



BMET 1309

**Introduction to Test,
Measurement, and Diagnostic
Equipment**



About Us

The College of Biomedical Equipment Technology (CBET) is a majority Veteran owned and operated private college offering Biomedical Equipment Technician (BMET), Healthcare Technology Management (HTM) and Healthcare Information Systems Management training at the certificate and associates degree levels. Our leadership team is comprised of individuals with decades of experience in the healthcare industry and education. Similarly, our instructional staff is comprised of industry experts and award-winning educators dedicated to providing quality education, training, and career services to our students.

Locations

Main Campus

105 Windy Meadows, Suites 201
Schertz, Texas 78154
www.cbet.edu

Mission

“The College of Biomedical Equipment Technology delivers premier education and training in Healthcare Technology Management and Information Technology to equip students to meet the evolving needs of the industries we serve.”

ABOUT THE COURSE

The Introduction to Test, Measurement, and Diagnostic Equipment course is designed as an Interactive Distance Learning (IDL) course including asynchronous and synchronous live virtual instruction. The participant experience includes an introduction to Test, Measurement, and Diagnostic Equipment (TMDE) utilized in the performance of maintenance activities on biomedical devices. Students will participate in discussions on the material and equipment covered throughout the course and explain the functions of commonly used test equipment, the importance of calibration, traceability, and documentation in the healthcare industry.

- History of Metrology
- Metrology Standards Organizations
- Medical Device Testing Standards and Organizations
- Electrical Safety Testing Requirements
- Medical Device Technology
- Medical Device Test, Measurement, and Diagnostic
- Troubleshooting Methodologies

COURSE DESCRIPTION

The course is designed to support a student's career readiness by developing a better understanding of the skills required of positions within the Healthcare Technology Management career field. Students will analyze various types of TMDE that is utilized in the performance of scheduled and unscheduled maintenance activities within Healthcare Delivery Organizations (HDO), including Hospitals, Independent Service Organizations (ISO), Original Equipment Manufacturers (OEM), and other service providers. Students will participate in discussions on the material and equipment covered throughout the course and explain the functions of commonly used test equipment, the importance of calibration, traceability, and documentation within the healthcare industry.

LEARNING OBJECTIVES

- LO1. Develop and demonstrate an understanding of the history of Metrology, International and National Metrology Standards, Calibration, and Traceability as it applies to healthcare.
- LO2. Develop and demonstrate an understanding of electrical safety testing standards, standards organizations, testing methodologies, and associated TMDE.
- LO3. Develop and demonstrate an understanding of physiological monitoring technologies, testing methodologies, and associated TMDE.
- LO4. Develop and demonstrate an understanding of clinical laboratory standards organizations and laws, basic clinical laboratory equipment, testing methodologies, and associated TMDE.
- LO5. Develop and demonstrate an understanding of the history and evolution of multimeters, basic troubleshooting techniques, and associated TMDE.
- LO6. Develop and demonstrate an understanding of defibrillators and electrosurgical unit technologies, testing methodologies, and associated TMDE.

TIME-ON-TASK

Time on task is the total learning time spent by a student in this course, including instructional time and time spent studying and completing course assignments and other activities (e.g., reading, research, writing, individual and group projects.) These activities are:

- Attending the weekly webinars
- Reading course presentations/ "lectures"
- Reviewing course notes
- Reading assignment references, books, or other course materials
- Participation in online discussions
- Conducting research
- Writing papers or other assignments
- Completing other assignments (e.g., projects)

Instructional Team

The Biomedical Equipment I is led by instructors via webinar and interactive distance learning formats. In addition to the weekly live sessions, instructors are accessible via the Learning Management System (LMS) daily, and by appointment via Zoom between the hours of Monday through Friday from 1700-2100 (CST).



Zachary (Zack) Nelson serves as an adjunct instructor for the College of Biomedical Equipment Technology and Imaging Academy. In his capacity as an adjunct instructor, Zack leverages his extensive experiences and knowledge of the HTM field. Prior to joining the College, Zack has worked 25+ years in various locations as Biomedical Equipment Technician (BMET), Field Service Engineer (FSE), Lead BMET, and currently the Director of Biomedical Engineering at a critical access hospital in Arizona. Throughout the course, Zack can be contacted directly through CANVAS messaging or via e-mail at znelson@cbet.edu, during office hours, Monday through Friday, 0800-1700 CST.

