the institution must establish a **Healthcare Informatics & AI Computing Laboratory**. This facility requires high-performance digital infrastructure rather than traditional electronic workbenches.

1. Hardware & Networking Infrastructure (Per Batch of typically 30 Students)

- **High-Performance Workstations:** 30 desktop computers (Minimum Specs: Intel Core i7 / AMD Ryzen 7, 16GB+ RAM, dedicated GPU with CUDA support for accelerated machine learning tasks, 512GB SSD).
- **Enterprise Networking Rack:** A dedicated, isolated physical server rack in the lab containing:
 - 2x Managed Layer 3 Network Switches (e.g., Cisco Catalyst).
 - 1x Enterprise Router and Hardware Firewall.
 - 2x Wireless Access Points (WAPs) capable of multiple SSID broadcasting for telemetry mapping exercises.
- **Instructor Command Station:** A high-end workstation connected to dual high-definition digital projectors to display code execution and network topologies simultaneously.

2. Software Requirements & Licensing

- **Programming & AI Environment:** Python 3.x distribution (via Anaconda), Jupyter Notebooks, SciKit-Learn, Pandas, and SciPy.
- **Database & Server Software:** Local installations of MySQL or PostgreSQL.

- **Healthcare-Specific Open Source Tools:**

- *EHR/HIS Sandbox:* A localized, sandbox installation of an open-source EMR such as OpenEMR or GNU Health.
- *Imaging & Standards:* Open-source DICOM viewer software (e.g., Horos for macOS or RadiAnt for Windows) and a lightweight PACS server emulator (e.g., Orthanc).
- *Network Analysis:* Wireshark for capturing and analyzing LAN traffic and HL7 message streams.

3. Physical Space & Ergonomics

- **Collaborative Pods:** Desks arranged in clusters of 4 to 6 to facilitate group-based network configurations and simulated inter-departmental workflow exercises.
- **Uninterruptible Power Supply (UPS):** Centralized battery backup for the entire laboratory to prevent database corruption or loss of machine learning training progress during localized power fluctuations.

DMET 106: Eng. Workshop & Drawing

Here is the comprehensive list of 14 practical experiments for the **Eng. Workshop & Drawing** course. This curriculum is designed to transform theoretical engineering concepts into tangible, physical skills—ensuring students can confidently read blueprints, fabricate missing parts, and perform board-level repairs.

Following the list are the detailed specifications for the required workshop, laboratory, and computing facilities.

List of 14 Practical Experiments

Unit 1: Orthographic Projections

1. Manual Drafting Basics:

- *Description:* Using drafting instruments to draw standard title blocks, line types, and dimensioning arrows on A3 drawing sheets.
- *Medical Tech Application:* Learning the strict visual grammar required to read global engineering documents.

2. First and Third Angle Projections:

- *Description:* Drafting the front, top, and side orthographic views of basic 3D mechanical blocks using both first-angle and third-angle projection methods.
- *Medical Tech Application:* Interpreting standard mechanical drawings of hospital bed actuators and mounting brackets.

3. Interpreting OEM Service Manuals:

- *Description:* Analyzing exploded-view mechanical diagrams from actual medical device service manuals (e.g., an anesthesia machine's pneumatic block) and identifying specific part dimensions.
- *Medical Tech Application:* Navigating complex manufacturer documentation to order the correct physical replacement parts.

Unit 2: Isometric Projections & CAD Basics

4. Isometric Sketching from 2D Plans:

- *Description:* Converting a set of 2D orthographic projections into a hand-drawn 3D isometric sketch on grid paper.
- *Medical Tech Application:* Quickly sketching a broken mechanical linkage to communicate the failure to a fabrication shop.

5. Introduction to 2D CAD Software:

- *Description:* Navigating the interface of drafting software (e.g., AutoCAD or DraftSight) to draw basic geometric shapes, apply layers, and insert dimensions.
- *Medical Tech Application:* The foundational skill for modifying or creating digital blueprints.

6. Hospital Infrastructure Floor Planning (CAD):

- *Description:* Using CAD software to draft a basic 2D layout of an Intensive Care Unit (ICU), including the placement of beds, medical gas outlets, and electrical panels.
- *Medical Tech Application:* Assisting in hospital facility planning and ensuring equipment installations meet spatial and regulatory requirements.

Unit 3: Fitting & Welding Workshop

7. Precision Bench Fitting:

- *Description:* Using hacksaws and flat/half-round files to manually reduce a mild steel block to exact dimensions, verified using a vernier caliper.
- *Medical Tech Application:* Developing the "feel" for metalwork and precision required when fabricating custom mounting brackets for patient monitors.

8. Internal & External Threading (Tapping & Die):

- *Description:* Drilling precise holes and using manual tap and die sets to cut internal and external threads into metal components.

- *Medical Tech Application:* Repairing stripped screw threads on heavy equipment chassis (like surgical tables or centrifuges) without having to replace the entire frame.

9. Basic Arc Welding Joints:

- *Description:* Operating a shielded metal arc welding (SMAW) machine to perform simple lap and butt joints on mild steel plates.
- *Medical Tech Application:* Safely executing emergency structural repairs on damaged wheelchair frames, IV poles, or hospital bed rails.

Unit 4: Sheet Metal & 3D Printing

10. Sheet Metal Fabrication (Chassis Building):

- *Description:* Marking, cutting with aviation snips, bending on a brake, and riveting an aluminum sheet to form a protective three-sided box.
- *Medical Tech Application:* Fabricating custom metal enclosures for power supplies or replacing damaged protective covers on mobile X-ray machines.

11. CAD to STL Conversion & Slicing:

- *Description:* Taking a 3D digital model, exporting it as an STL file, and configuring layer height, infill, and supports using slicing software (e.g., Ultimaker Cura).
- *Medical Tech Application:* The digital preparation phase required before physically printing a replacement part.

12. 3D Printing & Enclosure Prototyping:

- *Description:* Operating a desktop FDM 3D printer to fabricate a custom housing for a microcontroller-based module (e.g., an ESP32 clinic queue display) or a replacement mechanical gear/knob.
- *Medical Tech Application:* Rapidly manufacturing plastic components that OEMs no longer supply for legacy medical equipment.

Unit 5: PCB Fabrication & Soldering

13. Chemical PCB Etching & Drilling:

- *Description:* Transferring a circuit layout onto a copper-clad board, utilizing chemical etchants (like Ferric Chloride) to remove excess copper, and using a mini-drill press to create component through-holes.
- *Medical Tech Application:* Prototyping custom test circuits or creating replacement interconnect boards when factory replacements are delayed.

14. Soldering, Desoldering & Motherboard Maintenance:

- *Description:* Soldering components to IPC standards, then using solder wick and desoldering pumps to remove multipin ICs from a donor board (e.g., a damaged display driver board). Finally, utilizing isopropyl alcohol to thoroughly clean the motherboard of residual flux and prevent micro-shorts.
- *Medical Tech Application:* The critical, high-value skill of repairing expensive medical device motherboards at the component level rather than swapping out the entire board.

Laboratory, Computing, and Special Facilities Required

This course requires a multi-zoned facility that strictly separates "clean" computing tasks from "dirty" mechanical and chemical fabrication tasks.

1. Engineering Drawing & CAD Computing Lab (Clean Zone)

- **Physical Drafting Area:** Adjustable, large-format drafting tables (A3/A2 size) equipped with mini-drafters or T-squares for manual drawing experiments.
- **Computing Workstations:** High-performance desktop PCs (minimum 16GB RAM, dedicated GPUs) capable of smoothly running CAD software. Ratio of 1 PC per student.
- **Software:** Licenses for 2D/3D CAD platforms (e.g., AutoCAD, SolidWorks, or open-source alternatives like FreeCAD) and 3D printer slicing software.
- **Printers/Plotters:** A large-format A3/A2 digital plotter for printing out digital floor plans and schematics.

2. Fitting, Welding & Sheet Metal Workshop (Heavy Zone)

- **Workbenches:** Heavy-duty, vibration-dampened steel workbenches equipped with heavy 6-inch bench vises (1 vise per 2 students).
- **Hand Tools & Measurement:** Comprehensive sets of engineering files (rough, bastard, smooth), hacksaws, ball-peen hammers, center punches, tap and die sets, and high-precision dial or digital vernier calipers.
- **Machinery:** Benchtop drill presses and sheet metal bending brakes/shears.
- **Welding Booth:** A dedicated, fire-proofed welding booth with a basic arc welding inverter, heavy-duty exhaust ventilation, welding helmets (auto-darkening), thick leather aprons, and gauntlets.

3. Prototyping & PCB Fabrication Lab (Chemical/Electronics Zone)

- **3D Printing Station:** 2 to 3 desktop FDM (Fused Deposition Modeling) 3D printers (e.g., Creality Ender or Prusa models) with a stock of PLA and PETG filament.
- **Chemical Etching Area:** A well-ventilated, chemical-resistant sink area for safely handling and disposing of PCB etching solutions (Ferric Chloride). Eye-wash stations are mandatory here.
- **Soldering Stations:** ESD-safe (Electrostatic Discharge) temperature-controlled soldering irons, digital multimeters, solder suckers, copper desoldering wick, electronic-grade rosin-core solder, and isopropyl alcohol for board cleaning.
- **Fume Extraction:** Localized fume extractors (charcoal filtered) at every soldering station to protect students from inhaling vaporized flux and lead particulates.

4. Safety & Environmental Provisions

- **PPE Mandates:** Strict enforcement of safety goggles, closed-toe steel-capped boots, and appropriate gloves for the mechanical and chemical zones.
- **Fire & First Aid:** Easily accessible Class ABC and CO2 fire extinguishers, fully stocked burn kits, and a dedicated safety shower/eyewash station near the chemical etching area.

Year 1: Semester 2

DMET 107: Human Anatomy & Physiology II

Here is the comprehensive list of 14 practical experiments for the **Human Anatomy & Physiology II** course. Since this is the second half of the sequence, the experiments step up in complexity, focusing heavily on dynamic systems, fluid exchange, and electrophysiology—the exact phenomena that life-support and critical care machines interact with.

Following the list are the detailed specifications for the required laboratory, computing, and specialized simulation facilities.

List of 14 Practical Experiments

Unit 1: Respiratory System

1. Spirometry and Lung Volumes:

- *Description:* Using a clinical spirometer to measure Tidal Volume (TV), Vital Capacity (VC), and Forced Expiratory Volume (FEV1) on a healthy volunteer.

- *Medical Tech Application:* Understanding the diagnostic baselines that pulmonary function test (PFT) machines measure to diagnose asthma or COPD.

2. Lung Mechanics and Compliance Simulation:

- *Description:* Utilizing mechanical test lungs (calibrated rubber resuscitation bags) to demonstrate the difference between high-compliance (healthy) and low-compliance (stiff) lungs.
- *Medical Tech Application:* The foundational physical concept required to understand how ICU ventilators adjust pressure and volume delivery to avoid lung injury (barotrauma).

3. Capnography and Dead Space:

- *Description:* Measuring exhaled CO₂ levels using a basic mainstream or sidestream capnograph sensor and observing the normal rectangular waveform.
- *Medical Tech Application:* Learning to identify clinical airway disconnections or blockages by analyzing real-time EtCO₂ (End-Tidal CO₂) waveforms on patient monitors.

Unit 2: Nervous System

4. EEG Electrode Placement (10-20 System):

- *Description:* Mapping and applying the international 10-20 electrode placement system on a mannequin or volunteer's scalp.
- *Medical Tech Application:* Engineers cannot troubleshoot poor signals on an Electroencephalogram (EEG) machine if they do not know the correct anatomical montage.

5. Nerve Conduction and EMG Basics:

- *Description:* Using surface electrodes to measure muscle action potentials (Electromyography) during voluntary contraction and measuring nerve conduction velocity.
- *Medical Tech Application:* Understanding the biological signal source for rehabilitation equipment, biofeedback devices, and prosthetic control systems.

6. Reflex Arcs and Sensory-Motor Loops:

- *Description:* Testing the patellar (knee-jerk) reflex and pupillary light reflex to map the speed of involuntary neurological loops.
- *Medical Tech Application:* Aiding in the understanding of surgical neuro-monitoring tools used to ensure nerves are not severed during spinal operations.

Unit 3: Digestive System

7. Endoscopic Optics and GI Tract Navigation:

- *Description:* Using a teaching borescope or flexible training endoscope to navigate an anatomical model of the stomach and duodenum.
- *Medical Tech Application:* Understanding the tight bending radii, optical fiber constraints, and working channels of gastroscopes and colonoscopes to perform proper maintenance and leak testing.

8. Fluid Dynamics of Enteral Feeding:

- *Description:* Simulating gastrointestinal peristalsis vs. mechanical pumping by measuring the flow rates of viscous simulated nutrient fluids through different French-gauge feeding tubes.
- *Medical Tech Application:* Understanding the pressure resistance and occlusion alarms built into clinical enteral feeding pumps.

9. Enzyme Kinetics and pH Diagnostics:

- *Description:* Performing a basic biochemical test to observe the breakdown of starch by amylase under varying pH levels.
- *Medical Tech Application:* The biological foundation behind the automated biochemistry analyzers and blood gas analyzers used in hospital laboratories.

Unit 4: Excretory System

10. Principles of Hemodialysis (Diffusion & Osmosis):

- *Description:* Creating a mock dialyzer using semi-permeable cellulose membrane tubing to demonstrate the diffusion of solutes (simulated urea) from a high-concentration fluid to a low-concentration fluid.
- *Medical Tech Application:* The absolute core physical and biological principle that governs life-saving Hemodialysis and CRRT machines.

11. Uroflowmetry Simulation:

- *Description:* Measuring the volumetric flow rate of a simulated liquid over time using a load-cell based beaker system.
- *Medical Tech Application:* Understanding the diagnostic equipment used in urology clinics to detect prostate enlargement or bladder dysfunction.

12. Urinalysis and Specific Gravity:

- *Description:* Using clinical dipsticks and optical refractometers to measure the specific gravity and chemical makeup of simulated urine samples.
- *Medical Tech Application:* Learning the optical and chemical baselines required to maintain automated urine chemistry analyzers.

Unit 5: Endocrine & Reproductive Systems

13. Fetal Heart Rate Monitoring (Doppler Ultrasound):

- *Description:* Using a teaching fetal Doppler on a specialized maternal-fetal simulator to locate the fetal heartbeat and differentiate it from the maternal pulse.
- *Medical Tech Application:* Troubleshooting Cardiotocography (CTG) monitors and understanding the acoustic challenges of fetal monitoring.

14. Neonatal Thermal Regulation:

- *Description:* Using a thermal mannequin or a heated water bladder to map radiant heat loss and demonstrate how ambient temperature drops impact body heat.
- *Medical Tech Application:* The physiological justification for the complex servo-controlled heating loops inside infant incubators and radiant warmers.

Laboratory, Computing, and Special Facilities Required

To safely and effectively conduct these experiments, the institution must establish an **Advanced Physiology & Biomechatronics Laboratory**. This space bridges the gap between a wet biology lab and dry electronics testing facility.

1. Physical Laboratory Infrastructure

- **Zoned Workspaces:** * *Wet Zone:* Chemical-resistant benches with sinks for dialysis simulations, urinalysis, and enzyme experiments.
 - *Dry/Electronics Zone:* Insulated benches for DAQ (Data Acquisition) systems, EEG/EMG recording, and computing.

- **Hygiene & Safety:** Standard biohazard disposal bins, eyewash stations, and strict sterilization protocols for shared items like spirometer mouthpieces (using disposable antibacterial filters).

2. Specialized Simulators and Anatomical Models

- **Airway & Respiratory Trainers:** Intubation heads and anatomical respiratory tree models to visualize the trachea and bronchi.
- **Maternal-Fetal Simulators:** Mannequins designed specifically for practicing Doppler placement and understanding reproductive anatomy.
- **GI Tract Models:** Hollow anatomical models of the esophagus and stomach designed specifically for teaching endoscopic navigation.
- **Test Lungs:** Calibrated mechanical test lungs with adjustable compliance and resistance springs (standard equipment in any respiratory therapy or clinical engineering department).

3. Medical & Diagnostic Equipment

- **Neuro-Physiology Kits:** Educational Data Acquisition (DAQ) systems (such as *Biopac Student Lab* or *Vernier Physiology Kits*) complete with safe, isolated ECG, EEG, and EMG surface electrodes.
- **Respiratory Gear:** Handheld diagnostic spirometers (with disposable mouthpieces) and basic teaching capnographs.
- **Excretory/Dialysis Supplies:** Semi-permeable dialysis tubing (cellulose), synthetic urine kits, and clinical refractometers.
- **Optics:** Educational borescopes or retired/refurbished flexible endoscopes (specifically for mechanical handling, not clinical use).

4. Computing Facilities

- **DAQ Workstations:** High-performance laptops or PCs dedicated to the physiology DAQ systems, allowing students to record, amplify, and analyze real-time action potentials and muscle fatigue curves.
- **Interactive 3D Anatomy Software:** A central smartboard running dynamic physiology software (like *Complete Anatomy* or *PhysioEx*). *PhysioEx* is particularly valuable here as a pre-lab tool, allowing students to virtually simulate complex renal or endocrine functions that are difficult or unethical to replicate in a physical lab.

DMET 108: Diagnostic Equipment I (Vitals/NIBP)

Here is the comprehensive list of 14 practical experiments for the **Diagnostic Equip. I (Vitals/NIBP)** course. This sequence is designed to demystify standard ward equipment, taking students from basic physical measurements to utilizing high-end clinical simulators for legally compliant calibration.

Following the list, you will find the detailed specifications for the required clinical metrology laboratory and specialized simulation facilities.

List of 14 Practical Experiments

Unit 1: Clinical Thermometry

1. Thermistor Static Calibration:

- *Description:* Submerging NTC patient skin-temperature probes in a precision, circulating water bath and verifying their resistance values at multiple temperature points against the manufacturer's lookup tables.
- *Medical Tech Application:* Ensuring the reusable temperature probes on infant radiant warmers and incubators are perfectly calibrated to prevent hypothermia or overheating.

2. IR Tympanic Validation:

- *Description:* Verifying the accuracy, optical focus, and thermal drift of clinical infrared ear and non-contact forehead thermometers against a standardized blackbody reference source.
- *Medical Tech Application:* Executing routine checks on the heavily used predictive thermometers deployed across general triage wards.

Unit 2: Principles of Sphygmomanometry

3. Aneroid Gauge Static Calibration:

- *Description:* Connecting manual blood pressure dials to a pneumatic manifold alongside a high-precision digital reference manometer to verify linearity, zero-point accuracy, and mechanical hysteresis across a 0-300 mmHg range.
- *Medical Tech Application:* The physiological and mechanical baseline required to maintain the manual diagnostic devices used universally in clinical triage.

4. Pneumatic Leakage Testing:

- *Description:* Wrapping a BP cuff tightly around a rigid PVC cylinder (mandrel), pressurizing the system to 250 mmHg, and measuring the pressure drop over 60 seconds to identify microscopic bladder or valve leaks.
- *Medical Tech Application:* Isolating the most common cause of "Cuff Loose" or "Timeout" errors in both manual and automated BP machines.

Unit 3: Automated NIBP Technologies

5. NIBP Pneumatic Teardown & Component Mapping:

- *Description:* Disassembling a retired automated NIBP module to physically identify the micro-diaphragm pump, proportional solenoid dump valve, pneumatic manifold, and piezo-resistive pressure transducer.
- *Medical Tech Application:* Transitioning from viewing NIBP as a "black box" to understanding the replaceable electromechanical sub-components.

6. Solenoid Valve Step-Deflation Characterization:

- *Description:* Applying varying PWM voltages to a proportional NIBP dump valve to observe and graph controlled, step-wise deflation rates (ideal target: 3-5 mmHg per heartbeat).
- *Medical Tech Application:* Troubleshooting NIBP modules that deflate too rapidly (missing the systolic peak) or too slowly (causing patient bruising and discomfort).

7. Oscillometric Waveform Visualization:

- *Description:* Tapping directly into the analog output pins of an NIBP pressure transducer to view the raw, microscopic oscillometric pulse envelope superimposed on the cuff deflation curve using a Digital Storage Oscilloscope (DSO).
- *Medical Tech Application:* Understanding exactly how the machine's algorithm calculates the Mean Arterial Pressure (MAP) to derive systolic and diastolic values.

Unit 4: Pulse Oximetry (SpO2)

8. SpO2 Optical Continuity Testing:

- *Description:* Using a digital multimeter and an oscilloscope to verify the electrical integrity, forward voltage drops, and alternating pulse timing of the Red LED and Infrared LED inside a reusable SpO2 finger clip.

- *Medical Tech Application:* Rapidly diagnosing cable breaks or blown optical emitters in high-turnover patient monitoring cables.

9. PPG Signal Separation (AC vs. DC):

- *Description:* Probing the operational amplifiers inside a pulse oximeter test board to view the raw analog signal, specifically measuring the massive DC baseline (ambient tissue/venous blood) versus the tiny AC pulsatile waveform.
- *Medical Tech Application:* Understanding the signal-to-noise ratio challenges that cause pulse oximeters to fail on patients with low perfusion or shock.

10. Optical Interference & Artifact Diagnostics:

- *Description:* Measuring the exact disruptive effect of ambient fluorescent light (50Hz/60Hz noise), simulated motion artifacts, and simulated nail polish on a live Photoplethysmography waveform.
- *Medical Tech Application:* Educating nursing staff on proper probe placement and troubleshooting false alarms caused by environmental factors in the ICU.

Unit 5: Equipment Calibration & Testing

11. Patient Simulator Familiarization:

- *Description:* Navigating the interface of a clinical multi-parameter simulator to output specific, synchronized ECG, respiration, and temperature values to a bedside monitor.
- *Medical Tech Application:* The foundational skill for conducting full-system checks on complex patient monitors without requiring a human subject.

12. Dynamic NIBP Simulation & Alarm Verification:

- *Description:* Connecting a patient monitor to an NIBP simulator to generate synthetic Korotkoff-equivalent pulses, testing the monitor's alarm limits by pushing values past strict hypertensive and hypotensive thresholds.
- *Medical Tech Application:* Ensuring clinical alarms will reliably trigger during a real patient emergency.

13. SpO2 Functional Analysis:

- *Description:* Securing a pulse oximeter probe onto an optical "artificial finger" simulator to verify the equipment accurately tracks programmed oxygen saturation drops from 98% down to critical hypoxic levels (e.g., 85%).
- *Medical Tech Application:* Legally verifying the life-saving accuracy of respiratory monitoring equipment.

14. Comprehensive Preventive Maintenance (PM) Documentation:

- *Description:* Performing a complete PM inspection on a vital signs monitor using OEM service manuals. Students will document calibration tolerances, electrical safety parameters, and functional outcomes in a format compliant with rigorous hospital quality management standards (such as drafting the logs required for an Apex Manual).
- *Medical Tech Application:* Mastering the strict compliance, auditing, and documentation workflows that govern modern clinical engineering departments.

Laboratory, Computing, and Special Facilities Required

To conduct this course, the institution must establish a **Clinical Metrology & Simulation Laboratory**. Because students are learning the exact calibration routines used to keep hospital patients safe, the equipment must reflect current industry standards.

1. Physical Laboratory Infrastructure

- **Workstations:** Standard engineering benches equipped with hospital-grade, isolated electrical power outlets. This prevents ground loops and main electrical interference from corrupting sensitive oscilloscope readings or safety tests.
- **Wet/Dry Zoning:** A designated "wet zone" with sealed, water-resistant benches for the circulating water baths used in thermometry calibration, safely separated from the electronic NIBP teardown areas.

2. Specialized Clinical Simulators & Reference Tools

- **Multi-Parameter Simulators:** 2 to 3 high-end patient simulators (e.g., Fluke ProSim 8 or Rigel Medical equivalents) capable of generating synchronized ECG, respiration, temperature, and invasive blood pressure signals.
- **NIBP Analyzers:** Dedicated pneumatic analyzers with built-in rigid mandrels (simulated adult and neonatal arms) to test automated blood pressure pumps dynamically.
- **SpO2 Functional Testers:** Optical "artificial finger" testers (e.g., Fluke SPOT Light) that can absorb and emit specific wavelengths to test oximeter accuracy.
- **Metrology Standards:** High-precision digital pressure manometers (accurate to ± 0.5 mmHg) and precision circulating water baths (stable to $\pm 0.1^\circ\text{C}$).

3. Hardware Inventory (Device Library)

- **Functional Equipment:** A library of working manual aneroid sphygmomanometers, standalone digital predictive thermometers, and modern multi-parameter vital sign monitors.
- **Triage/Scrap Inventory:** A surplus of discarded, defective SpO2 finger probes, ripped BP cuffs, and retired NIBP pneumatic modules for students to physically disassemble, probe, and reverse-engineer.

4. Computing & Software Facilities

- **Service Documentation Hub:** Dual-monitor PCs at the workstations loaded with PDF readers to display massive, complex OEM service manuals and exploded-view mechanical diagrams.
- **CMMS Access:** A simulated Computerized Maintenance Management System (CMMS) database where students can practice logging their Preventive Maintenance (PM) results, tracking equipment service histories, and generating the compliance reports required for hospital accreditation audits.

DMET 109: Digital Logic Design

List of 14 Practical Experiments

Unit 1: Number Systems & Boolean Algebra

1. IC Familiarization & Universal Gate Implementation:

- *Description:* Identifying standard 74XX series TTL integrated circuits (ICs), understanding pinouts, and using NAND and NOR gates to physically build the logic of AND, OR, and NOT gates on a breadboard.
- *Medical Tech Application:* The foundational skill for reading logic-level schematics and finding substitute replacement ICs on older medical device motherboards.

2. Boolean Simplification using Karnaugh Maps (K-Maps):

- *Description:* Taking a complex 4-variable truth table, minimizing it using a K-Map, and wiring the simplified circuit to prove it produces the exact same output with fewer physical chips.
- *Medical Tech Application:* Optimizing multi-condition alarm states (e.g., triggering a single "Critical" buzzer only if Heart Rate is low, SpO2 is low, AND Blood Pressure is dropping).

Unit 2: Logic Gates & Combinational Circuits

3. Hardware Safety Interlock Simulation (Combinational Logic):

- *Description:* Designing a combinational circuit using AND, OR, and XOR gates that only outputs a "HIGH" signal when three specific, simultaneous conditions are met.
- *Medical Tech Application:* Tracing the physical safety interlocks on a Class 4 surgical laser (the laser can only fire if: the room door switch is closed, the safety key is turned, AND the foot pedal is pressed).

4. Design of Half and Full Adders/Subtractors:

- *Description:* Wiring XOR, AND, and OR gates to perform binary addition and subtraction, verifying the sum and carry outputs.
- *Medical Tech Application:* Understanding the basic Arithmetic Logic Unit (ALU) operations inside the microcontrollers of portable diagnostic equipment.

5. Parity Generator and Checker:

- *Description:* Designing an Even/Odd parity bit generator and testing it against a receiver circuit to detect a flipped bit.
- *Medical Tech Application:* The fundamental error-detection hardware used to ensure that telemetry data (like wireless ECG transmission) hasn't been corrupted by RF noise.

Unit 3: Multiplexers & Decoders

6. Data Routing using a 4:1 Multiplexer (MUX):

- *Description:* Using a 74153 (or similar) MUX IC to route four distinct input signals through a single output line by toggling the select pins.
- *Medical Tech Application:* Replicating how patient monitors route multiple analog sensor inputs (ECG, Respiration, Temp, NIBP) into a single Analog-to-Digital Converter to save motherboard space.

7. Demultiplexer (DEMUX) Operation:

- *Description:* Taking a single serialized data line and routing it to specific outputs using a 1:4 DEMUX.
- *Medical Tech Application:* Distributing clock or control signals to specific sub-modules within an ultrasound machine.

8. BCD to 7-Segment Display Decoding:

- *Description:* Wiring a Binary Coded Decimal (BCD) to 7-segment decoder IC (like the 7447) to drive a physical LED display.
- *Medical Tech Application:* Repairing the legacy physical digital displays often found on robust, older-generation syringe pumps and infant warmers.

Unit 4: Sequential Circuits (Flip-flops, Counters)

9. Truth Table Verification of Flip-Flops (SR, D, JK, T):

- *Description:* Wiring and testing basic flip-flops to understand edge-triggering and state-holding.
- *Medical Tech Application:* Understanding latching circuits, such as an ICU alarm that triggers and stays on (held in memory) until a nurse manually presses the reset button.

10. Synchronous Counters & Logic Locking:

- *Description:* Designing an up/down counter circuit with a logic-gate lock mechanism, preventing the state variable from incrementing until a specific external input switch is held closed.
- *Medical Tech Application:* Used for state-machine pacing, similar to locking an automated clinic queue system to prevent token incrementation until the doctor physically interacts with a "consultation complete" button.

11. Shift Registers (SISO and SIPO):

- *Description:* Using D flip-flops to build Serial-In/Serial-Out and Serial-In/Parallel-Out shift registers to capture and move a string of bits.
- *Medical Tech Application:* The hardware logic used for serial data buffering from a continuous SpO2 finger probe before sending it to the main processor.

Unit 5: A/D and D/A Converters

12. R-2R Ladder Digital-to-Analog Converter (DAC):

- *Description:* Constructing a 4-bit DAC using precision resistors and an Op-Amp, using digital toggle switches to generate discrete analog voltage steps.
- *Medical Tech Application:* Understanding how microcontrollers generate the analog pacing pulses in external cardiac pacemakers or audio alerts.

13. Successive Approximation ADC Basics:

- *Description:* Simulating the logic of an ADC by using a comparator, a DAC, and control logic to find the digital equivalent of an unknown analog input voltage.

- *Medical Tech Application:* The absolute standard method for digitizing continuous analog ECG and EEG waves.

14. High-Frequency Sampling and Aliasing limits:

- *Description:* Using a benchtop ADC module to sample generated frequencies spanning from 50 kHz to 800 kHz, specifically observing how lowering the sample rate below the Nyquist limit distorts the digital output.
- *Medical Tech Application:* A critical concept for designing high-frequency multi-channel biosensors—like those used in impedance pneumography—where under-sampling ruins the diagnostic waveform.

Laboratory, Computing, and Special Facilities Required

To conduct these experiments efficiently, the institution must establish a **Digital Logic & Microprocessor Laboratory**. Digital ICs operate on strict 5V or 3.3V logic levels; stray voltages, static, or floating pins will cause erratic behavior, making a highly controlled environment essential.

1. Physical Laboratory Infrastructure

- **Workstations:** 10 to 15 anti-static (ESD-protected) laboratory workbenches.
- **Digital IC Trainer Kits:** Each bench must have a high-quality digital trainer board. These boards include built-in, regulated +5V DC power supplies, 1Hz to 100kHz adjustable clock pulse generators, logic-level input toggle switches (debounced), and LED logic output indicators. This saves students from having to wire power, ground, and basic inputs from scratch for every single experiment.

2. Hardware & Bench Instrumentation

- **Component Inventory:** Large, highly organized bins of 74XX series TTL logic ICs (AND, OR, NOT, NAND, NOR, XOR, Multiplexers, Decoders, Flip-flops, Counters) and 4000 series CMOS ICs.
- **Breadboards & Wiring:** High-quality, multi-bus solderless breadboards and pre-cut solid-core jumper wires. (Avoid stranded wires, as they fray and short-circuit adjacent IC pins).
- **Measurement Tools:** * Dual-channel Digital Storage Oscilloscopes (DSOs) to visualize clock pulses, propagation delays, and ADC quantization steps.
 - Digital Multimeters (DMMs) to verify 5V logic HIGHs and ground continuity.
- **IC Testers:** A dedicated benchtop digital IC tester. Students should test their chips *before* inserting them into a breadboard to rule out faulty hardware when troubleshooting logic errors.

3. Computing & Simulation Facilities

- **Simulation Workstations:** Laptops or desktop PCs at a 1:2 or 1:3 ratio.
- **Logic Simulation Software:** Software such as **Proteus**, **Logisim** (excellent open-source educational tool), or **NI Multisim**.
- **Pre-Lab Workflow:** Before physically wiring complex sequential circuits like synchronous counters (which require massive amounts of wire routing), students should build and simulate the circuit digitally. This visualizes truth tables instantly and ensures the Boolean logic is flawless before they attempt hardware implementation.

DMET 110: Microprocessors & Controllers

Here is the comprehensive list of 14 practical experiments for the **Microprocessors & Controllers** course. This sequence bridges the gap between legacy assembly language (still running in older auto-analyzers) and modern microcontroller prototyping, enabling students to build functional medical device subsystems.

Following the list, you will find the detailed specifications for the required laboratory, computing, and prototyping facilities.

List of 14 Practical Experiments

Unit 1: 8085 Microprocessor Architecture

1. Memory Mapping & Data Transfer:

- *Description:* Writing an 8085-assembly program to move blocks of hexadecimal data between memory registers.
- *Medical Tech Application:* Simulating how a legacy hematology analyzer buffers raw sensor data before processing.

2. Arithmetic & Checksum Generation:

- *Description:* Developing assembly logic to calculate the byte checksum of a data string.
- *Medical Tech Application:* A critical operation for verifying data integrity before transmitting test results from an auto-analyzer to a Central Nursing Station.

Unit 2: 8051 Microcontroller Basics

3. Hardware Timer Interrupts:

- *Description:* Programming the 8051 internal timers to generate a highly precise 1Hz square wave on a specific output pin.

