QUALIFICATION SPECIFICATION								
								SECTION A
QUALIFICATION DEVELOPER	Botswana International University of Science & Technology							
TITLE	Bachelor of Engineering (Honours) in Materials and Metallurgical Engineering					**NCQF LEVEL**		**8**
FIELD	Manufacturing, Engineering and Technology		**SUB-FIELD**	Materials and Metallurgical Engineering				
New qualification	✓	Review of existing qualification						
SUB-FRAMEWORK	General Education			TVET		Higher Education		✓
QUALIFICATION TYPE	Certificate			Diploma		Bachelor		
	Bachelor Honours		✓	Master		Doctorate/ PhD		
CREDIT VALUE						636		

RATIONALE AND PURPOSE OF THE QUALIFICATION

RATIONALE

Materials is an extremely important area of technology as any physical thing that is made has to be created from materials. Frequently the properties those materials can achieve are what controls the performance. Materials Scientists and Engineers understand why materials have certain properties and research new materials with better performance to help produce and use these materials in real products, large and small [1]. In view of this, the Bachelor Materials and Metallurgical Engineering qualification at Botswana International University of Science and Technology is multidisciplinary, fundamental and strategic to the development of minerals and related industries in Botswana and the region. At present, BIUST is the only tertiary institution in Botswana that is training Materials and Metallurgical Engineers in response to the critical need and shortage of Materials and Metallurgical Engineers in Botswana particularly, the SADC region and the world general [2]. The Human Resource Development Council (HRDC) report of 2016, lists some specialization areas of Materials and Metallurgical Engineering as one of the top occupations in high demand in the Mining, Minerals, Energy and Water Resources and Manufacturing sector and also highlights the need for continuous engagement with industry to develop graduates that are ready to

address the ever changing needs of industry [2]. The qualification is designed for the exploration, extraction and processing of materials and mineral resources in Botswana and the region. The qualification seeks to produce skills and competences among Materials and Metallurgical Engineers that will champion the beneficiation of natural resources such as minerals and other materials e.g. metals, polymers, ceramics, wood, composites, leather, and the likes, for the industrial development as well as private practice for economic development [3]. The qualification is undertaking world class quality research and teaching that is problem oriented, interdisciplinary, and relevant to society that will contribute towards business development in Botswana and the region. Unlike other traditional engineering disciplines and/or professionals, Botswana does not currently train its own Materials and Metallurgical Engineers, but its economic development and sustainability depends largely on these professionals. The qualification aligns with the mission of the University as it focuses on energy, water, resources, and process engineering with are critical for the sustainable development of Botswana as stipulated in the University's mission and vision statement.

PURPOSE OF QUALIFICATION

The purpose of this qualification is to produce industry–ready Materials and Metallurgical graduates with knowledge, skills and competences to:

- Design, optimize and manage construction processes for the production of metals, and other engineering materials.
- Develop and manage Materials and Metallurgical processes and products in processing industries.
- Identify, diagnose and solve unpredictable problems encountered with process equipment and product quality in the process industry.
- Apply advanced specialist knowledge to solve environmental problems related to the sustainable use of natural resources within the Materials and Metallurgical process industries.
- Implement and develop safety, health, environmental, and quality (SHEQ) protocols and procedures within the Materials and Metallurgical industries.

ENTRY REQUIREMENTS (including access and inclusion)

- The minimum entry requirement is Certificate IV NCQF Level 4 (Botswana General Certificate of Secondary Education, BGCSE) or its equivalent with passes in Mathematics, Physics, Chemistry and English Language).

• Recognition Prior Learning (RPL) and Credit Accumulation and Transfer (CAT) will be considered for entry to this qualification for applicants who do not meet the minimum entry requirement.

