Biomedical Electronics Technician (BMD)
Competency Requirements

Biomedical electronics technicians are expected to obtain knowledge of the principles of modern biomedical techniques, the proper procedure in the care, handling and maintenance of biomedical equipment and to display an attitude/behavior expected of an electronics technician who works in a hospital or healthcare environment. Once the CET has acquired these skills, abilities and knowledge, he or she will be able to enter employment in any part of the biomedical electronics field. With minimal training in areas unique to specific products, the CET should become a profitable and efficient part of the medical workforce.

Biomedical Electronics Technicians must be knowledgeable and have abilities in the following technical and human relations areas:

1.0 THE HUMAN NERVOUS SYSTEM

- 1.1 Explain the major functions of the nervous system
- 1.2 List the major parts/divisions of the nervous system
- 1.3 Describe the functions of each part/division of the nervous system including the peripheral and the autonomic nervous system
- 1.4 Define the terms related to each part/division of the nervous system. e.g.: homeostasis; nerve impulse; neuron; reflex action; equilibrium cerebral dysfunction; lobes; etc.
- 1.5 Describe the function of the EEG machine
  - 1.5.1 List the functional problems associated with the EEG machine
  - 1.5.2 List the basic care/maintenance procedures of the EEG machine
- 1.6 Describe the function of the cerebellum
- 1.7 Describe the function of the cerebrum
- 1.8 Describe the function of the central nervous system

2.0 MEDICAL ELECTRODES

- 2.1. Define an electrode
- 2.2 Define the term “biopotentials”
- 2.3 Explain how impedance mismatches between electrodes and skin surfaces can affect accuracy in measurements
- 2.4 Give an approximate impedance of wet human skin
- 2.5 Give an approximate impedance of dry skin
- 2.6 Define the term “Half cell potential”
- 2.7 Name different types of electrodes and the body organs to which they are applied
- 2.8 Describe the shapes of electrodes as they relate to their applications
- 2.9 Describe the chemical/paste applied between electrode and skin
- 2.10 Define the types of “artifacts” and their causes
- 2.11 List some measures which can be adopted to minimize or avoid artifacts

3.0 CABLES AND CABLING

- 3.1 Describe the unshielded twisted pair (UTP)
- 3.2 State where UTP cabling is used
- 3.3 Demonstrate ability to install RJ45/48 connectors and fittings
- 3.4 Explain the difference between single twisted pair and CAT-5
- 3.5 Explain where 10baseT is used and its frequency capabilities
- 3.6 Describe the T568A / T568B standards and explain their purpose
- 3.7 Explain how Cable TV coaxial cable wiring is used for data and voice services
- 3.8 Explain the differences between coax types RG 58, RG 59 and RG 6

4.0 COMPUTER

- 4.1 Describe the interrelationship between computers and communications technology usage
- 4.2 Explain how a Modem interfaces with the computer
  - 4.2.1 Explain CTI—Computer Telephony Integration
- 4.3 Describe worldwide numbering systems
- 4.4 Define network control points
- 4.5 Define database

5.0 TRANSDUCERS

- 5.1 Describe a transducer
- 5.2 Sketch the configuration of a Wheatstone Bridge
- 5.3 Explain how a Wheatstone Bridge can be compared in configuration with most biomedical transducers
- 5.4 Describe the types of transducers used in biomedical instrumentation
- 5.5 Sketch the electrical configuration of different transducers
- 5.6 Name the units of transducer sensitivity
- 5.7 Define the terms associated with transducers. e.g.: piezoresistance, thermocouple, impedance

