Master of Science in Biomedical Engineering

Program Manual

College of Applied Medical Sciences

Majmaah University

Al Majmaah 11952

كلية العلوم الطبية التطبيقية
College of Applied Medical Sciences

1 Introduction

The College of Applied Medical Sciences (CAMS), being one of thirteen ehcolleges at Majmaah University (MU) was established in 2009 to meet the industrial need in the Kingdom of Saudi Arabia for skilled health care profession. Since its establishment, it has been playing a significant role in providing both private and public health sectors with highly competent professional graduates who are equipped with the most recent knowledge, and skills in their respective health care fields. The Master of Science in Biomedical Engineering Program was established to cover the need to provide specialists in biomedical engineering that is needed in academic, healthcare institutions and companies. Since our Country's national priority is "Living healthy and being healthy". The knowledge which students gain from the master program will help to build technical and domain specific skills. A master degree in biomedical engineering increases the employability and skills of the graduates and more attractive to employers. Current Biomedical Technologists with bachelor's degree, can choose our master program to advance their career.

2 Department Vision

Creativity and innovation in teaching medical devices technology, establishing local and national partnership and contribute to scientific research internationally.

3 Program Mission

To prepare competencies in the Biomedical Engineering field through an educational environment supportive of scientific research and community service to cope with the evolution of healthcare systems and technique.

4 Program Goals

- Applying principles and tools from the physical sciences and engineering to biology, physiology and medicine.
- Translating knowledge and innovations to clinical practice
- Maintaining a nationally recognized and rigorous graduate program
- Training biomedical engineers to work effectively in a wide range of settings, from academia to industry; and,
- Advocating and disseminating BME to the public at large.

5 Master of Science in Biomedical Engineering (BME) Program

5.1 Introduction

Medical technology is becoming increasingly important in health care. Our educational program focuses on the development of new biomedical technology for life science research and advanced health care. In addition, to traditional areas of mechanical and electrical engineering; Students will have the opportunity to take advanced courses that include medical instrumentation, biosensors, image processing, signal processing, instrumentation devices, nano-devices and nano-sensors. It provides a strong foundation in Engineering science and Informatics that flows smoothly into graduate studies in Biomedical Technology Sciences. This program gives the opportunity to students to see the interdependence of different biomedical engineering disciplines in the development of modern medical devices Individuals completing this program will be able to work as engineers in the rapidly expanding medical equipments, and systems industry. Others could pursue master program in biomedical fields, medical sciences or biomedical informatics. Using this background to enter any of these areas will assure a long-term appreciation of the interdisciplinary approach.

5.2 Program Objectives

The program aims to develop the technical knowledge, expertise and transferable skills for a career in this growing engineering field. Master of Science in Biomedical Engineering program objectives are:

- Use principles of bioengineering, basic biomedical sciences, and statistics to solve complex engineering problems and tasks to cope up with the evolution in Health Care System.
- To acquire learning skills and the ability to apply their bioengineering knowledge to evaluate biomedical technologies or systems in Biomedical Engineering.
- To use the analytical tools to perform fundamental and applied research in biomedical engineering to produce the Novel and innovative products.
- Able to positively impact on the society to develop ethical, economic and environmental skills to serve the community in a better way.

5.3 Program Learning Outcomes

Master of Science in Biomedical Engineering (BME) program adopted learning outcomes domain as prescribed by NCAAA student outcomes.

5.Program learning Outcomes*(PO)	
Knowledge and Understanding :	
A1	To recognize the main concepts,principles and theories of biomedical engineering applications.
A2	To determine the effect of biomedical engineering knowledge in developing research and professional practice.
Skills	
B1	To apply practical and theoretical knowledge of biomedical engineering to deal with novel and unpredictable professional contexts.
B2	To identify, formulate and solve biomedical engineering problems.
B3	To develop significant novel ideas about biomedical engineering aspects
B4	To plan and execute a major research by applying practical and theoretical knowledge; improve processes;
Values	
C1	To apply ethical principles and commit to professional ethics, responsibilities and norms of biomedical engineering practice
C2	To function effectively as a member or leader in diverse teams in multi-disciplinary settings.
C3	Ability to understand and prepare effective reports.
C4	Ability to produce project documentation.
C5	Ability to communicate effectively with different kinds of audiences.