Instructional Methods and Activities

The student online learning environment is structured to mirror the course syllabus and includes all the information students require to successfully navigate the course. The online learning environment, referred to as CANVAS, provides a means for students to engage, communicate, and learn. CBET instructors will actively engage students in CANVAS via discussion board forums and other activities designed to cultivate student engagement and participation.

Online Classes (Daily): Students are expected to engage in CANVAS. Courses include weekly assignments, quizzes, tests, and other requirements prescribed by the instructor. Students are responsible for completing weekly assignments in a timely manner as prescribed by the instructor(s). It is important to remember that in addition to the resulting grades, completion of weekly assignments is also used to measure student engagement, attendance, and participation.

Weekly Live Webinars: Mandatory instructor led webinars will be conducted at least once per week (60 Minutes). Additionally, students may request one-on-one counseling or tutoring sessions based on the instructor's availability. Webinars are not optional; however, we understand that from time-to-time students may not be able to attend in person. If you cannot attend a live session, the webinars will be posted in CANVAS for review.

Online Discussion Forum (Daily/Weekly): CANVAS includes a discussion board with weekly prompts and instructions for completing daily/weekly assignments. Students are required to respond to all weekly discussion board topics and instructor-directed prompts. Responses must be substantive and meet the minimum word count requirement. Additionally, students are required to engage with peers by responding to no fewer than two student responses per week. Student participation and attendance in CANVAS is reported to the Director of Education on a weekly basis and the information is used, in part, to measure attendance and participation in the course.

Late/Make-up work: All assignments must be completed on time and as instructed to receive full credit. Make-up work shall:

1. Be supervised by an instructor approved for the subject being made up.
2. Require the student to demonstrate the same knowledge or competence expected of a student who attended the scheduled class session.
3. No more than 5% of the missed work can be made up. All work must be completed and submitted within seven (7) calendar days of its original due date. All coursework must be submitted no later than six (6) calendar days after the course ends.

WEEK 1/MODULE 1 (Introduction to Metrology)

Learning Objective 1: Develop and demonstrate an understanding of the history of Metrology, International and National Metrology Standards, Calibration, and Traceability as it applies to healthcare.	
TLO 1	History of Metrology, Applied Metrology, Legal Metrology, and Scientific Metrology.
TLO 2	International Standards of Units and Standards Organizations.
TLO 3	Calibration and Traceability.

Module 1 Overview:

The first course module requires students to demonstrate their understanding of the history of metrology, international and national standards, international and national standards organizations, calibration and traceability concepts.

Week 1 Discussion Questions

Discussion Question (DQ) 1: Introduce yourself to the class by describing your (1) professional background, (2) where you work currently, and (3) why you are interested in entering the Healthcare Technology Management (HTM) (Biomedical) career field. If you are already in the HTM Industry, describe your career objectives related to this program. [Minimum 200-word response for full credit]

Discussion Question (DQ) 2: For this discussion, we are going to work toward applying what you learned from this week's material. Discuss at least two of the following topics: (1) Why is standardization in metrology important? (2) How is calibration traceability established? (3) What were the SI Base Units established in 1960? [200-word minimum response due by Thursday and at least two responses to your peers of 150-word minimum due by Sunday]

Webinar Session (60 Minutes): The Module 1 webinar will include a course overview and instructions to improve the student's ability to access the materials. Following the introductory portion, we will explore; History of Metrology, Scientific Metrology, Applied Metrology, Legal Metrology, International System (SI) of Units, SI Base Units, SI Coherent Derived Units, Calibration, and Traceability.

Week 1 Assignments

Assignment 1: Reading assignment (0 points) – Read chapters 1 through 7 of The Metrology Handbook. Supplemental reading – “The Measure of All Things, A Brief History of Metrology”, “Adjustment, calibration, and verification”, “Traceability”

Assignment 2: Video assignment (0 points) - “Why Metrology Matters”

Assignment 3: Summary - students must upload a Word document summarizing the information presented during the week referencing the reading assignments, video assignments, discussion questions, and webinar. [250-word minimum, due by Sunday 11:59 PM Central Time]

Assignment 4: Quiz - 10-questions covering the material presented in the reading, video, and webinar. 30-minute time limit, 50 points.