6.0 MEDICAL ELECTRONICS SAFETY

- 6.1 Define electrical safety
- 6.2 List the names of major organizations which publish electrical safety codes and standards
- 6.3 List responsibilities of hospital staff regarding safety
- 6.4 Relate how preventive maintenance reduces electrical hazards
- 6.5 Define corrective maintenance
- 6.6 Define preventive maintenance
- 6.7 Explain the insurance and legal requirements regarding electrical safety
- 6.8 Develop an electrical safety program for a typical hospital
- 6.9 Explain the physiological effects of poor safety measures on the human body
- 6.10 Define leakage current
- 6.11 Explain the usefulness of A.C. line isolation systems
- 6.12 List the dangers associated with poor grounding
- 6.13 Describe required grounding of electronics equipment
- 6.14 Explain how hazards through ground faults can be reduced
- 6.15 Administer electrical safety tests on equipment
- 6.16 Explain precautions required for H.I.V. or TB prevention for hospital workers
- 6.17 List precautions for working with/on ladders
- 6.18 List extra precautions biomed personnel must take to maintain cleanliness standards in medical facilities
- 6.19 Describe the following safety code standards:
  - 6.19.1 NFPA 99
  - 6.19.2 NFPA 70
  - 6.19.3 NFPA 102
  - 6.19.4 CFR 21
- 6.20 Describe microshock (also called cardiac shock)
- 6.21 Describe macroshock
- 6.22 State the ground resistance limit for *existing* portable medical equipment in patient care areas
- 6.23 State the ground resistance limit for *new* portable medical equipment in patient care
- 6.24 State the chassis leakage current limit for portable medical equipment in patient care areas
- 6.25 State the lead leakage current limit for portable medical equipment in patient care areas
- 6.26 Describe the current radiation safety rules required in medical equipment use and maintenance
- 6.27 Describe the current rules for safety in the maintenance and use of medical laser equipment
- 6.28 Describe fire safety rules commonly required for medical equipment maintenance personnel
- 6.29 Describe chemical rules commonly required for medical equipment maintenance personnel

7.0 HEMODIALYSIS EQUIPMENT

- 7.1 Describe the functions of the kidneys
- 7.2 Define terms used in the study of the kidneys (e.g.: dialysis, renal, dialysate, etc.)
- 7.3 Explain why kidney failure requires hemodialysis treatment
- 7.4 State the functions of the dialysis machine
- 7.5 Sketch the main function blocks of a dialysis machine (e.g.: power supply, pressure monitor, blood pump, control panel and these systems - temperature, bath delivery, drain, circulating)
- 7.6 Explain the function of each block or section of the machine
- 7.7 State the special safety precautions associated with the wet environment of a dialysis machine (e.g.: magnetically coupled motor shaft impeller system, ground fault interrupters)
- 7.8 State some of the common problems with dialysis machines
- 7.9 List a weekly maintenance schedule for a dialysis machine

8.0 NETWORKING

8.1 Describe the problems which are commonly encountered when interconnecting electronics products
8.2 Explain electrical surge potentials
8.3 List ways to combat damage from electrical surges
8.4 Describe medical industry safety standards
8.5 State the expected voltage, current or signals expected at interconnection or equipment interface points
8.6 Describe PCIA and wireless computer communications interfacing procedures used with medical equipment
8.7 Describe the Internet and its usefulness in medical data communications
8.8 Explain TCP/IP duties and protocols
8.9 Explain security problems with Internet service

9.0 MEDICAL ULTRASOUND INSTRUMENTS

9.1 Describe applications of medical diagnostic ultrasound (cardiology, ob/gyn, radiology, etc.)
9.2 Explain the purpose of ultrasound in medical applications
9.3 Define the terms associated with ultrasound (e.g.: wavelength, acoustics, reflection, refraction, piezo effects, echocardiography, Doppler effects)
9.4 Explain the physics of sound waves w.r.t., wavelength, velocity, period, frequency, reflection, refraction and resonator
9.5 Explain the biological effects of ultrasound
9.6 Describe the operation of the instruments used in delivering ultrasound (e.g.: the Doppler flow meter, blood pressure monitor, fetal monitor, echocardiography and echoencephalography)
9.7 Describe the operation ultrasound instruments
9.8 List safety precautions regarding the maintenance and use of ultrasound instruments
9.9 Describe the types of transducers used in medical diagnostic ultrasound
9.10 Distinguish between “sector” scans and “linear” scans
9.11 Define “axial resolution” and “lateral resolution”
9.12 Define “dead zone” as it applies to ultrasound
9.13 Describe the “front end” of an ultrasound scanner
9.14 Define “scan conversion”
9.15 Distinguish between “Spectral Doppler” and “Color Flow Doppler”
9.16 Define and describe a DICOM system
9.17 Explain the components of a video signal

10.0 MATHEMATICS

10.1 Use mathematics to solve biomedical problems
10.2 Describe color coding systems used for electronics components and electrical wiring
10.3 Apply decibels to calculate signal loss in coaxial and fiber wiring
10.4 Convert numbering systems such as binary, decimal, octal and hexadecimal
10.5 Demonstrate the ability to use scientific calculators
10.6 Prepare cost estimates for a major electronic repair or installation

11.0 BUILDING WIRING

11.1 List the standards used in the electrical wiring of buildings
11.2 Explain methods of pre-wiring and ways to wire existing buildings including entry, attic and crawl space precautions and methods of fishing walls and routing wiring through false ceilings.
11.3 Explain National Electrical Code (NEC®) or other safety rules pertaining to building wiring and grounding

