QUALIFICATION SPECIFICATION

SECTION A

QUALIFICATION DEVELOPER	Botswana International University of Science and Technology		
TITLE	Bachelor of Engineering (Honours) in Biomedical Engineering	**NCQF LEVEL**	8
FIELD	Manufacturing, Engineering and Technology	**SUB-FIELD**	Engineering and Engineering Trades
New qualification	✓	Review of existing qualification	

SUB-FRAMEWORK	General Education		TVET		Higher Education	✓
QUALIFICATION TYPE	Certificate		Diploma		Bachelor	
	Bachelor Honours	✓	Master		Doctor	
CREDIT VALUE:630						

RATIONALE AND PURPOSE OF THE QUALIFICATION

Rationale

The 2019 Global Innovation Index Report titled "Creating Healthy Lives- The Future of Medical Innovation" describes today's innovation in health as more than just developing new medicine but creating equipment capable of assisting in the diagnosis of diseases and devices for health monitoring and treatment. In the Sub-Saharan Africa region Botswana is nowhere near the top contenders; South Africa, Kenya, and Mauritius in innovation economies.[1]. Vision 2036 advocates for Batswana to attain the necessary skills and competencies that will drive innovative solutions to leading challenges in various local sectors including the healthcare[2].

Biomedical Engineering and Technology have been distinguished as one of the disciplines that are currently encountering deficiencies in the labour market[3]. The lack of local training institutions for Biomedical Engineering has contributed tremendously to the shortage of skilled Biomedical engineers. The problem has resulted in a heavy reliance on expensive international training which limits training capacity, locally. Shortage of Biomedical engineers with bachelor's degree qualifications has led to outsourcing of services to the small, sometimes non-qualified service providers for medical equipment supply and maintenance needs. The highest qualification for the majority of local employees managing the acquisition and maintenance of medical equipment supply is a two year diploma, which puts limitations on generation of innovative solutions. This hinders diversified economic growth.

The local local education and training opportunities of Biomedical engineers will alleviate the challenges of skilled engineers who can apply their skills in meical technology design, rehabillitation engineering and related biomedical engineering services.

The qualification allows the students to cover all the basics of engineering mathematics, electronic devices & circuits, general biology for engineers, fundamental of biomedical engineering, electric circuits theory, electro magnetic field theory, object-oriented programming, principles of communication engineering, signals & systems, biomedical engineering design, control systems, anatomy & physiology for engineers, data structures & algorithms, digital signal processing, medical imaging systems, radiological health engineering, biomedical transport processes, microcontrollers, biomedical industrial training, biomedical industrial training, telemedicine, electrophysiologiocal signals acquisition, rehabilitation engineering & technology, clinical & industrial biomedical engineering, biomechanics, medical sciences for engineers, biomaterials, biomedical engineering final year project II, advanced digital system design, image & video signal processing, advanced medical engineering design. The qualified Biomedical Engineering graduates will be ready to be trained for employment, conduct research and innovation in: medical instrumentation design, rehabilitation equipment engineering, medical imaging, medical devices sales and consultancy.

Purpose of the Qualification

The purpose of this qualification is to produce graduates with highly specialized knowledge, skills and competences to:

- Design, develop and evaluate biological and health systems and products.
- Function effectively individually or in collaboration with others to generate innovative solutions to engineering problems.
- Apply the necessary and relevant skill sets to advance biomedical engineering technology.
- Conduct basic research in the field of Biomedical Engineering to inform solutions to some of the leading medical challenges.
- Adapt to new and different professional environments where teamwork, communications, time management are necessary.

ENTRY REQUIREMENTS (including access and inclusion)

Minimum entry requirements: Certificate IV, NCQF Level 4 Recognition of Prior Learning (RPL) and Credit Accumulation and Transfer (CAT) will be applicable or considered for entry into this qualification as per the relevant provider policies in line with the National RPL and CAT policies.