WEEK 2/MODULE 2 (Electrical Safety)

Learning Objective 2: Develop and demonstrate an understanding of electrical safety testing standards, standards organizations, testing methodologies, and associated TMDE.

TLO 1	Physiological Effect of Electricity
TLO 2	Electric Macro-shock and Micro-shock
TLO 3	Codes and Standards
TLO 4	Equipment Safety Practices
TLO 5	Electrical Safety Testing
TLO 6	Virtual Reality Lab – Electrical Safety Analyzers

Module 2 Overview:

During week 2 students will develop an understanding of the physiological effects of electricity on the human body, macro-shock and micro-shock, medical equipment electrical safety codes, standards and standards organizations, medical equipment safety practices, and electrical safety testing of medical equipment.

Week 2 Discussion Questions

Discussion Question (DQ) 1: For this discussion, we are going to work toward applying what you learned from this week's material. Discuss at least two of the following topics: (1) What is micro-shock and macro-shock? (2) What is the freezing or "can't let go" current? (3) What are the classes and types of Medical Electrical Equipment per IEC 60601? [200-word minimum response due by Thursday and at least two responses to your peers of 150-word minimum due by Sunday]

Webinar Session (60 Minutes): The week 2 webinar will be oriented towards physiological effects of electricity on the human body, macro-shock and micro-shock, medical equipment electrical safety codes, standards and standards organizations, medical equipment safety practices, and electrical safety testing of medical equipment.

Week 2 Assignments

Assignment 1: Reading Assignment (0 Points) - "Electrical Safety Testing part 1", "Electrical Safety Testing part 2", and "An Introduction to electrical safety testing in accordance with IEC 62353".

Supplemental reading- "Rigel Medical A Practical guide to IEC 60601" and "Ralph Nader's Most Shocking Expose".

Assignment 2: Video Assignment (0 Points) - "Electrical Analyzers and testing Procedure for NFPA 99with Fluke ESA 609"

Assignment 3: Week 2 Summary - Students must upload a Word document summarizing the information presented during the week referencing the reading assignments, video assignments, discussion questions, and webinar. [250-word minimum, due by Sunday 11:59 PM Central Time]

Assignment 4: Quiz - 10-questions covering the material presented in the reading, video, and webinar. 30-minute time limit, 50 points.

Assignment 5: Virtual Reality Lab, Electrical Safety Analyzers, 100 points

WEEK 3/MODULE 3 (Risk Management)

Learning Objective 3: Develop and demonstrate an understanding of physiological monitoring technologies, testing methodologies, and associated TMDE.

TLO 1	Physiological Patient Monitors and Telemetry. Non-Invasive Blood Pressure, Pulse Oximetry, End Tidal CO ₂ , Respirations, and Temperature.
TLO 2	Electrocardiogram
TLO 3	Multiparameter Patient Simulators
TLO 4	Testing Methodologies
TLO 5	Common Issues

Module 3 Overview:

During module 3 students will develop and demonstrate an understanding of physiological monitoring technologies, testing methodologies, and associated TMDE.

Week 2 Discussion Questions

Discussion Question (DQ) 1: (1) What are two methods of measuring Non-Invasive Blood Pressure (NIBP)? (2) What are two methods of measuring Respiration Rate (RESP)? (3) What are two methods of measuring Oxygen Saturation (SpO₂)? [200-word minimum response due by Thursday and at least two responses to your peers of 150-word minimum due by Sunday]

Webinar Session (60 Minutes): The week 3 webinar will be oriented towards physiological patient monitors and telemetry, parameters that are measured such as Non-Invasive Blood Pressure, Pulse Oximetry, End Tidal CO₂, Respirations, and Temperature. Electrocardiography, Multiparameter Patient Simulators, Testing Methodologies, and common issues.

Week 2 Assignments

Assignment 1: Reading assignment (0 Points) - "Testing of Multiparameter Patient Monitors" and "NIBP Monitoring and Testing".