- *Medical Tech Application:* Simulating the mandatory audible timing circuit for a clinical "Code Blue" or critical equipment failure alarm.

4. **Serial UART Communication:**

- *Description:* Configuring the 8051 serial port to transmit 8-bit ASCII diagnostic error codes to a connected terminal.
- *Medical Tech Application:* Replicating how legacy infusion pumps broadcast status codes (e.g., "E04: Air in Line") to serial data loggers.

5. **Stepper Motor Sequencing:**

- *Description:* Writing a program to sequence the coils of a bipolar stepper motor via a motor driver IC.
- *Medical Tech Application:* Understanding the exact mechanical drive logic used inside volumetric syringe pumps to push fluid at a controlled millimeter-per-hour rate.

Unit 3: Arduino Architecture & IDE

6. **IDE Setup & Visual Fault Indicators:**

- *Description:* Configuring the Arduino IDE and writing a basic loop to trigger a visual LED sequence based on simulated system states (Normal, Warning, Critical).
- *Medical Tech Application:* Structuring the fundamental firmware loops that drive the status lights on portable diagnostic equipment.

7. **Hardware Debouncing & State Machines:**

- *Description:* Designing a state-machine where an input switch (e.g., pin D8) is logically locked and cannot trigger a secondary action until the first action completely clears.
- *Medical Tech Application:* Establishing the logic required for automated OPD clinic queue management, preventing accidental double-clicks from skipping a patient token.

Unit 4: Interfacing Sensors with Arduino

8. **Analog-to-Digital Conversion (ADC) with Thermistors:**

- *Description:* Reading a raw voltage from an NTC thermistor using `analogRead()` and applying the Steinhart-Hart equation in C++ to output an accurate Celsius value to the serial monitor.
- *Medical Tech Application:* The core firmware logic required to read reusable skin-temperature probes in neonatal incubators.

9. Optical Sensor Polling (PPG):

- *Description:* Interfacing a basic analog photodiode/IR emitter pair to capture a raw volumetric pulse wave from a finger, printing the integer values to the Arduino Serial Plotter.
- *Medical Tech Application:* Capturing the raw physical data necessary to build a Pulse Oximeter (SpO2) monitor.

10. I2C Display Interfacing:

- *Description:* Wiring and programming an I2C OLED or LCD screen to display the real-time sensor data acquired in the previous experiments.
- *Medical Tech Application:* Building the user interface for standalone medical devices, such as a bedside digital thermometer.

Unit 5: I/O Programming

11. PWM Motor Drive Control:

- *Description:* Generating varying Pulse Width Modulation (PWM) signals through a logic-level MOSFET to control the RPM of a small DC motor.
- *Medical Tech Application:* Controlling the centrifuge speed in a blood bank or regulating the blower motor in a CPAP machine.

12. Relay Control & High-Voltage Isolation:

- *Description:* Using a 5V digital output pin to safely switch a 12V electromechanical relay, ensuring the microcontroller is optically or magnetically isolated from the high-power load.
- *Medical Tech Application:* Replicating the logic used to safely activate the heavy AC heating elements in an infant radiant warmer without frying the logic board.

13. Hardware Safety Interrupts (Limit Switches):

- *Description:* Programming an external hardware interrupt that instantly overrides the main loop () and halts the PWM motor drive when a physical tactile switch is pressed.
- *Medical Tech Application:* Mimicking a syringe pump occlusion alarm, where high pressure physically hits a limit switch and the firmware must stop the motor instantly to prevent patient injury.

14. Prototype: Automated IV Drip Counter:

- *Description:* Combining an optical IR break-beam sensor, the I2C LCD, a buzzer, and debounced buttons to count simulated IV fluid drops. The system

will trigger the relay and buzzer if the drop rate falls below a programmed threshold.

- *Medical Tech Application:* Integrating all learned I/O skills into a functional, clinically relevant embedded system prototype.

Laboratory, Computing, and Special Facilities Required

To effectively teach this course, the institution requires a dedicated **Embedded Systems & Prototyping Laboratory**. Digital microcontrollers are highly sensitive to static and voltage spikes, so the environment must be tightly controlled.

1. Physical Laboratory Infrastructure

- **Workstations:** 10 to 15 anti-static (ESD-protected) laboratory workbenches.
- **Component Storage:** Highly organized, static-safe component bins for delicate ICs, microcontroller boards, and sensors.

2. Computing & Simulation Facilities

- **Workstations:** High-performance desktop PCs (minimum 16GB RAM) at a strict 1:1 or 1:2 student-to-computer ratio.
- **Legacy Simulation Software:** Installed simulators for 8085 and 8051 architectures (such as **GNUSim8085** or **EdSim51**). This allows students to verify their assembly code line-by-line before dealing with physical hardware faults.
- **Modern IDEs:** The **Arduino IDE** and **Visual Studio Code (VS Code)** for modern C++ embedded development.

3. Hardware & Trainer Kits

- **Legacy Microprocessor Kits:** Standalone 8085 and 8051 hardware training boards equipped with built-in hex keypads and 7-segment LED displays. These teach the absolute fundamentals of memory addressing.
- **Modern Prototyping Boards:** An inventory of **Arduino Uno R3** or **Arduino Nano** boards.
- **Interfacing Peripherals:**
 - I2C LCD/OLED modules (16x2 character displays).
 - Logic-level MOSFET modules and 5V Relay modules.
 - Small 5V/12V DC motors and NEMA 17 stepper motors with appropriate A4988 driver boards.
- **Sensor Inventory:** NTC thermistors, analog photodiode/IR emitter pairs (for PPG), and limit switches/pushbuttons.

- **Breadboards & Wiring:** High-quality solderless breadboards and pre-cut solid-core jumper wires.

4. Bench Instrumentation

- **Digital Storage Oscilloscopes (DSOs):** Crucial for Units 2, 4, and 5. Students must be able to visually see the square waves generated by timers, the duty cycle of their PWM motor controls, and the digital packets traveling along I2C data lines.
- **Digital Multimeters (DMMs):** For verifying circuit continuity, measuring thermistor resistance, and ensuring safe voltage isolation around relay circuits before power is applied.

DMET 111: Power Electronics for Medical

Here is the comprehensive list of 14 practical experiments for the **Power Electronics for Medical** course. This sequence is specifically designed to safely transition students from low-voltage electronics to the high-voltage, high-current environments that drive massive hospital infrastructure.

Following the list, you will find the detailed specifications for the required high-power electrical laboratory, computing, and specialized safety facilities.

List of 14 Practical Experiments

Unit 1: Power Diodes & Thyristors

1. V-I Characteristics of SCRs and TRIACs:

- *Description:* Plotting the forward/reverse bias characteristics and determining the exact gate trigger current and holding current required to fire high-power thyristors.
- *Medical Tech Application:* Understanding the solid-state switching foundation used in the heavy AC power drives of hospital autoclaves and large surgical lighting arrays.

2. IGBT & Power MOSFET Switching Dynamics:

- *Description:* Driving a high-power MOSFET and measuring its turn-on/turn-off times using a Digital Storage Oscilloscope (DSO). Students will observe the severe thermal output under high-frequency switching and map the heat dissipation across an aluminum heat sink.
- *Medical Tech Application:* Diagnosing thermal runaway in the high-voltage generator boards of X-ray machines.

3. Phase-Controlled Rectification (Motor Drive Simulation):

- *Description:* Building a single-phase half-wave and full-wave controlled rectifier circuit to drive a heavy inductive DC load, observing the effect of the freewheeling diode.
- *Medical Tech Application:* Calibrating and repairing the heavy DC motor drives used in high-capacity blood bank centrifuges.

Unit 2: Inverters & Converters

4. DC-DC Boost Converter Load Testing:

- *Description:* Constructing a *boost* converter to step up a 12V DC input to a stable 24V DC output under varying resistive loads, calculating the overall conversion efficiency.
- *Medical Tech Application:* Troubleshooting the internal power management systems of battery-operated emergency transport ventilators.

5. Pulse Width Modulation (PWM) Inverter Analysis:

- *Description:* Using a microcontroller to generate a PWM signal, driving an H-bridge inverter to convert a DC source into an AC waveform. Students will analyze the harmonic distortion of the output.
- *Medical Tech Application:* Repairing the compact DC-AC inverters that allow portable ultrasound machines to run off internal battery packs without polluting the diagnostic signal with electrical noise.

6. Four-Quadrant Motor Control (H-Bridge Reversal):

- *Description:* Implementing a full H-bridge power circuit to drive a DC motor in forward, reverse, and dynamic braking modes.
- *Medical Tech Application:* Servicing the heavy motorized positioning drives of mobile C-arms and motorized operating tables.

Unit 3: Switched Mode Power Supplies (SMPS)

7. Medical SMPS Teardown & Reverse Engineering:

- *Description:* *Disassembling* a retired multi-parameter patient monitor to extract the SMPS. Students will trace the PCB tracks to identify the EMI filter, bridge rectifier, primary switching MOSFET, high-frequency transformer, and opto-isolator feedback loop.
- *Medical Tech Application:* Transitioning the power supply from a "black box" to a highly repairable, modular circuit.

8. Component-Level Diagnostics & Board Rework:

- *Description:* Simulating a power surge failure. Students will learn to isolate short-circuited driver IC pins, safely desolder blown power MOSFETs, test opto-isolator continuity, and properly clean carbonized flux and debris from the motherboard using isopropyl alcohol before reassembly.
- *Medical Tech Application:* Executing board-level repairs to save hospitals thousands of dollars, rather than replacing entire proprietary power supply modules when grid voltage spikes occur.

9. EMI/RFI Filter Performance Testing:

- *Description:* Scoping the input stage of an SMPS to measure how effectively the passive LC filter suppresses high-frequency switching noise from feeding back into the 230V/50Hz mains supply.
- *Medical Tech Application:* Ensuring that a repaired power supply does not pollute the hospital's electrical grid, which could otherwise corrupt sensitive EEG or ECG signals in adjacent rooms.

Unit 4: Uninterruptible Power Supplies (UPS)

10. Transfer Time Analysis (Online vs. Line-Interactive):

- *Description:* Using a DSO to capture the exact millisecond gap in the AC waveform when the main power is physically cut and the UPS inverter takes over the load.
- *Medical Tech Application:* Proving why an ICU ventilator requires a true "Online Double-Conversion" UPS (zero transfer time), while a nursing station computer can survive on a cheaper Line-Interactive model.

11. Battery Bank Profiling & Internal Resistance:

- *Description:* Performing a deep discharge load test on Valve-Regulated Lead-Acid (VRLA) and Lithium-ion battery packs, using an internal resistance (IR) meter to identify degraded cells.
- *Medical Tech Application:* Conducting mandatory preventive maintenance on hospital crash-cart defibrillators and critical backup arrays to ensure they don't fail during a blackout.

12. Critical Load Capacity Sizing:

- *Description:* Calculating the total Volt-Ampere (VA) and Wattage draw of a simulated ICU bed setup (Ventilator + Syringe Pumps + Monitor) to properly size a UPS system, accounting for the power factor and inductive inrush currents.
- *Medical Tech Application:* Assisting the hospital facility management team in auditing ward power capacities.

Unit 5: Medical Grade Isolation Transformers

13. Isolated Power System (IPS) Leakage Testing:

- *Description:* Wiring a 1:1 Medical Isolation Transformer and measuring the drastic reduction in earth leakage current when standard hospital equipment is plugged into the isolated secondary side versus the direct mains side.
- *Medical Tech Application:* Understanding the primary hardware safeguard that prevents patient microshocks in catheterization labs and ICUs.

14. Line Isolation Monitor (LIM) Fault Triggering:

- *Description:* Constructing a simulated "wet environment" Operation Theatre circuit. Students will intentionally induce varying resistive faults from the isolated power lines to ground, verifying that the LIM alarms precisely at the mandated 2mA to 5mA threshold without tripping the main breaker.
- *Medical Tech Application:* Executing the critical safety audits required to certify an Operation Theatre for surgical use.

Laboratory, Computing, and Special Facilities Required

Because this course transitions from microvolt signals to lethal 230V/50Hz mains power and high-current DC systems, the laboratory environment requires strict industrial safety measures and specialized metrology.

1. Physical Laboratory Infrastructure (High Power Lab)

- **Electrical Safety Interlocks:** The lab must feature a master emergency "Kill Switch" system (Emergency Power Off - EPO) accessible at the instructor's desk and at various points in the room.
- **Grounded & Insulated Workstations:** Heavy-duty workbenches equipped with high-grade ESD and high-voltage insulating rubber floor mats (Class 0 or higher).

- **Workstation Isolation:** Every individual student workbench *must* be powered through its own heavy-duty isolation transformer and Residual Current Device (RCD). Students cannot safely probe an SMPS primary side with a grounded oscilloscope without this isolation.

2. Specialized Metrology & High-Power Equipment

- **Digital Storage Oscilloscopes (DSOs) with Differential Probes:** Standard passive scope probes will short to ground and explode if connected to the primary side of an SMPS or the floating side of an H-bridge. High-Voltage Active Differential Probes are an absolute, non-negotiable requirement for this lab.
- **Power Supplies & Loads:** * High-current programmable DC power supplies (e.g., 0-60V, 10A+).
 - Heavy-duty sliding rheostats and inductive load banks (small fractional-horsepower DC/AC motors) to simulate physical medical machinery.
- **Thermal Diagnostics:** Infrared (IR) digital thermometers or basic thermal imaging cameras to safely visualize heat dissipation and thermal runaway on MOSFET heat sinks without touching them.

3. Component Rework Stations

- **Advanced Soldering Hubs:** Temperature-controlled hot air rework stations designed for desoldering multi-pin power ICs and heavy through-hole components mounted to large copper ground planes.
- **Consumables:** High-quality flux, solder wick, conformal coating spray, and industrial isopropyl alcohol dispensing bottles for mandatory PCB cleaning.

4. Computing Facilities

- **Simulation Workstations:** Standard PCs configured at a 1:2 ratio.
- **Simulation Software:** Access to power electronics simulation environments like MATLAB/Simulink (Simscape Electrical), NI Multisim, or LTspice. Students must simulate the high-current loops of Buck/Boost converters and PWM inverters before physically building them to avoid component destruction.

DMET 112: Technical Communication and Professional Ethics

Here is the list of 14 practical experiments (structured as applied workshops and clinical simulations) for the **Technical Communication and Professional Ethics** course, followed by the specific facility requirements needed to execute them.

Because communication and ethics rely heavily on human interaction and legal documentation, these "experiments" focus on drafting high-stakes correspondence, role-playing high-stress clinical scenarios, and practicing secure data management.

List of 14 Practical Experiments & Simulations

Unit 1: Grammar, Syntax & Professional Code of Ethics

1. Drafting Standard Operating Procedures (SOPs)

- **Description:** Students are provided with a messy, poorly translated technical manual for a syringe pump. They must extract the key steps and rewrite them into a clear, grammatically flawless, single-page SOP suitable for nursing staff.
- **Medical Tech Application:** Ensuring absolute clarity when writing instructions or preparing technical manuals to prevent lethal use-errors on the ward.

2. The "Pressured Sign-Off" Role-Play

- **Description:** A simulated role-play where a student acts as the on-call engineer, and the instructor acts as a senior surgeon demanding an anesthesia machine be cleared for an urgent surgery, despite it failing a leak test. The student must verbally refuse the sign-off while maintaining professional composure and citing the ethical code.
- **Medical Tech Application:** Prioritizing patient safety over hospital profit or hierarchical pressure, and maintaining professional integrity in real-time.

3. Translating Engineering Jargon to Administrative Summaries

- **Description:** Students translate a dense, highly technical fault log (e.g., describing a blown IGBT in an X-ray generator) into a clear, one-paragraph summary designed for non-technical hospital administrators to justify repair costs.
- **Medical Tech Application:** Communicating complex technical realities to financial decision-makers without causing confusion.

Unit 2: Professional Writing, Emails & Patient Privacy

4. Drafting OEM Correspondence & Spare Part Requisitions

- **Description:** Students must draft a professional, formatted email to a foreign Original Equipment Manufacturer (OEM) service manager. The email must request a specific proprietary spare part, reference the service manual's part number, and request a quotation.
- **Medical Tech Application:** Executing the daily professional correspondence required to manage vendor relationships and keep hospital supply chains moving.

5. The HIPAA/GDPR Data Sanitization Drill

- **Description:** Students are given a simulated, decommissioned ultrasound hard drive populated with mock Protected Health Information (PHI). They must execute the software protocols to completely wipe and anonymize the diagnostic data, then write a "Certificate of Destruction."
- **Medical Tech Application:** Ensuring strict compliance with patient privacy laws before sending broken storage media back to vendors or e-waste recyclers.

6. Writing SLA Compliance and Vendor Complaint Letters

- **Description:** Based on a scenario where a vendor has failed to meet their 98% uptime guarantee on an MRI machine, students draft a formal, legally precise complaint letter to the vendor citing the Service Level Agreement (SLA) terms.
- **Medical Tech Application:** Managing vendor service contracts and protecting the hospital's financial and operational interests through documented communication.

Unit 3: Technical Report Writing

7. The ICU Incident Report Simulation

- **Description:** Following a simulated clinical incident (e.g., a patient monitor shutting down during a code blue), students must draft a formal incident report. They must remain objective, documenting the physical state of the machine, error codes, and immediate actions taken, without assigning premature blame.
- **Medical Tech Application:** Legally documenting critical breakdown events in a way that protects both the patient's clinical record and the engineer from malpractice liability.

8. Root Cause Analysis (RCA) Documentation

- **Description:** Using the "5 Whys" and Ishikawa (Fishbone) frameworks, students write a comprehensive RCA report investigating a recurring failure (e.g., repeated ECG cable wire breaks).
- **Medical Tech Application:** Transitioning from reactive repairs to engineered solutions by documenting the systemic cause of equipment damage.

9. Preventive Maintenance (PM) Legal Logging

- **Description:** Students perform a physical PM check on a defibrillator and must fill out the corresponding digital or paper compliance record, ensuring every checkbox and parameter limit is legally documented and signed.
- **Medical Tech Application:** Creating the auditable paper trail required for national hospital accreditation (like NABH/JCI).

Unit 4: Presentation Skills

10. Designing an In-Service Training Slide Deck

- **Description:** Students design a 10-slide presentation aimed at training clinical staff on a new infusion pump. The focus is on slide design, minimizing text, utilizing clear visuals, and highlighting critical safety alarms.
- **Medical Tech Application:** Creating the visual materials required to conduct effective in-service training sessions for doctors and nurses.

11. Executing the Mock Clinical Training Presentation

- **Description:** Students stand up and deliver their in-service training presentation to an audience of peers acting as distracted clinical staff. They must practice public speaking techniques, manage their body language, and handle hostile or confusing Q&A.
- **Medical Tech Application:** Building the confidence to command a room of high-level medical professionals and ensuring they understand how to safely operate newly installed devices.

Unit 5: Hospital Etiquette, Interpersonal Communication & Social Responsibility

12. High-Stress OT Conflict Resolution Simulation

- **Description:** A simulated scenario where a piece of equipment fails mid-surgery. The student must enter the mock Operation Theatre, actively listen to a frustrated surgeon's complaint, de-escalate the tension, and calmly communicate the repair timeline.
- **Medical Tech Application:** Working calmly in high-stress environments without disrupting clinical workflows or escalating interpersonal conflicts.

13. Bedside Manner & Patient Interaction Drill

- **Description:** Students simulate repairing a motorized bed or bedside monitor while a "patient" is occupying it. They must practice knocking, introducing themselves, explaining what they are doing in a reassuring tone, and respecting the patient's privacy and space.
- **Medical Tech Application:** Maintaining hospital etiquette and empathy when engineering duties intersect directly with vulnerable patients.

14. Drafting an E-Waste & Sustainability Proposal

- **Description:** Students research and draft a formal, localized proposal for the safe recycling of the hospital's biomedical e-waste and lead-acid UPS batteries, outlining the environmental and legal benefits.
- **Medical Tech Application:** Championing social responsibility and sustainable engineering practices within hospital administration.

Laboratory, Computing, and Special Facilities Required

To successfully run this course, standard electronic workbenches are ineffective. The institution must set up a **Clinical Communications & Simulation Studio**.

1. Simulation & Role-Play Environment

- **Mock Clinical Bay:** A section of the room designed to look like a patient room or ICU bay, complete with a hospital bed, a dummy patient (mannequin), and disconnected medical equipment (monitors, pumps). This is essential for the bedside manner, OT conflict, and in-service training role-plays.
- **Roundtable Conference Setup:** For conducting Root Cause Analysis meetings, vendor complaint simulations, and collaborative report writing.

2. AV & Presentation Infrastructure

- **Recording Cameras & Microphones:** Mounted cameras to record students during their in-service training presentations and conflict resolution role-plays. Video playback is critical for students to review and critique their own body language, tone, and pacing.
- **Interactive Smartboard/Projector:** A high-quality display for students to deliver their slide deck presentations.

3. Computing & Software Requirements

- **Professional Communication Workstations:** PCs equipped with standard office suites (Microsoft Office/Google Workspace) for drafting technical reports, creating slide decks, and formatting official emails.
- **Data Sanitization Sandboxes:** Workstations running simulated hospital hard drives and industry-standard data wiping software (e.g., DBAN or similar secure-erase tools) to practice the HIPAA/GDPR PHI destruction drills safely.
- **CMMS Emulators:** Access to a basic Computerized Maintenance Management System to practice logging Preventive Maintenance records legally.

Year 2: Semester 3

DMET 201: Diagnostic Equipment II (ECG/EEG)

Here is the comprehensive list of 14 practical experiments for the **Diagnostic Equip. II (ECG/EEG)** course. This sequence takes students from the macro-voltages of cardiac muscle down to the highly sensitive micro-voltages of neurological activity, culminating in the life-saving mechanics of artificial pacing.

Following the list, you will find the detailed specifications for the required electrophysiology laboratory and specialized clinical testing facilities.

List of 14 Practical Experiments

Unit 1: Electrocardiography (ECG) Principles

1. 12-Lead ECG Placement & Acquisition:

- *Description:* Students will identify anatomical landmarks to properly place limb and precordial (V1-V6) electrodes on a simulated torso, acquiring a clean 12-lead diagnostic trace using a standard clinical ECG machine.
- *Medical Tech Application:* Understanding exact electrode placement is required to diagnose "lead reversal" errors that often confuse nursing staff and physicians.

2. Einthoven's Triangle & Vector Verification:

- *Description:* Using a multi-parameter patient simulator, students will generate specific cardiac vectors and use an oscilloscope to verify the mathematical relationship of the bipolar limb leads ($\text{Lead II} = \text{Lead I} + \text{Lead III}$).
- *Medical Tech Application:* Verifying the internal pre-amplifier logic of bedside cardiac monitors.

3. Driven-Right-Leg (DRL) Circuit Analysis:

- *Description:* Measuring the Common Mode Rejection Ratio (CMRR) of an ECG machine with the DRL electrode connected versus disconnected.
- *Medical Tech Application:* Proving why the right-leg ground is strictly required to stabilize the trace and prevent the baseline from drifting off the screen.

Unit 2: ECG Artifacts & Troubleshooting

4. Mains Interference (50/60Hz) Diagnostics:

- *Description:* Intentionally inducing electromagnetic interference (bringing a power cord near unshielded ECG leads) and utilizing the ECG machine's internal notch filter to observe the removal of the 50Hz "fuzzy" baseline.
- *Medical Tech Application:* The most common daily troubleshooting task in a hospital ward, teaching students to separate physiological data from environmental noise.

5. Baseline Wander & Somatic Tremor Simulation:

- *Description:* Inducing low-frequency baseline wander (simulating patient respiration) and high-frequency somatic tremor (simulating shivering), then applying the appropriate diagnostic high-pass and low-pass filters to clean the trace.
- *Medical Tech Application:* Conditioning signals accurately during stress-test (treadmill) ECGs where movement artifacts are severe.

6. Electrode-Skin Impedance & Cable Continuity:

- *Description:* Using a multimeter and an impedance meter to test the continuity of a 10-lead patient trunk cable and measuring the resistance drop across skin prepped with alcohol versus abrasive prep gel.
- *Medical Tech Application:* Rapidly diagnosing "Lead Off" alarms and preventing the unnecessary disposal of expensive reusable patient cables.

Unit 3: Electroencephalography (EEG) Systems

7. International 10-20 System Mapping:

- *Description:* Using *measuring* tape and washable markers to map the Nasion, Inion, and pre-auricular points on a clinical training mannequin to accurately plot the 10-20 EEG electrode grid.
- *Medical Tech Application:* The absolute foundation for maintaining and setting up neurological diagnostic equipment for epilepsy monitoring or sleep studies.

8. EEG Microvolt Sensitivity Calibration:

- *Description:* Injecting a calibrated 50 μV (microvolt) square wave from an EEG simulator into a neuro-amplifier to verify channel sensitivity, pen/display deflection, and the noise floor.
- *Medical Tech Application:* Ensuring that a neurology machine is actually amplifying brainwaves rather than just amplifying the internal thermal noise of its own circuit boards.

9. Spectral Analysis of Brainwaves (FFT):

- *Description:* Capturing simulated Alpha (8-13 Hz) and Beta (14-30 Hz) waves and using digital signal processing software (like Python or MATLAB) to perform a Fast Fourier Transform, converting the time-domain wave into a frequency spectrum.
- *Medical Tech Application:* Understanding how modern digital EEGs automatically color-code and quantify brain states for neurologists.

Unit 4: Electromyography (EMG)

10. Surface EMG (sEMG) Rectification & Integration:

- *Description:* Acquiring raw, high-frequency sEMG signals from a contracting bicep (using an educational bio-amplifier). Students will write a software script to full-wave rectify and integrate the chaotic signal into a smooth, readable amplitude envelope.
- *Medical Tech Application:* Calibrating the bio-feedback machines used heavily in sports medicine and physical rehabilitation.

11. Nerve Conduction Velocity (NCV) Simulation:

- *Description:* Using a dual-channel oscilloscope and an electrical stimulator simulator to measure the exact millisecond time delay (latency) between a stimulation pulse and the resulting muscle action potential.
- *Medical Tech Application:* Troubleshooting the specialized equipment used to diagnose nerve damage and carpal tunnel syndrome.

Unit 5: Pacemakers

12. Pacemaker Pulse Characterization:

- *Description:* Connecting an external temporary pacemaker to a Digital Storage Oscilloscope (DSO) to visually capture, measure, and document the pulse width (milliseconds) and amplitude (milliamps) of the pacing spike.
- ** Medical Tech Application:* Verifying the exact energy delivery of external pacing boxes before they are attached to post-cardiac-surgery patients.

13. Asynchronous vs. Synchronous Pacing Modes:

- *Description:* Connecting a pacemaker to an advanced clinical simulator. Students will test the "Demand" (synchronous) mode by programming the simulator to generate a healthy heartbeat, verifying that the pacemaker successfully *inhibits* its own shock.
- *Medical Tech Application:* Ensuring a pacemaker does not blindly fire on top of a patient's natural heartbeat, which could trigger a fatal arrhythmia.

14. Transcutaneous Pacing Validation (Defibrillator):

- *Description:* Utilizing a *specialized* Defibrillator/Pacemaker Analyzer to test the non-invasive transcutaneous pacing pads of a clinical defibrillator, verifying the current output matches the dial setting under varying impedance loads (simulating different patient body types).
- *Medical Tech Application:* Executing the critical preventive maintenance required for emergency crash-cart defibrillators.

Laboratory, Computing, and Special Facilities Required

To conduct this course, the institution requires an **Electrophysiology & Neurological Monitoring Laboratory**. Because this course deals with signals ranging from 1 millivolt (ECG) down to 10 microvolts (EEG), the environment must be highly shielded from electromagnetic interference (EMI).

1. Physical Laboratory Infrastructure

- **Low-Noise Environment:** Workbenches must be situated away from heavy mechanical equipment (like elevators or HVAC compressors).
- **Electrical Isolation:** All workstations must be powered via Medical Grade Isolation Transformers to prevent ground loops from destroying sensitive microvolt readings.
- **Faraday Cage (Optional but Highly Recommended):** A small, shielded enclosure or mesh tent for the EEG experiments, demonstrating how physical shielding completely eliminates 50Hz mains powerline noise from a microvolt signal.

2. Specialized Clinical Simulators & Diagnostic Tools

- **Multi-Parameter Patient Simulators:** High-end clinical simulators (e.g., Fluke ProSim series) capable of generating complex 12-lead arrhythmias, pacemaker spikes, and microvolt EEG waveforms.
- **Defibrillator/Pacemaker Analyzers:** Devices specifically designed to safely absorb the high currents of transcutaneous pacemakers and measure their exact output timings (e.g., Fluke Impulse 7000DP).
- **Clinical Diagnostic Hardware:** * At least two functional, standard 12-lead ECG machines with thermal printers.
 - Educational or retired multi-channel EEG headboxes.
 - External temporary pacemakers (medtronic or similar equivalents) for benchtop testing.
- **Measurement Instrumentation:** High-bandwidth Digital Storage Oscilloscopes (DSOs) with isolation probes to safely measure pacemaker pulses without shorting the equipment.

3. Medical Consumables & Anatomy Models

- **Electrodes & Conductives:** A high-volume supply of standard snap ECG electrodes, reusable gold-cup EEG electrodes, Ten20 conductive neuro-paste, and NuPrep abrasive skin prep gel.
- **Anatomical Phantoms:** Life-sized human torso and head mannequins for practicing precise 12-lead and 10-20 system electrode placements.

4. Computing Facilities

- **Signal Processing Workstations:** Dual-monitor PCs capable of running heavy signal processing environments (like Python with SciPy/MNE-Python libraries, MATLAB, or LabVIEW).
- **Software Interfaces:** Open-source or educational software that allows students to pull live data from bio-amplifiers (like Biopac Student Lab) to perform real-time spectral analysis and Fast Fourier Transforms (FFT) on neurological data.

DMET 202: Medical Imaging Systems

List of 14 Practical Experiments

Unit 1: Physics of X-Rays

1. X-Ray Tube Teardown & Stator Analysis:

- *Description:* Disassembling a decommissioned rotating anode X-ray tube. Students will map the cathode filament circuit, inspect the tungsten anode for pitting (arc damage), and measure the resistance of the induction stator coils.
- *Medical Tech Application:* Understanding the physical failure points of the most expensive consumable in a radiology department.

2. Half-Value Layer (HVL) & Filtration Measurement:

- *Description:* Using a non-invasive solid-state dosimeter and aluminum filtration plates to measure the HVL of a low-dose educational X-ray source, verifying that soft, tissue-damaging radiation is being successfully filtered out.
- *Medical Tech Application:* Executing the legally mandated safety audits that protect patients from unnecessary radiation skin burns.

3. kVp, mAs, and Exposure Linearity QA:

- *Description:* Utilizing a clinical QA multimeter (e.g., RaySafe or Fluke Rayhound) to verify that the X-ray console's dial settings (kVp and mAs) perfectly match the actual radiation output over multiple sequential exposures.
- *Medical Tech Application:* Calibrating generator boards to ensure diagnostic image contrast is consistent, preventing doctors from misdiagnosing fractures due to over/under-exposed film.

Unit 2: Computed Tomography (CT)

4. Slip-Ring Maintenance & Brush Replacement:

- *Description:* Working on a simulated or decommissioned CT gantry to safely discharge static, access the high-voltage slip-ring assembly, clean the brass tracks, and replace the carbon transmission brushes.
- *Medical Tech Application:* Performing the most critical preventive mechanical maintenance required to keep a fast-spinning CT scanner from suffering catastrophic data-transmission failures.

5. Hounsfield Unit (HU) Water/Air Calibration:

- *Description:* Scanning a standard water phantom in a small-scale/educational CT simulator. Students will map the resulting pixels to verify that water reads exactly at 0 HU and air reads at -1000 HU.
- *Medical Tech Application:* Daily calibration of the CT detector arrays to ensure that a radiologist can mathematically differentiate a benign cyst from a solid tumor based on tissue density.

6. CT Pitch & Slice Thickness Verification:

- *Description:* Using a geometric step-wedge phantom to verify the mechanical table feed (pitch) matches the electronic slice thickness programmed at the console.
- *Medical Tech Application:* Diagnosing table-drive servo motor degradation, which can cause motion artifacts or missed pathology in 3D reconstructions.

Unit 3: Magnetic Resonance Imaging (MRI)

7. RF Cabin Attenuation Testing (Faraday Cage):

- *Description:* Using an RF signal generator and a spectrum analyzer to test the electromagnetic shielding integrity of a simulated copper-lined MRI room, scanning the door seals and ventilation wave-guides for RF leaks.
- *Medical Tech Application:* Troubleshooting "zipper artifacts" on MRI scans caused by external radio stations or hospital Wi-Fi penetrating the scan room.

8. Surface Coil Tuning & Impedance Matching:

- *Description:* Connecting a decommissioned MRI receive coil (e.g., a knee or head coil) to a Network Analyzer to measure its resonant frequency and adjust the variable tuning capacitors to perfectly match the scanner's Larmor frequency.
- *Medical Tech Application:* Repairing the delicate RF coils that are frequently dropped or damaged by clinical staff.

9. Superconducting Magnet Quench Protocol Drill:

- *Description:* A scenario-based safety drill where students must execute the emergency procedures for a localized liquid helium boil-off (quench), including activating exhaust fans, breaking the magnetic field, and safely extracting a simulated patient from the room.
- *Medical Tech Application:* Mastering the life-and-death safety protocols unique to Zone IV MRI environments.