5.3 Master of Science in Biomedical Engineering

The **biomedical engineering (BME) discipline** is one of the rapidly growing engineering domain due to the recent advancements made in medical technologies and treatment and diagnosis strategies. These advancements will likely to provide immense benefits to global society. The **Master's degree program** in **Biomedical Engineering** is designed to provide advanced training in biomedical engineering. The program requires students to establish the necessary foundation in systems-level biology/physiology/pathophysiology and mathematics, in addition to advanced biomedical engineering coursework. This program will give students the opportunity to learn and implement advanced technologies and to perform leading edge research in biomedical engineering.

General requirements for Master's degree: Based on **National Qualification Framework (NQF)**, a minimum of 39 credit hours beyond those required for the Master's degree, of which a minimum of 31 credit hours must be in graduate level course work and 6 credits of thesis work which is partial fulfillment of the requirements for the degree of Master of Biomedical Engineering. Requirements also allow a maximum of 2 credits for research methodology and 2 credits for research project out of 39 credits.

The students who got admitted may be from any undergraduate engineering stream and hence the curriculum is planned to meet the course requirements in three different levels of courses. The course work is distributed as follows:

Sl. No	Nature of Courses and Level of Coverage	Weightage (Credits)
1	Mathematics and Basic Science Courses	6
2	Biomedical engineering graduate level courses	12
3	Advanced Biomedical engineering graduate level courses	11
4	Research Methodology and Research Project	4
5	Thesis	6
	Total	39

Master of Science in Biomedical Engineering (By Course Work and Thesis)				
Sl. No	**Course nature**	**Credits**		
		Lecture	**Practical /Tutorial**	**Total**
	First Semester			
BME 611	Mathematical Methods for Biomedical Engineers	2	0	2
BME 612	Cellular and Molecular Biology	1	1	2
BME 613	Human Anatomy & Physiology for Biomedical Engineers	2	0	2
BME 614	Biomedical Sensors and Instrumentation	2	1	3
BME 615	Research methodology	2	0	2
	Total Credits			**11**
	Second Semester			
BME 621	Biosignal Processing	2	1	3
BME 622	Biomechanics and Biodynamics	2	0	2
BME 623	Physiological Modelling	2	0	2
BME 624	Healthcare Technology Management	2	0	2
BME 625	Research Project	0	2	2

	Total Credits			**11**
	Third Semester			
BME 631	Applied Medical Image Processing (2D and 3D)	2	1	3
BME 632	Rehabilitation Engineering (Prosthetics and Orthotics)	2	0	2
BME 633	Design Standards and Regulations for Medical Devices	2	0	2
BME 634	Biomaterials and Artificial Organs	2	0	2
BME 635	Hospital Planning, Organization and Management	2	0	2
	Total Credits			**11**
	Fourth Semester			
BME 641	**Thesis (**Individual Student need to do research work along with a supervisor in the department. The Outcome of this work shall lead to develop novel devices, processess for the benefit of society and shall lead to a publication in a reputed periodical.	**0**	**6**	**6**
	Total Credits			**39**

5.4 INDIVIDUAL COURSE DESCRIPTIONS

FIRST SEMESTER (11 Credit Hours)

BME 611. Applied Mathematics for Biomedical Engineers (2 Credits): The course will cover mathematical techniques needed to solve advanced problems encountered in biomedical engineering. Fundamental concepts are presented with emphasis placed on applications of these techniques to biomedical engineering problems. Topics include solution of ordinary differential equations using the Laplace transformation, Fourier series and integrals, solution of partial differential equations including the use of Bessel functions and Legendre polynomials and an introduction to complex analysis.

***Course prerequisites*:** Familiarity with multi-variable calculus, linear algebra, and ordinary differential equations.

BME 612. Cellular and Molecular Biology (2 Credits): This course will introduce the students to classical and modern concepts in cellular and molecular biology. The course will emphasize the importance of both modern and classical biomedical research and medicine of a comprehensive understanding of cell structure and function. Modern cell biology is a unifying discipline that describes the structure and function of cells in all their genetic, biochemical, developmental, physiological and pathophysiological aspects. This course will introduce students to the dynamic relationships between cell structure and the biochemical reactions that are necessary for cell growth, differentiation, survival and death with an emphasis on eukaryotic cells.

***Course prerequisites*:** Familiarity with biological terms of cells

BME 613. Human Anatomy and Physiology for Biomedical Engineers (2 Credits): This course is intended to lay a foundation for the study of bioengineering, with a focus on learning terminology and concepts essential to the understanding of human anatomy and physiology. The course provides a broad introduction to the subject of human anatomy and physiology, centered on learning the subject matter and analyzing functional physiology from an engineering viewpoint. There is a perceived need for anatomy instruction for graduate students enrolled in a biomedical engineering program.