QUALIFICATION SPECIFICATION SECTION B	
GRADUATE PROFILE (LEARNING OUTCOMES)	**ASSESSMENT CRITERIA**
1. Demonstrate highly specialized knowledge and understanding of fundamental concepts and principles of Biomedical Engineering	1.1 Core concepts and principles of biomedical engineering are identified and applied correctly. 1.3 Demonstrate the relationship among the core concepts and principles of biomedical engineering and communications are demonstrated 1.2 Apply range and limits of the applicability of the core concepts and principles of biomedical engineering. 1.3 Apply the appropriate concepts and principles of biomedical engineering when solving practical societal and problems in industry. 1.4 Appraise the limitations of basic techniques used in biomedical engineering.
2. Access, evaluate and synthesize scientific information.	2.1 Utilize the library, internet and other data storage and other facilities to access information.

	2.2 Evaluate the quality of information using scientific reasoning. 2.3 Information from a variety of sources, which may be contradictory or divergent, is synthesised. 2.4 Appropriate procedures for generating relevant information are designed, selected and applied with due concern for bias and for any ethical or safety considerations. 2.5 Appropriate forms of enquiry are conducted by applying standard procedures within the discipline of Biomedical Engineering, such as theoretical, experimental, and computational techniques. 2.6 Data is collected and recorded accurately, truthfully and in appropriate formats. 2.7 Data and scientific evidence are analysed and from such analysis valid arguments and conclusions are presented.
3. Demonstrate mastery of professional practice in biomedical engineering applications when solving complex and unpredictable problems.	3.1 Combine the theoretical tools and the law controlling biomedical electronic circuits to analyze critical quantities in biomedical systems. 3.2 Identify flawed scientific reasoning and demonstrate logical thinking. 3.3 Inductive (effect to cause or specific to general) and deductive (cause to effect or general to specific) reasoning can be discriminated. 3.4 Perform Hypothetico-deductive reasoning. 3.5 Cause-effect relations can be discerned in the face of some level of uncertainty or gap in available information.

4. Communicate effectively the scientific understanding applicable to solving biomedical engineering problems in writing, orally and using visual, symbolic and/or other forms of representation.	4.1 Use correct scientific and engineering language to produce clear and coherent written documents, which follow appropriate engineering conventions. 4.2 Present scientific and engineering information is verbally to clients. 4.3 Appropriate referencing conventions are used, plagiarism is avoided, and intellectual property is respected. 4.4 Use non-verbal forms of representation correctly and appropriately.
5. Conduct biomedical engineering design involving investigative research, interviewing techniques and indirect methods of proof used to solve problems in biomedical engineering and related systems.	5.2 Concrete and abstract problems, in familiar and unfamiliar contexts, are formulated, analysed and solved. 5.3 The knowledge of theory is applied to real-world and contexts, and particularly to problems in industry. 5.4 Knowledge is integrated, e.g. from various disciples or modes of enquiry, is solving scientific and industrial problems. 5.5 Capacity to control the validity of measurement results comparing them to the model and simulation results. 5.6 Produce high quality scientific and technical reports based on the experimental data systematically checking all reports with anti-plagiarism tools.
6. Demonstrate effective Information and Communication Technology (ICT) skills applicable to biomedical engineering system.	6.1 Wire correctly basic and complex biomedical electronics circuits. 6.2 Follow consistent steps to realize any system starting from theory and simulation to the final system.