Supplemental reading – "Masimo Rainbow SpO₂ technology and testing", "There is no such thing as a SpO₂ simulator", "Tips for Testing Patient Monitors".

Assignment 2: Video assignment (0 points) - "Vital Aspects of Testing Vital signs Monitoring", Principles of Electrocardiograph", and "Fundamentals of Pulse Oximetry".

Assignment 3: Week 3 Summary - students must upload a Word document summarizing the information presented during the week referencing the reading assignments, video assignments, discussion questions, and webinar. [250-word minimum, due by Sunday 11:59 PM Central Time]

Assignment 4: Quiz - 10-questions covering the material presented in the reading, video, and webinar. 30-minute time limit, 50 points.

WEEK 4/MODULE 4 (Basic Clinical Laboratory Equipment)

Learning Objective 4: Develop and demonstrate an understanding of clinical laboratory standards organizations and laws, basic clinical laboratory equipment, testing methodologies, and associated TMDE.

TLO 1	Explore the AAMI website and identify HTM-related certifications; relate the certifications to the Biomedical Equipment Technician career path.
TLO 2	Examine the Certified Associate in Biomedical Technology (CABT) certification and identify the value of the CABT certification to a Biomedical Equipment Technician.
TLO 3	Examine the Certified Biomedical Equipment Technician (CBET) certification and identify the value of the CBET certification to a Biomedical Equipment Technician.
TLO 4	Evaluate potential salary based on education, location, experience, organization, and other factors influencing compensation.
TLO 5	Evaluate other industry recognized certifications, such as those offered by CompTIA and DNV Health; relate the value of additional industry certifications to the Biomedical Equipment Technician career path.

Module 4 Overview:

During module 4 students will develop and demonstrate an understanding of clinical laboratory standards organizations and laws, basic clinical laboratory equipment, testing methodologies, and associated TMDE.

Week 4 Discussion Questions

Discussion Question (DQ) 1: (1) How has the Clinical Laboratory Improvement Amendments, or CLIA policies and regulations impacted the Biomedical Equipment Technician's role in testing and documenting clinical laboratory equipment? (2) What is hemolysis and what are the negative physiological side effects? [200-word minimum response due by Thursday and at least two responses to your peers of 150-word minimum due by Sunday]

Webinar Session (60 Minutes): The module 4 webinar will include be orientated towards: laboratory standards and accreditation organizations, centrifuges, CO2 incubators, cold storage (blood bank refrigerators, general use lab refrigerators, and freezers), microscopes, as well as general laboratory equipment.

Week 4 Assignments

Assignment 1: Reading assignment (0 points) - "Routine Maintenance of Centrifuges" and "Practical tips for microscope care and maintenance"

Assignment 2: Video assignment (0 points) – "Centrifuges", "How to check centrifuge speed", and "Laboratory Microscopes".

Assignment 3: Week 4 Summary - students must upload a Word document summarizing the information presented during the week referencing the reading assignments, video assignments, discussion questions, and webinar. [250-word minimum, due by Sunday 11:59 PM Central Time]

Assignment 4: Quiz. 10-questions covering the material presented in the reading, video, and webinar. 30-minute time limit, 50 points.

WEEK 5/MODULE 5 (Training Management)

Learning Objective 5: Develop and demonstrate an understanding of the history, evolution, and use of multimeters, multimeter safety, manometers, digital pressure meters, digital thermometers, and basic troubleshooting techniques.

TLO 1	Multimeters – History, Safety, and Measuring Current, Resistance, and Voltage.
TLO 2	Manometers.
TLO 3	Digital Pressure Meters.
TLO 4	Digital Thermometers.
TLO 5	Troubleshooting.

Module 5 Overview:

During module 5 students will develop and demonstrate an understanding of the history, evolution, and use of multimeters, multimeter safety, manometers, digital pressure meters, digital thermometers, and basic troubleshooting techniques.

Week 5 Discussion Questions

Discussion Question (DQ) 1: (1) What is Root-Mean-Square (RMS) as applicable to multimeters? (2) What is the first step in troubleshooting an equipment malfunction? (3) What are the 5 whys? [200-word minimum response due by Thursday and at least two responses to your peers of 150-word minimum due by Sunday]

Webinar Session (60 Minutes): The module 5 webinar will include be orientated towards: the history, evolution, and use of multimeters, multimeter safety, manometers, digital pressure meters, digital thermometers, and basic troubleshooting techniques.