***Course prerequisites*:** Familiarity with biological terms of Human anatomy.

BME 614. Biomedical Sensors and Instrumentation (3 Credits): This course gives an understanding of the principles of biomedical sensors and knowledge on how bio-signals are registered, amplified and analyzed. The science and technology that goes into the plethora of sensors, although highly interdisciplinary, mainly derives from basic principles in physics and electrical engineering. This course will (re)introduce these principles and illustrate the application of these principles in a number of classes of medical sensors. It will also review some of the basic ideas and constraints that go into making of a medical device and finally touch upon a few nontechnical principles in applications of medical devices.

***Course prerequisites*:** Familiarity with common types of sensors in engineering perspective.

BME 615. Research methodology (2 Credits): This course offers the students to learn how research is being done, and to put that knowledge into practice. Students will learn how to apply a great number of statistical techniques, draw conclusions from those, and determine what statistical technique would be suitable for a given dataset and/or research question. This course will emphasis on interpreting results and communicating those to the world at large. This course will provide an opportunity for students to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches.

***Course prerequisites*:** *Nil*

SECOND SEMESTER (11 Credit Hours)

BME 621. Biosignal Processing (3 Credits): This course introduces digital signal processing fundamentals and stressing on problems in biomedical engineering and clinical research. It will cover principles and algorithms for processing both stationary and non-stationary signals. Main topics covered will be data acquisition methods, preprocessing, post processing and feature extraction. The focus of the course is also on practical's that provide experience in processing physiological data from the standard data base. The practical's will be done in MATLAB and LabVIEW environments during weekly lab sessions.

***Course prerequisites*:** Fundamental knowledge on signals and systems and various mathematical transforms

BME 622. Biomechanics and Biodynamics (2 Credits): The course will focus on the fundamentals of biomechanics of human skeletal system and analysis of movement, which is used in clinical and research settings to understand how various pathologies impact movement and how interventions can be implemented to aid those affected by movement disorders. The major focus is kinematic analyses in in 2D and 3D inverse dynamics.

***Course prerequisites*:** Familiarity with basic mechanics terms and definitions, applied mechanics of any system.

BME 623. Physiological Modelling (2 Credits): This course introduces students to physiological control systems and mathematical modeling techniques to evaluate the structure and function of physiological systems through the analysis of their dynamic behavior. It includes the major physiological control systems of human body such as blood flow in cardiova-

-scular, air exchange in lungs, urea secretion in kidney, modeling of glucose-insulin metabolic system, fundamental principles, processes and tools in model development, Analysis and synthesis of dynamic models, Compartmental models of physiological systems.

***Course prerequisites*:** BME 611 Mathematical Methods for Biomedical Engineers

BME 624. Healthcare Technology Management (2 Credits): This course delivers the foundations needed for clinical engineering aspects such as diagnosis, drug development and medical devices. This course will cover the fundamental part of managing, maintaining, and/or designing medical devices used or proposed for use in various healthcare settings from the home, the field, the doctor's office, and the hospital. In reality, several medical conditions requiring extensive and continuous monitoring and early and accurate diagnosis becoming increasingly desirable, technology for biomedical applications is rapidly becoming one of the key ingredients future healthcare. Some of the healthcare technology management professional's functions will be discussed.

***Course prerequisites*:** BME 611 Mathematical Methods for Biomedical Engineers

BME 625. Research Project (2 Credits): The first year research project is scheduled for the second semester. In starting of the second semester, Individual Student need to work along with a supervisor in the department. The quality of the work shall lead to a publication in a reputed periodical. Progress of the work will be monitored by an expert team twice in a semester.

***Course prerequisites*:** *Nil*

THIRD SEMESTER (11 Credit Hours)

BME 631. Applied Medical Image Processing (2D and 3D) (3 Credits): This course will cover the topics on fundamentals of imaging systems, main stages of image processing and recent advancements in medical image processing systems. The modern trend in medical diagnosis is to create 3D medical model of human organ based on 2D image such as CT and MRI, because 3D model includes and reflects more information in detail than 2D image. Topics that are covered include medical image formats, enhancement, segmentation, registration, and visualization in both 2D and 3D images. MATLAB and 3D simulations tools will be used to implement basic algorithms.