12.0 OPTICAL WIRING

12.1 Demonstrate the rules for disposal and eye safety when working with fiber optics cabling
12.2 Describe the types of optical cables-show knowledge of different parameters and reasons for choosing each
12.3 Describe the conversion process from copper to fiber signals and from fiber to copper
12.4 Define and explain the term SONET

13.0 RADIOLOGY

13.1 List the main functions of an X-ray machine
13.2 Describe the therapeutic applications of X-ray machines
13.3 State the diagnostic (measurement) function of an X-ray machine
13.4 State the different categories of X-ray machines (e.g.: still picture, continuous and motion picture)
13.5 List the dangers associated with X-rays
13.6 Name the units used for measuring radioactivity (e.g.: curie, Roentgen, Dose rate)
13.7 Explain the terms used in the study of radiology (e.g.: gamma, beta and alpha rays, nuclear radiation, etc.)
13.8 Sketch the circuit diagram of an X-ray tube
13.9 Sketch the circuit diagram of a Geiger-Mueller tube
13.10 Explain how the X-ray tubes work
13.11 Discuss the safety precautions associated with the handling of X-ray tubes
13.12 List common problems/faults of X-ray tubes
13.13 Sketch the circuit diagram of an X-ray machine

14.0 TEST EQUIPMENT AND TOOLS

14.1 Demonstrate proper use of common biomedical and electronic test equipment
14.2 Describe the use of Time Domain Reflectometers and OTDRs
14.3 List services which provide test equipment calibration for commonly used biomedical instruments
14.4 Describe proper use and care of soldering and desoldering equipment and the hazards of utilizing leaded solder
14.5 Show ability to properly prepare cable ends
14.6 Install fittings on cable ends and splices
14.7 Describe the functions of a medical oscilloscope
14.8 List the main differences between a medical, and a laboratory or service oscilloscope
14.9 List the characteristics of a medical oscilloscope (sweep speed, display format, persistence, etc.)
14.10 Sketch the block diagram of a medical oscilloscope
14.11 Explain the difference between a single beam and a dual trace scope
14.12 Define related terms e.g.: gating amplifier, bouncing ball, and nonfade designs

15.0 TROUBLESHOOTING

15.1 Demonstrate proper usage of test equipment as well as common DVM's, signal tracers and sources, oscilloscopes and loop and network testing equipment
15.2 Describe "Last good, first Bad" troubleshooting
15.3 Describe "Divide and Conquer" troubleshooting technique
15.4 Show how to use static arresting test procedures
15.5 List types of EMI which may affect the validity of test equipment results
15.6 Demonstrate diagnosis and repair of defective electronic medical equipment

16.0 OPERATING ROOM FAMILIARIZATION

16.1 Describe the functions of the Operating Room (OR)
16.2 Describe the protocols involved in working in the OR (dress code, cleanliness and attitude)
16.3 List the duties of the personnel employed in the OR (e.g.: the nursing staff, biomedical technician, surgeon, etc.)
16.4 List the special equipment used in the OR
16.5 List the functions of the equipment used in the OR
16.6 Describe why anesthetics are used and what types are commonly used
16.7 List the safety precautions observed in the OR
16.8 List the different methods of sterilization
16.9 Define terms used in surgery. e.g.: antiseptic, suture thread, autoclave, orderlies, sterilization spore strip, etc.
16.10 Describe different methods of sterilization (steam, ETO, etc.)

17.0 INSTRUMENTATION—RESPIRATORY

17.1 List the principle pulmonary parameters measured (capacities such as vital, functional, inspiratory, total lung; tidal, inspiratory reserve, expiratory, reserve, residual minute)
17.2 Describe the various respiratory transducers

17.3 List the instruments used with the respiratory system (spirometers, apnea monitor, etc.)
17.4 Describe the function of the instruments used in the respiratory system
17.5 Define the various volumes measured (Tidal, inspiratory reserve, expiratory, reserve, residual minute)
17.6 Describe the operation of adult and pediatric ventilators

18.0 INSTRUMENTATION-THE MEDICAL LABORATORY

18.1 State the main functions and composition of blood
18.2 List the instruments used in the medical laboratory including:
- 18.2.1 calorimeters
- 18.2.2 photometer
- 18.2.3 spectrophotometer
- 18.2.4 pH analyzer
- 18.2.5 autoanalyzer
- 18.2.6 chromatograph
- 18.2.7 dialyzer

18.3 State the maintenance procedures for the following medical lab instruments:
- 18.3.1 Blood Gas Analyzers
- 18.3.2 Co-Oximeters
- 18.3.3 Centrifuges
- 18.3.4 Microscopes
- 18.3.5 Cell Counters
- 18.3.6 Chemistry Analyzers