QUALIFICATION SPECIFICATION **SECTION B**	
GRADUATE PROFILE (LEARNING OUTCOMES)	**ASSESSMENT CRITERIA**
1. Apply a range of advanced and specialised engineering principles to systematically diagnose and solve complex Materials and Metallurgical Engineering problems	1.1 Interpret test results for raw materials and products to improve and optimize processes to achieved required product specifications for customer satisfaction. 1.2 Use principles of mass and energy balances, mass and heat transfer in assessing complex engineering problems in Materials and Metallurgical industries for sustainability and profitability. 1.3 Develop models to diagnose and solve industry related problems.
2. Apply advanced and specialised knowledge of mathematics, natural science and engineering sciences to defined and applied Materials and Metallurgical Engineering procedures, processes, systems and methodologies to solve complex problems.	2.1 Integrate principles from Physical Metallurgy, Extractive Metallurgy, Process Metallurgy, Environmental Engineering and Materials Development and Engineering with engineering science to solve Materials and Metallurgical Engineering problems. 2.2 Develop processes and or procedures to produce material, components and products for various industrial specification and national development.
3. Perform procedural and non-procedural design of complex Materials and Metallurgical Engineering components, systems, works,	3.1 Develop process flowsheets and process instrumentation diagrams (PID) according

products, or processes to meet desired needs normally within applicable standards, codes of practice and legislation.	to set standards to meet project objectives. 3.2 Perform mass and energy balance on processes for optimization, sustainability and profitability. 3.3 Select appropriate materials, equipment and standards to meet design specifications. 3.4 Perform costing and project evaluation. 3.5 Perform safety and loss prevention using techniques such as HAZOP and process plant site selection to meet legislative requirements.
4. Conduct investigations of complex Materials and Metallurgical Engineering problems through locating, searching, and selecting relevant data from codes, data bases and literature, designing and conducting experiments, analysing and interpreting results to provide valid conclusions.	4.1 Formulate research objectives, research questions and hypothesis to address an industrial problem. 4.2 Search and compile relevant data using codes, databases and literature to address a specific industrial problem. 4.3 Plan and conduct plant trials addressing a specific industrial problem. 4.4 Analyse results from plant trials and laboratory experiment to address specific industrial problem, and 4.5 Draw conclusions from result, identify limitations and make appropriate recommendations.
5. Apply advanced specialist knowledge in engineering methods, skills, tools, including Information technology.	5.1 Select appropriate techniques, resources, and modern engineering tools (engineering software) to solve industry related problems.

	5.2 Understand the constraints of using different engineering application packages, when solving an industry related problem. 5.3 Use appropriate software to predict and model complex Materials and Metallurgical Engineering problems.
6. Communicate professional and technical information to stakeholders and the community at large.	6.1 Use oral and written communication effectively with engineering audiences and stakeholders. 6.2 Report results obtained from procedural work, research, and design projects in a professional manner. 6.3 Explain accurately the impact of engineering activities/processes to relevant stakeholders.
7. Demonstrate advanced and specialised knowledge and understanding of the impact of Materials and Metallurgical Engineering activity on the society, economy, industrial and physical environment, and address issues by analysis and evaluation.	7.1 Monitor industrial processes on the society and environment. 7.2 Identify the impact of industrial processes on society and environment. 7.3 Evaluate the environmental and socio-economic factors of Materials and Metallurgical Engineering processes. 7.4 Use engineering and scientific tools to solve Materials and Metallurgical Engineering processes.
8. Demonstrate advanced and specialised knowledge and understanding of Materials and Metallurgical Engineering management principles and apply these to one's own work, as a member and leader in a team and to manage projects.	8.1 Implement quality planning in project management. 8.2 Apply risk and value management in decision making.

	8.3 Demonstrate good leadership (e.g. delegation and coordination) in project planning and execution. 8.4 Work as a member of a team and or lead a team in planning and executing individual and or group project(s). 8.5 Take responsibility and accountability in the tasks/project as a team member/team leader.
9. Demonstrate mastery to engage in independent and life-long learning through well-developed learning skills.	9.1 Work independently on project to achieve a desired objective. 9.2 Show competency when executing assigned industrial task(s). 9.3 Exercise autonomy, initiative an0d authority in planning and executing project(s).
10. Apply ethical principles and commit to professional ethics, responsibilities, and norms of engineering technology practice.	10.1 Adhere to ethical principles and professional practice, responsibilities, and norms of engineering practice in executing projects. 10.2 Observe social responsibilities when executing project(s). 10.3 Uphold professional integrity in an impartial manner.
11. Demonstrate highly specialised knowledge and understanding of economic decision-making.	11.1 Perform cost estimation for project(s). 11.2 Implement cost optimization in decision-making process.