***Course prerequisites*:** BME 611 Mathematical Methods for Biomedical Engineers and BME 621 Biosignal Processing.

BME 632. Rehabilitation Engineering (Prosthetics and Orthotics) 2 Credits: Rehabilitation engineering is a discipline having as its ultimate objective the application of technology to enhance life's quality for the disabled. This course will focus on rehabilitation engineering aspects that addresses prosthetics and orthotics, wheelchair design, seating and positioning, and automobile modifications for individuals with disabilities. The course also includes visits to a local prosthetic and orthotic facility to observe typical fabrication, fitting, and alignment procedures and a driver rehabilitation program for exposure to driver assessment, training, and common vehicle modifications.

***Course prerequisites*:** BME 614 Biomedical Sensors and Instrumentation and BME 622 Biomechanics and Biodynamics courses.

BME 633. Design, Standards and Regulations for Medical Devices (2 Credits): Introduces students to a systematic approach in medical device design/development, standards and regulations. The course emphasizes engineering/design methodology. This course will describe the nature of medical device safety as a risk management process that must encompass the life span of medical devices from their conception to disposal. Course topics will include understanding the U.S. FDA 510K, PMA, IDE and European CE marking (93/42/EEC, 90/385/EEC and 98/79/EEC), medical device risk management (ISO 14971), and design control and quality system implementation (21 CFR Part 820 and ISO 13485).

***Course prerequisites*:** BME 614 Biomedical Sensors and Instrumentation

BME 634. Biomaterials and Artificial Organs (2 Credits): This course will give an overview of the basic knowledge of biomaterials engineering and artificial organs. Structure, mechanical, physical and biological properties of tissues and implant materials are related to each other. Response of the implant materials to the biological system (biocompatibility) is related to degradation process of metals and metal-based alloys. Ceramic and polymer materials will be discussed. Membranes processing and their applications in drug delivery, hemodialysis, blood filtration and oxygenation in the area of artificial organs are presented. Materials that are used in medical devices or that interface with biological systems.

***Course prerequisites*:** BME 614 Biomedical Sensors and Instrumentation BME 622 Biomechanics and Biodynamics

BME 635. Hospital Planning, Organization and Management (2 Credits): This course will give an overview of the organization of hospitals, internal operations, processes, roles, management techniques, information needs and technology utilization in the different departments of the hospital system. The course emphasizes modern hospital planning techniques, including quality, application, and implementation. This course primarily focuses on health facilities design and departments in healthcare and public health organizations.

***Course prerequisites*:** Familiarity with hospital terms and nothing specific required.

FOURTH SEMESTER (6 Credit Hours)

BME 641. Thesis Work (6 Credit hours)

Individual Student need to work along with a supervisor in the department. The Outcome of this work shall lead to develop novel devices, processess for the benefit of society. The quality of the work shall lead to a publication in a reputed periodical. Progress of the work will be monitored by an expert team twice in a semester.

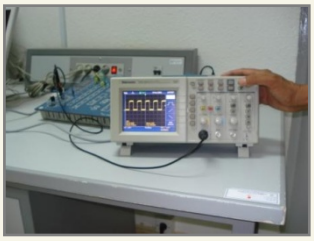
***Course prerequisites*:** Successful Completion of 50 percentage of total credits excluding thesis.

5.7 Where does BME graduates work?

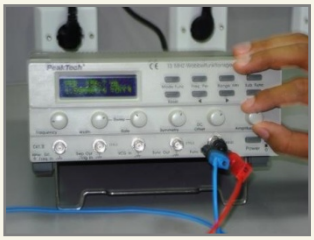
- ✓ Hospitals and Clinics
- ✓ Specialized Medical Companies
- ✓ Scientific Research Centres such as Universities
- ✓ Computer, networking and software companies
- ✓ Information System Management Companies
- ✓ Health Insurance Companies

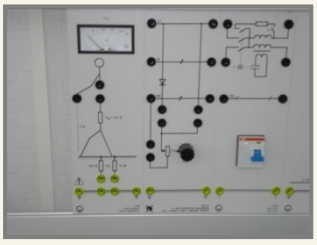
Laboratory Name	Medical Electronics
Skills Acquired in the laboratory	▪ Ability to understand the basic principles for electronic components like transistor and diode ▪ Knowledge of basic electronic elements ▪ Ability to use the tools used in the building and testing of electronic circuits ▪ Knowledge of the components, the properties and the applications of operational amplifiers ▪ Acquiring information about the various sensors used in electronic medical devices ▪ Identification of the theoretical principles of the working methods of the device, calibration methods and methods of determining faults ▪ Knowledge about how to use different types of testing devices, including multi-purpose digital scales and signal oscilloscope

