SECTION A:		QUALIFICATION DETAILS			

QUALIFICATION DEVELOPER (S)	Botswana International University of Science and Technology

TITLE	Bachelor of Science in Industrial Mathematics		*NCQF LEVEL*	7

FIELD	Natural, Mathematical and Life Sciences	*SUB-FIELD*	Mathematical Sciences	*CREDIT VALUE*	480

New Qualification		√	*Review of Existing Qualification*	

SUB-FRAMEWORK	*General Education*		*TVET*		*Higher Education*	√

QUALIFICATION TYPE	*Certificate*	*I*	*II*	*III*	*IV*	*V*	*Diploma*	*Bachelor*	√
	Bachelor Honours		*Post Graduate Certificate*			*Post Graduate Diploma*		
	Masters				*Doctorate/ PhD*			

RATIONALE AND PURPOSE OF THE QUALIFICATION

RATIONALE

Mathematics plays an indispensable role in the advancement of science and engineering, as well as in creating new and complex technologies. For the sustainable economic development of Botswana it has been indicated that transforming to knowledge-driven economy is vital. In this regard, the first and the second pillars of Vision 2036 and National Development Plan (NDP 11) of the country depict that Botswana's economy will be completely changed to a knowledge-based economy from a resource based economy, with access to a skilled and internationally competitive workforce. The African Union (AU) through the New Partnership for Africa's Development (NEPAD) has identified mathematics as one of the key subjects that must be strengthened if Africa is to join the technological and innovation revolution. Thus, it is imperative to develop skills, which perfectly suit Botswana's environment and set Botswana's competitive products (both human and natural resources) on an international scale. According to the report by Human Resource Development Council 2016

(HRDC 2016) of Botswana, there is a need to fill top demand occupations in the fields of transport and logistics sectors (logistic managers, quality assurance officers, traffic controllers etc.), manufacturing (computer numerical control operators), information and communication technology (database designers, computer network professionals, applications programmers, system analysts, software developers etc.), research, innovation, science and technology sector (big data, climate change, software engineering etc.), education and training sectors (teachers, computer programming, software design etc.) and other creative industries sectors (creative and innovation thinking, ICT etc.).

Stakeholders from various specialised sectors in Botswana have been consulted and remained actively engaged in the design of this qualification. The invaluable input from the industry stakeholders also helped the qualification developers to have an insight on the current and future needs in the areas where graduates of this qualification are required.

PURPOSE

The purpose of this qualification is to produce graduates who have competencies, knowledge and transferable skills. Graduates from this qualification should be able to:
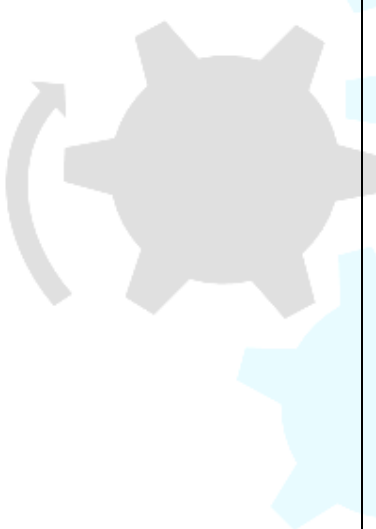
- Solve industrial problems using analytical, computational, modelling and programming skills.
- Solve problems with deterministic and non-deterministic systems from relevant industries.
- participate in the highly skilled work force that the industries require.
- Use entrepreneurial skills to create jobs.

ENTRY REQUIREMENTS (including access and inclusion)

The minimum entry requirements is:

NCQF level 4 in a related field with provisions for exemptions, where applicable, in line with Credit Accumulation and Transfer (CAT) or Recognition of Prior Learning (RPL) policy.

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QUALIFICATION SPECIFICATION	SECTION B