Week 5 Assignments

Assignment 1: Reading assignment (0 points) – “The Basics of Digital Multimeters” and “ABCs of multimeter safety”

Assignment 2: Video assignment (0 points) – “Measuring voltage with a digital multimeter”, “Measuring resistance with a digital multimeter”, “Measuring current with a digital multimeter”, and “Beginners Troubleshooting Medical Device Power”

Assignment 2: Week 5 Summary - students must upload a Word document summarizing the information presented during the week referencing the reading assignments, video assignments, discussion questions, and webinar. [250-word minimum, due by Sunday 11:59 PM Central Time]

Assignment 2: Quiz - 10-questions covering the material presented in the reading, video, and webinar. 30-minute time limit, 50 points.

WEEK 6/MODULE 6 (Advanced Systems)

Learning Objective 6: Develop and demonstrate an understanding of defibrillators and electrosurgical unit technologies, testing methodologies, and associated TMDE.

TLO 1	Defibrillators: history, maintenance, and troubleshooting
TLO 2	Automatic External Defibrillators: history, maintenance and troubleshooting
TLO 3	Electrosurgical Units: maintenance and troubleshooting
TLO 4	Electrosurgical Diathermy: maintenance and troubleshooting
TLO 5	Virtual Reality Lab: Zoll R Series Defibrillator PM
TLO 6	Virtual Reality Lab: ESU FT10 PM

Module 6 Overview:

During module 6 students will develop and demonstrate an understanding of defibrillators, automatic external defibrillators, electrosurgical units, electrosurgical diathermy units, testing methodologies, and associated TMDE.

Week 6 Discussion Questions

Discussion Question (DQ) 1: (1) Monophasic vs Biphasic Defibrillation, (2) Cardioversion vs Pacing, and (3) Monopolar vs Bipolar Mode Electrosurgery. [200-word minimum response due by Thursday and at least two responses to your peers of 150-word minimum due by Sunday]

Webinar Session (60 Minutes): The module 6 webinar will include be orientated towards: the history, maintenance, and troubleshooting of defibrillators and automatic external defibrillators (AED), maintenance and troubleshooting of electrosurgical and diathermy units.

Week 6 Assignments

Assignment 1: Reading assignment (0 points) – “What is defibrillator testing”, “PM on ESU”.

Supplemental reading (0 points) – “10 Best Practices for ESU Testing”

Supplemental videos (0 points)

Assignment 2: Week 6 Summary - students must upload a Word document summarizing the information presented during the week referencing the reading assignments, video assignments, discussion questions, and webinar. [250-word minimum, due by Sunday 11:59 PM Central Time]

Assignment 3: 50 questions covering the materials presented over the 6-week course. 90-minute time limit, 100 points (15% of course grade)

Assignment 4: Virtual Reality Lab, Zoll Defibrillator PM, 100 points

Assignment 5: Virtual Reality Lab, ESU FT10 PM, 100 points

Note: Please remember to complete the end of course survey prior to the last day of class.

Course Grade Distribution

Discussion Board Requirements	25%
Weekly Webinars and Assignments	30%
Weekly Quizzes	30%
Mid-Term & Final Exam	15%

Discussion Board Grading Criteria (25% of overall grade)

Students are required to respond to all weekly discussion board topics and instructor-directed prompts. Responses must be substantive and meet the minimum word count requirement. Additionally, students must engage with peers by responding to no fewer than two peer-to-peer responses per week. The following rubric is used as a guide by instructors to evaluate and grade student responses to discussion questions and peer-to-peer engagement:

	Beginning	Developing	Accomplished	Exemplary
	0-25 Points	25-50 Points	50-75 Points	75-100 Points
Weekly Discussion Question Responses (Minimum of two 200-word responses per week).	Contributes fewer than the required 2 Discussion Question (DQ) responses.	Contributes 2 Discussion Question (DQ) responses but one or both fail to meet minimum word-count requirements for the DQ.	Contributes by providing 2 Discussion Question (DQ) responses and meets the minimum word count requirements for the DQ.	Exceeds required DQ word count requirements and/or provides an exemplary response to a DQ.
Weekly Engagement with peers (Minimum of two 200-word responses to peers each week).	Contributes fewer than the required peer-to-peer responses in the discussion forum.	Contributes 2 peer-to-peer responses in the discussion forum but fails to meet minimum word-count requirements and lacks substance.	Contributes by providing 2 peer-to-peer responses and meets the minimum word count requirement for the peer-to-peer response.	Exceeds required peer-to-peer response requirements by meeting the minimum word count requirement and providing substantive responses to peers.
Quality and Content of DQ responses and peer-to-peer responses in the Discussion Forum.	Postings in the discussion forum are not relevant to the assigned topic, are inaccurate, or misrepresented.	Postings in the discussion forum address peripheral topics, are generally accurate, but may contain factual omissions and/or errors.	Postings are generally substantive; however, responses rely too heavily on opinion than fact. Postings meet word count requirements but lack scholarly tone or appropriate references.	Discussion Question and Peer-to-Peer postings consistently contribute to the discussion, contain substantive comments backed by relevant references and encourage open dialogue and additional discussion in the class.

Weekly Assignments (30% of overall grade)

Mandatory instructor-led webinars will be conducted at least once per week (60 Minutes). Webinars are not optional; however, we understand that from time-to-time students may not be able to attend in person. If you cannot attend a live session, the webinars will be posted in CANVAS for review. Instructors will assign weekly assignments associated with the live webinars.

Weekly Quizzes (30% of overall grade)

Students will be assigned homework on a weekly basis. Homework may consist of a wide variety of deliverables. Quizzes are assigned in weeks one, two, and five. Worksheets are assigned in weeks two and four. Homework may include a wide array of requirements, ranging from written assignments, research projects, Power-Point presentations, and a host of other activities. In all cases, instructors will endeavor to ensure that students possess a clear understanding of the requirements and expectations.

Exams (15% of overall grade)

The course includes a midterm exam in week three and a final exam in week six. The exam format includes multiple choice, true or false questions, diagrams, and matching. An exam review will be conducted during the live webinar on weeks three and six.

Grading System for the College of Biomedical Equipment Technology

A	90-100	4.0	F	59 & Below	0.0
B	80-89	3.0	W	Withdrawal	N/A
C	70-79	2.0	I	Incomplete	N/A
D	60-69	1.0	T	Transfer	N/A

To receive an incomplete “I”, the student must petition the instructor for an extension to complete the required coursework. The student must be able to pass the course with the completed work and garner a grade of 70 or better. Incomplete grades that are not completed within 7 business days after the beginning of the next session will be converted to the existing grade earned in the course and will affect the student’s GPA accordingly. CBET reserves the right to extend the time needed to fulfill the incomplete.

An “I” does not count towards the Grade Point Average (GPA) until a grade is assigned. A “W” is given when a student is dropped from the roster during the course and does not replace the previous grade(s). Grades of “W” and “F” are recorded in the academic transcript and reflected in the GPA. When a course is repeated after failure or withdrawal, the later grade will replace the first grade in calculating the CGPA. The clock hours of the course repetition are counted toward the maximum timeframe. CBET shall record a grade of “incomplete” for a student who withdraws but is not entitled to a refund if the student requests the grade at the time the student withdraws, and the student withdraws for an appropriate reason unrelated to the student’s academic status.

A student must repeat a course in which a grade of “F” was received. A student can repeat each course once, however, once they reach 1.5 times the length of time required for graduation, they will be dropped from the program. If a student fails any course a second time, he/she will be dropped from the program. A failed course will be rescheduled for the earliest possible module at the discretion of the Director of Education. Students will be charged to retake the course.

Additional Resources and Points of Contact

Students requiring additional administrative support are encouraged to contact the Colleges Student Advocate, Mrs. Terri Gomez, at 210.233.1102 or via e-mail at tgomez@cbet.edu

For a complete list of administrative policies and regulations refer to the CBET Catalog at <https://cbet.edu/course-catalog>

NOTE: THE INSTRUCTOR RESERVES THE RIGHT TO MODIFY THIS SYLLABUS and COURSE OUTLINE