Unit 4: Diagnostic Ultrasound

10. Tissue-Mimicking Phantom QA (Axial/Lateral Resolution):

- *Description:* Scanning a clinical tissue-mimicking phantom (containing embedded nylon wires at specific depths) to measure the exact axial and lateral geometric resolution of various ultrasound probes.
- *Medical Tech Application:* Verifying that a hospital's ultrasound fleet meets diagnostic accreditation standards.

11. Transducer Array & Dead-Crystal Identification:

- *Description:* Utilizing a transducer tester or a paperclip-reverberation test across the face of a linear array probe to identify individual burnt-out piezoelectric crystals (dropouts).
- *Medical Tech Application:* Deciding whether an expensive ultrasound probe requires full replacement or if the localized crystal damage is clinically acceptable.

12. Doppler Flow Velocity Calibration:

- *Description:* Scanning a motorized Doppler string phantom or a continuous-flow fluid phantom to verify that the color Doppler shift accurately calculates the velocity of simulated blood flow (cm/s).
- *Medical Tech Application:* Ensuring cardiac ultrasound machines accurately diagnose heart valve regurgitation and arterial blockages.

Unit 5: Nuclear Medicine (PET/SPECT)

13. Geiger-Müller Calibration & Half-Life Simulation:

- *Description:* Using a calibrated GM counter and an exempt, educational-grade isotope (like Barium-137m) to measure radioactive decay over time, plotting the exact decay curve to calculate the half-life.
- *Medical Tech Application:* Understanding the time-sensitive logistics of handling radiopharmaceuticals like FDG before a PET scan.

14. Gamma Camera Spatial Resolution Testing:

- *Description:* Placing a four-quadrant bar phantom over an educational scintillation detector to assess the spatial resolution and identify non-uniformities (hot/cold spots) across the photomultiplier tube array.
- *Medical Tech Application:* Performing the mandatory daily QA tuning of a hospital's SPECT or PET imaging detectors.

Laboratory, Computing, and Special Facilities Required

Competency Based Curriculum for “Diploma in Medical Equipment Technology”
(Intellectual property of National Commission for Allied and Healthcare Professions, Ministry of Health and Family Welfare)

To safely teach this course, the institution must construct a highly specialized **Radiological Testing & Medical Imaging Laboratory**. This facility requires strict adherence to statutory safety norms (such as those outlined by AERB, AICTE, and NCAHP) to legally conduct ionizing radiation experiments.

1. Physical Laboratory Infrastructure

- **Radiation Shielding:** If the lab houses an active, educational-grade X-ray unit, the walls, doors, and observation windows of that specific zone must be lined with statutory thicknesses of lead (Pb).
- **MRI Safety Zoning:** A dedicated area featuring a scaled-down Faraday cage (copper-lined mesh enclosure) to teach RF attenuation and demonstrate Zone III/IV strict ferromagnetic access controls.
- **Heavy-Duty Workbenches:** Industrial benches capable of supporting the massive weight of lead-lined tube housings and CT gantry assemblies during teardown exercises.

2. Specialized Metrology & Diagnostic Phantoms

- **Radiological QA Meters:** Non-invasive, solid-state X-ray multimeters (e.g., Fluke RaySafe X2) to safely measure kVp, mAs, HVL, and dose without dismantling the X-ray generators.
- **Clinical Phantoms:** Ultrasound tissue-mimicking and Doppler fluid phantoms (e.g., ATS Laboratories or CIRS).
 - CT water/air calibration phantoms and step-wedge acrylic blocks.
 - Nuclear medicine bar phantoms.
- **RF Analyzers:** Vector Network Analyzers (VNAs) and spectrum analyzers equipped with near-field probes for tuning MRI coils and detecting RF cabin leaks.

3. Hardware Inventory (Device Library)

- **Functional Educational Equipment:** Low-dose, self-shielded educational X-ray cabinets (like those used in material science) and basic functional ultrasound carts.
- **Triage/Scrap Inventory for Teardown:** Retired rotating anode X-ray tubes, discarded high-voltage CT slip rings, and damaged phased-array ultrasound probes.

4. Computing & IT Facilities

- **Diagnostic Viewing Stations:** High-resolution dual-monitor workstations equipped with open-source medical image viewers (e.g., Horos or Radiant) to manipulate contrast, Hounsfield units, and 3D reconstructions.
- **Localized Mini-PACS Network:** To simulate a hospital's radiology network architecture, the lab should feature a completely isolated Picture Archiving and Communication System (PACS). This can be efficiently deployed via a low-power archiving gateway—such as a clustered Raspberry Pi 4 setup running open-source Orthanc software—to route, store, and query DICOM images without burdening the main campus IT network.

DMET 203: Respiratory & Therapeutic Technology

Here is the comprehensive list of 14 practical experiments for the **Respiratory & Therapeutic Tech** course. This sequence takes students from the basic pneumatics of human breathing through to the complex, life-supporting mechanics of ICU ventilators and anesthesia workstations.

Following the list, you will find the detailed specifications for the required respiratory and pneumatics testing laboratory.

List of 14 Practical Experiments

Unit 1: Respiratory Mechanics

1. Gas Law Verification (Boyle's Law in Action):

- *Description:* Using a sealed, graduated pneumatic syringe attached to a digital manometer. Students will compress the volume at varying intervals and calculate the inversely proportional pressure changes.
- *Medical Tech Application:* The absolute foundation for understanding how a ventilator calculates volume delivery based on internal cylinder pressures.

2. Lung Compliance Modeling (Test Lungs):

- *Description:* Attaching a ventilator test lung to a manual resuscitator bag (Ambu bag) equipped with a pressure gauge. Students will swap the test lung's restrictive bands to simulate high compliance (healthy) versus low compliance (stiff/ARDS) lungs, graphing the required pressure to achieve a 500mL volume.
- *Medical Tech Application:* Understanding why ventilators alarm for "High Peak Inspiratory Pressure" when a patient's lung condition worsens.

3. Airway Resistance Fluidics:

- *Description:* Pumping a constant flow of air through various endotracheal tubes (ranging from 8.0mm adult to 3.0mm neonatal sizes) and measuring the massive pressure drop across the narrower tubes.
- *Medical Tech Application:* Recognizing how mucus blockages or biting a tube drastically increases airway resistance, requiring ventilator limit adjustments.

Unit 2: Spirometry & PFT

4. Spirometer Calibration (3-Liter Syringe):

- *Description:* Using a standardized 3-Liter precision calibration syringe to inject air into a clinical spirometer at varying flow rates (slow, medium, fast).
- *Medical Tech Application:* Executing the daily, legally mandated calibration routine required before any patient undergoes a Pulmonary Function Test (PFT).

5. Pneumotachometer Disassembly & Cleaning:

- *Description:* Taking apart a Fleisch or Lilly type pneumotachometer to inspect the delicate internal capillary tubes or resistive screens for moisture buildup or damage.
- *Medical Tech Application:* The primary maintenance task to fix spirometers that are reading inaccurately due to condensation or patient saliva.

6. Hot-Wire Anemometer Flow Validation:

- *Description:* Passing known flow rates (using a mass flow controller) over a heated thermistor element and mapping the voltage drop required to maintain the element's temperature.
- *Medical Tech Application:* Understanding the solid-state sensor technology used inside modern, portable spirometers and neonatal ventilators.

Unit 3: Impedance Pneumography

7. Thoracic Impedance Measurement:

- *Description:* Applying ECG electrodes to a clinical patient simulator and using an oscilloscope to capture the high-frequency carrier wave injected by the monitor to measure the minute resistance changes of the chest expanding.
- *Medical Tech Application:* Visualizing how patient monitors detect breathing without using a physical airflow sensor.

8. Apnea Alarm & Artifact Troubleshooting:

- *Description:* Using the patient simulator to program a 20-second apnea (no breathing) event. Students will then introduce simulated cardiac oscillation (heartbeats mimicking breaths) to see if the monitor falsely misses the apnea alarm.
- *Medical Tech Application:* Teaching students how to adjust the "Cardiovascular Artifact Rejection" threshold—a critical skill for preventing alarm fatigue in the ICU.

Unit 4: Mechanical Ventilators

9. Ventilator Pneumatic Teardown:

- *Description:* Disassembling the pneumatic block of a retired ICU ventilator. Students will trace the gas pathway from the high-pressure O₂/Air inlets, through the proportional solenoid valves, to the exhalation block.
- *Medical Tech Application:* Transitioning the ventilator from a "magic box" to an understandable network of fluidic valves.

10. Tidal Volume & Flow Verification (Gas Flow Analyzer):

- *Description:* Connecting an active ICU ventilator to a high-end Gas Flow Analyzer and a test lung. Students will set the ventilator to deliver 500mL and legally verify the actual delivered volume, peak flow, and PEEP.
- *Medical Tech Application:* The absolute core of ventilator Preventive Maintenance (PM); ensuring the machine is not under-ventilating or over-pressurizing the patient.

11. Oxygen Blender & FiO₂ Calibration:

- *Description:* Programming the ventilator to deliver specific oxygen concentrations (e.g., 21%, 50%, 100%). Students will use a paramagnetic or galvanic oxygen analyzer to verify the internal blender is mixing the gases perfectly.
- *Medical Tech Application:* Calibrating the O₂ cells on a ventilator to prevent oxygen toxicity (too much O₂) or hypoxia (too little O₂).

Unit 5: Anesthesia Workstations

12. High-Pressure & Low-Pressure Leak Testing:

- *Description:* Executing the mandatory pre-use checklist on an anesthesia machine. Students will manually pressurize the breathing circuit and the vaporizers to ensure there are no microscopic leaks.

- *Medical Tech Application:* A daily safety requirement in the Operating Theatre (OT) to prevent anesthetic gases from leaking into the room and sedating the surgical staff.

13. Vaporizer Interlock System Verification:

- *Description:* Testing the mechanical safety interlocks on the anesthesia backbar to ensure that it is physically impossible to turn on the Isoflurane and Sevoflurane vaporizers at the same time.
- *Medical Tech Application:* Verifying the critical fail-safes designed to prevent fatal anesthetic overdoses.

14. CO2 Absorber (Soda Lime) Management:

- * *Description:* Changing the soda lime canister in an anesthesia circle system and verifying the unidirectional valves are functioning. Students will observe the chemical color change of exhausted soda lime.
- * *Medical Tech Application:* Maintaining the closed-loop breathing system that prevents a patient from rebreathing their own carbon dioxide during a long surgery.

Laboratory, Computing, and Special Facilities Required

To conduct this course, the institution requires a specialized **Respiratory Therapy & Pneumatics Laboratory**. This environment is unique because it requires high-pressure medical gases and highly calibrated metrology equipment.

1. Physical Laboratory Infrastructure

- **Medical Gas Pipeline (or Simulation):** The laboratory must be equipped with piped 50-PSI medical air and oxygen (or robust air compressors mimicking medical air, and large O2 cylinders securely chained to the walls). Ventilators and anesthesia machines cannot function without high-pressure drive gases.
- **Ventilation (AGSS):** If actual vaporizers are used (even with simulated agents), the room must have active exhaust ventilation to mimic a hospital Anesthetic Gas Scavenging System.

2. Specialized Metrology & Calibration Equipment

- **Gas Flow Analyzers:** 2 to 3 high-end clinical respiratory analyzers (e.g., Fluke VT900A, TSI Certifier, or IMT Analytics FlowAnalyser). These are the most critical pieces of equipment in the lab, used to measure pressure, flow, volume, and oxygen concentration simultaneously.
- **Calibration Syringes:** 3-Liter precision calibration syringes (e.g., Hans Rudolph) for spirometry.

- **Test Lungs:** A fleet of mechanical test lungs (ranging from simple 1-liter bags to complex, adjustable compliance/resistance dual-lung simulators like the Michigan Instruments TTL).

3. Hardware Inventory (Device Library)

- **Functional Equipment:** At least one functional ICU ventilator (e.g., Puritan Bennett, Maquet, or Dräger) and one basic functional anesthesia workstation for the PM testing (Units 4 & 5).
- **Triage/Scrap Inventory for Teardown:** Retired CPAP/BiPAP machines, discarded proportional solenoid valves, and decommissioned spirometers for Unit 2 and Unit 4 teardown experiments.

4. Computing Facilities

- **Data Acquisition (DAQ) Workstations:** PCs loaded with the proprietary software for the Gas Flow Analyzers. This allows students to digitally capture pressure-volume loops and flow-time curves, exporting them into Excel to build their calibration reports.

DMET 204: Analytical & Lab Instruments

Here is the comprehensive list of 14 practical experiments for the **Analytical & Lab Instruments** course. This sequence is designed to bridge the gap between heavy electromechanical systems and the highly sensitive optical physics required for clinical pathology.

Following the list, you will find the detailed specifications for the required pathology instrumentation laboratory and specialized clinical testing facilities.

List of 14 Practical Experiments

Unit 1: Centrifuges & Incubators

1. RCF Calibration & Tachometer Verification:

- *Description:* Using an optical photo-tachometer to independently verify the rotational speed (RPM) of a clinical centrifuge against its digital display, and manually calculating the Relative Centrifugal Force (RCF) based on rotor radius.
- *Medical Tech Application:* Legally validating that blood tubes are spinning at the exact G-force required to separate plasma without rupturing red blood cells (hemolysis).

2. PID Controller Tuning in Incubators:

- *Description:* Interfacing with the digital temperature controller of a microbiological incubator to manually adjust the Proportional, Integral, and Derivative (PID) values, observing how it affects temperature overshoot and stabilization time.
- *Medical Tech Application:* Calibrating culture incubators to strictly maintain 37.0°C without aggressive thermal cycling that could destroy sensitive bacterial cultures.

3. Safety Interlocks & Motor Diagnostics:

- *Description:* Testing the electromechanical lid-lock safety circuits of a centrifuge to ensure the motor cannot engage while open. Students will also inspect and measure the resistance of stator coils on a Brushless DC (BLDC) drive.
- *Medical Tech Application:* Performing the mandatory safety checks that prevent catastrophic, high-speed rotor failures in crowded pathology labs.

Unit 2: Colorimeters & Spectrophotometers

4. Beer-Lambert Law Verification (Standard Curve):

- *Description:* Preparing *serial* dilutions of a colored chemical solution and measuring their Optical Density (OD). Students will plot a standard curve to prove the linear relationship between absorbance and concentration.
- *Medical Tech Application:* The *exact* foundational process an automated biochemistry analyzer uses to calculate a patient's blood glucose or cholesterol levels.

5. Spectrophotometer Wavelength Calibration:

- *Description:* Using standard reference filters (such as Holmium Oxide or Didymium glass) to verify that the monochromator grating is perfectly aligned and selecting the correct wavelength of light.
- *Medical Tech Application:* Diagnosing a misaligned optical bench, which is the leading cause of globally skewed test results in clinical chemistry.

Unit 3: Auto-analyzers (Biochemistry)

6. Peristaltic Pump Flow Rate Calibration:

- *Description:* Replacing the silicon tubing in a peristaltic pump assembly, adjusting the roller occlusion pressure, and measuring the precise volumetric output (in microliters per minute) using an analytical balance.

- *Medical Tech Application:* Maintaining the fluidic heart of an auto-analyzer to ensure chemical reagents are dispensed in exact, repeatable volumes.

7. Robotic Arm & Stepper Motor Alignment:

- *Description:* Using a service terminal or diagnostic software to manually command the X-Y-Z stepper motors of an automated sample probe, aligning it perfectly with the center of a target cuvette.
- *Medical Tech Application:* Repairing and re-aligning high-throughput robotic arms after a mechanical crash or belt replacement.

8. Fluidic Manifold Troubleshooting:

- *Description:* Isolating a simulated clog or micro-leak in the complex Teflon tubing manifold of a retired discrete analyzer using syringe pressure testing and vacuum gauges.
- *Medical Tech Application:* The most common daily troubleshooting task required to keep high-volume hospital laboratories running without downtime.

Unit 4: Blood Cell Counters

9. Coulter Principle (Impedance) Simulation:

- *Description:* Using an educational micro-fluidic rig to pass varying-sized conductive particles through a micro-aperture, observing the resulting voltage spikes (impedance pulses) on an oscilloscope to differentiate particle sizes.
- *Medical Tech Application:* Understanding exactly how a 3-part hematology analyzer differentiates a small lymphocyte from a large neutrophil based purely on electrical resistance.

10. Aperture Clog Cleaning & Baseline Verification:

- *Description:* Executing the OEM chemical "zap" or backflush cleaning cycles on a hematology analyzer, and using a multimeter to measure the baseline electrical impedance across the ruby aperture before and after cleaning.
- *Medical Tech Application:* Resolving false-low platelet counts caused by protein buildup inside the microscopic counting chambers.

11. Quality Control (QC) & Levey-Jennings Charting:

- *Description:* Running standardized commercial control blood through a cell counter over multiple simulated "days," logging the data, and plotting a Levey-Jennings chart to identify systemic shifts or trends in accuracy.

- *Medical Tech Application:* Mastering the daily statistical quality assurance protocols legally required in every accredited hospital laboratory.

Unit 5: Blood Bank Equipment (Refrigeration)

12. Refrigeration Cycle Thermodynamic Mapping:

- *Description:* Using *digital* manifold gauges and clamp-on thermocouples to map the pressures and temperatures across the compressor, condenser, expansion valve, and evaporator of a biomedical refrigerator.
- *Medical Tech Application:* Diagnosing a failing compressor or low refrigerant charge before a deep freezer (-80°C) fails and destroys thousands of dollars in biological samples.

13. Independent Alarm & Data Logger Validation:

- *Description:* *Intentionally* raising the temperature of a simulated blood bank refrigerator to verify that the independent, battery-backed high-temperature alarm triggers exactly at the regulatory threshold (e.g., 6.0°C).
- *Medical Tech Application:* Ensuring the strict, legally mandated "cold chain" is maintained for life-saving whole blood and plasma products.

14. Platelet Agitator Motion Analysis:

- *Description:* *Measuring* the stroke length and oscillation frequency of a platelet incubator agitator, and intentionally inducing a mechanical jam to test the motion-failure alarm.
- *Medical Tech Application:* Maintaining the constant, gentle agitation required to keep donated blood platelets viable for transfusion.

Laboratory, Computing, and Special Facilities Required

To effectively teach this course, the institution requires a dedicated **Bio-Analytical & Pathology Instrumentation Laboratory**. This space combines heavy electromechanical maintenance with the strict cleanliness of optical physics.

1. Physical Laboratory Infrastructure

- **Workstations:** High-mass, vibration-dampened workbenches specifically for centrifuge testing.
- **Zoning & Ventilation:** A dedicated "Wet Lab" zone equipped with sinks, chemical spill kits, and localized fume extraction for safely handling the cleaning reagents and simulated control fluids used in auto-analyzers.

- **Electrical Utilities:** Plentiful 220V/110V outlets with dedicated circuit breakers for running multiple compressors (refrigerators) and high-draw heating elements (incubators) simultaneously.

2. Specialized Metrology & Diagnostics Equipment

- **Optical Calibration Tools:** NIST-traceable optical density filters (Holmium Oxide/Didymium) for checking spectrophotometer accuracy.
- **Thermal & Kinetic Tools:** High-precision digital photo-tachometers (for RPM verification) and multi-channel data-logging thermometers (for mapping temperature stability inside incubators and deep freezers).
- **Fluidic Calibration:** High-precision analytical balances (accurate to 0.1 mg) to gravimetrically verify the micro-liter dispense volumes of peristaltic pumps.
- **HVAC/Refrigeration Tools:** Digital manifold gauge sets and refrigerant leak detectors for analyzing vapor-compression cycles in blood bank freezers.

3. Hardware Inventory (Device Library)

- **Functional Equipment:** Basic visible/UV spectrophotometers, benchtop clinical centrifuges, and bacteriological incubators.
- **Triage/Scrap Inventory for Teardown:** The laboratory must acquire retired or decommissioned complex equipment. specifically:
 - At least two retired 3-part or 5-part hematology analyzers (for aperture cleaning and fluidic tracing).
 - Retired biochemistry auto-analyzer robotic arms and peristaltic pump assemblies.
 - Small biomedical refrigerators or platelet agitators.

4. Computing Facilities

- **Workstations:** Standard desktop PCs at a 1:2 or 1:3 ratio.
- **Software:** Spreadsheet software (Excel or open-source equivalents) for calculating standard optical curves and constructing Levey-Jennings statistical charts. Access to simulated Laboratory Information System (LIS) interfaces to understand how these analyzers push their digital results to the central hospital network.

DMET 205: Surgical & Critical Care Equip

Here is the comprehensive list of 14 practical experiments for the **Surgical & Critical Care Equip** course. This sequence shifts the focus from diagnostic imaging to therapeutic intervention, where machines directly alter a patient's physiology. The margin for error here is strictly zero, as these devices involve delivering high-voltage shocks, cutting tissue with radio frequencies, and directly pumping drugs into the bloodstream.

Following the list, you will find the detailed specifications for the required therapeutic and wet-lab testing facilities.

List of 14 Practical Experiments

Unit 1: Electrosurgical Units (Diathermy)

1. ESU Waveform Analysis (Cut vs. Coagulation):

- *Description:* Connecting an active ESU to a high-voltage differential probe and a Digital Storage Oscilloscope (DSO). Students will visually compare the continuous, low-voltage sine wave of "Pure Cut" against the interrupted, high-voltage burst wave of "Coagulation."
- *Medical Tech Application:* Understanding the electrical crest factors that determine whether tissue is smoothly incised or deeply charred to stop bleeding.

2. ESU Power Output Verification (Load Testing):

- *Description:* Utilizing a clinical ESU Analyzer to measure the true Wattage delivered by the diathermy machine across varying simulated tissue impedances (e.g., 100 ohms to 1000 ohms).
- *Medical Tech Application:* Calibrating the ESU to ensure surgeons receive the exact cutting power they set on the dial, preventing unintended deep-tissue burns.

3. Return Electrode Monitoring (REM) Circuit Validation:

- *Description:* Using a variable resistance decade box to simulate a patient return pad peeling off the skin. Students will map the exact resistance window (usually between 10 and 135 ohms) at which the ESU legally must lock out and alarm.
- *Medical Tech Application:* Testing the primary safety mechanism that prevents severe, localized electrical burns on a patient's thigh or back during surgery.

Unit 2: Defibrillators

4. Capacitor Charge & Discharge Profiling:

- *Description:* Measuring the exact time (in seconds) it takes for a defibrillator's high-voltage capacitor to reach maximum charge (e.g., 360 Joules), and observing the internal safety bleed-off mechanism if the shock is not delivered within 60 seconds.
- *Medical Tech Application:* Diagnosing aging internal batteries or failing high-voltage charging circuits that could delay a life-saving shock during a cardiac arrest code.

5. Delivered Energy Verification (Biphasic Testing):

- *Description:* Firing a defibrillator into a specialized Defibrillator Analyzer (simulating a 50-ohm human chest). Students will verify that a selected 200-Joule shock actually delivers exactly 200 Joules, viewing the truncated exponential biphasic waveform.
- *Medical Tech Application:* Executing the daily and monthly legal metrology checks required for every emergency crash-cart in the hospital.

6. Synchronized Cardioversion Timing Validation:

- *Description:* Feeding a simulated ECG rhythm with a prominent R-wave into the defibrillator. Students will use the analyzer to verify that the defibrillator waits to deliver the shock exactly on the peak of the R-wave, avoiding the vulnerable T-wave.
- *Medical Tech Application:* Ensuring the machine does not inadvertently induce fatal Ventricular Fibrillation while trying to correct an atrial arrhythmia.

Unit 3: Hemodialysis Machines

7. Dialysate Conductivity & Temperature Calibration:

- *Description:* Using an external reference meter to calibrate the dialysis machine's internal sensors, ensuring the dialysate fluid is mixed to the exact physiological sodium concentration and heated precisely to 37°C.
- *Medical Tech Application:* Preventing hemolysis (destruction of red blood cells) caused by over-heated or improperly concentrated dialysate fluid.

8. Proportioning Pump Hydraulics & Flow Verification:

- *Description:* Disassembling a simulated hydraulic block to inspect the proportioning pumps, then running a volumetric test to ensure the machine is pulling the exact ratio of acid/bicarbonate concentrate into the purified water stream.
- *Medical Tech Application:* Troubleshooting the complex, scale-prone fluid pathways that frequently cause dialysis machines to fail.

9. Air-in-Line & Blood Leak Detector Testing:

- *Description:* Intentionally introducing microscopic air bubbles and simulated blood (dye) into the venous return line to test the ultrasonic air detector and the optical blood-leak sensor.
- *Medical Tech Application:* Verifying the critical fail-safes designed to prevent fatal air embolisms and massive blood loss during a 4-hour dialysis session.

Unit 4: Infusion & Syringe Pumps

10. Volumetric Flow Rate Calibration (ml/hr):

- *Description:* Connecting an infusion pump to an Infusion Device Analyzer (IDA) or a highly precise glass burette. Students will program a rate of 50 ml/hr and legally verify the output over a 30-minute window.
- *Medical Tech Application:* Ensuring critical care drugs (like Vasopressors or Insulin) are not over-dosed or under-dosed due to worn-out peristaltic pump fingers.

11. Occlusion Pressure Alarm Validation:

- *Description:* Introducing a physical kink or blockage into the IV tubing and using a pressure transducer to measure the exact PSI/mmHg at which the pump alarms and stops drug delivery.
- *Medical Tech Application:* Calibrating the pump to quickly detect when an IV catheter has infiltrated a patient's vein, preventing severe tissue necrosis from drug pooling.

12. Syringe Pump Stepper Motor Mechanics:

- *Description:* Disassembling the carriage mechanism of a syringe pump to inspect the stepper motor, lead screw, and half-nut assembly, followed by cleaning and re-lubricating the drive shaft.

- *Medical Tech Application:* Maintaining the ultra-precise mechanical tolerances required to deliver micro-infusions (e.g., 0.1 ml/hr) in the Neonatal ICU.

Unit 5: Infant Incubators & Warmers

13. Incubator Spatial Temperature Mapping:

- *Description:* Using an Incubator Analyzer equipped with a 5-point thermocouple array (corners and center of the mattress). Students will map the convection currents inside the closed canopy to ensure uniform heat distribution.
- *Medical Tech Application:* Preventing cold-stress or hyperthermia in premature neonates who cannot regulate their own body temperature.

14. Over-Temperature & Fan-Failure Safety Cut-offs:

- *Description:* Intentionally blocking the convection fan or overriding the primary servo-controller to force the incubator to overheat. Students will verify that the independent, secondary hardware cut-off immediately kills the heater at 39°C.
- *Medical Tech Application:* Auditing the life-critical thermal safety circuits that protect infants from catastrophic equipment malfunctions.

Laboratory, Computing, and Special Facilities Required

To safely teach this course, the institution must construct a hybrid **Critical Care & Wet-Fluidics Laboratory**. This environment must seamlessly support high-voltage electrical safety testing alongside complex water and hydraulic plumbing.

1. Physical Laboratory Infrastructure

- **Wet & Dry Zones:** The lab must be physically divided. The "Dry Zone" requires standard grounded, anti-static workbenches for ESU and Defibrillator testing. The "Wet Zone" requires stainless steel benchtops with central drainage grids, a purified water supply (RO water), and floor drains to support Hemodialysis machine teardowns and fluid calibrations.
- **High-Power Electrical Supplies:** Dedicated 15A/20A circuits required to handle the sudden, massive current draw of a defibrillator charging or an ESU firing at maximum wattage.

2. Specialized Clinical Metrology & Analyzers

This lab requires the highest financial investment in specialized test equipment. Standard multimeters are entirely useless here.

- **ESU Analyzers:** High-frequency, variable-load analyzers (e.g., Fluke QA-ES III or Rigel Uni-Therm) capable of measuring high-voltage, high-frequency surgical currents.
- **Defibrillator Analyzers:** Heavy-duty load boxes (e.g., Fluke Impulse 7000DP) capable of absorbing and measuring 360-Joule biphasic shocks safely.
- **Infusion Device Analyzers (IDA):** Automated multi-channel fluid analyzers to measure precise micro-flow rates and occlusion pressures simultaneously.
- **Incubator Analyzers:** Specialized pucks (e.g., Fluke INCU II) that measure spatial temperature, relative humidity, airflow, and decibel levels inside an infant canopy.

3. Hardware Inventory (Device Library)

- **Functional Equipment:** At least one operational Defibrillator/Monitor, one ESU (monopolar and bipolar capable), a multi-channel infusion pump, and an infant warmer for QA testing.
- **Decommissioned Fluids Equipment:** Older hemodialysis machines (e.g., Fresenius or Gambro) are highly complex hydraulically. Having a decommissioned unit strictly for teaching students how to rebuild proportioning pumps and de-calcify hydraulic blocks is essential.

4. Computing & Documentation Facilities

- **Automated Testing Software:** PCs installed at the metrology workbenches, loaded with analyzer automation software (like Fluke Ansur). This allows students to connect the ESU/Defib analyzers to the PC via USB, run automated test sequences based on IEC 60601 safety standards, and generate professional, legally compliant PDF calibration certificates.

DMET 206: Optical & Laser Systems

Here is the comprehensive list of 14 practical experiments for the **Optical & Laser Systems** course. This sequence safely introduces students to the precise physics of optics before transitioning them into the highly regulated, zero-tolerance safety environment of surgical lasers and endoscopic visualization.

Following the list, you will find the detailed specifications for the required optical and laser safety laboratory.

List of 14 Practical Experiments

Unit 1: Physics of Light & Fiber Optics

1. Light Source Color Temperature & Spectrum Analysis:

- *Description:* Using a digital spectrometer to analyze and graph the emission spectra of traditional Xenon bulbs, Halogen lamps, and modern LED cold light sources.
- *Medical Tech Application:* Understanding why surgeons prefer specific light sources for distinguishing subtle shades of red in highly vascular tissues during surgery.

2. Fiber Optic Cable Transmission & Breakage Analysis:

- *Description:* Injecting a calibrated light source into a surgical fiber-optic light cable and using a lux meter to measure transmission efficiency. Students will physically inspect the cable against a bright background to map "black spots" indicating broken glass fibers.
- *Medical Tech Application:* Executing the daily triage required to decide if a Rs. 50000 light cable is clinically acceptable or must be scrapped.

3. Total Internal Reflection & Numerical Aperture Validation:

- *Description:* Using a visible laser diode and an optical acrylic block to physically measure the critical angle and calculate the numerical aperture (light-gathering ability) of an optical fiber.
- *Medical Tech Application:* Understanding the core physics that allows light to bend through a looping colonoscope without escaping the fiber.

Unit 2: Types of Medical Lasers

4. Wavelength & Tissue Penetration Simulation:

- *Description:* Utilizing educational-grade, low-power lasers of varying wavelengths (e.g., 405nm blue, 650nm red, 850nm IR) on synthetic tissue-mimicking gelatin phantoms to physically measure how deep different colors penetrate before absorption.
- *Medical Tech Application:* Knowing exactly why a urologist requires a Holmium laser for crushing deep kidney stones, while a dermatologist uses a CO2 laser for surface ablation.

5. Solid-State Laser Cavity Alignment (Educational Kit):

- *Description:* Working with an open-cavity educational laser kit (Class 2/3R) to align the highly reflective (HR) and output coupler (OC) mirrors around an active gain medium to achieve stimulated emission.
- *Medical Tech Application:* Mastering the ultra-precise optical alignment required when servicing heavy Nd:YAG surgical lasers.

6. Thermal Beam Profiling:

- *Description:* Firing a laser into specialized thermal sensitive paper or a beam profiling camera to map the energy distribution (e.g., Gaussian vs. Top-Hat profiles) across the diameter of the beam.
- *Medical Tech Application:* Diagnosing degraded laser optics that are causing a surgical beam to cut unevenly.

Unit 3: Surgical Applications of Lasers

7. Articulated Arm Mirror Alignment:

- *Description:* Using a visible Helium-Neon (HeNe) aiming beam to precisely align the series of 45-degree mirrors inside a decommissioned, multi-jointed articulated delivery arm.
- *Medical Tech Application:* Repairing the heavy delivery systems used in CO₂ lasers, which frequently fall out of alignment when bumped by operating room staff.

8. Laser Output Power Calibration (Wattage):

- *Description:* Firing an educational surgical laser directly into a calibrated thermal power meter to verify that the programmed 10 Watts on the control console equals exactly 10 Watts of delivered energy.
- *Medical Tech Application:* Performing the legally mandated preventive maintenance checks required to prevent severe patient burns from over-powered lasers.

9. Surgical Optical Fiber Cleaving & Polishing:

- *Description:* Using specialized optical stripping tools and a ruby cleaver to cleanly cut the end of a flexible surgical laser fiber, followed by inspecting the flat face under a 400x fiber microscope.
- *Medical Tech Application:* Repairing damaged delivery fibers locally, saving the hospital thousands of dollars in replacement costs.

Unit 4: Endoscopy & Laparoscopy Systems

10. Pneumatic Leak Testing of Flexible Endoscopes:

- *Description:* Submerging a decommissioned gastroscope or colonoscope in a water bath, attaching a specialized pressure pump, and inflating the internal channels to check for microscopic air bubbles.
- *Medical Tech Application:* The absolute most critical maintenance task in endoscopy. Failing to detect a leak allows toxic sterilization fluids to destroy the Rs. 12,00,000 internal camera electronics.