Laboratory Name	Bio-Signals Processing
Skills Acquired in the laboratory	▪ Identification of the theory of operation of processor and logic gates. ▪ Programming of programmable integrated circuits ▪ Calibration of signals ▪ Learn how to build and test digital circuits ▪ Learn how to deal with digital and analog signals



Laboratory Name	Electrical Skills
Skills Acquired in the laboratory	▪ Understanding the basic principles of function of electrical circuit components ▪ Learn the basic laws of the current and voltage in electrical circuits ▪ Analysis of electrical circuits ▪ Usage of ammeter and voltmeter ▪ Usage of signal generator, oscilloscope and power supply ▪ Familiarity with the various types of electrical motors and how to control them ▪ Ability to identify the risks associated with working in the medical field and how to prevent them ▪ Mastery of security principles for human operators working with medical devices



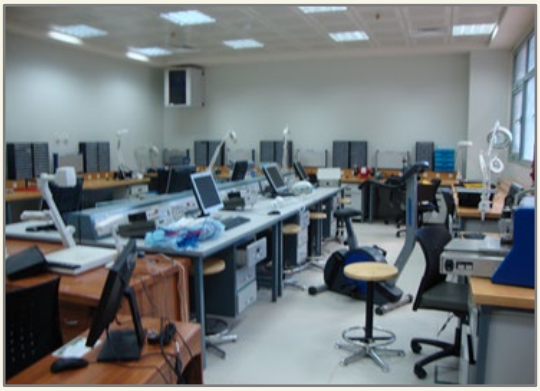


Laboratory Name	Medical Imaging

Skills Acquired in the laboratory	▪ Knowledge of the working principles of Ultrasound Imaging devices ▪ Knowledge of the working principles of X-ray Imaging ▪ Usage of contrasts in imaging ▪ Knowledge of the working principles of Fluoroscopy ▪ Comparison of modality X-ray vs. Ultrasound ▪ Learning the Radiation Hazard and Control

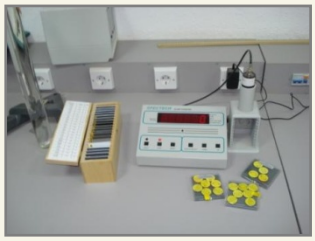
Laboratory Name	**Medical Devices Workshop**

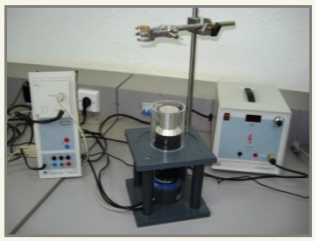
Skills Acquired in the laboratory	▪ To obtain the necessary skills to use different types of hand tools (mechanical and electrical) and electronic instruments. ▪ To learn to distinguish between electrical and electronic parts and to design and manufacture a simple electrical circuit. ▪ To develop student skill to do the maintenance of medical devices using various tools.



Laboratory Name	**Radiology**

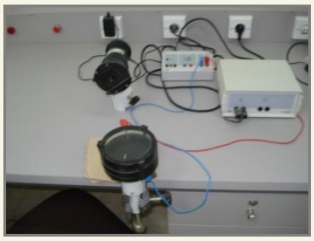
Skills Acquired in the laboratory	▪ Knowledge of the working principle of Computed Tomographic Imaging in generations from 1-5 ▪ Knowledge of the working principle of Magnetic Resonance Imaging ▪ Usage of contrasts in imaging ▪ Knowledge of the working principle of Nuclear Imaging (Gamma Camera, Radio Pharmaceuticals, SPECT and PET) ▪ Comparison of CT modality vs. MRI, Nuclear Imaging vs. other modalities





Laboratory Name	**Bio-Physics**

Skills Acquired in the laboratory	▪ Recognize the importance of accuracy in physical measurement methods ▪ Analysis of the characteristics of physical concepts and their applications in the area of specialization ▪ The application principles of physics to provide safe health care ▪ Acquire the technical skills needed to operate the machines and devices according to physical laws



Laboratory Name	Advanced Medical Devices
Skills Acquired in the laboratory	▪ The student's understanding of important concepts in vital signs devices and surveillance equipment, surgical devices and medical imaging devices. ▪ Acquiring the theoretical principles of operation of devices and methods of calibration, installation and use of appropriate inspection tools.