QUALIFICATION STRUCTURE SECTION C			
FUNDAMENTAL COMPONENT Subjects / Units / Modules /Courses	**Title**	**Level**	**Credits**
	Introduction to Technical Communication and Academic Literacy	5	6
	General Chemistry I	5	12
	Introduction to Computing	5	12
	Pre-Calculus	5	12
	Introduction to Physics I	5	12
	General Chemistry II	5	12
	Introductory Calculus	5	12
	Introductory Physics II	5	12
	Introductory statistics	5	12
	Engineering Graphics	5	12
	Workshop Practice	5	12
	Introduction to Engineering	5	6
	Technical and Professional Communication	5	6
	Procedural Programming	5	12
	Engineering Mathematics I	5	12
	Engineering Mechanics I (Statics)	5	12
	Material Science	6	12
	Introductory Physical Chemistry	5	12
	Fundamentals of Electrical Engineering I	6	12
	Engineering Mathematics II	5	12
	Design Methods	5	6
	Strength of Materials	6	12
CORE COMPONENT Subjects / Units / Modules /Courses	Process Engineering I	6	12
	Unit Operations I	6	12
	Research methods for Engineering and Technology	6	12
	Physical Metallurgy	6	12

	Process Control I	6	12
	Process Engineering II	6	12
	Engineering Mathematics III	6	12
	Elements of Pyrometallurgy	6	12
	Non-metallic Materials I (Polymer and Composites)	6	12
	Metallurgical Engineering Thermodynamics	6	12
	Foundry Technology	6	12
	Process Engineering Management	6	12
	Engineering Mathematics IV	6	12
	Engineering Project Management	6	12
	Mineral Processing	6	12
	Heat Treatment Processes	7	12
	Tribology & Corrosion	7	12
	Hydrometallurgy & Electrometallurgy	7	12
	Nanotechnology	7	12
	Economics, Business & Entrepreneurship	7	12
	Industrial Training	7	36
	Powder Metallurgy	8	12
	Process Modelling, Simulation & Optimisation	8	12
	Chemical, Materials & Metallurgical Engineering Research Project (I & II)	8	24
	Chemical, Materials & Metallurgical Engineering Design Project (I & II)	8	36
	Materials Selection and Economics	8	12
ELECTIVE COMPONENT Subjects / Units / Modules /Courses	Mechanical Metallurgy	8	12
	Non-metallic Materials II (Ceramics & Glass Materials)	8	12
	Leather Technology	8	12
	Coal Technology	8	12

	Welding and other Joining Processes	8	12
	Iron and Steel	8	12
	Refractory Technology	8	12

RULES OF COMBINATIONS, CREDIT DISTRIBUTION (where applicable):

Fundamental Level 5 204 Credits
Fundamental Level 6 36 Credits
Core Level 6 180 Credits
Core Level 7 96 Credits
Core Level 8 96 Credits
Electives Level 8 24 Credits
Total 636 Credits

ASSESSMENT AND MODERATION ARRANGEMENTS

ASSESSMENT

All assessments, formative and summative, research and others (mostly work integrated learning) leading/contributing to the award of credits or a qualification should be based on learning outcomes and/or sub-outcomes. The qualification assessments are based on the following:

Coursework/Formative/CA	Summative	Research	Others
34%	51%	9%	5%

MODERATION

This qualification will be moderated both internally and externally as per ETP policy.

RECOGNITION OF PRIOR LEARNING (if applicable)

RPL and CAT will be considered for the award of this qualification.

PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)

Vertical Pathway

- Master of Engineering in Materials and Metallurgical Engineering.
- Master of Engineering in Materials Science and Engineering.
- Master of Engineering in Metallurgical Engineering.
- Master of Science in Materials Engineering.

Horizontal Pathway

- Postgraduate Diploma in Materials and Metallurgical Engineering.
- Postgraduate diploma in Mechanical Engineering.
- Post graduate diploma in Engineering Management.