11. Camera Control Unit (CCU) White Balancing & QA:

- *Description:* Connecting an endoscopic camera to a CCU and a surgical monitor. Students will use standard optical color charts and resolution targets to calibrate the white balance and measure the visual line pairs per millimeter.
- *Medical Tech Application:* Ensuring the surgical video feed has perfect color accuracy and no electromagnetic interference (EMI) artifacts before a laparoscopic surgery begins.

12. Rigid Endoscope Hopkins Rod-Lens Inspection:

- *Description:* Utilizing a high-intensity light source and a magnification loupe to inspect the internal rod-lenses of a 30-degree rigid laparoscope for cracked cement, moisture invasion, or chromatic aberration.
- *Medical Tech Application:* Triage diagnostics to determine if a dropped laparoscope can be sent for a minor objective-lens repair or requires a total rebuild.

Unit 5: Laser Safety Guidelines

13. Optical Density (OD) Eyewear Validation:

- *Description:* Using a *spectrometer* or a laser power meter to shoot specific wavelengths through various pairs of surgical laser safety goggles, verifying that the eyewear mathematically blocks the light according to its rated Optical Density.
- *Medical Tech Application:* Auditing hospital safety gear to ensure a surgeon's retinas are actually protected from a specific invisible infrared laser.

14. Operation Theatre Interlock & Safety Auditing:

- *Description:* Wiring a standard door-switch interlock system to a simulated laser console. Students will verify that the laser instantly physically shuts its beam the moment the laboratory door is opened.
- *Medical Tech Application:* Designing and validating the strict engineering controls required to legally *classify* an Operation Theatre as a Nominal Hazard Zone for Class 4 surgical lasers.

Laboratory, Computing, and Special Facilities Required

To conduct this course, the institution must construct a highly specialized **Optical Systems & Laser Safety Laboratory**. This environment requires strict architectural safety controls, as even stray reflections from educational lasers can cause permanent eye damage.

1. Physical Laboratory Infrastructure

- **Class 4 Safety Architecture:** The lab must have heavy, non-reflective matte paint on all walls and ceilings to prevent specular reflections.
- **Windowless or Blocked:** Total control over ambient light is required for the optics and endoscopy experiments. Any external windows must be fitted with laser-blocking blackout shades.
- **Access Control:** The main doors must feature automated electronic interlocks tied to a prominent illuminated "Laser in Use" warning sign outside the corridor.
- **Ventilation:** If tissue-mimicking phantoms or thermal paper are being ablated, a localized smoke evacuation system must be installed over the workbenches.

2. Specialized Metrology & Optical Equipment

- **Optical Metrology:** High-quality Thermal Power Meters (capable of measuring up to 20-50 Watts safely), digital spectrometers, and lux meters.
- **Laser Safety Gear:** A fleet of laser safety goggles covering multiple wavelength bands (e.g., specific OD ratings for 1064nm Nd:YAG and 10,600nm CO₂).
- **Endoscopy Triage Tools:** Automated and manual pneumatic leak testers for flexible endoscopes, CCU testing carts with high-definition medical monitors, and fiber-optic microscopes for inspecting cleaved fibers.

3. Hardware Inventory (Device Library)

- **Educational Lasers:** Open-cavity educational laser kits (like Diode-Pumped Solid-State kits) that allow students to physically manipulate the mirrors and gain mediums.

- **Decommissioned Surgical Inventory:** Discarded flexible endoscopes (colonoscopes/bronchoscopes) with internal channel damage for leak-test training.
 - Scrapped rigid laparoscopes and arthroscopes.
 - Retired articulated laser delivery arms (mirrors intact).
 - Xenon and LED surgical light sources.

4. Computing Facilities

- **Optical Simulation Workstations:** Standard dual-monitor PCs loaded with educational optical ray-tracing software (e.g., educational versions of Zemax, or free alternatives like RayOptics). This allows students to simulate the focal length of a Hopkins rod-lens system before inspecting the physical hardware.

Year 2: Semester 4

DMET 207: Clinical Engineering Asset Management

Here is the comprehensive list of 14 practical experiments for the **Clinical Engineering Asset Management** course. Because this course pivots from hands-on hardware repair to the administrative and financial governance of a hospital's technology fleet, these "experiments" are structured as data-driven simulations, workflow analyses, and strategic audits.

Following the list, you will find the detailed specifications for the required Management & IT Simulation laboratory.

List of 14 Practical Experiments

Unit 1: Role of Clinical Engineer / Medical Equipment Technologist

1. Clinical Acuity & Breakdown Triage Simulation:

- *Description:* Students are presented with a simulated morning inbox containing 10 simultaneous breakdown calls across various departments (e.g., a failing ICU ventilator vs. a broken OPD weighing scale). They must triage and assign technician dispatch priority based on patient risk and departmental impact.
- *Medical Tech Application:* Developing the critical decision-making skills required of a Clinical Engineering Head during high-stress equipment failures.

2. Workflow Mapping & RCA (Root Cause Analysis):

- *Description:* Using flowcharting software (like Visio or draw.io), students map the complete workflow of a piece of equipment from the moment a nurse reports a fault to its final return to the ward. They will integrate a "5 Whys" RCA into the workflow for a simulated recurring failure.
- *Medical Tech Application:* Standardizing hospital protocols to eliminate bottlenecks in repair turnaround times.

Unit 2: Computerized Maintenance Management Systems (CMMS)

3. Asset Onboarding & Standard Nomenclature:

- *Description:* Students are given 5 physical devices (or specifications). They must accurately log them into a CMMS using standardized global nomenclature (e.g., GMDN or ECRI codes), capturing serial numbers, warranty dates, and manufacturer details.
- *Medical Tech Application:* Preventing database corruption caused by technicians entering "BP Machine" versus "NIBP Monitor" in the hospital's central asset ledger.

4. Work Order (WO) Lifecycle Management:

- *Description:* Executing the complete digital lifecycle of a repair: opening a WO, allocating spare parts from the digital inventory, logging active repair labor hours, and closing the WO with standardized resolution codes.
- *Medical Tech Application:* The foundational daily task that ensures a clinical engineering department can legally prove a device was repaired properly before touching a patient.

5. KPI Extraction & Calculation (MTBF & MTTR):

- *Description:* Exporting a raw CSV dataset of 500 historical work orders. Students will use spreadsheet pivot tables to calculate the Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR) for specific equipment classes.
- *Medical Tech Application:* Using hard data to prove to hospital administration whether a specific brand of infusion pump is unreliable and costing the hospital too much in downtime.

Unit 3: Preventive Maintenance Planning

6. OEM to PM Checklist Translation:

- *Description:* Extracting the recommended maintenance procedures from a dense, 200-page OEM service manual (e.g., for a surgical table) and translating them into a concise, 15-point actionable checklist for a junior technician.
- *Medical Tech Application:* Standardizing maintenance protocols to ensure technicians do not skip critical safety steps during routine inspections.

7. Risk-Based Maintenance (RBM) Scoring Matrix:

- *Description:* Applying a clinical risk scoring system (like the Fennigkoh and Smith model) to an equipment inventory. Students will mathematically calculate which devices require PM every 6 months (high-risk life support) versus those that can safely be moved to "run-to-failure" status.
- *Medical Tech Application:* Optimizing a department's limited labor hours by focusing only on equipment that directly impacts patient safety.

8. Annual Maintenance Calendar Optimization:

- *Description:* Designing a 12-month PM schedule for a simulated 100-bed hospital. Students must balance the monthly workload (technician hours) while navigating constraints (e.g., Operating Theatre equipment can only be serviced on Sunday nights).
- *Medical Tech Application:* Ensuring 100% regulatory compliance without disrupting the hospital's clinical revenue generation.

Unit 4: Equipment Lifecycle & Condemnation

9. Depreciation Modeling (Financial Forecasting):

- *Description:* Using spreadsheet financial formulas to model the 10-year depreciation of a high-value asset (like an MRI scanner) using both Straight-Line and Declining Balance methods.
- *Medical Tech Application:* Advising the hospital CFO on the current book value of medical assets to secure capital budgets for replacements.

10. Condemnation Report & Justification:

- *Description:* Analyzing a simulated repair history for an aging Ultrasound machine where the required replacement probe costs 60% of the machine's current depreciated value. Students will draft a formal, legally sound condemnation report recommending it be scrapped.

- *Medical Tech Application:* The formal financial and clinical justification required to permanently remove a medical device from a hospital's inventory.

11. E-Waste & Biohazard Disposal Compliance Audit:

- *Description:* Mapping out the legally compliant disposal route for a condemned patient monitor, separating the hazardous e-waste (lithium batteries, PCBs) from standard waste, per local statutory environmental regulations.
- *Medical Tech Application:* Protecting the hospital from severe environmental fines and legal liabilities during the equipment scrapping process.

Unit 5: Inventory & Spares Management

12. ABC Inventory Categorization:

- *Description:* Analyzing a hospital's annual spare parts consumption dataset. Students will perform an ABC analysis to categorize parts into "A" (high value/low volume, like X-ray tubes) down to "C" (low value/high volume, like ECG electrodes).
- *Medical Tech Application:* Optimizing the department's financial capital by strictly controlling expensive inventory while ensuring cheap, critical consumables never run out.

13. Reorder Point & Safety Stock Calculation:

- *Description:* Calculating the exact mathematical reorder points for critical ICU consumables based on vendor lead times, average daily consumption, and required safety stock margins.
- *Medical Tech Application:* Preventing catastrophic equipment downtime caused simply by forgetting to order a Rs. 500 proprietary sensor.

14. AMC/CMC Vendor SLA Evaluation:

- *Description:* Reviewing two simulated vendor contracts (Service Level Agreements) for an Annual Maintenance Contract (AMC) and a Comprehensive Maintenance Contract (CMC). Students will identify hidden penalty clauses, guaranteed uptime requirements, and exclusions.
- *Medical Tech Application:* Developing the contract negotiation skills required to protect the hospital when dealing with aggressive third-party service vendors.

Laboratory, Computing, and Special Facilities Required

Unlike the hardware-heavy laboratories of previous semesters, this course requires a **Clinical Engineering IT & Management Hub**. The environment must simulate the central administrative office of a modern healthcare facility.

1. Physical Laboratory Infrastructure

- **Corporate/Office Layout:** Instead of standard electronic workbenches, this lab should feature ergonomic IT workstations arranged in clusters (to simulate departmental teams), along with a central conference area with a projector or smartboard for presenting workflow RCAs and condemnation reports.
- **Triage Whiteboards:** Large physical whiteboards or digital Kanban boards for the visual simulation of active work orders and technician dispatching.

2. Computing Facilities (Hardware)

- **Workstations:** High-performance desktop PCs or laptops at a strict **1:1 student ratio**.
- **Dual Monitor Setups:** Highly recommended. Students will frequently need to have a 300-page OEM PDF manual open on one screen while building a PM checklist or entering data into a CMMS on the second screen.

3. Software Infrastructure

- **CMMS Educational Instance:** This is the most critical requirement. The institution must procure an educational license or host an open-source CMMS (such as openMAINT, Snipe-IT configured for medical, or a sandbox instance from vendors like eMaint, Nuvolo, or EQ2). The students must interact with a live database.
- **Data Analytics & Office Suite:** Microsoft Excel (with the Data Analysis Toolpak enabled) or Google Sheets for heavy KPI calculations, ABC inventory sorting, and depreciation modeling. Visio, Lucidchart, or draw.io for workflow mapping.

4. Specialized Data Sets (The "Simulated Hospital")

Because students cannot generate years of repair data in a single semester, the faculty must build or procure a **"Simulated Hospital Database."** This includes:

- A pre-populated asset ledger containing 500+ realistic medical devices with purchase prices, serial numbers, and warranty dates.
- A CSV file of 1,000+ historical work orders (including realistic user errors, part failures, and timestamps) to be used for the MTTR/MTBF calculations in Experiment 5.

- Redacted, real-world examples of OEM Service Level Agreements (SLAs) and AMC/CMC contracts for Unit 5 contract evaluations.

DMET 208: Hospital Facility Management

Here is the comprehensive list of 14 practical experiments for the **Hospital Facility Management** course. This sequence shifts the student's focus away from individual medical devices and scales it up to the macro-infrastructure required to keep a 24/7 healthcare facility legally compliant and operationally safe.

Following the list, you will find the detailed specifications for the required Hospital Infrastructure & Utilities Laboratory.

List of 14 Practical Experiments

Unit 1: Medical Gas Pipeline Systems (MGPS)

1. MGPS Architecture & Color-Coding Audit:

- *Description:* Students trace a scaled-down physical gas pipeline or a detailed architectural blueprint, auditing the system against standard medical color codes (e.g., Yellow for Vacuum, Black/White for Medical Air, White/Blue for Oxygen) to identify simulated installation errors.
- *Medical Tech Application:* Preventing catastrophic mix-ups where a patient is inadvertently connected to a medical air line instead of an oxygen line.

2. Automatic Changeover Manifold Simulation:

- *Description:* Operating a simulated dual-bank cylinder manifold. Students will monitor the line pressure and verify that the pneumatic changeover valve automatically switches to the reserve bank when the primary bank pressure drops below a critical threshold.
- *Medical Tech Application:* Guaranteeing an uninterrupted oxygen supply to life-support ventilators during midnight cylinder changeovers.

3. Area Valve Service Unit (AVSU) & Alarm Triage:

- *Description:* Testing a ward-level AVSU box by intentionally dropping the pipeline pressure to trigger the high/low audio-visual alarms. Students practice the emergency shut-off protocols used during a localized ward fire.
- *Medical Tech Application:* Acting as the critical first responder to MGPS failures, ensuring nurses and doctors evacuate patients safely during gas leaks or fires.

Unit 2: Hospital HVAC & Infection Control

4. Differential Pressure Mapping (OT vs. Isolation):

- *Description:* Using a digital differential pressure manometer to map the air pressure gradients between a simulated corridor and two mock rooms. Students must verify that the Operating Theatre maintains a sterile positive pressure (+2.5 Pa) and the Infection Isolation Ward maintains a negative pressure (-2.5 Pa).
- *Medical Tech Application:* Ensuring the hospital HVAC system is physically preventing airborne pathogens (like Tuberculosis) from escaping isolation wards.

5. Air Velocity & ACH (Air Changes per Hour) Calculation:

- *Description:* Utilizing a vane anemometer or a hot-wire anemometer to measure the air velocity at an HVAC supply grille. Students mathematically calculate the total volumetric flow rate and the resulting ACH for the room volume.
- *Medical Tech Application:* Performing the mandatory engineering audits required by accreditation bodies to prove an Operating Theatre is receiving the mandated 20+ air changes per hour.

6. HEPA Filter Integrity & Laminar Flow Testing:

- *Description:* Using a localized fog generator and a handheld particle counter to visualize the laminar airflow over a simulated surgical table and test the sealing edges of a HEPA filter for microscopic particulate leaks.
- *Medical Tech Application:* Certifying the ultra-clean air environments required for highly susceptible procedures like orthopedic joint replacements.

Unit 3: RO Water Systems for Dialysis

7. City Water Pre-Treatment & Chlorine Auditing:

- *Description:* Testing the input tap water and the post-carbon-filter water using chemical reagent strips to measure total hardness and verify the absolute removal of free chlorine and chloramines.
- *Medical Tech Application:* Protecting expensive Reverse Osmosis membranes from chemical degradation and preventing lethal chlorine toxicity in dialysis patients.

8. RO Membrane TDS Rejection & Conductivity Logging:

- *Description:* Using Total Dissolved Solids (TDS) and conductivity meters to measure the electrical resistance of the product water against the feed water, calculating the percentage rejection rate of the RO membrane.
- *Medical Tech Application:* Determining the exact moment an RO membrane has degraded beyond clinical safety limits and requires replacement.

9. Disinfection Loop & Endotoxin Sampling Protocol:

- *Description:* Executing a simulated chemical or thermal disinfection cycle on the RO fluid loop. Students practice the aseptic fluid-sampling techniques required to send water to a pathology lab for endotoxin and bacterial culture testing.
- *Medical Tech Application:* Managing the strict microbiological hygiene of the hospital's dialysis water plant.

Unit 4: Biomedical Waste Management

10. Statutory BMW Segregation & Color-Coding Drill:

- *Description:* A rapid-response triage simulation where students are presented with 20 mixed waste items (e.g., bloody gauze, used syringes, expired medicines, broken glass). They must sort them into the legally mandated Yellow, Red, White, and Blue bins within a time limit.
- *Medical Tech Application:* Enforcing absolute compliance with national biomedical waste handling rules to protect sanitation workers from needle-stick injuries and hospital-acquired infections.

11. E-Waste & Hazardous Chemical Disposal Workflow:

- *Description:* Drafting the legally compliant disposal manifest for a condemned UPS system. Students must document the safe extraction of lead-acid batteries and the quarantine of obsolete PCBs containing heavy metals.
- *Medical Tech Application:* Shielding the hospital from severe environmental fines by managing the toxic byproduct of medical technology.

Unit 5: Backup Power & Generators

12. Automatic Transfer Switch (ATS) Changeover Metrology:

- *Description:* Using a power quality analyzer and a dual-trace oscilloscope to capture the exact millisecond delay when the main utility power is cut and the Diesel Generator (DG) via the ATS takes the load.

- *Medical Tech Application:* Verifying that the hospital's emergency generator steps in fast enough to prevent life-support systems from rebooting.

13. Central UPS Load-Bank Testing:

- *Description:* Connecting a high-capacity resistive load bank to a simulated central hospital UPS. Students draw a massive, continuous current to perform a deep-discharge test on the battery string, verifying the actual backup run-time matches the theoretical rating.
- *Medical Tech Application:* Guaranteeing that the ICU has a verified 30-minute power window to keep ventilators running if the main Diesel Generators fail to start during a blackout.

14. Critical vs. Non-Critical Load Shedding Audit:

- *Description:* Mapping a *simulated* hospital electrical distribution board. Students must identify and isolate non-essential loads (e.g., lobby HVAC, administrative lighting) to ensure the emergency generator only powers critical life-safety panels (OT, ICU, MGPS compressors).
- *Medical Tech Application:* Managing emergency power logistics during a catastrophic, multi-day regional grid failure.

Laboratory, Computing, and Special Facilities Required

To conduct this course, the institution must construct a highly specialized **Hospital Infrastructure & Utilities Laboratory**. This lab requires heavy mechanical plumbing, high-power electrical distribution, and advanced environmental metrology to satisfy the rigorous statutory mandates of technical boards (such as AICTE and SBTE) and allied healthcare accreditation bodies (like NCAHP and NABH).

1. Physical Laboratory Infrastructure

- **The "Mock Ward" Setup:** A structurally isolated section of the lab containing two small enclosed rooms with adjustable HVAC dampers. This allows students to physically manipulate the airflow to create positive (OT) and negative (Isolation) pressure gradients.
- **Scaled MGPS Manifold:** A wall-mounted, non-pressurized (or low-pressure compressed air) mock medical gas manifold featuring color-coded copper piping, an automatic changeover valve, and a functional electronic Area Valve Service Unit (AVSU) with audio-visual alarms.
- **Scaled RO Water Plant:** A low-capacity, fully functional Reverse Osmosis water purification skid, featuring multimedia pre-filters, carbon blocks, a high-pressure pump, and a small RO membrane housing with sample tap points.

2. Specialized Metrology & Facility Testing Tools

- **Environmental Metrology:** Digital differential pressure manometers, hot-wire and vane anemometers, handheld laser particle counters, and digital psychrometers (for temperature/humidity validation).
- **Water Quality Tools:** Industrial-grade Total Dissolved Solids (TDS) meters, conductivity probes, and chemical titration/reagent test kits for chlorine and water hardness.
- **Power Quality Metrology:** Heavy-duty power quality analyzers to measure power factor, harmonics, and ATS transfer times, along with access to a portable resistive load bank (e.g., 5kW to 10kW) for safe UPS battery discharge testing.

3. Hardware Inventory (Device Library)

- **Biomedical Waste Infrastructure:** A complete, legally compliant set of heavy-duty, color-coded biomedical waste bins (Yellow, Red, White translucent puncture-proof sharps containers, and Blue cardboard boxes) alongside simulated medical waste (using safe, clean props like dyed water for blood and blunt training syringes).
- **HVAC Components:** Decommissioned HEPA filter housings and various types of ventilation grilles to practice air velocity measurements.

4. Computing & IT Facilities

- **Facility Management Workstations:** Standard desktop PCs loaded with Building Management System (BMS) simulation software. This allows students to view the entire hospital's infrastructure on a single digital dashboard, monitoring real-time oxygen tank levels, HVAC differential pressures, and DG fuel levels, mirroring the command center of a modern, multi-specialty hospital.

DMET 209: Hospital Safety & Standards

Here is the comprehensive list of 14 practical experiments for the **Hospital Safety & Standards** course. This sequence is absolutely critical; it transitions students from theoretical engineering into legally accountable clinical technicians who understand that a single procedural failure can result in catastrophic harm to patients or staff.

Following the list, you will find the detailed specifications for the required safety testing laboratory and specialized compliance facilities.

List of 14 Practical Experiments

Unit 1: Macro & Micro-shock Hazards

1. Human Body Resistance Profiling:

- *Description:* Using precision digital multimeters to measure human skin resistance under dry, sweaty (saline-moistened), and abraded (simulated via conductive gel) conditions.
- *Medical Tech Application:* Understanding mathematically why wet environments (like operating theaters or ICU beds) drastically lower the resistance threshold, making otherwise safe voltages deadly.

2. Microshock vs. Macroshock Pathway Simulation:

- *Description:* Utilizing a passive resistor-network phantom (simulating human tissue and a direct cardiac catheter pathway) to inject a safe, microampere test current. Students will calculate the current density at the "heart" node versus the "skin" node.
- *Medical Tech Application:* Proving why a 10-microampere leakage current—imperceptible on the skin—can trigger ventricular fibrillation if applied directly to an invasive cardiac catheter.

Unit 2: IEC 60601 Standard Overview

3. Electrical Safety Analyzer (ESA) Familiarization:

- *Description:* Navigating the interface of a clinical Electrical Safety Analyzer. Students will learn to intentionally induce open-ground and reverse-polarity fault conditions safely inside the testing unit.
- *Medical Tech Application:* The mandatory first step before testing any piece of hospital equipment.

4. Protective Earth & Enclosure Leakage Testing:

- *Description:* Connecting a Class I device (e.g., an infusion pump) to the ESA to measure grounding resistance and chassis leakage current under normal and single-fault conditions.
- *Medical Tech Application:* Verifying that the metal casing of a device will not electrocute a nurse if internal wiring frays and touches the chassis.

5. Applied Part Leakage Testing (Type B, BF, CF limits):

- *Description:* Testing the patient-connected leads (applied parts) of an ECG machine. Students will verify that the leakage current meets the strict Type CF (Cardiac Floating) limits, which are much lower than standard Type B limits.
- *Medical Tech Application:* Ensuring that diagnostic cables physically attached to a patient's chest are electrically isolated from mains power.

6. Insulation Resistance Measurement:

- *Description:* Applying a high DC test voltage (e.g., 500V DC) across the mains and chassis of a Class II (double-insulated) device using a Megohmmeter to ensure the internal insulation has not degraded.
- *Medical Tech Application:* Routine safety testing for devices without a protective earth ground, such as portable pulse oximeters or handheld ophthalmoscopes.

Unit 3: Biological & Chemical Hazards

7. Simulated Biohazard Exposure & PPE Protocols:

- *Description:* Applying a UV-fluorescent training lotion (simulating bloodborne pathogens) to a piece of medical hardware. Students must don full PPE, handle the equipment, and carefully doff the PPE. A UV blacklight is then used to reveal any cross-contamination on their skin or clothes.
- *Medical Tech Application:* Establishing the strict physical discipline required before handling returned laboratory analyzers, ventilators, or surgical tools.

8. Chemical Decontamination Workflows:

- *Description:* Practicing the mechanical and chemical cleaning protocols for different materials (plastics, metals, optics) using simulated clinical disinfectants (like glutaraldehyde or isopropyl alcohol analogs).
- *Medical Tech Application:* Safely sterilizing a device chassis before opening it for internal electronic repairs without damaging the sensitive electronics inside.

9. Biomedical Waste Segregation:

- *Description:* A timed, scenario-based drill where students must correctly sort simulated clinical waste (sharps, soiled dressings, chemical batteries, electronic PCBs) into strictly color-coded hospital disposal bins according to international guidelines.

- *Medical Tech Application:* Complying with strict hospital infection control and environmental regulations.

Unit 4: Fire Safety in Hospitals

10. Electrical Overload Simulation:

- *Description:* Intentionally overloading a localized, fused circuit with high-draw heating elements to observe the tripping characteristics of standard MCBs (Miniature Circuit Breakers) versus RCDs (Residual Current Devices).
- *Medical Tech Application:* Understanding how faulty ward equipment triggers electrical fires and how to calculate safe load distributions for ICU power strips.

11. Spark Hazards in Oxygen-Enriched Environments:

- *Description:* Using a sealed, spark-ignition demonstration chamber (using safe, inert gas equivalents) to observe how slightly higher oxygen concentrations drastically lower the energy required to ignite a fire.
- *Medical Tech Application:* Designing and testing equipment for Operating Theatres to ensure relays and switches do not create micro-sparks near anesthesia or oxygen lines.

Unit 5: Ergonomics & Radiation Safety Basics

12. Ergonomic Load Assessment:

- *Description:* Using dynamometers and force gauges to measure the physical strain required to lift or push heavy medical equipment (like mobile C-arms or heavy incubators) using proper versus improper biomechanics.
- *Medical Tech Application:* Preventing chronic back injuries, which are a leading cause of early retirement in the clinical engineering field.

13. Radiation Distance & The Inverse Square Law:

- *Description:* Using a safe, educational-grade exempt radioactive source and a Geiger-Müller counter to measure radiation intensity as the distance from the source is doubled and tripled.
- *Medical Tech Application:* Proving the ALARA principle; understanding exactly how far an engineer must stand from an active X-ray machine to remain safe.

14. Lead Shielding & Half-Value Layer (HVL) Testing:

- *Description:* Placing varying thicknesses of lead, aluminum, and standard hospital drywall between the educational radiation source and the detector to calculate the exact material thickness required to cut the exposure dose in half.
- *Medical Tech Application:* Verifying the integrity of lead aprons and understanding the structural shielding built into Radiology department walls.

Laboratory, Computing, and Special Facilities Required

To conduct this course, the institution must establish a **Clinical Safety & Compliance Laboratory**. This space must bridge the gap between heavy electrical testing and clinical infection control.

1. Physical Laboratory Infrastructure

- **Zoning:** The lab must be strictly divided into a "Clean Zone" (for electrical testing and documentation) and a "Simulated Dirty Zone" (equipped with stainless steel sinks and chemical-resistant benchtops for decontamination and PPE drills).
- **Workstations:** Grounded, ESD-protected electronic workbenches equipped with Medical Grade Isolation Transformers to safely conduct fault testing without tripping the building's main breakers.

2. Specialized Safety & Metrology Instrumentation

- **Electrical Safety Analyzers (ESAs):** 2 to 3 clinical-grade ESAs (e.g., Fluke ESA609, ESA612, or Rigel 288+). These are the most critical pieces of equipment for Unit 2, automating the complex leakage current measurements required by the IEC 60601 standard.
- **Radiation Safety Equipment:** Educational-grade Geiger-Müller counters, personal dosimeter badges, standard hospital lead aprons (both intact and intentionally damaged for testing), and safe, exempt-quantity educational isotope sources.
- **Ergonomic & Force Tools:** Digital force gauges or dynamometers for push/pull limit testing.
- **Simulated Contamination Kits:** UV-fluorescent training powders/lotions and high-intensity UV blacklights for the infection control experiments.

3. Medical Consumables & PPE

- **Infection Control Supplies:** A high-volume supply of clinical PPE (nitrile gloves, N95 masks, isolation gowns, face shields).

- **Waste Management:** Standardized, color-coded hospital biomedical waste bins (e.g., Yellow for anatomical/infectious, Red for contaminated plastics, Blue for glass, Puncture-proof containers for sharps).

4. Computing Facilities

- **Compliance Workstations:** PCs loaded with automated safety testing software (often provided by the ESA manufacturer, like Fluke Ansur).
- **Regulatory Database Access:** Digital access to the IEC 60601 standard outlines and local hospital accreditation guidelines (e.g., JCI, NABH) so students can learn to log their safety analyzer printouts into a legally compliant Computerized Maintenance Management System (CMMS) database.

This framework ensures students respect the immense physical and legal responsibility that comes with repairing life-support equipment.

DMET 210: Regulatory & Quality Assurance

Here is the comprehensive list of 14 practical experiments, followed by the details of the specific facilities required to conduct them effectively.

List of 14 Practical Experiments

Unit 1: FDA & CE Marking Overview

1. Device Classification & Database Navigation

- *Description:* Students are given a list of 10 diverse medical devices (e.g., tongue depressor, MRI scanner, implantable pacemaker). They must navigate the FDA Product Classification Database and the EU MDR rules to correctly classify each device and identify the required regulatory pathway.
- *Medical Tech Application:* Determining the legal pathway, cost, and time-to-market required before a hospital can adopt, or a manufacturer can sell, a new healthcare technology.

2. 510(k) Predicate Device Analysis

- *Description:* Using the FDA's 510(k) Premarket Notification database, students must locate a recently cleared device (e.g., a new pulse oximeter) and extract its "Summary Statement" to analyze how the manufacturer proved substantial equivalence to a legally marketed predicate device.
- *Medical Tech Application:* Understanding the legal and engineering loopholes medical device companies use to bring new iterations of technology to market without conducting years of expensive clinical trials.

3. The CE Technical File Audit

- *Description:* Students are provided with a redacted, simulated CE Marking Technical File for a Class IIa device. They must audit the file to ensure all essential requirements (Essential Principles checklist, clinical evaluation report, Instructions for Use) are present and legally compliant.
- *Medical Tech Application:* Acting as the quality gatekeeper for a hospital, ensuring that imported European devices meet strict safety directives before they are deployed in patient wards.

Unit 2: ISO 13485 (Medical Devices QMS)

4. Drafting an ISO-Compliant SOP

- *Description:* Students must write a rigorous, ISO 13485-compliant Standard Operating Procedure (SOP) for the intake, decontamination, and initial diagnostic testing of a returning, potentially biohazardous infusion pump.
- *Medical Tech Application:* Standardizing clinical engineering workflows so that every technician in the hospital repairs and cleans equipment using the exact same safe, legally defensible method.

5. FMEA (Failure Mode and Effects Analysis)

- *Description:* In accordance with ISO 14971, students perform a line-by-line FMEA on a neonatal incubator. They must calculate the Risk Priority Number (RPN) for various failure modes (e.g., heater runaway) and propose specific engineering mitigations.
- *Medical Tech Application:* Proactively identifying and engineering out deadly equipment failures before the device is ever connected to a vulnerable patient.

6. Traceability Matrix Construction

- *Description:* Given a simulated Bill of Materials (BOM) for a patient monitor, students build a forward and backward traceability matrix connecting component batch numbers to final device serial numbers.
- *Medical Tech Application:* Enabling rapid, life-saving equipment recalls by tracking exactly which hospital ward (or which patient) received a device containing a defective component.

Unit 3: NABH Accreditation for Hospitals

7. NABH Chapter 4 (FMS) Gap Analysis

- *Description:* Students perform a physical walkthrough of the college laboratory. Using the NABH Facility Management and Safety (FMS) checklist, they must identify and document compliance gaps (e.g., missing fire extinguishers, uncalibrated test tools, poor electrical grounding).
- *Medical Tech Application:* Preparing a hospital for a massive external regulatory audit, ensuring the facility does not lose its accreditation (and thereby its insurance billing rights).

8. NABL Calibration Verification

- *Description:* Students are handed a stack of calibration certificates for the hospital's biomedical test equipment (e.g., electrical safety analyzers). They must audit the certificates to verify that the third-party lab holds valid NABL accreditation and that the calibration is traceable to national standards.
- *Medical Tech Application:* Ensuring that the multimeters and simulators used to test life-support equipment are themselves perfectly accurate and legally certified for use in a court of law.

9. The Mock NABH Audit Role-Play

- *Description:* Instructors act as strict external auditors. Students act as the hospital's Biomedical Department Head and must rapidly retrieve specific Preventive Maintenance (PM) logs, breakdown reports, and staff training records from a CMMS.
- *Medical Tech Application:* Developing the composure, administrative speed, and professional vocabulary required to confidently answer aggressive questions from national healthcare regulators.

Unit 4: AERB Regulations (Radiation)

10. e-LORA Portal Simulation

- *Description:* Students navigate a sandbox simulation or detailed walkthrough of the AERB's e-LORA (e-Licensing of Radiation Applications) portal. They must draft the mandatory documentation required to declare a new X-ray room layout for regulatory approval.
- *Medical Tech Application:* Managing the strict legal prerequisites required to install radiation-emitting equipment without violating national atomic energy laws.

11. Radiation QA Data Interpretation

- *Description:* Students are provided with raw test data from a Quality Assurance agency regarding a C-Arm machine (e.g., kVp accuracy, mA linearity, half-value layer). They must analyze the data against strict AERB tolerance limits to determine if the machine legally passes or fails.
- *Medical Tech Application:* Mathematically verifying that diagnostic imaging machines are perfectly calibrated and are not delivering lethal, uncontrolled radiation doses to patients and operators.