	6.3 Perform tasks related to basic computer literacy skills. 6.4 The validity of ICT solutions for problems posed by Biomedical Engineering as a discipline are critically assessed. 6.5 ICT that is appropriate to Biomedical Engineering as a discipline is used for: computational applications; simulation applications; pattern recognition; automation and control; managing large volumes of data.
7. Apply highly specialized knowledge and demonstrate the impact of biomedical engineering activity on and around oneself.	7.1 Ability to take all the precautions to protect oneself, colleagues and the work environment against Biomedical engineering risks and the output of any invention. 7.2 Scientific knowledge that is relevant to current societal issues is identified.
8. Demonstrate the skills to work effectively as a member of a team or group in biomedical engineering projects or investigations.	8.1 Evidence of successful and effective contributions in group work is provided. 8.2 The outcomes of engineering group work are communicated effectively and with respect for the contributions of each group member. 8.3 Organisational skills in managing group work are applied.
9. Apply highly specialized knowledge in biomedical engineering principles and ways of thinking to societal and industrial issues, considering ethical and cultural considerations.	9.1 Engineering knowledge that is relevant to current societal and industrial issues is identified. 9.2 Public information dealing with current engineering related issues is critically evaluated. 9.3 Ethically and culturally sensitive decisions on the effects of engineering-based activities on society are made. 9.4 The socio-economic impact of engineering interventions in society and industry is identified.

	9.5 Engineering knowledge is applied for the direct benefit of society and also to drive industry.
10. Demonstrate the ability to manage and organise their learning activities responsibly. Independent learning ability.	10.1 Appropriate study skills are demonstrated (learning from text, note-taking, summarising, analysis and synthesis). 10.2 Effective learning strategies which suite personal needs and context are developed and used. 10.3 Demonstrate effective time management.
11. Apply social, legal, ethical and professional issues in biomedical engineering decision making.	11.1 Ability to maintain continued competence and to keep abreast of up-to date tools and techniques is identified. 11.2 Understanding of the system of professional development is demonstrated 11.3 Acceptance of responsibility for own actions by individual is identified 11.4 Judgment in decision making during problem solving and design issues is identified 11.5 Limitation of decision making to area of current competence is identified.
12. Undertake a biomedical engineering research project under supervision and demonstrate management skills.	12.1 Evidence of closely aligning learning to professional practice; 12.2 Ability to develop and apply skills whilst integrating knowledge to complete a practical industry project in own area or a project related to any research institutions affiliated to Engineering. 12.3 Biomedical Engineering research investigations are performed which produce meaningful results. 12.4 Appropriate analysis of the data is undertaken, and results are discussed in terms of

	published scientific literature and presented in the form of a written dissertation.

QUALIFICATION STRUCTURE			SECTION C
FUNDAMENTAL COMPONENT Subjects / Units / Modules /Courses	**Title**	**Level**	**Credits**
	Pre-Calculus	5	12
	General Chemistry I	5	12
	Introductory Physics I	5	12
	Programming Logic	5	12
	Engineering Graphics	5	12
	Introduction to Technical Communication & Academic Literacy	5	6
	Introduction to calculus	5	12
	General Chemistry II	5	12
	Introductory Physics II	5	12
	Introduction to Statistics	5	12
	Introduction to Engineering	5	6
	Workshop practice (Measurements and instrumentation elements)	5	12
	Engineering Mathematics I	5	12
	Procedural Programming	5	12
	Fundamentals of Electrical Engineering I	5	12
	Technical and Professional Communication	5	6
	BioMaterials	5	12
	Applied Mechanics I (Statics)	5	12
	General Biology for Engineers	5	12
	Level 5 Fundamental Credits		**204**
CORE COMPONENT Subjects / Units / Modules /Courses	Engineering Mathematics II	5	12
	Object-Oriented Programming	5	12
	Fundamental of Electrical Engineering II	5	12
	Fundamental of Biomedical Engineering	5	12