Employment Pathways:

- Foundry metallurgist
- Physical metallurgist
- Extractive metallurgist
- Welding engineer
- Metallurgical and quality control supervisor
- Metallurgical inspector analyst
- Materials Engineer
- Process Control Engineer
- Metallurgical Plant Design Engineer
- Corrosion Engineer
- Foundry Engineer
- Heat Treatment Engineer
- Failure Analysis Consultant
- Tribologist
- Materials Consultants
- Mineral processing engineer

QUALIFICATION AWARD AND CERTIFICATION

Minimum standards of achievement for the award of the qualification

A candidate is required to achieve the minimum stipulated total credits of 636 credits in order to be awarded Bachelor of Engineering in Materials and Metallurgical Engineering. The candidate must also attain and fulfil all the rules of combination required for this qualification.

Certification

Candidates meeting prescribed requirements will be awarded the certificate in accordance with standards prescribed for the award of the qualification and applicable policies. Candidates who do not meet the prescribed minimum standards may, where applicable, be considered for appropriate exit awards in accordance with applicable policies.

REGIONAL AND INTERNATIONAL COMPARABILITY

Summary of Similarities and Differences Observed

The BEng in Materials and Metallurgical Engineering discipline was designed to be comparable to similar programmes being offered by other research-based institutions in the world such as the University of Witwatersrand in Johannesburg, South Africa and two international programmes at the Colorado School of Mines (CSM) (USA) and Atilim University, (AU) (Turkey). Hence, this qualification is competitive and comparable internationally. The qualification is also designed in-line with ECSA requirements which is affiliated with the Washington Accord.

The courses differ in terms of duration, the programme offered at Wits, CSM and AU are 4-years programmes while the BIUST programme is 5 years. In terms of total credits for the course, there are comparable with that at Wits and CSM, however, the AU qualification has 480 credits, however, the AU programme has 480 credits. All the institutions cover the basic science courses (mathematics, physics, chemistry, and computer science) in the first two years, however, the other institutions commence with core Metallurgical and Materials engineering courses from their respective first years of study, while BIUST devotes the first two-years of study on the basic and general science subjects. For the programme at BIUST these modules are classified as foundational level courses and are not included in the total credits for the qualification.

In terms of the courses taught all the programmes cover the core Metallurgical and Materials engineering courses namely: Thermodynamics/physical chemistry; Physical metallurgy; Unit operations; Materials

Science and Engineering; Process and Plant design; Equipment/materials; Extractive Metallurgy; Corrosion and Wear, Welding and forming Processes, Non-ferrous metallurgy, Heat treatment processes, Metallic and Non-metallic materials: synthesis, processing, and applications, and Materials selection and designs. All the programmes offer specialisation in the advanced electives in emerging and existing Metallurgical and Materials engineering fields, however, these vary depending on institutional focus. All the programmes require some form of industrial attachment for certain periods with any industries which deals with engineering materials, however, these are not credit bearing as is the case at BIUST where it accounts for 36 credits.

Generally, the qualifications summarized above are similar in that all of them cover the basic courses in Metallurgical and Materials Engineering from extraction to production process, materials quality and design requirements, the tools and equipment as well as the application to the changing world. The qualifications are based on outcome-based terms and are credit based and all the qualifications give recognition to evidence of prior learning.

Comparability and articulation of the proposed qualification

The main difference observed was in the area of access to industry to assist in training the learners. All the compared institutions are from the developed world while Botswana is still at the developing stage of industrialisation. The proposed qualification generally compares well with the three qualifications studied in terms of content, scope and learning hours to be achieved before assessment.

Graduates from all the programmes can register for the candidacy phase for professional registration as engineers and can be directly admitted to postgraduate diplomas and Master's degree programmes both in engineering and management. All the other programmes are accredited under the Washington Accord as their respective national engineering councils are signatories to this Accord, however, the Engineers Registration Board (ERB) is not a signatory to this Accord.

Graduates from all the programmes can work as: Foundry Metallurgist, Physical Metallurgist, Extractive Metallurgist, Welding Engineer, Metallurgical and quality control supervisor, Metallurgical inspector analyst, Materials Engineer, Process Control Engineer, Metallurgical Plant Design Engineer, Corrosion Engineer, Foundry Engineer, Heat Treatment Engineer, Failure Analysis Consultant, Tribologist, Materials Consultants and Mineral Processing Engineer.

REVIEW PERIOD

5 years in line with the NCQF.