Unit 5: Post-Market Surveillance

12. FDA MAUDE Database Investigation

- *Description:* Students use the FDA's Manufacturer and User Facility Device Experience (MAUDE) database to search for recent adverse events related to a specific brand of ventilators. They must synthesize a report on the most common failure modes occurring globally.
- *Medical Tech Application:* Leveraging global failure data to predict, intercept, and prevent similar equipment breakdowns in the clinical engineer's own hospital facility.

13. Drafting a CAPA (Corrective and Preventive Action)

- *Description:* Following a simulated string of repetitive failures where nurses keep breaking the ECG lead wires on patient monitors, students must draft a formal CAPA report. This requires identifying the root cause and proposing a permanent training or procurement fix.
- *Medical Tech Application:* Closing the loop on recurring hospital errors, transitioning from simply fixing broken items to engineering out the root cause of the damage permanently.

14. The Hospital-Wide Recall Execution Drill

- *Description:* A simulated "Urgent Medical Device Correction" notice is issued for a critical software bug in 50 ventilators. Using CMMS software, students must race the clock to locate the serial numbers, "quarantine" them in the system, and document the simulated application of the firmware patch.
- *Medical Tech Application:* Managing a high-stress crisis response to physically remove dangerous, recalled machinery from the hospital floor before a patient is injured.

Laboratory, Computing, and Special Facilities Required

To conduct these regulatory and compliance experiments, standard electronic workbenches are not required. Instead, the institution must establish a **Regulatory Informatics & Quality Assurance Laboratory**.

This space should mirror a corporate hospital administration hub and a digital informatics center.

1. Computing & IT Infrastructure

- **Informatics Workstations:** A dedicated computer lab with a 1:1 student-to-PC ratio. The computers must have high-speed internet access, as the majority of modern regulatory work relies on querying massive global databases (FDA, CE, AERB).
- **CMMS Software Access:** This is strictly mandatory. The lab must have an educational license or a localized sandbox version of a Computerized Maintenance Management System (CMMS). Students cannot learn NABH compliance or recall management without hands-on experience using industry-standard asset tracking software.
- **Spreadsheet & Documentation Software:** Advanced proficiency in Microsoft Excel (or Google Sheets) is required for building FMEA matrices, Risk Priority Number calculations, and traceability logs.

2. Physical Laboratory Setup

- **The "Audit Boardroom":** A section of the lab should be set up as a formal conference table. This is used for the mock NABH audit role-plays (Experiment 9) and CAPA presentations, training students to defend their documentation professionally under pressure.
- **Document Control Archives:** Physical (or securely networked digital) filing cabinets containing redacted, real-world examples of CE Technical Files, ISO 13485 SOPs, and completed FDA 510(k) submissions for student reference.

3. Specialized Reference Materials

- **Statutory Rulebooks:** The lab must maintain updated physical or digital copies of the NABH Standards for Hospitals, the AERB Safety Code for Medical Diagnostic X-Ray Equipment, and the ISO 13485:2016 standard.
- **Redacted QA Reports:** A library of genuine, redacted Quality Assurance test reports for radiological equipment (X-ray, CT) and calibration certificates for biomedical test tools.

DMET 211: Advanced Diagnostics & Repair

Here is the comprehensive list of 14 practical experiments for the **Advanced Diagnostics & Repair** course. As this is the final, major project semester, these experiments transition students from basic preventive maintenance to elite, component-level forensic engineering. The goal here is to train technicians who can save a hospital tens of thousands of dollars by repairing a single proprietary circuit board rather than replacing the entire machine.

Following the list, you will find the detailed specifications for the required Advanced Rework & Metrology Laboratory.

List of 14 Practical Experiments

Unit 1: Advanced PCB Troubleshooting

1. Multi-Layer Power Rail Tracing (Thermal Forensics):

- *Description:* Students are given a "dead" multi-layer motherboard from a decommissioned ventilator. They will use a benchtop power supply to inject a controlled low voltage into the shorted power rail and utilize a thermal imaging camera to locate the exact microscopic ceramic capacitor causing the dead short.
- *Medical Tech Application:* Salvaging a Rs. 5,00,000 proprietary motherboard instead of discarding the entire machine due to a cheap failed component.

2. OEM Schematic & Boardview Navigation:

- *Description:* Using dual-monitor workstations, students will cross-reference a dense, 50-page OEM schematic PDF with digital Boardview software to trace a complex logic signal from a physical test point back through multiple integrated circuits (ICs) to the main CPU.
- *Medical Tech Application:* Navigating the deliberately complex "black box" engineering of high-end medical equipment without relying on manufacturer support.

3. The "Blind Fault" Diagnostic Challenge:

- *Description:* Instructors intentionally induce a hidden open circuit (e.g., a cut microscopic trace or a lifted IC pin) on a functional medical sensor board. Students must use digital multimeters in continuity and diode-mode to logically deduce the location of the fault without a schematic.
- *Medical Tech Application:* Developing the intuitive, high-speed diagnostic logic required during high-pressure emergency repairs.

Unit 2: Oscilloscope & Spectrum Analyzer Mastery

4. Digital Bus Decoding (I2C & SPI):

- *Description:* Connecting a Mixed Signal Oscilloscope (MSO) or logic analyzer to a medical device's internal sensor board. Students will capture and mathematically decode the hexadecimal data packets being sent via I2C or SPI protocols from a sensor to the microcontroller.
- *Medical Tech Application:* Proving whether a patient monitor's sudden failure is due to a broken SpO2 hardware sensor or corrupted digital firmware communication.

5. Advanced Oscilloscope Triggering (Glitch Capture):

- *Description:* Configuring an oscilloscope's advanced triggers (e.g., pulse-width, runt, or logic triggering) to automatically capture a rare, millisecond-long voltage drop on an active power supply line.
- *Medical Tech Application:* Pinpointing the exact cause of "ghost reboots" where an infusion pump randomly restarts once every 24 hours.

6. EMI Sniffing with Near-Field Probes:

- *Description:* Using a Spectrum Analyzer equipped with magnetic and electric near-field probes to sweep a simulated Electrosurgical Unit (ESU) PCB, identifying the exact unshielded components leaking high-frequency radio noise.
- *Medical Tech Application:* Troubleshooting electromagnetic interference (EMI) that causes surgical monitors to glitch or freeze whenever the surgeon activates a cutting tool.

Unit 3: Surface Mount Technology (SMT) Rework

7. Thermal Profiling & High-Mass Ground Plane Rework:

- *Description:* Using an *infrared* (IR) bottom-heater and a hot air rework station to safely desolder a heavy DPAK power MOSFET from a thick, copper-heavy motherboard. Students must follow a strict thermal profile to avoid delaminating the PCB or destroying adjacent plastic connectors.
- *Medical Tech Application:* Safely executing high-heat repairs on dense power supply boards.

8. Micro-Soldering Under a Stereomicroscope:

- *Description:* Utilizing a trinocular stereomicroscope and ultra-fine soldering tips (e.g., JBC or Metcal) to manually replace microscopic passive components (0402 or 0201 package sizes) and repair broken PCB traces using 0.1mm jumper wire.
- *Medical Tech Application:* Repairing the highly miniaturized boards found inside expensive ultrasound probe connectors or portable telemetry transmitters.

9. QFP / QFN IC Replacement & Flux Chemistry:

- *Description:* Removing a high-pin-count Quad Flat Package (QFP) microcontroller, properly wicking the old solder, applying the correct tacky flux, and flowing a new IC into place using the surface tension of molten solder, followed by strict isopropyl alcohol cleaning.
- *Medical Tech Application:* Performing the ultimate level of board repair, proving mastery over the delicate chemistry and physics of modern lead-free solder.

Unit 4: Testing Patient Simulators

10. Metrology & Calibration Traceability Verification:

- *Description:* Cross-checking the biomedical department's primary Patient Simulator (e.g., Fluke ProSim) against a certified, higher-tier golden standard bench multimeter to verify that the simulator's output (e.g., a 1mV ECG signal) is actually legally accurate.
- *Medical Tech Application:* Understanding that the tools used to test life-support machines must themselves be rigorously calibrated, otherwise the entire hospital's safety record is legally compromised.

11. Rare Arrhythmia & Alarm Threshold Auditing:

- *Description:* Programming a multi-parameter simulator to generate complex, rare cardiac arrhythmias (e.g., Torsades de Pointes or Atrial Fibrillation) and pushing those signals into a central ICU monitoring station to verify that the software algorithms correctly identify the rhythm and trigger the mandatory audio-visual alarms.
- *Medical Tech Application:* Auditing the software logic of clinical diagnostic tools to prevent alarm fatigue and missed fatal events.

Unit 5: Root Cause Analysis (RCA)

12. The "5 Whys" & Fishbone Diagram Investigation:

- *Description:* A forensic case study where students are presented with a burnt infusion pump motor. They must systematically use the "5 Whys" and build an Ishikawa diagram to trace the failure back from the burnt motor, through a jammed gear, to a fluid leak, ultimately arriving at the root cause: an improper cleaning protocol by nursing staff.
- *Medical Tech Application:* Preventing recurring equipment failures by fixing systemic hospital protocols rather than just swapping broken hardware.

13. Fault Tree Analysis (FTA) of a Critical Misfire:

- *Description:* Using boolean logic (AND/OR gates) to build a top-down Fault Tree for a simulated catastrophic event: a defibrillator failing to deliver a shock during a code. Students map all possible hardware, software, and human-error pathways that could lead to that specific outcome.
- *Medical Tech Application:* Engineering highly resilient, fail-safe maintenance schedules for life-critical equipment.

14. Failure Mode and Effects Analysis (FMEA) Draft:

- *Description:* Taking a newly *proposed* (hypothetical) medical device and drafting a complete FMEA table. Students will assign Risk Priority Numbers (RPN) based on severity, occurrence, and detection ratings for various theoretical failure modes.
- *Medical Tech Application:* Transitioning from a reactive repair technician to a proactive quality assurance engineer capable of participating in medical device R&D.

Laboratory, Computing, and Special Facilities Required

To conduct this course, the institution must construct a highly specialized **Advanced Diagnostics & Rework Laboratory**. This cannot be a standard electronics bench; it must mimic the forensic repair centers of major medical device OEMs.

1. Physical Laboratory Infrastructure

- **ESD-Safe Environment:** The entire laboratory must be strictly Electrostatic Discharge (ESD) safe. This includes grounded conductive floor mats, anti-static workbenches, and mandatory grounded wrist straps for all students.
- **Fume Extraction:** High-end soldering and flux chemistry release toxic rosin and lead-free particulate smoke. Every workbench must be equipped with articulated, localized HEPA/Carbon fume extraction arms.

2. Specialized Metrology (Forensic Level)

- **Mixed Signal Oscilloscopes (MSOs):** High-bandwidth DSOs (e.g., 200MHz+) equipped with digital logic analyzer channels and built-in bus decoding software for I2C, SPI, and UART.
- **Spectrum Analyzers:** RF Spectrum analyzers (e.g., 1GHz to 3GHz range) equipped with magnetic and electric near-field probe kits for EMI sniffing.
- **Thermal Imaging Cameras:** Benchtop or high-resolution handheld thermal cameras (e.g., FLIR) specifically featuring macro lenses for viewing heat dissipation on microscopic SMD components.

3. Advanced Rework Stations

- **Micro-Soldering Hubs:** High-frequency, cartridge-style soldering stations (e.g., JBC or Metcal) that provide instantaneous thermal recovery, crucial for working on thick multi-layer boards.
- **Hot Air & IR Pre-heaters:** Digital hot air rework stations paired with infrared bottom-heaters to prevent board warping during heavy IC removal.
- **Stereomicroscopes:** Trinocular boom-stand microscopes (7x to 45x zoom) equipped with high-definition HDMI cameras to allow instructors to project a student's micro-soldering technique onto a large screen for the class to observe.

4. Hardware Inventory (Device Library)

- **Clinical Simulators:** High-end, multi-parameter patient simulators (e.g., Fluke ProSim 8) capable of outputting invasive blood pressure, precise ECG rhythms, and SpO2 optical signals.
- **High-Value Scrap Inventory:** A heavy supply of decommissioned, multi-layer proprietary motherboards from ventilators, ultrasound machines, and patient monitors to act as the targets for destructive desoldering practice and schematic reverse-engineering.

5. Computing Facilities

- **Diagnostic Workstations:** Every rework bench requires a dual-monitor PC. Students must be able to view a high-resolution Boardview file (e.g., using software like OpenBoardView) on one screen while referencing a dense PDF schematic or a live microscope camera feed on the other.

DMET 212: Major Project

While a Major Project is traditionally a fluid, self-directed endeavor, structuring it into 14 strictly evaluated "experiments" (or developmental milestones) is an excellent way to

maintain academic rigor and uniformity across the curriculum. By treating each phase of the engineering design process as a graded practical session, students are prevented from procrastinating and are forced to document their methodology systematically.

Here is the comprehensive list of 14 practical experiments for the **Major Project** course. These sessions transition the student from theoretical research to the physical fabrication and legal defense of a novel medical device.

Following the list, you will find the detailed specifications for the required Biomedical Innovation & Prototyping Hub.

List of 14 Practical Experiments (Developmental Milestones)

Unit 1: Problem Identification & Literature Review

1. Clinical Needs Assessment & Pain Point Observation:

- *Description:* Students conduct a supervised observational session in a simulated or partner clinical environment (e.g., ICU or OPD). They must document three distinct workflow inefficiencies or equipment hazards, utilizing a formal "Needs Statement" framework.
- *Medical Tech Application:* Training engineers to observe the hospital environment through the eyes of frustrated end-users (nurses and doctors) to find problems worth solving.

2. Prior Art & Patent Database Searching:

- *Description:* Using digital databases (Google Patents, IEEE Xplore, FDA 510(k) clearances), students conduct a prior art search on their chosen problem to ensure they are not reinventing an existing product.
- *Medical Tech Application:* Understanding the intellectual property landscape before committing time and capital to an engineering project.

3. Scope Definition & Feasibility Matrix:

- *Description:* Students draft a strict boundary document defining what their prototype will and will *not* do. They must map their proposed solution against a feasibility matrix evaluating technical complexity, cost, and time constraints.
- *Medical Tech Application:* Preventing "feature creep" and ensuring the project can actually be built within a 6-month timeframe.

Unit 2: Design Proposal & Budgeting

4. System Architecture & Block Diagram Design:

- *Description:* Creating a top-down block diagram of the proposed device, mapping out every micro-controller, power supply rail, sensor input, and actuator output required for the system to function.
- *Medical Tech Application:* Establishing the foundational electrical and logical blueprint of a new medical device.

5. **Bill of Materials (BOM) & Component Sourcing:**

- *Description:* Building an exhaustive, itemized BOM spreadsheet. Students must research actual suppliers (e.g., Digi-Key, Mouser), calculate lead times, and factor in shipping and taxes to build a realistic total budget.
- *Medical Tech Application:* Learning the harsh realities of supply chain logistics and component pricing.

6. **The "Pitch Deck" & Budget Defense:**

- *Description:* A formal presentation where students pitch their CAD concept and BOM to a faculty panel (acting as venture capitalists or hospital administrators), defending their design choices to secure their allotted project funding.
- *Medical Tech Application:* Mastering the executive communication skills required to secure R&D funding.

Unit 3: Implementation/Prototyping Phase

7. **Breadboard Integration & Signal Verification:**

- *Description:* Assembling the core sensor and micro-controller circuit on a solderless breadboard. Students use an oscilloscope to verify that raw analog signals (like an amplified ECG wave) are cleanly reaching the analog-to-digital converter (ADC) before permanent soldering.
- *Medical Tech Application:* Proving the underlying physics of the design work before committing to expensive, permanent manufacturing.

8. **Custom PCB Design & Routing:**

- *Description:* Using Electronic Design Automation (EDA) software to convert the breadboard schematic into a functional, multi-layer Printed Circuit Board (PCB) layout, ensuring proper ground planes and trace widths for medical-grade noise reduction.
- *Medical Tech Application:* Transitioning from a messy student prototype to a professional, manufacturable hardware standard.

9. **Enclosure Fabrication & Hardware Assembly:**

- *Description:* Designing an ergonomic, bio-compatible outer casing using 3D modeling software and physically printing it using FDM or SLA 3D printers. Students then mount their PCBs, screens, and batteries into the housing.
- *Medical Tech Application:* Understanding human-factors engineering, ensuring a device is easy to clean, comfortable to hold, and physically robust.

Unit 4: Testing & Data Collection

10. Firmware State-Machine Debugging:

- *Description:* Writing, flashing, and debugging the embedded C/C++ or Python code. Students must test edge-cases to ensure the firmware does not freeze or crash when a sensor is suddenly disconnected.
- *Medical Tech Application:* Developing the bulletproof software logic required for life-critical medical devices.

11. Clinical Metrology & Simulator Validation:

- *Description:* Connecting the physical prototype to a golden-standard clinical simulator (e.g., a Fluke ProSim). Students must run their device through 50 test cycles to verify it reads the simulated vital signs accurately.
- *Medical Tech Application:* Proving the device works against a legally traceable international standard, not just on the student's own body.

12. Statistical Error Analysis:

- *Description:* Exporting the data logs from the simulator testing phase into a statistical software package. Students calculate the mean error, standard deviation, and confidence intervals of their prototype's accuracy.
- *Medical Tech Application:* Quantifying device reliability to prove it meets the strict accuracy thresholds mandated by medical regulatory bodies.

Unit 5: Final Report & Viva Voce

13. Technical Thesis Compilation & Peer Review:

- *Description:* Drafting the comprehensive final engineering report, including the abstract, methodology, circuit schematics, statistical results, and limitations. Students swap drafts for a rigorous double-blind peer review session.
- *Medical Tech Application:* Mastering the documentation standards required for FDA/CE technical files.

14. The Final Viva Voce & Live Prototype Demonstration:

- *Description:* The *ultimate* capstone defense. Students stand beside their project poster and must successfully operate their device live in front of external industry examiners, answering rapid-fire questions regarding their design architecture and failure modes.
- *Medical Tech Application:* Proving absolute technical competency and readiness to enter the professional clinical engineering workforce.

Laboratory, Computing, and Special Facilities Required

Unlike structured metrology or wet labs, the Major Project requires a **Biomedical Innovation & Prototyping Hub** (often called a Maker Space). This facility must be highly flexible, allowing students to seamlessly transition between writing software, 3D printing plastic, and soldering surface-mount components.

1. Physical Laboratory Infrastructure

- **The "Clean/Dirty" Zoned Layout:** The lab must be physically divided. The "Clean Zone" contains the computing and clinical metrology equipment. The "Dirty Zone" contains the physical fabrication tools (3D printers, CNC routers, Dremel tools) which generate dust and fumes.
- **Assembly Workbenches:** Large, open, ESD-safe tables with multiple power outlets, heavy-duty cutting mats, and articulated magnifying lamps for final hardware assembly.
- **Storage & Lockers:** Secure, lockable storage bins for each project group. Major projects involve dozens of loose, expensive components that must be securely stored over the 6-month semester.

2. Specialized Prototyping Hardware

- **PCB Fabrication & SMT Assembly:** Desktop CNC PCB milling machines (or chemical etching baths) for rapid in-house board manufacturing, alongside solder-paste dispensers and a small reflow oven for Surface Mount Technology (SMT) assembly.
- **Rapid Prototyping (3D Printing):** A fleet of Fused Deposition Modeling (FDM) 3D printers for fast, cheap structural iterations, and at least one Stereolithography (SLA) resin printer for creating highly precise, smooth, and watertight enclosures.
- **Test & Measurement Bench:** Dedicated stations equipped with basic digital storage oscilloscopes, variable benchtop power supplies, and function generators for immediate circuit testing.

3. Clinical Validation Simulators (Device Library)

- To fulfill Experiment 11, the lab must have access to a pool of multi-parameter patient simulators, electrical safety analyzers, and mechanical test lungs. Students cannot validate a medical prototype without pushing controlled, simulated human physiology into its sensors.

4. Computing & IT Facilities

- **High-Performance CAD/EDA Workstations:** PCs equipped with dedicated graphics cards capable of running heavy 3D rendering software (e.g., SolidWorks, Fusion 360) without lagging.
- **Software Licenses:** * Electronic Design Automation (EDA) software like Altium Designer, Autodesk Eagle, or KiCad for circuit routing.
 - Data analysis software like MATLAB, Minitab, or Python (Jupyter environments) for processing the statistical error testing.

To ensure your students successfully transition from theoretical concepts to a tangible, functional medical device, they need resources that focus heavily on applied engineering, rapid prototyping, and regulatory-compliant design documentation. A major project fails when a student builds a device that works on a breadboard but cannot be legally documented or safely enclosed for a clinical environment.

APPENDIX – III

LEARNING RESOURCES

Diploma in Medical Equipment Technology

ONLINE RESOURCES:

Year 1: Semester 1

DMET 101: Basic Electrical Engineering

Learning resources for **Basic Electrical Engineering** syllabus units and its 14 practical experiments.

Category 1: Open-Source Textbooks & Technical Manuals

1. Lessons In Electric Circuits (by Tony R. Kuphaldt)

- **Format:** Open-Source Textbook Series (Web/PDF)
- **Relevance:** This is the gold standard for open-source electrical engineering texts. Volume I (DC), Volume II (AC), and Volume III (Semiconductors) comprehensively cover **Unit 1** and **Unit 2**. The language is incredibly clear, making it perfect for diploma students bridging the gap between theory and practical breadboard experiments.
- **Access:** ibiblio.org/kuphaldt/electricCircuits

2. All About Circuits: Textbook

- **Format:** Interactive Digital Textbook
- **Relevance:** An excellent, continuously updated alternative to traditional textbooks. It covers KVL/KCL, Thevenin's theorem, transformers, and AC resonance. It integrates seamlessly with their online community and worksheets, making it a great resource for instructors designing lab manual questions.
- **Access:** allaboutcircuits.com/textbook

3. WHO: Maintenance and Repair of Laboratory, Diagnostic Imaging, and Hospital Equipment

- **Format:** Open-Access Technical Manual (PDF)
- **Relevance:** While not a traditional electrical textbook, the sections on electrical safety, grounding, and power conditioning are mandatory reading. It perfectly addresses **Unit 4 (Electrical Safety & Grounding)**, providing the clinical context for why leakage currents and microshocks are deadly.
- **Access:** who.int (Search title in the WHO document repository)

Category 2: Free-to-Audit Online Courses (MOOCs)

4. MIT OpenCourseWare (OCW) - 6.002 Circuits and Electronics

- **Format:** Open-Source University Course
- **Relevance:** Taught by Prof. Anant Agarwal, this legendary course provides the highest academic standard for **Unit 1** and **Unit 2**. The video lectures and problem sets are rigorous, demonstrating how basic circuit principles are applied to real-world engineering problems.
- **Access:** ocw.mit.edu

5. NPTEL / Swayam: Basic Electrical Technology

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** The National Programme on Technology Enhanced Learning (NPTEL) offers deep, foundational engineering modules. This specific course heavily emphasizes **Unit 3 (Transformers & Machines)**, providing the mathematical and physical basis for AC/DC motors and step-down transformers.
- **Access:** nptel.ac.in

6. Coursera / Georgia Tech: Linear Circuits 1 (DC Analysis)

- **Format:** Online Course (Free to Audit)
- **Relevance:** A highly structured, modular course that breaks down node-voltage analysis, mesh-current analysis, and Thevenin/Norton equivalents. It serves as an excellent foundational review for students before they attempt the complex multiloop circuit experiments.
- **Access:** coursera.org

Category 3: Interactive Simulators & Video Channels

7. Falstad Circuit Simulator

- **Format:** Open-Source Web HTML5 Simulator
- **Relevance:** This is an indispensable tool for every electrical lab. Students can visually construct circuits, watch current flow in real-time, and observe animated oscilloscope outputs. It allows students to safely test their AC resonance and Thevenin calculations before wiring physical, live circuits.
- **Access:** falstad.com/circuit

8. The Engineering Mindset

- **Format:** Animated Educational Video Series (YouTube)
- **Relevance:** This channel creates the best 3D visual animations of electrical systems on the internet. Their videos on *How Transformers Work*, *AC vs DC*, and *Electrical Grounding* are perfect for visual learners mastering **Unit 3** and **Unit 4**.

9. EEVblog (Dave Jones)

- **Format:** Video Channel (YouTube)
- **Relevance:** For **Unit 5 (Measuring Instruments)**, this channel is unmatched. The tutorials on "How to use a Multimeter" and "Oscilloscope Basics" are legendary in the engineering community. It provides raw, practical knowledge that bridges the gap between reading a manual and actually operating complex diagnostic bench tools.

DMET 102: Human Anatomy & Physiology I

To deliver the **Human Anatomy & Physiology I** course at the highest academic standard, the learning materials must bridge the gap between pure biological science and clinical engineering applications. Engineers need to understand the body not just as a living organism, but as an electro-mechanical system of pumps, levers, fluid dynamics, and electrical conduction pathways.

Here is a list of 9 high-quality, highly visual, and predominantly open-source (or free-to-audit) learning resources mapped directly to the syllabus units and practical experiments.

Category 1: Open-Source Textbooks & Digital References

1. OpenStax: Anatomy and Physiology 2e

- **Format:** Open-Source Textbook (Web/PDF)
- **Relevance:** Published by Rice University, this rigorously peer-reviewed text covers all 5 units of your syllabus perfectly. It provides incredibly detailed, high-resolution medical illustrations of the cardiovascular, skeletal, and muscular systems. It is the absolute gold standard for open-source biological education.
- **Access:** openstax.org/details/books/anatomy-and-physiology-2e

2. TeachMeAnatomy (Comprehensive 3D Encyclopedia)

- **Format:** Open-Access Clinical Encyclopedia (Web/App)
- **Relevance:** An essential resource for **Unit 2 (Skeletal System)** and **Unit 3 (Muscular System)**. It breaks down human anatomy using interactive 3D models and clinical correlates. It is highly structured, making it easy for engineering students to quickly reference joint mechanics and muscle insertion points.
- **Access:** teachmeanatomy.info

3. WikiBooks: Human Physiology

- **Format:** Open-Source Digital Book
- **Relevance:** This crowd-sourced, continually updated textbook is excellent for **Unit 4 (Blood)** and **Unit 5 (Cardiovascular)**. It focuses heavily on the *mechanisms* of the body (e.g., the exact chemical cascade of blood coagulation or the electrical timing of the SA node), which appeals directly to the engineering mindset.
- **Access:** en.wikibooks.org/wiki/Human_Physiology

Category 2: Free-to-Audit Online Courses (MOOCs)

4. edX / Harvard University: Human Anatomy (AnatomyX)

- **Format:** Online Course (Free to Audit)
- **Relevance:** This world-class course utilizes Harvard's actual dissection laboratories to teach musculoskeletal and cardiovascular anatomy. It provides the high-fidelity visual understanding of internal organs required before students can grasp how medical imaging (CT/MRI) visualizes these same structures.
- **Access:** edx.org

5. Coursera / University of Michigan: Anatomy Specialization

- **Format:** Online Course (Free to Audit)
- **Relevance:** A highly structured course that breaks down the major organ systems. The cardiovascular module is particularly outstanding, explicitly explaining the hemodynamics and cardiac cycles that students must understand to calibrate NIBP monitors and ECG machines.
- **Access:** coursera.org

6. NPTEL / Swayam: Biology for Engineers and Other Non-Biologists

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Created specifically for engineering students, this course (offered by IITs) bridges the gap between biology and technology. It focuses on viewing cells, tissues, and physiological processes through the lens of engineering principles, making it the perfect theoretical foundation for the diploma.
- **Access:** nptel.ac.in

Category 3: Highly Visual Video Channels (YouTube)

7. Ninja Nerd Science

- **Format:** In-Depth Educational Video Series
- **Relevance:** Zach Murphy (a Physician Assistant) draws complex physiological pathways on a whiteboard. His videos on the *Cardiac Conduction System* (Unit 5) and the *Sliding Filament Theory of Muscle Contraction* (Unit 3) are unparalleled. He explains the "why" and "how" behind biological mechanisms with extreme precision, which is exactly what diagnostic engineers need.

8. CrashCourse: Anatomy & Physiology

- **Format:** Animated Educational Video Series
- **Relevance:** Hosted by Hank Green, this fast-paced, highly visual 47-episode series covers every unit in the syllabus. It uses custom animations to explain microscopic concepts like **Unit 1 (Cell Biology)** and the mechanics of the heart. It serves as an excellent, engaging "pre-watch" assignment before morning lectures.

9. Kenhub - Learn Human Anatomy

- **Format:** 3D Animation Video Channel
- **Relevance:** Kenhub produces the cleanest, most medically accurate 3D anatomical animations available for free. Their videos are indispensable for the afternoon laboratory sessions, helping students spatially map the skeletal system, major arteries, and joint types before touching the physical 3D models or viewing radiological X-rays.

DMET 103: Basic Electronics & Devices

To deliver the **Basic Electronics & Devices** course at the highest academic standard, the learning materials must transition students from theoretical physics to practical, hands-on circuit building.

Here is a list of 9 high-quality, open-source (or free-to-audit) learning resources, mapped directly to the semiconductor, transistor, and operational amplifier units of the syllabus.

Category 1: Open-Source Textbooks & Digital References

1. Semiconductor Devices: Theory and Application (by James M. Fiore)

- **Format:** Open Educational Resource (OER) Textbook (Web/PDF)
- **Relevance:** Published specifically for electronics engineering technology students, this text perfectly covers **Units 1 through 4**. It includes practical examples, schematics, and laboratory exercises that directly mirror the breadboard experiments for diodes, BJTs, and FETs.
- **Access:** oercommons.org (Search author James M. Fiore)

2. Lessons In Electric Circuits (Volume III: Semiconductors)

- **Format:** Open-Source Textbook Series (Web/PDF)
- **Relevance:** Written by Tony R. Kuphaldt, this is widely considered the gold standard for open-source electronics education. The language is extremely clear, breaking down complex concepts like energy band theory and P-N junctions into digestible, logical steps.
- **Access:** ibiblio.org/kuphaldt/electricCircuits

3. All About Circuits (Volume III - Semiconductors)

- **Format:** Interactive Digital Textbook
- **Relevance:** An excellent, continuously updated resource that integrates theory with practical worksheets. The section on **Unit 5 (Operational Amplifiers)** is particularly strong, offering step-by-step math for calculating voltage gains in inverting and non-inverting configurations.
- **Access:** allaboutcircuits.com/textbook

Category 2: Free-to-Audit Online Courses (MOOCs)

4. MIT OpenCourseWare (OCW) - 6.002 Circuits and Electronics

- **Format:** Open-Source University Course
- **Relevance:** Taught by Prof. Anant Agarwal, this is a legendary, rigorous course. While it covers basic circuits, its modules on MOSFETs (Unit 4) and Operational Amplifiers (Unit 5) are world-class. It provides the high-level theoretical foundation that instructors need to deliver top-tier lectures.
- **Access:** ocw.mit.edu

5. NPTEL / Swayam: Basic Electronics

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** The National Programme on Technology Enhanced Learning provides highly structured engineering modules. This course delves deeply into the mathematical modeling of PN junction diodes, rectifiers, and BJT biasing, ensuring students meet strict engineering board standards.
- **Access:** nptel.ac.in

6. Coursera / Georgia Tech: Introduction to Electronics

- **Format:** Online Course (Free to Audit)
- **Relevance:** This modular course focuses heavily on active components. It teaches the practical application of diodes, bipolar junction transistors, and op-amps. It is a fantastic supplementary resource for students who need to review the math before attempting the physical lab experiments.
- **Access:** coursera.org

Category 3: Interactive Simulators & Video Channels

7. Falstad Circuit Simulator

- **Format:** Open-Source Web HTML5 Simulator
- **Relevance:** This is an absolute necessity for this course. Before students wire a physical Op-Amp or BJT on a breadboard—where a single misplaced wire can destroy the IC—they must simulate it here. They can visually watch the current flow, observe clipping in amplifiers, and view animated oscilloscope traces in real-time.
- **Access:** falstad.com/circuit

8. The Engineering Mindset

- **Format:** Animated Educational Video Series (YouTube)
- **Relevance:** This channel produces the best 3D visual animations of electronic components on the internet. Their videos on *How Diodes Work*, *How Transistors Work*, and *MOSFETs* allow students to visualize the invisible flow of electrons and "holes" across PN junctions, mastering **Unit 1** and **Unit 2** intuitively.

9. Afrotechmods

- **Format:** Electronics Engineering Video Channel (YouTube)
- **Relevance:** An incredibly practical channel that bridges theory and the breadboard. The tutorials on building Zener diode voltage regulators, understanding Op-Amp basics, and driving heavy loads with MOSFETs directly mirror the afternoon laboratory experiments. It provides the exact visual roadmap students need to successfully build physical circuits.

DMET 104: Sensors & Transducers

To deliver the **Sensors & Transducers** course at the highest academic and clinical standard, the learning materials must bridge the gap between raw physical phenomena, complex electrochemistry, and biomedical hardware design.

Here is a list of 9 high-quality, open-source, and free-to-access learning resources. They are specifically mapped to the syllabus units, ranging from basic strain gauges to advanced biopotential and impedance sensing.