	Electric Circuits Theory	5	6
	Electro Magnetic Field Theory	5	12
	Workshop Technology & Skills Development	5	12
	Level 5 Core Credits		**78**
	Engineering Mathematics III	6	12
	Research Methods for Engineering and Technology	6	12
	Data Structures and Algorithm	6	12
	Biomedical engineering Design 1	6	12
	Digital Electronics	6	12
	Principles of Communication Engineering	6	12
	Engineering Mathematics IV	6	12
	Biomedical engineering design 2	6	12
	Electronic Circuit Analysis and Design	6	12
	Digital Signal Processing	6	12
	Control Systems	6	12
	Anatomy and Physiology for Engineers	6	12
	Level 6 Core Credits		**144**
	Biomedical Instrumentation & Design (Design 3)	7	12
	Economics, Business & Entrepreneurship	7	12
	Medical Imaging System	7	12
	Radiological Health Engineering	7	12
	Biomedical Transport Processes	7	12
	Microcontrollers	7	12
	Biomedical Industrial Training	7	36
	Level 7 Core Credits		**108**
	Biomedical Engineering Final Year Project I	8	12
	Telemedicine	8	12
	Electrophysiological Signals Acquisition	8	12
	Rehabilitation Engineering & Technology	8	12
	Clinical and Industrial Biomedical Engineering	8	12
	Engineering, Business and Society	8	12
	Biomedical Engineering Final Year Project II	8	12

	Level 8 Core Credits		**72**
ELECTIVE COMPONENT Subjects / Units / Modules /Courses	Advanced Digital System Design	8	12
	Electromagnetic Interference/Compatibility	8	12
	Embedded Systems Design	8	12
	Electrical Machine Design	8	12
	Remote Control and Telemetry	8	12
	Biomechanics	8	12
	Digital Control Systems	8	12
	Reliability and Maintainability	8	12
	Biomedical Devices Design	8	12
	Medical Sciences for Engineers	8	12
	Image and Video Signal Processing	8	12
	Robotics Modelling and Simulation	8	12
	AI and Neural Networks	8	12
	Biomaterials	8	12

Rules of combinations, Credit distribution (where applicable):

Fundamentals	Level 5	204 Credits
Core	Level 5	78 Credits
Core	Level 6	144 Credits
Core	Level 7	108 Credits
Core	Level 8	72 Credits
Electives	Level 8	24 Credits (minimum)
Total		630 Credits

ASSESSMENT AND MODERATION ARRANGEMENTS
Assessments arrangement **Formative assessments:** The types of assessments used in this Qualification is 40% of Continuous Assessment. Continuous assessment calculation: **Summative assessments:** The type of assessment used here is a final examination, which is 60%. Continuous assessment and final exam are combined using the following formula: FM = 60% EM + 40%CA Where: Final mark (FM), Exam Mark (EM), Continuous assessment (CA). There is provision for internal and external moderation. Assessment and moderation must be conducted by suitably qualified personell preferably registerd and accredited by a recognized professional body or authority.
RECOGNITION OF PRIOR LEARNING (if applicable)
A clear framework through which students can accumulate learning credits and transfer such credits toward appropriate qualifications helps to validate and recognize learning gained through formal and informal means, provides flexibility to students, and allows students to progress relatively seamlessly through their lifelong learning journey. Candidates may apply for recognition of prior learning whether such learning has been gained through formal study, through workplace learning, or through any other formal or informal means. Any candidate applying for recognition of prior learning (RPL) will be expected to provide evidence of such learning that must be relevant, sufficient, valid, verifiable, and authentic. In addition, the candidate may be interviewed by a member of staff or have to take a formal test, which may include a live demonstration of skills and competencies, to assess competence. RPL and CAT will be considered for award of credits as part of this Qualification.
PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)
Learning Pathway: Those who have achieved the qualification can progress as mentioned below

Vertical:

Completion of a Bachelor of Engineering (Honours) in Biomedical Engineering meets the requirement for admission to a

- Master of Engineering in Biomedical Engineering
- Master of Engineering in Electronics and Electrical Engineering
- Master of Engineering in Computer and Telecommunications Engineering
- Master of Engineering in Control and Instrumentation
- Master of Engineering in Industrial Bioengineering

Horizontal:

A Bachelor of Engineering (Honours) in Biomedical Engineering candidate could continue to pursue:

- Bachelor of Engineering in Electronics and Instrumentation Engineering
- Bachelor of Engineering in Electrical and Electronics
- Bachelor of Engineering in Computer and Telecommunications Engineering
- Bachelor of Engineering in Control and Instrumentation Engineering

Employment Pathway:

The qualification will produce graduates suitable for training in these Biomedical engineering related positions

- Bioinstrumentation engineers
- Medical Devices Research and Development Engineers
- Rehabilitation Engineers
- Medical Imaging Engineer
- Medical Devices Sales Engineer
- Clinical Engineer
- Biomedical engineering Consultancy

QUALIFICATION AWARD AND CERTIFICATION

The learner will be awarded **Bachelor of Biomedical Engineering (Honours)** after attaining 630 credits as specified in the rules of combination and credit distribution. If the student does not meet the prescribed minimum standards of the qualification the learner will exit with a transcript. Certificate will be awarded to the candidates who have met the qualification requirements.

REGIONAL AND INTERNATIONAL COMPARABILITY

Medical Engineering (BEng) QAA FHEQ Level 6

The Cardiff Medical Engineering programme is one of the best established in the UK and is perfectly suited to anyone wishing to combine classical engineering training with a medical application. You'll be taught by a dedicated team of research-active academic staff, and the course includes a number of lectures by colleagues from our School of Biosciences, School of Medicine and Cardiff & Vale NHS Trust. The aim of the course is to produce a highly competent engineer who can pursue a career in clinical engineering, bioengineering or engineering fields outside medicine. Note that if Chartered status is important to you, a four-year Cardiff MEng course may offer a quicker, more direct route than the BEng course.

BEng Biomedical Engineering, University of Stellenbosch, NQF level 8

The three - year undergraduate Bachelor of Engineering Science in Biomedical Engineering BEng Sc (BME) combines subjects in science, engineering, medicine and biology, as well as specific biomedical engineering courses. It is a *pre-professional qualification*; thus, the graduate is not eligible for any professional registration based on this degree alone. After you graduate, there are various routes you can take to obtain a professional qualification, such as Medicine (MBBCh), BSc(Eng) in Electrical or Information Engineering, and BSc(Hons) in Physics. You can apply for admission into the third year of BSc (Eng) in Electrical / Information Engineering. However, the entry requirements for MBBCh and BSc(Hons) in Physics are competitive and may vary.

BS, Mechatronics Engineering Technology, Purdue University

This qualification seeks to develop engineers with the ability to develop electromechanical products that are ubiquitous in modern life, dealing with interconnections that allow electronic control of mechanical, pneumatic, and hydraulic systems. Candidates are required to achieve a minimum of 120 credits. Graduates for this qualification may pursue a Master's of Science in Engineering Technology. Graduates may work as industrial engineers, product engineer, project managers and engineering consultant.

Bachelor of Engineering (Hons) Biomedical Engineering, BIUST, NCQF level 8

This qualification seeks to provide an educational approach where the emphasis is placed on integrated studies and on the production of graduates who are generalists, rather than specialists. It aims to meet the increasing demand for engineers with cross-disciplinary skills, particularly in Botswana industries which use electro-mechanical systems such as mining, production & manufacturing, power generation, transport, health, entertainment, etc. Candidates are required to achieve a minimum of 648 credits. Graduates for this qualification may pursue MEng degrees in Mechatronics & industrial instrumentation, mechanical & energy, computer & telecommunications and, electrical & electronics at NCQF Level 9. Graduates may work as robotics engineers, software engineers, automation engineers, control systems engineers, instrumentation engineers, maintenance engineers, reliability engineers, asset management engineers, Mechanical Design Engineers, data scientist / big data analyst, electronics design engineer, electrical design engineer, consulting engineers and researchers.
REVIEW PERIOD
5 years in line with the NCQF