19.0 ELECTROSURGERY GENERATORS

19.1 Describe the function of the Electrosurgery (ESU) generator
19.2 Describe the operation of the Electrosurgery generator
19.3 Sketch the block diagram and related waveforms of an Electrosurgery generator
19.4 List the safety measures to be adopted when using the Electrosurgery generator
19.5 Describe the type of waveforms generated (coagulate, cut)
19.6 List the frequencies commonly used by Electrosurgical scalpels
19.7 Describe “REM” (return electrode monitoring)
19.8 Describe testing requirements for Electrosurgery Units

20.0 INTENSIVE AND CORONARY CARE UNITS

20.1 Describe the function and purpose of the special care units in the hospital
20.2 List the instrument systems used in ICU and CCU
20.3 Troubleshoot common problems associated with equipment used in ICU and CCU (e.g.: bedside monitors, cardiotachometers, alarms, lead fault indicators, central monitoring consoles, invasive blood pressure and radiotelemetry)

21.0 CARDIAC SUPPORT SYSTEM

21.1 Describe the principles of defibrillation
21.2 Describe the principles and operation of the pacemaker
21.3 Describe the principles and operation of the cardioverter
21.4 Describe the principles and operation of the intra-aortic balloon pump
21.5 List three types of cardiac arrhythmias
21.6 Describe the events taking place in each part of the ECG waveform
21.7 Detail the minimum energy required from an implantable pacemaker
21.8 Detail the minimum energy required from an external pacemaker
21.9 Troubleshoot problems associated with cardiac support machines
21.10 Describe the principles and operation of the cell saver machine
21.11 Sketch the main parts of a basic cardiopulmonary bypass circuit
21.12 Describe all the available types of blood pumps including:
- 21.12.1 roller pump
- 21.12.2 modified roller pump for pulsatile perfusion
- 21.12.3 centrifugal pump

21.13 Describe proper testing of a defibrillator (general steps)

22.0 BIOELECTRIC AMPLIFIERS

22.1 Describe the functions of the bioelectric amplifier
22.2 State the requirements for bioelectric amplifiers
22.3 Describe the basic principles of operation of a bioelectric amplifier
22.4 Describe the different configurations used in the design of bioelectric amplifiers
22.5 State the principles of operation of isolation amplifiers
22.6 List the basic properties of the operational amplifier
22.7 Sketch the circuit diagram of an op amp
22.8 Calculate voltage gain, impedance (input and output) and other characteristics of op amps
22.9 Define terms used in bioelectric amps (e.g.: inverter, offset null, zero suppression, summing junction, common mode rejection and virtual ground)

End of Biomedical Competencies Listings
(with 22 major Categories)

Prerequisite: Associate C.E.T. or equivalent

Notes:

The purpose in distributing the above Competencies list is to provide a detailed syllabus for electronics educational institutions and instructors. Also to go further and explain what the student should be able to do with each of the items included in the Categories and Competencies listings.

Find An ETA Test Site:

http://www.eta-i.org/testing.html

Suggested Study Material:

TechCareers: Biomedical Equipment Technicians; Bowles; ISBN 978-1934302293; TechCareers-TSTC Publishing, 2008, ppg108.
Introduction to Biomedical Equipment Technology, 4E; Carr, Brown; ISBN 978-0130104922; Prentice Hall, 2000, ppg. 743.
Electromagnetic Compatibility in Medical Equipment: A Guide for Designers and Installers; Kimmel, Gerke; ISBN 978-0935184808; CRC Press, 1995
Principles of Biomedical Instrumentation and Measurement; Aston; ISBN 978-0675209434; Prentice Hall, 1990
Biomedical Instrumentation And Measurements, 2E; Cromwell, Weibell, Pfeiffer; ISBN 978-0130764485; Prentice Hall, 1979
Biophysical Measurements; Strong; ASIN: B000B78AY0; Tektronix, 1973 (oop)
Biomed: From the Student's Perspective (English Translation Version); Villafane; ISBN 978-1615396634; www.techniciansfriend.com
Critical Careers: A Guide to Opportunities in Medical Equipment Service; Bowles; ISBN 978-0970105844; Upstream Press, 2001
Servicing Electrocardiographs; Kanter; ISBN 978-0672212109; H.W.Sams, 1975
Bebop to the Boolean Boogie, Third Edition: An Unconventional Guide to Electronics; Maxfield; ISBN 978-1856175074; Newnes, 2008

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