Category 1: Open-Source Textbooks & Industrial Guides

1. Lessons In Industrial Instrumentation (by Tony R. Kuphaldt)

- **Format:** Open-Source Textbook (Web/PDF)
- **Relevance:** This is arguably the most comprehensive open-source text on physical measurement. It covers **Unit 1 (Classification)** and **Unit 2 (Resistive & Capacitive Transducers)** with incredible practical depth, explaining exactly how Wheatstone bridges, thermistors, and capacitive fluid sensors are calibrated and linearized in real-world environments.
- **Access:** ibiblio.org/kuphaldt/socratic/sinst

2. IntechOpen: Biosensors - Recent Advances and Mathematical Challenges

- **Format:** Open-Access Academic Book Series (PDF)
- **Relevance:** IntechOpen hosts peer-reviewed, open-access books that are perfect for the complex biochemistry required in **Unit 5**. The chapters on ion-selective electrodes, glass pH sensors, and the Clark oxygen electrode provide the deep electrochemical theory necessary for understanding Arterial Blood Gas (ABG) analyzers.
- **Access:** intechopen.com/books/biosensors

3. Analog Devices & Texas Instruments: Biomedical Application Notes

- **Format:** Free Industrial Engineering Guides (Web/PDF)
- **Relevance:** For **Unit 4 (Biopotential Electrodes)**, standard textbooks often fall short of modern engineering realities. The application notes from these semiconductor manufacturers offer masterclasses on interfacing Ag/AgCl surface electrodes to digital systems. Documents covering multi-frequency impedance converters (like the AD5933) are invaluable for understanding frequency sweeps from 50 kHz to 800 kHz, specifically for applications like impedance pneumography and body composition analysis.
- **Access:** analog.com and ti.com (Search: "Biomedical Application Notes" or "Impedance Measurement")

Category 2: Free-to-Audit Online Courses (MOOCs)

4. NPTEL / Swayam: Sensors and Actuators

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** The National Programme on Technology Enhanced Learning provides highly rigorous modules that align with top-tier engineering board standards. This course covers the static and dynamic characteristics of transducers, piezoelectric resonance, and optical sensors (**Unit 1 and Unit 3**), complete with robust mathematical modeling.
- **Access:** nptel.ac.in

5. NPTEL / Swayam: Biomedical Signal Processing

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** This course is critical for **Unit 4**. It provides extensive lectures on the electrode-electrolyte interface, half-cell potentials, and polarization. It teaches students exactly how skin impedance degrades microvolt ECG and EEG signals, bridging the gap between a physical sensor and a digital waveform.

- **Access:** nptel.ac.in

6. Coursera / University of Colorado: Sensor Circuit Design

- **Format:** Online Course (Free to Audit)
- **Relevance:** This course focuses heavily on the analog front-end required to actually read a sensor. It teaches how to design the conditioning circuits for strain gauges, load cells, and photodiodes, making it a perfect theoretical companion to the breadboard experiments in the laboratory.
- **Access:** coursera.org

Category 3: Interactive Simulators & Video Channels

7. Texas Instruments Precision Labs - Medical

- **Format:** Video Training Series (Web/YouTube)
- **Relevance:** An unparalleled free resource. Their dedicated medical playlists visually explain the physics and circuit design behind clinical Pulse Oximetry (SpO₂) utilizing LEDs and photodiodes (**Unit 3**), as well as deep dives into bio-impedance and continuous vital sign monitoring.
- **Access:** ti.com/precisionlabs or YouTube

8. RealPars

- **Format:** Animated Educational Video Series (YouTube)
- **Relevance:** RealPars creates the absolute best 3D animations of industrial and physical sensors. While geared toward automation, their visual breakdowns of how capacitive displacement sensors, ultrasonic transducers, and RTDs physically operate internally are excellent for visual learners mastering **Unit 2 and Unit 3**.

9. Applied Science (Ben Krasnow)

- **Format:** Advanced Engineering Video Channel (YouTube)
- **Relevance:** For students needing to see the extreme boundaries of sensor technology, this channel is highly inspiring. The creator builds electron microscopes, X-ray tubes, and piezoelectric stages from scratch. It provides incredible practical context on handling delicate transducers, shielding against electromagnetic noise, and designing custom optical sensors.

DMET 105: Intro to Healthcare IT and Artificial Intelligence in Medicine

To ensure this interdisciplinary course is delivered at an elite global standard, the learning resources must cover network protocols, data standards (HL7/DICOM), database mechanics, and machine learning—all contextualized for healthcare.

Here is a list of **9 highly relevant learning resources** split across open-source textbooks, free-to-audit online courses, and high-quality video repositories.

Category 1: Open-Source & Open-Access Textbooks

1. **Healthcare Information Technology Exam Guide** by Kathleen A. McCormick & Brian Schmotter (McGraw-Hill LPE / Open Library)
 - **Format:** Textbook / Digital Access
 - **Relevance:** Covers Units 1, 2, and 3. This is the absolute gold standard for understanding how networking architecture, OSI models, and data privacy (HIPAA) map directly to hospital information workflows (HIS/EHR). It bridges the gap between general IT and clinical safety.
2. **Python Programming and Numerical Methods: A Guide for Engineers and Scientists** by Qingkai Kong, Timmy Siau, & Alexandre Bayen (UC Berkeley Open-Access)
 - **Format:** Open-Access Digital Book
 - **Relevance:** Covers Unit 4. This peer-reviewed, free digital textbook skips non-technical filler and teaches Python syntax, data array manipulation (NumPy/Pandas), and numerical plotting specifically for engineering data data mining and analysis.
 - **Access:** pythonnumericalmethods.berkeley.edu
3. **Medical Device Cybersecurity: Architecture and Technologies** (Open-Access Papers & MITRE ATT&CK Playbook for Healthcare)
 - **Format:** Open Repositories (MITRE & FDA Digital Library)
 - **Relevance:** Covers Unit 1 and 2. It provides real-world engineering blueprints on how to isolate telemetry networks, configure network switches, and build hard boundaries between medical VLANs and public hospital Wi-Fi networks.

Category 2: Free-to-Audit Online Courses (MOOCs)

4. Introduction to Healthcare IT and Data Standards (Johns Hopkins University via Coursera)

- **Format:** Online Course (Free to Audit)
- **Relevance:** Covers Units 2 and 3. This course breaks down the complex inner structures of HL7 v2 text strings, DICOM image headers, and PACS imaging network routing systems exactly as required for hospital-wide deployment.
- **Access:** coursera.org/jhu

5. AI in Healthcare Specialization (Stanford University via Coursera)

- **Format:** Online Course (Free to Audit)
- **Relevance:** Covers Units 4 and 5. This globally renowned program explores how machine learning models are designed for clinical diagnostics, how confusion matrices evaluate vital sign classifiers, and addresses the legal and ethical "black box" problems.
- **Access:** coursera.org/stanford

6. Introduction to Databases and SQL Querying (Stanford Online)

- **Format:** Open Interactive Course
- **Relevance:** Covers Unit 2. A completely free, hands-on path for learning relational databases (RDBMS), primary/foreign keys, and building optimized SQL statements (SELECT, INSERT, UPDATE) to manage clinical engineering software.

Category 3: Open-Source Video Channels & Repositories

7. Powering Healthcare IT: HL7 and DICOM Tutorials by Caristix & dcm4chee

- **Format:** YouTube Video Series / Open Documentation
- **Relevance:** Covers Unit 3 & Lab Experiments. These visual, step-by-step video guides show technicians exactly how to use network packet sniffers (like Wireshark) to parse incoming HL7 text alerts and simulate image pushing/pulling across local PACS environments.

8. StatQuest with Josh Starmer (Machine Learning Series)

- **Format:** Animated Video Channel
- **Relevance:** Covers Unit 4. Josh Starmer strips away the overwhelming mathematical jargon and uses intuitive, color-coded visual animations to explain classification algorithms, Random Forests, clustering, and confusion matrices.

9. Data Science & Ethics in Medicine (MIT OpenCourseWare)

- **Format:** Video Lectures & Syllabus Repositories
- **Relevance:** Covers Unit 5. Derived from actual MIT lecture halls, this open series explores algorithmic bias, corrupted medical training data, and the strict safety mandates under the FDA's Software as a Medical Device (SaMD) guideline.
- **Access:** ocw.mit.edu

DMET 106: Eng. Workshop & Drawing

To deliver the **Eng. Workshop & Drawing** course at a premier standard, the learning materials must transition students from viewing engineering as an abstract science to mastering the physical reality of fabrication.

Here is a list of 9 high-quality, open-source, and free-to-access learning resources mapped directly to the mechanical drafting, CAD, welding, and PCB fabrication units of the syllabus.

Category 1: Open-Source Digital Manuals & Textbooks

1. FreeCAD Official Documentation & Tutorials

- **Format:** Open-Source Digital Manuals
- **Relevance:** FreeCAD is a highly capable, completely open-source parametric 3D modeler. Their official documentation is an excellent, cost-free alternative to proprietary software manuals for teaching **Unit 2 (CAD Basics)**. It provides step-by-step guides for students transitioning from 2D orthographic sketches to 3D digital models.
- **Access:** wiki.freecadweb.org

2. Prusa3D Knowledge Base

- **Format:** Open-Access Web Guides
- **Relevance:** For **Unit 4 (3D Printing)**, Josef Prusa's open-source company provides the most comprehensive, easy-to-read materials on FDM printing. Their guides cover everything from STL file slicing and support generation to troubleshooting warped plastics, ensuring students can reliably fabricate prototype enclosures.
- **Access:** help.prusa3d.com

3. SparkFun & Adafruit Learning Systems

- **Format:** Open-Source Electronics Tutorials
- **Relevance:** These platforms offer the absolute best digital manuals for **Unit 5 (PCB Fabrication & Soldering)**. They provide highly visual, step-by-step guides on through-hole soldering, SMD rework, and translating breadboard schematics into physical copper boards. The tutorials are incredibly practical for students building custom microcontroller-based projects like automated clinic queue displays or IoT healthcare modules.
- **Access:** learn.sparkfun.com and learn.adafruit.com

Category 2: Free-to-Audit Online Courses (MOOCs)

4. NPTEL / Swayam: Engineering Drawing and Computer Graphics

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Aligned perfectly with top-tier regional engineering standards, this course covers **Unit 1 (Orthographic Projections)** with extreme rigor. It is highly structured and provides excellent video lectures on first-angle and third-angle projections, ensuring students understand the strict visual grammar required for interpreting technical blueprints.
- **Access:** nptel.ac.in

5. MIT OpenCourseWare - 2.007 Design and Manufacturing I

- **Format:** Open-Source University Course
- **Relevance:** This is MIT's legendary hands-on shop course. The free syllabi, lecture notes, and videos cover the foundational physics and techniques of **Unit 3 (Fitting & Welding)** and sheet metal fabrication. It bridges the gap between theoretical mechanical engineering and actual shop-floor machining.
- **Access:** ocw.mit.edu

6. Fab Academy Curriculum (MIT Center for Bits and Atoms)

- **Format:** Open-Source Global Curriculum
- **Relevance:** Directed by Neil Gershenfeld, this is the ultimate resource for rapid prototyping. The weekly modules cover computer-aided design, 3D printing, and electronics production (specifically milling and etching custom PCBs). It is a goldmine for instructors designing practical workshop experiments.
- **Access:** fabacademy.org

Category 3: Highly Relevant Video Channels (YouTube)

7. This Old Tony

- **Format:** Machining & Fabrication Video Channel
- **Relevance:** This channel is a masterclass for **Unit 3 (Fitting & Welding)**. The creator explains lathe work, threading, tapping, and arc welding with incredible visual clarity, humor, and practical safety advice. It is the perfect visual prerequisite before allowing students to handle heavy hand tools and dies in the physical shop.

8. EEVblog (Dave Jones) - Soldering Tutorials

- **Format:** Electronics Engineering Video Channel
- **Relevance:** For **Unit 5 (PCB Fabrication)**, Dave Jones provides the definitive industry-standard video tutorials on soldering. His specific multi-part series on through-hole soldering, desoldering multipin ICs, and understanding flux chemistry is mandatory viewing before students ever touch a soldering iron to a medical motherboard.

9. Product Design Online (Fusion 360 Tutorials)

- **Format:** CAD Video Channel
- **Relevance:** While Fusion 360 has proprietary tiers, it offers robust free educational licenses. This channel provides succinct, day-by-day video courses ("Learn Fusion 360 in 30 Days") that teach students how to model physical hardware, render sheet metal bends, and export files for 3D printing, directly supporting the CAD and additive manufacturing units.

Year 1: Semester 2

DMET 107: Human Anatomy & Physiology II

To deliver the **Human Anatomy & Physiology II** course at the highest academic standard, the learning materials must push past pure biology and emphasize how these complex bodily systems generate the physical and electrical signals that medical devices monitor.

Here is a list of 9 high-quality, predominantly open-source, and free-to-audit learning resources. They are mapped directly to the syllabus units, with a specific focus on respiratory mechanics, electrophysiology, and regional engineering standards.

Category 1: Open-Source Textbooks & Digital References

1. OpenStax: Anatomy and Physiology 2e

- **Format:** Open-Source Textbook (Web/PDF)
- **Relevance:** Continuing from Semester 1, this peer-reviewed text covers all 5 units of this syllabus perfectly. The chapters on the respiratory system are particularly valuable for engineers, detailing the exact physics of lung volumes, airway resistance, and gas exchange that govern mechanical ventilation and apnea screening.
- **Access:** openstax.org/details/books/anatomy-and-physiology-2e

2. TeachMePhysiology

- **Format:** Open-Access Clinical Encyclopedia (Web/App)
- **Relevance:** The sister site to TeachMeAnatomy. This resource focuses purely on the *function* of the body. It breaks down complex topics like the action potentials of the nervous system (Unit 2) and the filtration rates of the kidneys (Unit 4) into structured, easy-to-read clinical correlates.
- **Access:** teachmephysiology.com

3. Lumen Learning: Boundless Anatomy and Physiology

- **Format:** Open-Source Digital Textbook
- **Relevance:** A highly modular, easily searchable digital textbook. It is incredibly useful for **Unit 3 (Digestive)** and **Unit 5 (Endocrine)**, providing clear diagrams of hormone regulation loops and digestive tract anatomy that translate well into the fluid dynamics and chemical sensing concepts engineers must grasp.
- **Access:** courses.lumenlearning.com/boundless-ap

Category 2: Free-to-Audit Online Courses (MOOCs)

4. NPTEL / Swayam: Anatomy and Physiology

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Offered by the Indian Institutes of Technology (IITs), this platform provides world-class instruction aligned with regional engineering board standards. The curriculum bridges biological science with technical logic, making it an ideal theoretical backbone for diploma engineering students.
- **Access:** nptel.ac.in

5. Coursera / Duke University: Introductory Human Physiology

- **Format:** Online Course (Free to Audit)
- **Relevance:** A globally recognized, rigorous 33-hour course. It dives deep into the central nervous system, respiratory gas transport, and renal physiology. It is an excellent resource for faculty to use when designing the high-level theoretical lectures for Units 1, 2, and 4.
- **Access:** coursera.org

6. edX / University of Michigan: Anatomy of the Gastrointestinal, Reproductive and Endocrine Systems

- **Format:** Online Course (Free to Audit)
- **Relevance:** This specialized module focuses exclusively on the systems covered in **Unit 3 and Unit 5**. It uses actual cadaveric imaging and high-resolution graphics to explain the anatomical structures that gastroenterology and reproductive technologies interact with daily.
- **Access:** edx.org

Category 3: Highly Visual Video Channels (YouTube)

7. Respiratory Therapy Zone

- **Format:** Specialized Educational Video Channel
- **Relevance:** This is an absolute goldmine for **Unit 1 (Respiratory System)**. Created by and for respiratory therapists, it connects the raw anatomy of the lungs to the exact diagnostic waveforms (capnography, impedance pneumography, flow-volume loops) used to diagnose obstructive sleep apnea and monitor ICU ventilators.

8. Ninja Nerd Science

- **Format:** In-Depth Educational Video Series
- **Relevance:** Zach Murphy's whiteboard lectures on neurology are unparalleled. For **Unit 2 (Nervous System)**, his videos detailing the generation of action potentials, synapses, and the 10-20 EEG electrode placement system provide the exact electrophysiological grounding students need before troubleshooting diagnostic neuro-equipment.

9. Interactive Biology (by Leslie Samuel)

- **Format:** Animated Educational Video Series
- **Relevance:** This channel excels at breaking down the nervous system and the excretory system (**Unit 4**). The videos explaining how the nephron filters blood and how neurons fire are short, punchy, and highly visual, making them excellent "pre-lab" viewing assignments before students tackle the complex hemodialysis simulations.

DMET 108: Diagnostic Equipment I (Vitals/NIBP)

To deliver the **Diagnostic Equip. I (Vitals/NIBP)** course at the highest clinical and academic standard, the learning materials must transition students from understanding basic human physiology to executing legally compliant equipment calibrations.

Here is a list of 9 high-quality, open-source, and free-to-access learning resources. They are mapped directly to the thermometry, sphygmomanometry, optical physics, and clinical metrology units of the syllabus.

Category 1: Open-Source Manuals & Industrial Guides

1. Frank's Hospital Workshop

- **Format:** Open-Source Engineering Repository
- **Relevance:** This is universally considered the holy grail for clinical engineering students. It hosts an enormous, free repository of actual OEM service manuals, teardown guides, and calibration protocols for hundreds of patient monitors, NIBP modules, and pulse oximeters. It is the perfect companion for **Unit 3 (NIBP Teardown)** and **Unit 5 (Calibration & Testing)**.
- **Access:** frankshospitalworkshop.com

2. WHO: Medical Equipment Maintenance Programme Overview

- **Format:** Open-Access Global Health Document (PDF)
- **Relevance:** Published by the World Health Organization, this document is essential for **Unit 5**. It dictates the global standards for establishing Preventive Maintenance (PM) schedules, documenting calibration tolerances, and understanding the metrology hierarchy required to keep ward equipment safe.
- **Access:** who.int (Search: "Medical equipment maintenance programme overview")

3. Texas Instruments / Analog Devices: Medical Application Notes

- **Format:** Free Industrial Engineering Guides (Web/PDF)
- **Relevance:** Standard textbooks often oversimplify pulse oximetry. The biomedical application notes from these manufacturers provide deep dives into **Unit 4 (SpO₂)**, explicitly detailing the Beer-Lambert law, Red/Infrared LED timing cycles, and the analog circuit design required to extract a clean AC pulsatile PPG waveform from a massive DC tissue baseline.

Category 2: Free-to-Audit Online Courses & Training (MOOCs)

4. NPTEL / Swayam: Biomedical Instrumentation (IIT Madras)

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Aligned perfectly with rigorous regional engineering board standards, this course bridges the gap between physiological sensors and clinical hardware. The modules covering the mechanics of sphygmomanometers, plethysmography, and biopotential measurements provide the exact theoretical backbone required for **Units 2, 3, and 4**.
- **Access:** npTEL.ac.in

5. Fluke Biomedical Advantage Training

- **Format:** On-Demand Clinical Training Platform
- **Relevance:** Fluke manufactures the global standard for clinical patient simulators. They offer a completely free, self-paced digital training center covering the full spectrum of medical device quality assurance. The modules on NIBP testing, SpO₂ functional analysis, and electrical safety testing directly mirror the laboratory experiments in **Unit 5**.
- **Access:** advantagetraining.docebosaas.com

6. Coursera / University of Pennsylvania: Vital Signs: Understanding What the Body Is Telling Us

- **Format:** Online Course (Free to Audit)
- **Relevance:** An excellent foundational course for **Unit 1** and **Unit 2**. It explores the underlying anatomy and hemodynamics of vital signs. Students must understand the biological origin of Korotkoff sounds and core thermal regulation before they can effectively troubleshoot the machines designed to monitor them.
- **Access:** coursera.org

Category 3: Highly Visual Video Channels & Webinars

7. Fluke Biomedical (YouTube Channel)

- **Format:** Clinical Simulation Video Channel
- **Relevance:** While the Advantage platform handles theory, their YouTube channel provides the absolute best visual demonstrations of patient simulators in action. Watching technicians step through the menus of a ProSim 8 to trigger synthetic arrhythmias or simulate NIBP leaks is mandatory viewing before students handle the expensive physical simulators in the lab.

8. Ninja Nerd - Hemodynamics & Blood Pressure Series

- **Format:** Medical Educational Video Series (YouTube)
- **Relevance:** Zach Murphy's whiteboard lectures are highly visual and incredibly detailed. His specific series on hemodynamics perfectly breaks down the physics of blood flow, arterial resistance, and the auscultatory method. It allows engineering students to visualize the invisible physiological pressure drops that occur inside an inflating NIBP cuff.

9. TechNation (Webinars & Digital Archives)

- **Format:** Industry Webinars for Healthcare Technology Management (HTM)
- **Relevance:** TechNation provides free, archived webinars led by veteran Medical Equipment Technologists. These hour-long sessions cover real-world troubleshooting, such as diagnosing pneumatic leaks in automated BP modules, isolating optical interference in pulse oximetry, and mastering hospital quality management audits.

DMET 109: Digital Logic Design

To deliver the **Digital Logic Design** course at the highest academic standard, the learning materials must transition students from abstract Boolean algebra to the physical reality of wiring TTL integrated circuits.

Here is a list of 9 high-quality, open-source, and free-to-access learning resources. They are specifically mapped to the logic gates, sequential circuits, and data conversion units of your syllabus.

Category 1: Open-Source Textbooks & Interactive Books

1. Lessons In Electric Circuits (Volume IV - Digital)

- **Format:** Open-Source Textbook (Web/PDF)
- **Relevance:** Written by Tony R. Kuphaldt, this is the definitive open-source guide for **Unit 1** and **Unit 2**. It provides incredibly clear, practical explanations of Boolean algebra, K-Maps, and the internal workings of standard 74XX series TTL logic chips.
- **Access:** ibiblio.org/kuphaldt/electricCircuits

2. CircuitVerse: Interactive Digital Logic Book

- **Format:** Open-Source Interactive Web Book
- **Relevance:** This is a modern, interactive textbook where the circuit diagrams are literally alive. As students read about **Unit 3 (Multiplexers)** or **Unit 4 (Flip-flops)**, they can click toggle switches directly inside the book to see how the logic gates react in real-time.
- **Access:** learn.circuitverse.org

3. Digital Circuit Projects: An Overview of Digital Circuits Through Implementing Integrated Circuits

- **Format:** Open Educational Resource (OER) Lab Manual
- **Relevance:** Authored by Charles W. Kann (Gettysburg College), this OER manual is specifically designed for breadboard-based laboratory courses. It provides step-by-step schematics for wiring half-adders, decoders, and shift registers, making it the perfect companion for the afternoon lab sessions.
- **Access:** oer.galileo.usg.edu (Search title)

Category 2: Free-to-Audit Online Courses (MOOCs)

4. MIT OpenCourseWare (OCW) - 6.004 Computation Structures

- **Format:** Open-Source University Course
- **Relevance:** This world-class MIT course covers the entire digital logic syllabus, starting from raw CMOS transistors and building up to memory and ADCs (**Unit 5**). The lecture notes and problem sets are highly rigorous, providing the theoretical depth required for a top-tier engineering program.
- **Access:** ocw.mit.edu

5. NPTEL / Swayam: Digital Circuits

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Offered by the Indian Institutes of Technology (IITs), this course aligns perfectly with stringent engineering board standards. It provides heavy mathematical focus on K-Map simplification and synchronous counter design, ensuring students can design complex hardware safety interlocks without logical flaws.
- **Access:** nptel.ac.in

6. Coursera / Universitat Autònoma de Barcelona: Digital Systems - From Logic Gates to Processors

- **Format:** Online Course (Free to Audit)
- **Relevance:** A highly structured, modular course that bridges the gap between pure logic gates and modern microcontrollers. It serves as an excellent theoretical review for students before they attempt to build sequential memory circuits on their physical breadboards.
- **Access:** coursera.org

Category 3: Highly Visual Video Channels & Simulators

7. Ben Eater (Building an 8-bit Computer from Scratch)

- **Format:** Electronics Engineering Video Channel (YouTube)
- **Relevance:** This is universally considered the best digital logic video series on the internet. Ben Eater physically builds an entire computer on breadboards using the exact same 74XX series TTL chips your students will use. His videos on D-flip flops, registers, and clock modules (**Unit 4**) are mandatory viewing for mastering physical breadboard wiring.

8. Neso Academy - Digital Electronics

- **Format:** Educational Video Series (YouTube)
- **Relevance:** Neso Academy uses a clean, digital whiteboard format that is highly popular among engineering students. Their playlists systematically cover every single topic in the syllabus, from converting hexadecimal numbers to designing complex synchronous counters, making abstract mathematical concepts highly visual.

9. Logisim-Evolution (Documentation & Tool)

- **Format:** Open-Source Digital Logic Simulator
- **Relevance:** While this is a software tool, its included documentation and built-in tutorial libraries act as a standalone learning resource. Before wiring complex combinational circuits, students can drag and drop gates, simulate propagation delays, and run automated K-Map analyses to verify their designs digitally.
- **Access:** github.com/logisim-evolution

DMET 110: Microprocessors & Controllers

To deliver the **Microprocessors & Controllers** course at the highest academic standard, the learning materials must help students cross the frustrating gap between writing lines of code and actually making physical hardware move, display data, and trigger clinical alarms.

Here is a list of 9 high-quality, open-source, and free-to-audit resources. They are mapped directly to the legacy 8085/8051 architectures and the modern Arduino C++ prototyping units of your syllabus.

Category 1: Open-Source Textbooks & Digital Guides

1. Embedded Controllers Using C and Arduino (by James M. Fiore)

- **Format:** Open Educational Resource (OER) Textbook (Web/PDF)
- **Relevance:** This is an exceptional open-source textbook that perfectly bridges **Unit 3** and **Unit 4**. It focuses heavily on the ATmega328P architecture, teaching students exactly how analog-to-digital conversion works at the hardware level before they start relying too heavily on simplified `analogRead()` functions.
- **Access:** oercommons.org (Search author James M. Fiore)

2. The Arduino Official Documentation & Language Reference

- **Format:** Open-Access Digital Reference
- **Relevance:** The absolute standard for **Unit 3, Unit 4, and Unit 5**. When students are programming modern boards like an Arduino Nano ESP32, they must learn to read official documentation. The tutorials on hardware debouncing, I2C communication, and handling SPI data logs are mandatory reading for building robust clinical subsystems.
- **Access:** docs.arduino.cc

3. Wikibooks: Microprocessor Design & Embedded Systems

- **Format:** Open-Source Collaborative Texts
- **Relevance:** For **Unit 1 (8085)** and **Unit 2 (8051)**, finding high-quality open-source textbooks is challenging as the standard texts (like Gaonkar or Mazidi) are proprietary. These highly maintained Wikibooks provide excellent, free breakdowns of the fetch-execute cycle, ALU architecture, and basic assembly language instructions.
- **Access:** en.wikibooks.org/wiki/Microprocessor_Design

Category 2: Free-to-Audit Online Courses (MOOCs)

4. NPTEL / Swayam: Microprocessors and Microcontrollers

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Offered by the Indian Institutes of Technology (IITs), this course is the gold standard for regional engineering regulations. It provides exhaustive, highly structured lectures on the 8085 and 8051 architectures, memory mapping, and hardware interrupts (**Unit 1 and Unit 2**), ensuring students understand the legacy systems still operating inside older hospital laboratory equipment.
- **Access:** npTEL.ac.in

5. edX / UT Austin: Embedded Systems - Shape the World (Microcontroller Input/Output)

- **Format:** Online Course (Free to Audit)
- **Relevance:** A legendary, hands-on course that teaches C programming specifically for microcontrollers. It is incredibly relevant for **Unit 5 (I/O Programming)**, focusing heavily on state machines, switch debouncing, and safely interfacing with digital outputs.
- **Access:** edx.org

6. Coursera / UC Irvine: Introduction to the Internet of Things and Embedded Systems

Competency Based Curriculum for “Diploma in Medical Equipment Technology”
(Intellectual property of National Commission for Allied and Healthcare Professions, Ministry of Health and Family Welfare)

- **Format:** Online Course (Free to Audit)
- **Relevance:** This course focuses on modern, connected embedded systems. It is highly relevant for students taking their basic Arduino knowledge and expanding it into building functional medical prototypes that might eventually need to transmit data.
- **Access:** coursera.org

Category 3: Highly Visual Video Channels & Simulators

7. Neso Academy - Microprocessors (8085) Series

- **Format:** Educational Video Series (YouTube)
- **Relevance:** Neso Academy's digital whiteboard format is unparalleled for explaining assembly language. Their videos visually trace how hexadecimal data moves across address buses and through the ALU. This makes the abstract concepts of **Unit 1** highly digestible before students attempt to write their own memory-mapping code.

8. DroneBot Workshop

- **Format:** Advanced Electronics Video Channel (YouTube)
- **Relevance:** The definitive resource for **Units 3, 4, and 5**. This channel provides crystal-clear, step-by-step tutorials on the exact hardware your students will use. The videos on I2C LCD screens, driving motors with PWM, and solving switch debouncing issues are vital. It provides the exact visual roadmap needed when students are trying to build logic-locked state machines—such as an OPD queue system where the "nowServing" variable must remain locked until a physical interaction is completed.

9. Ben Eater - Building an 8-bit Computer from Scratch

- **Format:** Engineering Video Channel (YouTube)
- **Relevance:** While this series involves building a computer out of logic gates, it is the ultimate conceptual bridge. Watching Ben Eater physically wire the clock, registers, and memory of a breadboard computer makes the internal architecture of the 8085 and 8051 finally "click" for visual learners.

DMET 111: Power Electronics for Medical

To deliver the **Power Electronics for Medical** course at the highest academic and clinical standard, the learning materials must help students safely bridge the gap between theoretical semiconductor physics and the very real dangers of high-voltage, high-current hospital infrastructure.

Here is a list of 9 high-quality, open-source, and free-to-access resources. They are specifically mapped to thyristor switching, SMPS board-level rework, UPS topologies, and isolated power systems.

Category 1: Open-Source Manuals & Industrial Guides

1. Texas Instruments: Power Management Design Guides & Application Notes

- **Format:** Free Industrial Engineering References (PDF)
- **Relevance:** Standard textbooks often overcomplicate the math of power supplies while ignoring the physical layout. TI's application notes are the industry standard for **Unit 2** and **Unit 3**. They provide practical, highly detailed breakdowns on designing Buck/Boost converters, managing thermal dissipation on MOSFETs, and physically routing PCBs to minimize Electromagnetic Interference (EMI).
- **Access:** ti.com (Search: "Power Management Guide" or "SMPS Application Notes")

2. Frank's Hospital Workshop (Power Supply & X-Ray Generators)

- **Format:** Open-Source Engineering Repository
- **Relevance:** Essential for **Unit 1** and **Unit 3**. Frank's hosts actual OEM schematics for the high-voltage inverter boards found inside mobile X-ray machines and patient monitors. It allows students to study how medical manufacturers isolate their power rails before attempting to reverse-engineer a physical board.
- **Access:** frankshospitalworkshop.com

3. Schneider Electric: Energy University

- **Format:** Free Industrial Training Platform
- **Relevance:** Schneider Electric (parent company of APC) is a global leader in power backup. Their free Energy University provides the absolute best technical modules for **Unit 4 (UPS Systems)** and **Unit 5 (Isolated Power)**. The courses detail the exact differences between Line-Interactive and Online Double-Conversion topologies, as well as the sizing calculations required for critical ICU loads.
- **Access:** schneider-electric.com/energy-university

Category 2: Free-to-Audit Online Courses (MOOCs)

4. NPTEL / Swayam: Power Electronics

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Aligned perfectly with regional technical education and AICTE mandates, this rigorous course provides the heavy mathematical backing required for **Unit 1** and **Unit 2**. It deeply covers phase-controlled rectification, the V-I characteristics of SCRs and TRIACs, and the commutation techniques necessary to drive heavy inductive loads like medical centrifuges.
- **Access:** nptel.ac.in

5. Coursera / University of Colorado Boulder: Introduction to Power Electronics

- **Format:** Online Course (Free to Audit)
- **Relevance:** This is a world-class foundational course for **Unit 3**. It demystifies Switched Mode Power Supplies (SMPS), explaining flyback and forward converter topologies in a highly structured way, ensuring students understand the high-frequency switching required to shrink massive transformers down to the size of a laptop charger.
- **Access:** coursera.org

Category 3: Highly Visual Video Channels & Board Repair Communities

6. EEVblog (YouTube Channel)

- **Format:** Advanced Electronics Video Channel
- **Relevance:** Dave Jones' channel is mandatory viewing for lab safety and metrology. His videos explicitly demonstrate why connecting a standard grounded oscilloscope probe to the primary side of an SMPS will cause an explosion, teaching students the critical necessity of differential probes and isolation transformers.

7. DiodeGoneWild (YouTube Channel)

- **Format:** Component-Level Reverse Engineering Channel
- **Relevance:** The absolute best resource for the practical, hands-on goals of **Unit 3**. This channel painstakingly reverses-engineers blown power supplies. It bridges theory with practical rework, showing students exactly how to isolate short-circuited driver IC pins, troubleshoot high-voltage LED/backlight inverters, test opto-isolators, and properly clean carbonized flux from motherboards with isopropyl alcohol after replacing a blown MOSFET.

8. GreatScott! (YouTube Channel)

- **Format:** Applied Electronics & Prototyping Channel
- **Relevance:** Excellent for visualizing **Unit 2**. The channel features brilliant, easy-to-understand physical builds of Buck/Boost converters, PWM generation, and H-Bridge motor controls. It provides a visual, step-by-step understanding of how microcontrollers actively switch DC-DC converters under varying loads.

9. Engineering Mindset: How Inverters & UPS Work

- **Format:** 3D Animated Engineering Channel (YouTube)
- **Relevance:** Power factor, apparent power (VA), and true power (Watts) are notoriously difficult concepts for students to visualize. This channel uses stunning 3D fluid-dynamics animations to explain how inverters synthesize AC waveforms and how power transitions instantaneously from the grid to the battery bank inside a UPS system (**Unit 4**).

DMET 112: Technical Communication and Professional Ethics

To ensure this dual-focus course on **Technical Communication and Professional Ethics** is delivered at the highest standard, the resources must bridge the gap between effective corporate communication, strict legal frameworks, and complex moral philosophy.

Here is a list of **8 highly relevant, freely accessible learning resources**, categorized into open-source textbooks, free-to-audit courses, and video repositories.

Category 1: Open-Source Textbooks & Digital Guidelines

1. Open Technical Communication (OpenALG / Affordable Learning Georgia)

- **Format:** Open-Access Digital Textbook
- **Relevance:** Covers Units 1, 2, and 3. This comprehensive, peer-reviewed open textbook is the gold standard for teaching engineering students how to draft professional emails, structure technical reports, write clear standard operating procedures (SOPs), and communicate with vendors.
- **Access:** open.umn.edu/opentextbooks/textbooks/open-technical-communication

2. The Online Ethics Center (OEC) for Engineering and Science

- **Format:** Open-Access Case Study Repository
- **Relevance:** Covers Units 1 and 4. Maintained by the University of Virginia, this repository contains hundreds of real-world engineering ethics case studies, including scenarios on whistleblowing, pressured sign-offs, and prioritizing human safety over corporate profit.

3. WHO Medical Device Technical Series: Medical Equipment Maintenance Programme Overview

- **Format:** Open-Access WHO Publication (PDF)
- **Relevance:** Covers Units 3 and 5. This World Health Organization document provides the global baseline for how clinical engineers should legally document preventive maintenance (PM) and safely dispose of medical e-waste, tying directly into social responsibility.

Category 2: Free-to-Audit Online Courses (MOOCs)

4. Technical Writing Courses for Engineers (Google Developers)

- **Format:** Free Interactive Online Course
- **Relevance:** Covers Units 1 and 3. Google provides a completely free, world-class training program aimed at engineers. It focuses on grammar, syntax, active vs. passive voice, and how to write extremely clear, unambiguous technical instructions (critical for patient safety).
- **Access:** [developers.google.com/tech-writing]
(<https://developers.google.com/tech-writing>)

5. Data Privacy Fundamentals (Northeastern University via Coursera)

- **Format:** Online Course (Free to Audit)
- **Relevance:** Covers Unit 2. This course breaks down the legal frameworks of both HIPAA (US) and GDPR (Europe). It is essential for teaching students the absolute necessity of anonymizing Protected Health Information (PHI) before handling or scrapping medical hard drives.

6. Bioethics: The Law, Medicine, and Ethics of Reproductive Technologies and Genetics (Harvard University via edX)

- **Format:** Online Course (Free to Audit)
- **Relevance:** Covers Units 4 and 5. While broad, the modules on medical triage, resource allocation, and clinical liability are perfect for helping students navigate the moral distress of deciding which life-support machines to prioritize during mass casualty events or pandemics.

Category 3: Open-Source Video Channels & Repositories

7. Lean Enterprise Institute & ASQ (American Society for Quality) Channels

- **Format:** YouTube Video Series
- **Relevance:** Covers Unit 3. These channels provide highly practical, visual breakdowns of how to conduct a proper Root Cause Analysis (RCA) using the "5 Whys" and Ishikawa (Fishbone) diagrams, essential for investigating clinical equipment failures.

8. Stanford Graduate School of Business: "Think Fast, Talk Smart" Series

- **Format:** YouTube Video Lectures / Podcast
- **Relevance:** Covers Units 4 and 5. Excellent, free resources on public speaking, non-verbal body language, and conflict resolution. It is highly applicable to the role-play simulations where students must de-escalate angry surgeons in the Operation Theatre or deliver in-service training to distracted nurses.

Year 2: Semester 3

DMET 201: Diagnostic Equipment II (ECG/EEG)

To deliver the **Diagnostic Equip. II (ECG/EEG)** course at the highest clinical and academic standard, the learning materials must bridge the gap between microscopic physiological electrical firing and the macro-level hardware used to capture it safely.

Here is a list of 9 high-quality, open-source, and free-to-access learning resources. They are specifically mapped to the electrophysiology, noise troubleshooting, and pacemaker metrology units of the syllabus.

Category 1: Open-Source Technical Guides & Clinical Databases

1. Texas Instruments: Biosensing & ECG Front-End Application Notes

- **Format:** Free Industrial Engineering References (PDF)
- **Relevance:** Standard textbooks rarely explain the modern circuitry inside digital patient monitors. TI's application notes are the gold standard for **Unit 1**. They provide deep, highly practical breakdowns of how to design Driven-Right-Leg (DRL) circuits and how isolation amplifiers protect patients from lethal microshocks during ECG acquisition.
- **Access:** ti.com (Search: "ECG Front-End Application Notes")

2. PhysioNet: The Research Resource for Complex Physiologic Signals

- **Format:** Open-Source Database & Technical Tutorials (MIT/NIH)
- **Relevance:** This is the world's premier open-source repository for recorded bio-signals. For **Unit 2 (Artifacts)** and **Unit 3 (EEG)**, students can download massive datasets of real patient EEGs and ECGs corrupted by 50Hz noise, somatic tremors, and baseline wander, allowing them to practice digital signal filtering on real clinical data.
- **Access:** physionet.org

3. Frank's Hospital Workshop (Electrophysiology Section)

- **Format:** Open-Source Engineering Repository
- **Relevance:** Crucial for **Unit 1** and **Unit 5**. Frank's provides actual OEM service manuals, block diagrams, and calibration schematics for older standalone ECG machines, EEG headboxes, and external pacemakers. It removes the "black box" mystery from clinical hardware.
- **Access:** frankshospitalworkshop.com

Category 2: Free-to-Audit Online Courses & Interactive Simulators

4. NPTEL / Swayam: Biomedical Instrumentation

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Offered by the IITs, this aligns perfectly with regional engineering board standards. It provides rigorous mathematical and hardware-level explanations for **Units 1, 3, and 4**, specifically focusing on the design of high-gain/low-noise neuro-amplifiers and the physics of electrode-skin impedance.
- **Access:** nptel.ac.in

5. Practical Clinical Skills: ECG & Pacemaker Simulators

- **Format:** Open-Access Web Simulators
- **Relevance:** An excellent, interactive tool for **Unit 1** and **Unit 5**. Before students troubleshoot the hardware, they must recognize what normal and paced rhythms look like. This site offers free simulators that generate pacing spikes, asynchronous rhythms, and 12-lead vector changes dynamically.
- **Access:** practicalclinicalskills.com

6. Coursera / University of Pennsylvania: Vital Signs (Cardiac Electrophysiology Module)

- **Format:** Online Course (Free to Audit)
- **Relevance:** A strong foundational course bridging physiology and technology. It helps engineering students understand exactly *what* the machines are measuring, explaining the origins of motor unit action potentials (MUAPs) and neural firing required for **Unit 3** and **Unit 4**.
- **Access:** coursera.org

Category 3: Highly Visual Video Channels & Institutional Training

7. Ninja Nerd Science (Cardiology & Neurology Series)

- **Format:** Medical Educational Video Series (YouTube)
- **Relevance:** Zach Murphy's whiteboard sessions are globally recognized for making complex physiology digestible. His specific breakdowns of Einthoven's Triangle, 12-lead vector math, and brainwave classifications provide the perfect visual foundation before students touch the clinical hardware.

8. Fluke Biomedical Advantage: Defibrillator & Pacemaker Testing

- **Format:** On-Demand Clinical Training Platform
- **Relevance:** Fluke manufactures the industry-standard analyzers used to legally test life-support equipment. Their free training modules for **Unit 5** visually demonstrate how to capture a pacemaker pulse width on an analyzer and how to test the demand/synchronous functions of external pacing boxes safely.
- **Access:** advantagetraining.docebosaas.com

9. Natus Neuro & ASET Public Resources

- **Format:** Educational Webinars & Video Libraries (YouTube)
- **Relevance:** Natus is a leading manufacturer of neurology equipment. Their educational videos are the absolute best resource for **Unit 3**, providing clear, live-action demonstrations of how to physically measure a human head and accurately apply electrodes using the International 10-20 system.

With these resources, the students will be fully equipped to handle both the theoretical and clinical realities of electrophysiology equipment.

DMET 202: Medical Imaging Systems

To deliver the **Medical Imaging Systems** course at the highest clinical and academic standard, the learning materials must bridge complex quantum physics (like Larmor frequencies and positron emission) with the heavy mechanical engineering of spinning CT gantries and superconducting magnets.

Here is a list of 9 high-quality, open-source, and free-to-access resources. They are specifically mapped to X-ray physics, MRI safety, Ultrasound mechanics, and CT quality assurance.

Category 1: Open-Source Manuals, Repositories & Web-Books

1. IAEA: Training Material on Radiation Protection in Diagnostic Radiology

- **Format:** Open-Access Global Training Modules (Web/PDF)
- **Relevance:** The International Atomic Energy Agency (IAEA) sets the global standard for radiation safety. Their free training modules are the ultimate resource for **Unit 1 (X-Rays)** and **Unit 2 (CT)**. They provide exhaustive, mathematically backed explanations of Half-Value Layers (HVL), heel effects, and how to safely execute dosimetry audits on X-ray tubes.
- **Access:** iaea.org (Search: "Diagnostic Radiology Training Material")

2. Questions and Answers in MRI (by Allen D. Elster, MD)

- **Format:** Free Comprehensive Web-Book
- **Relevance:** This is globally recognized as the absolute best free resource for **Unit 3 (MRI)**. MRI physics is notoriously difficult for students to grasp. This site breaks down T1/T2 relaxation times, superconducting helium cryogenics, and gradient coils into easily digestible, highly visual Q&A formats without overwhelming the student with calculus.
- **Access:** mriquestions.com

3. Frank's Hospital Workshop (X-Ray & Ultrasound Section)

- **Format:** Open-Source Engineering Repository
- **Relevance:** A mandatory resource for **Unit 1** and **Unit 4**. Frank's hosts actual OEM service manuals, high-voltage generator schematics, and mechanical block diagrams for older mobile X-ray machines and ultrasound carts. It allows students to study how the high-voltage stator coils physically rotate an X-ray anode.
- **Access:** frankshospitalworkshop.com

Category 2: Free-to-Audit Online Courses (MOOCs)

4. edX / University of Queensland: Introduction to Biomedical Imaging

- **Format:** Online Course (Free to Audit)
- **Relevance:** A world-class foundational course that covers **Units 1 through 5**. It provides a highly structured academic overview of how different modalities interact with human tissue, explaining the fundamental differences between Hounsfield Units in a CT scan and acoustic impedance in an Ultrasound.
- **Access:** edx.org

5. NPTEL / Swayam: Medical Image Analysis

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Aligned perfectly with regional technical education mandates, this course provides the heavy mathematical and algorithmic backing required for **Unit 2**. It explains the digital signal processing and 3D reconstruction algorithms that a CT scanner uses to turn raw detector data into a readable image.
- **Access:** nptel.ac.in

6. How Equipment Works (Radiology Section)

- **Format:** Free Educational Website
- **Relevance:** Created by a clinician, this site is brilliant for **Unit 1** and **Unit 4**. It uses highly intuitive, cartoon-style illustrations to explain complex physics, such as exactly how piezoelectric crystals generate ultrasound waves and how Doppler shifts calculate blood velocity. It is perfect for visual learners who struggle with dense physics textbooks.
- **Access:** howequipmentworks.com

Category 3: Highly Visual Video Channels & OEM Animations

7. Radiology Tutorials (YouTube Channel)

- **Format:** Diagnostic Physics Video Channel
- **Relevance:** This channel provides exceptional, whiteboard-style breakdowns of **Unit 2 (CT)** and **Unit 5 (Nuclear Medicine)**. The creator meticulously explains pitch, multi-slice detector arrays, and how Gamma cameras use photomultiplier tubes to capture the radioactive decay of radiopharmaceuticals like FDG.

8. Albert Einstein College of Medicine: Ultrasound Physics (YouTube)

- **Format:** Open-Access University Lecture Series
- **Relevance:** The absolute best video resource for **Unit 4**. This free lecture series covers everything from acoustic impedance and spatial resolution to identifying dead crystals. It perfectly prepares students for testing tissue-mimicking phantoms in the laboratory.

9. Siemens Healthineers & GE Healthcare (Official YouTube Channels)

- **Format:** OEM Diagnostic Video Channels
- **Relevance:** You cannot easily open a live MRI or CT scanner to show students the internal mechanics. These official manufacturer channels provide multimillion-dollar 3D animations of the exact mechanical components explored in **Units 2 and 3**. Watching a 3D animation of a CT slip-ring spinning at 4 rotations per second, or visualizing a liquid helium quench in an MRI, safely bridges the gap between theory and heavy machinery.

DMET 203: Respiratory & Therapeutic Technology

To deliver the **Respiratory & Therapeutic Technology** course at the highest clinical and academic standard, the learning materials must help students navigate the complex intersection of human lung physiology and pressurized, automated fluidics.

Here is a list of 9 high-quality, open-source, and free-to-access learning resources. They are specifically mapped to respiratory mechanics, spirometry, impedance pneumography, and life-support machine calibration.

Category 1: Open-Source Manuals & Industrial Guides

1. Frank's Hospital Workshop (Ventilator & Anesthesia Repository)

- **Format:** Open-Source Engineering Repository
- **Relevance:** This is the most critical resource for **Unit 4** and **Unit 5**. Frank's hosts the actual OEM service manuals, pneumatic block diagrams, and troubleshooting guides for major ICU ventilators (like the Puritan Bennett 840) and anesthesia workstations. It allows students to study exact proportional solenoid valve configurations before touching the physical hardware.
- **Access:** frankshospitalworkshop.com

2. OpenStax: Anatomy and Physiology (The Respiratory System)

- **Format:** Open-Source Textbook (Web/PDF)
- **Relevance:** To understand **Unit 1**, engineers must understand the biological "machine" they are connecting to. This textbook provides a highly accessible breakdown of lung compliance, airway resistance, and the application of Boyle's Law to alveolar pressure.
- **Access:** openstax.org/details/books/anatomy-and-physiology

3. WHO: Technical Specifications for Respiratory Care Devices

- **Format:** Open-Access Global Health Document (PDF)
- **Relevance:** Published by the World Health Organization, this document sets the global regulatory standards for oxygen blenders, continuous positive airway pressure (CPAP) machines, and mechanical ventilators. It is excellent for teaching the rigorous compliance parameters required in **Unit 4**.
- **Access:** [who.int](https://www.who.int) (Search title)

Category 2: Free-to-Audit Online Courses & Industrial Training

4. edX / Harvard University: Mechanical Ventilation

- **Format:** Online Course (Free to Audit)
- **Relevance:** Originally expanded during the COVID-19 pandemic, this is an elite, world-class course that demystifies **Unit 4**. It meticulously explains the difference between volume-controlled and pressure-controlled modes, and how to read the complex flow-time and pressure-volume loops generated by a ventilator.
- **Access:** edx.org

5. NPTEL / Swayam: Biomedical Instrumentation & Signal Processing

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Aligned with regional engineering board standards, this course provides the heavy mathematical and electronic theory required for **Unit 2** and **Unit 3**. It deeply covers the physics of pneumotachometers, hot-wire anemometers, and the high-frequency carrier wave signal processing required to successfully extract respiration rates via Impedance Pneumography.
- **Access:** nptel.ac.in

6. Fluke Biomedical Advantage: Respiratory & Gas Flow Testing

- **Format:** On-Demand Clinical Training Platform
- **Relevance:** Fluke manufactures the clinical gas flow analyzers used globally for preventive maintenance. Their free training modules show students exactly how to calibrate an ICU ventilator, verify spirometry volumes using a 3-Liter syringe, and measure oxygen concentration (**Units 2 and 4**).
- **Access:** advantagegetraining.docebosaas.com

Category 3: Highly Visual Video Channels & OEM Animations

7. Dräger Global (Official YouTube Channel)

- **Format:** OEM Diagnostic & Respiratory Video Channel
- **Relevance:** Dräger is a world leader in anesthesia and ventilation. Their official channel features incredible 3D animations of the internal fluidics of **Unit 5**. Watching their breakdowns of circle breathing systems, vaporizers, and anesthetic gas scavenging systems (AGSS) makes complex pneumatic pathways immediately understandable.

8. Ninja Nerd: Respiratory Physiology Series

- **Format:** Medical Educational Video Series (YouTube)
- **Relevance:** Zach Murphy's visual whiteboard lectures are unmatched for bridging biology and physics. His specific videos on the "Work of Breathing" and pulmonary compliance are mandatory viewing for **Unit 1**. They allow engineering students to visualize the invisible pressure drops that trigger ventilator alarms.

9. Respiratory Therapy Zone

- **Format:** Educational Web Platform & YouTube Channel
- **Relevance:** Created for Respiratory Therapists, this channel explains exactly how clinical staff interact with the machines your engineers will be fixing. Their simple, clear breakdowns of Positive End-Expiratory Pressure (PEEP), Forced Vital Capacity (FVC), and ventilator modes provide critical clinical context for **Units 2 and 4**.

DMET 204: Analytical & Lab Instruments

To deliver the **Analytical & Lab Instruments** course at a world-class standard, the learning materials must help students bridge two very different domains: the heavy electromechanical systems of centrifuges and refrigeration, and the delicate optical physics required for clinical biochemistry.

Here is a list of 9 high-quality, open-source, and free-to-access learning resources. They are specifically mapped to the centrifugation, spectrophotometry, hematology, and refrigeration units of your syllabus.

Category 1: Open-Source Manuals & Industrial Guides

1. WHO: Maintenance Manual for Laboratory Equipment

- **Format:** Open-Access Global Health Manual (PDF)
- **Relevance:** Published by the World Health Organization, this is the definitive global guide for **Unit 1 (Centrifuges/Incubators)** and **Unit 2 (Colorimeters)**. It provides explicit, step-by-step instructions on replacing centrifuge carbon brushes, calibrating incubator thermostats, and cleaning optical cuvettes without scratching them.
- **Access:** who.int (Search: "Maintenance manual for laboratory equipment")

2. Frank's Hospital Workshop (Laboratory Section)

- **Format:** Open-Source Engineering Repository
- **Relevance:** This massive repository provides actual OEM service manuals for older discrete auto-analyzers and 3-part hematology counters. It is an absolute necessity for **Unit 3** and **Unit 4**, allowing students to study exploded-view mechanical diagrams of robotic sample arms and peristaltic fluidic manifolds.
- **Access:** frankshospitalworkshop.com

3. OpenStax: Chemistry 2e

- **Format:** Open-Source Textbook (Web/PDF)
- **Relevance:** To understand **Unit 2**, students must understand the underlying chemistry. This free textbook from Rice University clearly explains the Beer-Lambert Law, optical density, and the principles of spectrophotometry in a way that is highly accessible to engineering students who may not have a strong chemistry background.
- **Access:** openstax.org/details/books/chemistry-2e

Category 2: Free-to-Audit Online Courses & Industrial Training

4. NPTEL / Swayam: Bioanalytical Techniques and Experimental Biochemistry

- **Format:** Online Courses (Free to Audit/Download)
- **Relevance:** Offered by the Indian Institutes of Technology (IITs), these courses provide the rigorous theoretical backing required for **Unit 1** and **Unit 2**. The lectures dive deep into the mathematics of Relative Centrifugal Force (RCF), sedimentation principles, and the optics behind monochromators and photomultiplier tubes.
- **Access:** nptel.ac.in

5. Danfoss Learning: Vapor Compression & Refrigeration Basics

- **Format:** Industry E-Learning Platform (Free Access)
- **Relevance:** Danfoss is a global leader in compressor technology. Their free online learning portal is the ultimate resource for **Unit 5 (Blood Bank Equipment)**. It provides highly interactive modules on how vapor-compression cycles work, how expansion valves meter refrigerant, and how to troubleshoot deep freezers (-80°C).
- **Access:** learning.danfoss.com

6. Coursera / University of Geneva: Global Health at the Human-Animal Interface (Diagnostics Modules)

- **Format:** Online Course (Free to Audit)
- **Relevance:** While a broader global health course, its diagnostic modules provide excellent context on why automated, high-throughput pathology analyzers (**Unit 3**) are critical for identifying and managing large-scale outbreaks, connecting the mechanical engineering to its ultimate clinical purpose.
- **Access:** coursera.org

Category 3: Highly Visual Video Channels & OEM Animations

7. Beckman Coulter & Sysmex Official YouTube Channels

- **Format:** OEM Diagnostic Video Channels
- **Relevance:** It is nearly impossible to visualize how a blood cell counter works using just a textbook. These official manufacturer channels provide incredible 3D animations of **Unit 4**, visually demonstrating the Coulter Principle (electrical impedance pulses) and how hydrodynamic focusing forces red blood cells to pass through a laser in a single-file line.

8. Applied Science (YouTube Channel)

- **Format:** Advanced Engineering Video Channel
- **Relevance:** The creator, Ben Krasnow, physically builds complex laboratory equipment from scratch. His specific videos on building a homemade Coulter counter and electron microscopes demystify the "black box" nature of pathology equipment, showing students exactly how to detect microvolt impedance spikes from microscopic particles.

9. RealPars

- **Format:** Animated Industrial Engineering Video Series (YouTube)
- **Relevance:** This channel provides the absolute best visual explanations for the electromechanical systems in **Unit 1** and **Unit 3**. Their videos on how PID controllers actively stabilize temperatures (for incubators) and how stepper motors accurately position robotic arms (for auto-analyzers) are unparalleled for visual learners.

DMET 205: Surgical & Critical Care Equip

To deliver the **Surgical & Critical Care Equipment** course at the highest clinical and academic standard, the learning materials must emphasize absolute precision and life-critical safety. Students must understand that therapeutic devices do not just *monitor* physiology—they actively alter it through high-voltage shocks, thermal cutting, and direct intravenous fluidics.

Here is a list of 9 high-quality, open-source, and free-to-access resources. They are specifically mapped to electrosurgery physics, hemodialysis fluidics, defibrillator safety, and infusion metrology.

Category 1: Open-Source Manuals & Industrial Guides

1. WHO: Maintenance and Repair of Laboratory, Diagnostic Imaging, and Hospital Equipment

- **Format:** Open-Access Global Health Document (PDF)
- **Relevance:** Published by the World Health Organization, this is a foundational text for **Unit 2 (Defibrillators)** and **Unit 5 (Incubators)**. It provides step-by-step, highly practical troubleshooting flowcharts for repairing heavy therapeutic equipment in resource-constrained environments.
- **Access:** who.int (Search title)

2. Frank's Hospital Workshop (Surgery & Intensive Care Section)

- **Format:** Open-Source Engineering Repository
- **Relevance:** This repository is absolutely critical for **Units 1, 3, and 4**. Frank's hosts the actual OEM service manuals, hydraulic block diagrams, and calibration procedures for industry-standard equipment like Valleylab Electrosurgical Units, Fresenius Hemodialysis machines, and Alaris Infusion Pumps.
- **Access:** frankshospitalworkshop.com

3. Covidien / Medtronic: Principles of Electrosurgery

- **Format:** Free Clinical Engineering Guide (PDF)
- **Relevance:** The definitive guide for **Unit 1**. Medtronic (which acquired Valleylab, the pioneer of modern diathermy) provides this comprehensive guide explaining the exact physics of radiofrequency tissue interaction, crest factors, and how Return Electrode Monitoring (REM) physically prevents patient burns.
- **Access:** medtronic.com (Search: "Principles of Electrosurgery PDF")

Category 2: Free-to-Audit Online Courses & Industrial Training

4. NPTEL / Swayam: Medical Devices and Equipment

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Aligned with regional technical education mandates, this course provides the rigorous electronic and thermodynamic theories required for **Unit 2** and **Unit 5**. It covers the mathematical modeling of biphasic truncated exponential waveforms and the servo-control logic used in infant radiant warmers.
- **Access:** nptel.ac.in

5. Fluke Biomedical Advantage: Therapeutic Equipment Testing

- **Format:** On-Demand Clinical Training Platform
- **Relevance:** Fluke manufactures the gold-standard analyzers used globally to test these specific devices. Their free training modules for **Units 1, 2, 4, and 5** visually demonstrate how to legally verify a 360-Joule defibrillator shock, measure ESU high-frequency leakage, and calibrate an infusion pump's occlusion alarm.
- **Access:** advantagetraining.docebosaas.com

6. Coursera / Yale University: Introduction to Medical Software

- **Format:** Online Course (Free to Audit)
- **Relevance:** Highly relevant for **Unit 4 (Infusion Pumps)**. Infusion pumps are notorious for software-related safety recalls. This course helps engineering students understand the stringent FDA regulatory requirements and fail-safe logic built into medical device software to prevent lethal drug overdoses.
- **Access:** coursera.org

Category 3: Highly Visual Video Channels & OEM Animations

7. BOWA Medical & Erbe Elektromedizin (Official YouTube Channels)

- **Format:** OEM Surgical Video Channels
- **Relevance:** These leading German manufacturers of electrosurgical units provide the absolute best visual resources for **Unit 1**. Their stunning macro-lens videography and 3D animations show exactly what happens to cellular fluid when hit by pure-cut versus coagulation waveforms, bridging the gap between electrical engineering and surgical tissue effects.

8. ICU Advantage (YouTube Channel)

- **Format:** Critical Care Educational Video Channel
- **Relevance:** Created for intensive care nurses, this channel is invaluable for **Unit 3 (Hemodialysis)** and **Unit 4 (Infusion Pumps)**. It explains exactly *why* clinical staff interact with the machines the way they do, providing engineers with the clinical context needed to understand dialysate gradients, ultrafiltration, and continuous renal replacement therapy (CRRT).

9. Fresenius Medical Care (Official YouTube Channel)

- **Format:** OEM Hemodialysis Video Channel
- **Relevance:** Hemodialysis machines are incredibly complex hydraulic systems. Fresenius provides high-quality 3D animations for **Unit 3**, mapping the exact fluidic pathways of blood and dialysate through the proportioning pumps, heaters, and semi-permeable dialyzer membranes, making the "wet-lab" fluidics immediately understandable.

DMET 206: Optical & Laser Systems

To deliver the **Optical & Laser Systems** course at the highest clinical and academic standard, the learning materials must help students bridge the gap between abstract optical physics (like quantum stimulated emission) and the rigorous, zero-tolerance safety environment of the surgical theatre.

Here is a list of 9 high-quality, open-source, and free-to-access resources. They are specifically mapped to fiber optic transmission, laser physics, endoscopic repair, and optical density safety standards.

Category 1: Open-Source Manuals & Industrial Guidelines

1. Frank's Hospital Workshop (Endoscopy & Laser Repository)

- **Format:** Open-Source Engineering Repository
- **Relevance:** This is the most vital resource for **Unit 4**. Frank's hosts actual OEM service manuals and mechanical breakdowns for Olympus, Pentax, and Karl Storz endoscopes. It provides the exact step-by-step pneumatic leak testing procedures and Camera Control Unit (CCU) schematics that students will use in the lab.
- **Access:** frankshospitalworkshop.com

2. WHO: Maintenance and Repair of Laboratory, Diagnostic Imaging, and Hospital Equipment

- **Format:** Open-Access Global Health Document (PDF)
- **Relevance:** Published by the World Health Organization, the specific chapters on "Operating Theatre Equipment" provide excellent, standardized maintenance flowcharts for **Unit 1** (Xenon/LED cold light sources) and **Unit 4** (rigid and flexible endoscope care).
- **Access:** who.int (Search title)

3. Laser Institute of America (LIA): Medical Laser Safety Open Resources

- **Format:** Open-Access Safety Guidelines & Bulletins
- **Relevance:** LIA is the secretariat for the ANSI Z136.3 standard (Safe Use of Lasers in Health Care). Their free technical bulletins are the definitive texts for **Unit 5**. They provide the exact formulas students need to calculate Maximum Permissible Exposure (MPE), Nominal Hazard Zones, and the Optical Density (OD) required for safety eyewear.
- **Access:** lia.org

Category 2: Free-to-Audit Online Courses (MOOCs)

4. NPTEL / Swayam: Laser: Fundamentals and Applications

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Offered by IIT Kanpur, this course perfectly satisfies regional engineering board requirements for **Unit 2**. It provides the rigorous mathematical and quantum physics foundation necessary to understand spontaneous versus stimulated emission, population inversion, and the specific optical cavities of Nd:YAG and CO₂ lasers.
- **Access:** nptel.ac.in

5. Coursera / École Polytechnique: Optics and Lasers

- **Format:** Online Course (Free to Audit)
- **Relevance:** A world-class foundational course for **Unit 1** and **Unit 3**. It beautifully demystifies total internal reflection and light attenuation, explaining exactly how laser beams are guided through both articulated mirror arms and flexible optical fibers without losing wattage.
- **Access:** coursera.org

6. Coursera / University of Colorado Boulder: Optical Instruments and Testing

- **Format:** Online Course (Free to Audit)
- **Relevance:** Highly relevant for **Unit 4**. This course teaches the engineering behind optical visualization tools. It explains chromatic aberration, numerical aperture, and how complex lens arrays (like the Hopkins rod-lens system inside a laparoscope) are designed and tested for resolution.
- **Access:** coursera.org

Category 3: Highly Visual Video Channels & OEM Tutorials

7. Karl Storz & Olympus Medical (Official YouTube Channels)

- **Format:** OEM Surgical & Endoscopic Video Channels
- **Relevance:** You cannot teach endoscopy without showing the internal mechanics. These official channels provide brilliant 3D animations of the Hopkins rod-lens architecture (**Unit 4**) and detailed, live-action tutorials on how clinical staff handle, clean, and leak-test flexible colonoscopes, providing critical context for the lab experiments.

8. Lumenis (Official YouTube Channel)

- **Format:** OEM Surgical Laser Video Channel
- **Relevance:** Lumenis is a global pioneer in surgical lasers. Their channel is unmatched for **Unit 3**. It features high-definition, microscopic surgical footage showing exactly how Holmium lasers obliterate kidney stones (lithotripsy) and how CO2 lasers ablate soft tissue, clearly demonstrating the difference in tissue penetration based on wavelength.

9. Edmund Optics: Imaging Lab Video Series

- **Format:** Applied Optical Engineering Series (YouTube/Web)
- **Relevance:** Edmund Optics is a premier supplier of precision optics. Their "Imaging Lab" series provides crystal-clear, physical demonstrations of **Unit 1** concepts. They show how to use optical power meters, measure the numerical aperture of a fiber, and align complex lens systems on an optical table, perfectly mirroring the practical setups required for the laboratory.

Year 2: Semester 4

DMET 207: Clinical Engineering Asset Management

To deliver the **Clinical Engineering Asset Management** course at the highest administrative and operational standard, the learning materials must shift away from pure physics and electronics. Instead, they must focus on Healthcare Technology Management (HTM), financial logistics, and global regulatory compliance.

Here is a list of 9 high-quality, open-source, and free-to-access resources. They are specifically mapped to CMMS databases, maintenance planning, inventory control, and equipment lifecycles.

Category 1: Open-Access Global Health Guidelines

1. WHO: Introduction to Medical Equipment Inventory Management

- **Format:** Open-Access Global Health Document (PDF)
- **Relevance:** Published by the World Health Organization, this is the foundational text for **Unit 2** and **Unit 5**. It provides standard, globally recognized frameworks for classifying assets, assigning standardized nomenclature, and setting up the exact database structures required for a Computerized Maintenance Management System (CMMS).
- **Access:** who.int (Search: "Medical equipment inventory management")

2. WHO: Medical Equipment Maintenance Programme Overview

- **Format:** Open-Access Global Health Document (PDF)
- **Relevance:** This document is the ultimate guide for **Unit 3**. It explicitly details how to balance a hospital's workload by calculating risk-based maintenance schedules, helping students understand why a defibrillator is serviced every 6 months while a basic ward thermometer might be "run-to-failure."
- **Access:** who.int (Search title)

3. PAHO: Healthcare Technology Management Guidelines

- **Format:** Free Institutional Guide (PDF)
- **Relevance:** The Pan American Health Organization provides a brilliant breakdown of **Unit 4 (Equipment Lifecycle)**. It offers the actual financial and clinical frameworks required to draft a condemnation report and justifies the cost-to-repair ratio that dictates when an old machine should be scrapped.
- **Access:** paho.org (Search: "Maintenance manual for healthcare technology")

Category 2: Free-to-Audit Online Courses (MOOCs)

4. NPTEL / Swayam: Hospital Administration and Operations

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Offered by top management institutes in India, this course is vital for **Unit 1** and **Unit 5**. It transitions the student from an "engineer" to an "administrator," teaching them ABC inventory analysis, how to manage Annual Maintenance Contracts (AMC), and how to negotiate vendor Service Level Agreements (SLAs).
- **Access:** nptel.ac.in

5. Coursera / Rutgers University: Operations Management in Healthcare

- **Format:** Online Course (Free to Audit)
- **Relevance:** Excellent for **Unit 2**. While broader than just equipment, this course teaches the mathematical metrics of hospital operations. It provides the statistical foundation students need to calculate Key Performance Indicators (KPIs) like Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR).
- **Access:** coursera.org

6. Coursera / Imperial College London: Quality Improvement in Healthcare

- **Format:** Online Course (Free to Audit)
- **Relevance:** Perfect for **Unit 1**. It teaches students how to perform Root Cause Analysis (RCA) and workflow mapping, ensuring they can systematically identify bottlenecks in the clinical engineering department's repair processes.
- **Access:** coursera.org

Category 3: Webinars, Podcasts, and Professional Platforms

7. TechNation Webinars (HTM Archives)

- **Format:** Professional Development Digital Archives
- **Relevance:** TechNation is the premier community for Healthcare Technology Management (HTM) professionals. Their free webinar archive is packed with real-world case studies on **Unit 2** (implementing new CMMS software) and **Unit 5** (optimizing spare parts supply chains). It provides an unfiltered look at the administrative realities of the job.
- **Access:** [1technation.com/webinars](https://technation.com/webinars)

8. AAMI (Association for the Advancement of Medical Instrumentation) Resources

- **Format:** YouTube Channel & Open-Access Articles
- **Relevance:** AAMI writes the actual standards that govern clinical engineering. Their free videos and public articles discuss the ethics of clinical engineering (**Unit 1**) and the legal compliance required when documenting PM checklists and managing equipment recalls.
- **Access:** aami.org or AAMI YouTube Channel

9. Fluke Biomedical Advantage: CMMS Integration & Documentation

- **Format:** On-Demand Clinical Training Platform
- **Relevance:** Beyond just teaching hardware testing, Fluke offers excellent modules on how automated testing equipment interfaces directly with hospital CMMS databases. This shows students how modern departments eliminate manual data entry and automate their regulatory compliance reporting.
- **Access:** advantagetraining.docebosaas.com

DMET 208: Hospital Facility Management

To deliver the **Hospital Facility Management** course at the highest technical and operational standard, the learning materials must reflect the industrial scale of the subject. Students are no longer studying microscopic circuits; they are studying massive pneumatic, thermodynamic, and high-voltage architectures where a single failure can compromise the entire hospital.

Here is a list of 9 high-quality, open-source, and free-to-access resources. They are specifically mapped to Medical Gas Pipeline Systems (MGPS), isolation HVAC, Reverse Osmosis (RO) water plants, and emergency power grids.

Category 1: Open-Access Global Health Guidelines & Technical Memorandums

1. UK NHS: Health Technical Memorandum (HTM 02-01) - Medical Gas Pipeline Systems

- **Format:** Open-Access Engineering Standard (PDF)
- **Relevance:** This is the absolute global gold standard for **Unit 1**. While regional codes exist, the UK's HTM 02-01 is universally referenced for its rigorous engineering blueprints regarding liquid oxygen manifolds, automatic changeover valves, and the exact physical sizing of medical air compressors.
- **Access:** gov.uk (Search: "HTM 02-01 Medical gas pipeline systems")

2. WHO: Safe Management of Wastes from Health-Care Activities (The "Blue Book")

- **Format:** Open-Access Global Health Document (PDF)
- **Relevance:** The definitive textbook for **Unit 4**. It provides comprehensive, globally recognized frameworks for Biomedical Waste (BMW) segregation, detailing the exact chemical, thermal, and logistical methods required to safely dispose of biohazards, heavy metals, and electronic waste without polluting the local water table.
- **Access:** who.int (Search: "Safe management of wastes from health-care activities")

3. CDC / ASHRAE: Guidelines for Environmental Infection Control in Health-Care Facilities

- **Format:** Free Institutional Guide (Web/PDF)
- **Relevance:** Mandatory reading for **Unit 2**. It provides the strict mathematical formulas and engineering requirements for calculating Air Changes per Hour (ACH) and designing the positive/negative differential pressure cascades required for Operating Theatres and Tuberculosis isolation wards.
- **Access:** cdc.gov/infectioncontrol/guidelines/environmental

Category 2: Free-to-Audit Online Courses & Industrial Platforms

4. Schneider Electric: Energy University (Critical Power Facilities)

- **Format:** Free Industrial Training Platform
- **Relevance:** The absolute best resource for **Unit 5**. Schneider Electric provides specialized modules on hospital electrical architectures, explaining the exact mechanics of Automatic Transfer Switches (ATS), diesel generator load-stepping, and the sizing of massive, facility-wide Uninterruptible Power Supply (UPS) battery banks.
- **Access:** schneider-electric.com/energy-university

5. NPTEL / Swayam: Hospital Administration and Operations

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Aligned with regional standards, the facility management modules of this course perfectly support **Unit 4** and **Unit 5**. It transitions the student from a device technician to a facility manager, teaching the logistics of load-shedding during power grids failures and the administrative governance of hazardous waste contracts.
- **Access:** nptel.ac.in

6. Coursera / University of Geneva: Infection Prevention and Control (IPC)

- **Format:** Online Course (Free to Audit)
- **Relevance:** Highly relevant for **Unit 2** and **Unit 3**. It provides the clinical context for why facility engineers must maintain such strict environmental parameters. It explains exactly how pathogens travel through poorly filtered HVAC systems and how waterborne bacteria (endotoxins) can colonize an improperly disinfected RO water plant.
- **Access:** coursera.org

Category 3: Highly Visual Video Channels & OEM Engineering Guides

7. The Engineering Mindset (YouTube Channel)

- **Format:** 3D Animated Engineering Channel
- **Relevance:** Hospital infrastructure is heavily hidden behind walls and in basements. This channel provides unmatched 3D fluid-dynamics animations for **Unit 2** and **Unit 5**. It visually explains how large-scale HVAC chillers, Diesel Generators, and 3-phase transformers physically operate, making heavy mechanical engineering immediately understandable.

8. BeaconMedæx (Official YouTube Channel)

Competency Based Curriculum for “Diploma in Medical Equipment Technology”
(Intellectual property of National Commission for Allied and Healthcare Professions, Ministry of Health and Family Welfare)

- **Format:** OEM Medical Gas Video Channel
- **Relevance:** BeaconMedæa is a global leader in Medical Gas Pipeline Systems. Their technical channel provides crystal-clear visual tutorials for **Unit 1**, demonstrating how to test Area Valve Service Units (AVSU), the internal mechanics of a liquid oxygen vaporizer, and how automatic changeover manifolds physically actuate during a pressure drop.

9. Mar Cor Purification / Evoqua Water Technologies (Webinars & Videos)

- **Format:** OEM Water Treatment Video Channels
- **Relevance:** Dialysis water treatment is a highly niche field. These channels provide excellent, practical visual breakdowns for **Unit 3**. They detail the step-by-step physical flow of city water through multimedia filters, carbon tanks, and Reverse Osmosis membranes, explaining how to monitor Total Dissolved Solids (TDS) and perform thermal disinfection.

DMET 209: Hospital Safety & Standards

To deliver the **Hospital Safety & Standards** course at the highest academic and clinical standard, the learning materials must explicitly bridge the gap between engineering theory and strict regulatory compliance. Medical safety is highly governed by international law and standardized testing protocols, so the resources must reflect current industry benchmarks.

Here is a list of 9 high-quality, open-source, and free-to-access learning resources. They are specifically mapped to the IEC 60601 standards, electrical safety testing, biological hazards, and ergonomic units of your syllabus.

Category 1: Open-Source Manuals & Industrial Guidelines

1. A Practical Guide to IEC 60601-1 (by Rigel Medical)

- **Format:** Free Industrial Engineering Guide (PDF)
- **Relevance:** The actual IEC 60601-1 document costs hundreds of dollars and is notoriously difficult to read. This free, comprehensive booklet by Rigel Medical is the industry standard for teaching **Unit 2**. It breaks down Class I/II devices, Type B/BF/CF applied parts, and exact leakage current limits into clear, digestible charts for students.
- **Access:** rigelmedical.com (Search: "Practical Guide to IEC 60601-1")

2. WHO: Safe Management of Wastes from Health-Care Activities

- **Format:** Open-Access Global Health Manual (Web/PDF)
- **Relevance:** Often referred to as the "Blue Book," this World Health Organization manual is the definitive text for **Unit 3**. It provides the global framework for biomedical waste segregation, chemical decontamination, and handling equipment exposed to bloodborne pathogens.
- **Access:** who.int (Search title)

3. NIOSH/OSHA: Guidelines for Protecting Healthcare Workers

- **Format:** Open-Source Government Safety Portals
- **Relevance:** The National Institute for Occupational Safety and Health (NIOSH) provides exhaustive, free guides specifically addressing **Unit 4 (Fire Safety/Oxygen hazards)** and **Unit 5 (Ergonomics & Radiation)**. Their biomechanical guides on safely moving heavy medical equipment are essential for protecting Medical Equipment Technologists from career-ending back injuries.
- **Access:** cdc.gov/niosh/topics/healthcare

Category 2: Free-to-Audit Online Courses (MOOCs)

4. NPTEL / Swayam: Current Regulatory Requirements for Conducting Clinical Trials in India (and Equipment Standards)

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Offered by CDSA and the regulatory bodies of India, this course provides crucial regional context. While focused broadly on trials, it covers the statutory safety standards, ethics, and quality management systems required to ensure diagnostic equipment is legally safe for human use.
- **Access:** npTEL.ac.in

5. Fluke Biomedical Advantage: Electrical Safety Testing

- **Format:** On-Demand Clinical Training Platform
- **Relevance:** Fluke provides a completely free, self-paced training module dedicated entirely to **Unit 1** and **Unit 2**. It mathematically explains macro-shock versus micro-shock and provides step-by-step interactive tutorials on how to operate an Electrical Safety Analyzer (ESA) before students touch the physical hardware.
- **Access:** advantagetraining.docebosaas.com

6. Coursera / Johns Hopkins University: Patient Safety and Quality Improvement

- **Format:** Online Course (Free to Audit)
- **Relevance:** This course shifts the engineer's mindset from purely technical troubleshooting to a "culture of safety." It explores how device failures, poor ergonomics, and systemic errors lead to adverse patient outcomes, perfectly complementing the overarching theme of the course.
- **Access:** coursera.org

Category 3: Highly Visual Video Channels & Institutional Tools

7. Rigel Medical (YouTube Channel)

- **Format:** Clinical Simulation & Testing Video Channel
- **Relevance:** Rigel creates incredibly clear, visual walkthroughs of electrical safety testing. Watching their technicians deliberately trigger single-fault conditions (like lifting an earth ground) on a vital signs monitor, and watching the ESA capture the spike in leakage current, is mandatory viewing for **Unit 2**.

8. CDC: Infection Control & PPE Sequences

- **Format:** Institutional Video Repository (YouTube/CDC.gov)
- **Relevance:** For **Unit 3**, knowing how to clean a circuit board means nothing if the engineer contaminates themselves opening the device chassis. The CDC's visual demonstrations on the strict donning and doffing sequences for Personal Protective Equipment (PPE) are the gold standard for infection control drills.

9. TechNation Webinars (HTM Safety & Compliance)

- **Format:** Healthcare Technology Management Digital Archives
- **Relevance:** TechNation hosts free webinars led by veteran Medical Equipment Technologists addressing real-world safety disasters. Archived sessions covering topics like "Mitigating Fire Risks in the OR" or "Managing Lead Apron Integrity" provide highly engaging, practical case studies for **Unit 4** and **Unit 5**.

DMET 210: Regulatory & Quality Assurance

To deliver the **Regulatory & Quality Assurance** course at the highest professional standard, the learning materials must reflect the rigid, text-heavy reality of international law and hospital accreditation. Students need resources that unpack dense legal frameworks into actionable engineering protocols.

Here is a list of 8 high-quality, open-source, and free-to-access resources. They are specifically mapped to global FDA/CE regulations, ISO quality management, Indian statutory compliance (AERB/NABH), and post-market surveillance.

Category 1: Open-Access Regulatory Portals & Global Guidelines

1. FDA CDRH Learn (Center for Devices and Radiological Health)

- **Format:** Open-Access Video Modules & Regulatory Text
- **Relevance:** This is the US government's official educational portal and the absolute gold standard for **Unit 1** and **Unit 5**. It provides free, highly detailed modules on exactly how to navigate the 510(k)-clearance process, classify medical devices, and execute Corrective and Preventive Actions (CAPA) during a recall.
- **Access:** fda.gov/training-and-continuing-education/cdrh-learn

2. AERB Safety Codes and Guidelines (Medical X-Ray)

- **Format:** Official Statutory Documents (PDF)
- **Relevance:** Mandatory reading for **Unit 4**. The Atomic Energy Regulatory Board provides free access to their official safety codes. Students must use these actual documents to learn the legal formulas for calculating lead-shielding thicknesses and the step-by-step protocols for registering equipment on the e-LORA portal.
- **Access:** aerb.gov.in (Navigate to Publications > Regulatory Documents > Medical)

3. WHO: Global Model Regulatory Framework for Medical Devices

- **Format:** Open-Access Global Health Document (PDF)
- **Relevance:** A foundational text for **Unit 1**. The World Health Organization provides a brilliant, simplified overview of how different countries approach device regulation. It helps students compare the US FDA model against the European CE Marking requirements without getting lost in legal jargon.
- **Access:** who.int (Search title)

Category 2: Free-to-Audit Online Courses (MOOCs)

4. NPTEL / Swayam: Regulatory Requirements for Medical Devices and IVDs

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Backed by the Central Drugs Standard Control Organisation (CDSCO), this course is vital for **Units 1, 2, and 5**. It perfectly translates global standards (like ISO 13485) into the specific regulatory frameworks required for importing, maintaining, and auditing medical equipment within the Indian healthcare ecosystem.
- **Access:** nptel.ac.in

5. Coursera / University of Minnesota: Medical Device Regulatory Affairs

- **Format:** Online Course (Free to Audit)
- **Relevance:** An excellent academic breakdown for **Unit 2**. It walks students through the core philosophy of a Quality Management System (QMS) and teaches them how to build traceability matrices—ensuring they understand the legal weight of properly documenting equipment repairs.
- **Access:** coursera.org

Category 3: Industry Podcasts & Highly Visual Video Channels

6. Medical Device HQ (YouTube Channel)

- **Format:** Regulatory & QA Educational Channel
- **Relevance:** ISO standards are notoriously dry and difficult to read. This channel provides crystal-clear, whiteboard-style breakdowns of **Unit 2**. The creator meticulously explains the ISO 14971 Risk Management process, showing students exactly how to build a hazard traceability matrix for a medical device.

7. Greenlight Guru: The Global Medical Device Podcast

- **Format:** Professional Development Audio/Video Series
- **Relevance:** Greenlight Guru builds specialized QMS software for the medical device industry. Their free podcast is an incredible resource for **Unit 5**. It features interviews with actual FDA auditors and clinical quality engineers discussing real-world horror stories of botched equipment recalls and how a proper CAPA system could have prevented them.
- **Access:** greenlight.guru/podcast or via YouTube

8. Quality Council of India (QCI) & NABH Official Webcasts

- **Format:** Open-Access Training Seminars (YouTube/Web)
- **Relevance:** The absolute best resource for **Unit 3**. The QCI frequently uploads free seminars explaining the exact metrics auditors look for during a hospital inspection. It provides students with the "auditor's perspective" on facility management, equipment calibration logs, and patient safety goals.
- **Access:** qcin.org or QCI Official YouTube Channel

DMET 211: Advanced Diagnostics & Repair

To deliver the **Advanced Diagnostics & Repair** course at the highest professional standard, the learning materials must transition students from being "parts replacers" to forensic engineers. They need resources that teach deep-board diagnostics, advanced metrology, and systemic failure analysis.

Here is a list of 8 high-quality, open-source, and free-to-access resources. They are specifically mapped to advanced oscilloscope metrology, micro-soldering, thermal forensics, and Root Cause Analysis (RCA).

Category 1: Advanced Metrology & Oscilloscope Mastery

1. Tektronix: The XYZs of Oscilloscopes

- **Format:** Open-Access Engineering Primer (PDF)
- **Relevance:** This document is the absolute "bible" for **Unit 2**. Written by one of the world's leading test equipment manufacturers, it thoroughly demystifies advanced triggering, mixed-signal capture, and how to properly probe high-speed digital buses (like I2C and SPI) without introducing parasitic capacitance.
- **Access:** tek.com (Search: "XYZs of Oscilloscopes PDF")

2. EEVblog (YouTube Channel)

- **Format:** Advanced Electronics Engineering Channel
- **Relevance:** Dave Jones' channel is mandatory viewing for **Unit 1** and **Unit 2**. His specific tutorials on "How to use a Spectrum Analyzer and Near Field Probes" and his teardowns of complex multi-layer PCBs will teach students exactly how to hunt down RF leakage and logic-level data corruption that standard multimeters cannot see.

Category 2: SMT Rework & Thermal Forensics

3. PACE Worldwide: Basic to Advanced Rework & Repair

- **Format:** High-Definition Industrial Training Archive (YouTube)
- **Relevance:** PACE sets the industry standard for rework stations. Their highly visual, macro-lens training videos are essential for **Unit 3**. They perfectly demonstrate the exact flux chemistry, thermal profiling, and physical techniques required to safely desolder massive QFP and QFN chips without lifting delicate PCB traces.

4. iPad Rehab / NorthridgeFix (YouTube Channels)

- **Format:** Board-Level Forensic Repair Channels
- **Relevance:** While not strictly medical, these channels are the absolute best free resources in the world for **Unit 1**. They teach students modern "thermal forensics"—using bench power supplies to inject voltage into a shorted power rail and using thermal cameras to find the glowing, short-circuited microscopic capacitor. They also provide masterful tutorials on navigating digital Boardview files and complex schematics.

Category 3: Quality Engineering & Root Cause Analysis

5. ASQ (American Society for Quality) Resource Library

- **Format:** Open-Access Quality Engineering Articles & Templates
- **Relevance:** The definitive resource for **Unit 5**. ASQ provides highly detailed, free templates and methodological breakdowns for Failure Mode and Effects Analysis (FMEA) and Fault Tree Analysis (FTA). It teaches students the rigid, systemic logic required to investigate a catastrophic hospital equipment failure.
- **Access:** asq.org/quality-resources

6. Coursera / University System of Georgia: Six Sigma Principles

- **Format:** Online Course (Free to Audit)
- **Relevance:** Six Sigma is the corporate standard for defect reduction. This course heavily supports **Unit 5**, teaching students the formal "5 Whys" and Ishikawa (Fishbone) diagram methodologies. It transitions the student from a reactive technician into a proactive reliability engineer.
- **Access:** coursera.org

Category 4: Medical Simulators & Schematic Repositories

7. Fluke Biomedical Advantage: Patient Simulator Training

- **Format:** On-Demand Clinical Training Platform
- **Relevance:** The essential resource for **Unit 4**. Fluke manufactures the "ProSim" line, which is the global standard for patient simulators. Their free training modules explain exactly how to generate rare arrhythmias and verify that the simulator's output is legally traceable to international metrology standards (NIST/NABL).
- **Access:** advantagegetraining.docebosaas.com

8. Frank's Hospital Workshop (Component Level Repair Section)

- **Format:** Open-Source Engineering Repository
- **Relevance:** For **Unit 1**, students must practice reading complex, real-world medical schematics. Frank's repository hosts thousands of actual OEM service manuals, many of which include the deep-board schematics, test-point voltages, and block diagrams for patient monitors and power supplies that manufacturers usually keep highly classified.
- **Access:** frankshospitalworkshop.com

DMET 212: Major Project

To ensure your students successfully transition from theoretical concepts to a tangible, functional medical device, they need resources that focus heavily on applied engineering, rapid prototyping, and regulatory-compliant design documentation. A major project fails when a student builds a device that works on a breadboard but cannot be legally documented or safely enclosed for a clinical environment.

Here is a list of 8 high-quality, open-source, and free-to-access resources specifically selected to maximize the probability of success for a physical medical hardware project.

Category 1: Medical Innovation & Design Controls

1. Stanford Byers Center for Biodesign (Video Library & Innovator's Workbench)

- **Format:** Open-Access Video Lectures & Toolkits
- **Relevance:** This is the global gold standard for **Unit 1** and **Unit 2**. Stanford Biodesign focuses heavily on the "needs-driven" approach to medical technology. Their free video library features world-class medical device founders explaining exactly how to observe clinical pain points, conduct market research, and avoid building a prototype that no hospital actually wants to buy.
- **Access:** biodesign.stanford.edu

2. FDA CDRH: Design Control Guidance for Medical Device Manufacturers

- **Format:** Open-Access Regulatory Guidance (PDF)
- **Relevance:** Mandatory reading for **Unit 4** and **Unit 5**. Building a working circuit is only 20% of a medical capstone; proving it is safe is the other 80%. This document teaches students the legal engineering framework—how to document design inputs, perform verification testing against clinical simulators, and draft the final technical thesis.
- **Access:** [fda.gov](https://www.fda.gov) (Search: "Design Control Guidance for Medical Device Manufacturers")

Category 2: Hardware Prototyping & PCB Fabrication

3. Phil's Lab (YouTube Channel)

- **Format:** Advanced Electronics Engineering Channel
- **Relevance:** Essential for **Unit 3**. Medical devices require incredibly clean, noise-free analog signals (like ECG or EEG). Phil's Lab provides masterful, step-by-step tutorials on using open-source Electronic Design Automation (EDA) software like KiCad. He teaches exactly how to route mixed-signal PCBs, isolate ground planes, and design hardware that can pass strict medical electromagnetic interference (EMI) tests.

4. Hackaday.io (Open Source Medical Devices)

- **Format:** Open-Source Engineering Community & Project Repository
- **Relevance:** Highly relevant for **Unit 2** and **Unit 3**. Hackaday hosts thousands of fully documented, open-source hardware projects. Students can search for "medical" or "assistive tech" to study the complete Bill of Materials (BOM), CAD files, and C++ firmware of successful prototypes (such as open-source pulse oximeters or syringe pumps) to understand what a completed Major project should look like.
- **Access:** hackaday.io

5. Autodesk Fusion 360 Official Tutorials (YouTube)

- **Format:** CAD & 3D Printing Video Channel
- **Relevance:** Crucial for the mechanical fabrication in **Unit 3**. A bare PCB is not a medical device; it must be housed in a bio-compatible, ergonomic enclosure. These free tutorials teach students how to design complex 3D-printable enclosures, design snap-fit joints, and ensure their physical prototype can withstand the daily physical abuse of a clinical environment.

Category 3: Embedded Systems & Software Validation

6. Cornell University: ECE 4760 Designing with Microcontrollers (OpenCourseWare)

- **Format:** Open-Access Academic Video Lectures & Lab Manuals
- **Relevance:** The ultimate resource for **Unit 3** and **Unit 4**. Taught by the legendary Bruce Land, this open-courseware focuses entirely on building tangible, physical projects using microcontrollers. The course archives contain hundreds of previous student Major projects (including medical monitors and assistive devices) complete with the raw C code, schematics, and debugging methodologies.
- **Access:** ece4760.github.io or via YouTube (Search: "Cornell ECE 4760")

7. Coursera / Yale University: Introduction to Medical Software

- **Format:** Online Course (Free to Audit)
- **Relevance:** Highly specific training for **Unit 4**. Writing code for a hobby project is vastly different from writing firmware for a medical device. This course teaches students how to structure their code safely, manage state-machines, and use version control (GitHub) to mathematically validate that their software will not crash and harm a patient.
- **Access:** coursera.org

8. NPTEL / Swayam: Product Design and Manufacturing

- **Format:** Online Course (Free to Audit/Download)
- **Relevance:** Aligned with regional technical standards, this course supports **Unit 2** and **Unit 3**. It transitions students from "making a one-off prototype" to "Design for Manufacturing and Assembly" (DFMA). It ensures that the Bill of Materials they draft is actually scalable and that the physical design choices they make can be mass-produced cost-effectively.
- **Access:** nptel.ac.in

APPENDIX – IV

FACULTY REQUIREMENTS

Diploma in Medical Equipment Technology

1. General Faculty Requirement Framework (applies across the curriculum)

For a standard cohort of 20 to 40 students, nearly every one of the 24 subjects uses the same faculty model:

- Team: 1 Course Coordinator / Lead Lecturer + 2 Laboratory Instructors.
- Ratios: 1:30 for theoretical lectures (one Lead Lecturer per cohort); 1:10 for laboratory/practical sessions (one instructor per 10 students) — justified throughout on lab-safety and equipment-damage-prevention grounds.
- Lead Lecturer: Ph.D. or Master's degree (M.Tech / M.E. / M.S., or MBBS/MD for clinical-physiology subjects) in a discipline aligned to the subject. Minimum 3 years of experience (Ph.D./MD tenure counted toward this), drawn from academic teaching or applied industry/clinical R&D.
- Laboratory Instructors: Bachelor's degree (B.Tech / B.E.) or an Advanced Diploma in a subject-aligned discipline. Minimum 2 years of hands-on experience — typically as a field service engineer, hospital biomedical technician, or academic lab manager.
- Recurring competency themes: subject-specific equipment mastery and troubleshooting; strict safety-protocol enforcement (electrical, radiological, laser, biosafety, or gas-pressure hazards depending on the subject); and zoned/rotational supervision when a cohort of 30 is split into safety-limited groups of 10.

2. Faculty Requirements, qualifications, experience and expertise

Lead Lecturer — Qualification	Lab Instructor — Qualification	Key Subject-Specific Skills / Equipment
Ph.D./Master's (M.Tech/M.S./M.E.) — Electrical, Electronics or Biomedical Engg.	Diploma/Bachelor's (B.Tech/B.E.) — Electrical, Electronics or Biomedical Engg.	IEC 60601-1 medical electrical safety; DSOs, function generators, transformers, ELCB testing. Lab staff require valid electrical-safety certification + CPR/AED training
MBBS/MD (Physiology/Anatomy) or Ph.D./Master's (M.Sc./M.Tech) — Medical Physiology, Bioengineering or Clinical Anatomy	Bachelor's/Master's — Nursing, Allied Health Sciences, Biomedical Sciences or BME	Histology slides, 3D anatomical models, cardiopulmonary simulators; manual sphygmomanometers, stethoscopes, 12-lead ECG electrode placement
Ph.D./Master's (M.Tech/M.S./M.E.) — Electronics, Electrical or Biomedical Electronics	Diploma/Bachelor's (B.Tech/B.E.) — Electronics, Instrumentation or BME	SPICE simulation (LTspice/Multisim); DSOs (triggers, transients, phase- shift cursors); ESD safety protocols
Ph.D./Master's (M.Tech/M.S./M.E.) — Instrumentation & Control	Diploma/Bachelor's (B.Tech/B.E.) — BME, Electronics & Instrumentation or Applied Electronics	Wheatstone bridges, glass pH electrodes/KCl handling, DAQ software (NI LabVIEW/Python loggers); dry-electronics + wet- chemistry zone supervision
Ph.D./M.Tech/M.E./M.S. — Computer Science or Health Informatics	M.E/M.Tech/M.S. or distinguished B.E/B.Tech/B.S. — Data Science, Computer Engg. or BME	Python/Scikit- Learn/Pandas, SQL, Wireshark, HL7/DICOM parsing; FDA/SaMD regulations, AI ethics

Lead Lecturer — Qualification	Lab Instructor — Qualification	Key Subject-Specific Skills / Equipment
Ph.D./Master's (M.Tech/M.E.) — Mechanical Engg., Manufacturing Engg., Mechatronics or Industrial Design	Bachelor's/Advanced Diploma — Mechanical Engg. or Tool & Die Making (Machinist); and separately Electronics/Mechatronics/BME (PCB/Prototyping)	AutoCAD/SolidWorks/Fusion 360; welding & workshop safety certification; FDM 3D-printer maintenance, PCB etching (ferric chloride), IPC soldering standards
MBBS/MD (Physiology) or Ph.D./ Master's Clinical Physiology	Bachelor's (B.Sc./B.E/B.Tech) — BME, Respiratory Therapy, Neuro-diagnostics or Allied Health Sciences	Physiological DAQ (Biopac/Vernier), 10–20 EEG electrode placement, spirometry/capnography testing
Ph.D./Master's (M.Tech/M.E.) or highly experienced B.Tech/B.E. — BME, Clinical Engg. or Medical Electronics	Bachelor's/Advanced Diploma — BME, Instrumentation or Allied Health Sciences	Multi-parameter patient simulators (Fluke ProSim), SpO2 functional testers, pressure manometers; NABH/JCI PM & calibration documentation
Ph.D./Master's (M.Tech/M.E.) — E&TC, VLSI Design, Embedded Systems Design, Computer Engg. or Biomedical Electronics	Bachelor's/Advanced Diploma — Electronics, E&TC, Instrumentation or Computer Hardware	Proteus/Logisim simulation; 74XX IC inventory, digital trainer kits, DSO clock-pulse/propagation-delay visualization, 8085/8051 + embedded C/C++, Arduino IDE; DSOs for PWM/SPI/debouncing analysis; guided (not do-it-for-them) debugging

Lead Lecturer — Qualification	Lab Instructor — Qualification	Key Subject-Specific Skills / Equipment
Master's (M.Tech/M.E.) or Ph.D. — Power Electronics, Electrical Engg. or Biomedical Instrumentation	Bachelor's/Advanced Diploma — Electrical Engg., Power Electronics or Industrial Electronics	Buck/Boost & Flyback converters, Line Isolation Monitors (LIM); differential oscilloscope probes, SMPS/UPS component-level rework, 'one-hand rule' HV safety
Master's/Ph.D. — Professional/Technical Communication, Healthcare Administration, Bioethics or Clinical Engg.	Bachelor's/Diploma — Medical Equipment Technology, Nursing or Healthcare Management (role-play facilitation)	Technical/legal documentation, clinical liability & triage ethics; OT etiquette and clinical role-play simulation; AV/multi-camera recording, HIPAA/GDPR data-wipe sandbox management
Ph.D./Master's (M.Tech/M.E.) — BME, Clinical Engg. or Signal Processing	Bachelor's/Advanced Diploma — BME, Medical Electronics or Instrumentation Engg.	Gas Flow Analyzers (e.g. Fluke VT900A), spirometry calibration syringes, ventilator/anaesthesia-workstation teardown; high-pressure medical-gas line safety, Baseline-wander correction, R-peak detection, DRL circuits; 12-lead/10-20 EEG placement, pacemaker pulse capture on oscilloscope, ESU analyzers, defibrillator load boxes, volumetric infusion analyzers; hemodialysis hydraulic de-calcification, syringe-pump stepper rebuilds; strict water/high-voltage separation

Lead Lecturer — Qualification	Lab Instructor — Qualification	Key Subject-Specific Skills / Equipment
Master's (M.Tech/M.E.) or Ph.D. — BME, Medical Physics or Radiological Engg. (RSO certification desirable)	Bachelor's (B.Tech/B.E.) BME/Electronics or B.Sc. Radiological/Imaging Technology	X-ray tube teardown, RaySafe solid-state dosimeters, VNA-based MRI coil tuning; radiation QA (kVp/mAs/HVL), ferromagnetic Faraday- cage discipline, AERB e- LORA portal,
Ph.D./Master's (M.Tech/M.E./M.Sc.) — BME, Instrumentation & Control, Applied Physics or Clinical Laboratory Science	Bachelor's (B.Tech/B.E.) BME/Instrumentation or B.Sc. Medical Laboratory Technology	Beer-Lambert optics, peristaltic pumps, refrigeration cycles; hematology-analyzer micro-aperture cleaning, robotic sample-probe alignment, wet-lab/PCB contamination control
Master's (M.Tech/M.E.) or Ph.D. — Photonics, Optical Engg., Applied Physics or BME (MLSO certification recommended)	Bachelor's/Advanced Diploma — Optoelectronics, BME or Medical Instrumentation	Optical Density/eyewear calculations, Nominal Hazard Zone auditing; fiber stripping/cleaving, Hopkins rod-lens inspection, laser interlock/shutter discipline (ANSI Z136.3)

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Master's (M.Tech/M.E./M.H.A./MB A) or Ph.D. — BME, Clinical Engg., Hospital Administration or Healthcare Supply Chain, Hospital Administration/ Facility Management	Bachelor's (B.Tech/B.E.) — BME, Clinical Technology or IT; data-analytics/supply-chain certifications preferred	MTBF/MTTR statistics, CMMS administration, Excel pivot-table KPI extraction; ECRI/GMDN nomenclature, condemnation-report drafting, HVAC chillers, MGPS & RO water systems, HV power distribution; power-quality analyzers, differential-pressure manometers, vane anemometers; biomedical waste (BMW) law compliance, IEC 60601-1 leakage limits, macro/micro-shock thresholds, ALARA radiation-shielding principles; Electrical Safety Analyzers (Fluke ESA), bloodborne-pathogen (UV powder) drills, FDA 510(k)/CE MDR databases, CAPA reports; ISO 14971 hazard traceability matrices, mock-audit facilitation
Master's (M.Tech/M.E.) or Ph.D. — Electronics Engg., BME or Reliability Engineering (Six Sigma Black/Green Belt desirable)	Bachelor's/Advanced Diploma — Electronics or Instrumentation Engg.; IPC-A-610/J-STD-001 soldering certification a strong advantage	FMEA/Fault Tree Analysis, NABL/NIST calibration traceability; stereomicroscope micro-soldering, mixed-signal oscilloscope bus decoding, Board view/PDF schematic navigation