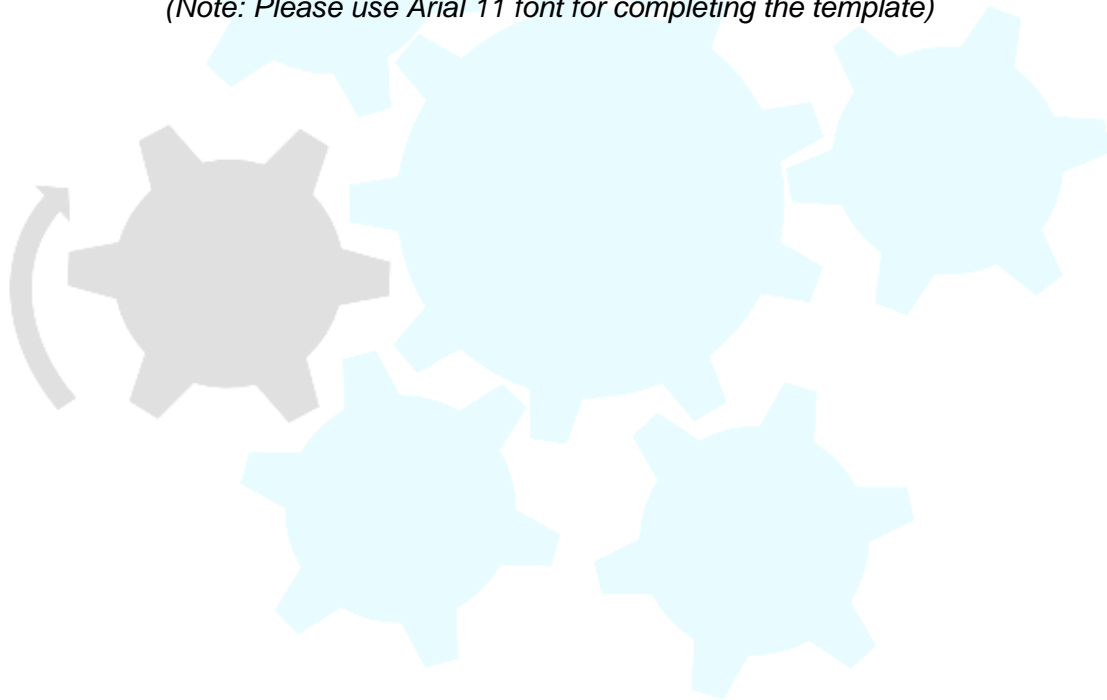| GRADUATE PROFILE (LEARNING OUTCOMES)	ASSESSMENT CRITERIA
1. Identify and solve complex industrial problems using mathematical and computational skills.	1.1 Describe and classify the principles of mathematical analysis and modelling. 1.2 Apply knowledge of contemporary principles of mathematics to analyse, design and describe complex industrial problems. 1.3 Describe the principles and concepts of mathematical computations and algorithmic analysis to analyse problems from relevant industries. 1.4 Develop computer programmes for implementing algorithms that solve complex and challenging industrial problems. 1.5 Apply computational skills to carry out introductory research in industrial problems and describe commercial software packages suitable for their problem as necessary. 1.6 Formulate and solve both concrete and abstract problems in industrial mathematics. 1.7 Demonstrate the ability to balance the complexity or accuracy of mathematical and/or statistical models and the timely delivery of solutions. 1.8 Select appropriate technologies to effectively gather data, analyse and communicate qualified information. 1.9 Analyse the diversity of industrial standards in different regions and apply them within their profession as an industrial scientist.
2. Analyse industrial problems using appropriate mathematical techniques and software.	2.1 Apply mathematical tools for solving industrial problems. 2.2 Develop mathematical skills and use in the industrial problems. 2.3 Classify and describe mathematical models for industrial problems and analyse them by using mathematical tools.

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		2.4 Develop mathematical skills in industry linked software.
		2.5 Write codes and develop algorithms linked with industrial problems.
3.	Classify scientific information related to industrial problems using specialised mathematical techniques.	3.1 Describe and classify the principles and concepts of mathematical procedures such as graphical or computational techniques, in conducting scientific research. 3.2 Analyse data and scientific evidences to distinguish facts from hypotheses.
4.	Classify and manage activities responsibly and effectively.	4.1 Demonstrate appropriate study skills e.g. learning from text, note-taking, summarising, analysing and synthesise information. 4.2 Develop effective learning strategies which suit personal needs and contexts. 4.3 Demonstrate effective time management, e.g. completing tasks by deadlines.
5.	Communicate scientific understanding orally and in writing using various forms of representation relevant to the target audience.	5.1 Produce written reports that communicate complex disciplinary and interdisciplinary ideas and information effectively for the intended audience and purpose, 5.2 Produce oral presentations that communicate complex disciplinary and interdisciplinary ideas and information effectively for the intended audience and purpose. 5.3 Communicate scientific results to the target audience using visual, symbolic, graphic etc. forms.
6.	Demonstrate ability to work effectively with others as a member of a team/group or organisation/ community in scientific projects or investigations.	6.1 Provide evidence of working effectively as a member of a team or group in scientific projects and / or investigations with significant contribution. 6.2 Demonstrate key capabilities to initiate, organise and manage group works. 6.3 Communicate effectively the outcomes of a scientific group work to relevant audiences.
7.	Identify entrepreneurial concepts, evaluate and appraise their	7.1 Formulate ideas and / or methods that can be transformed in to new products or services.

business plans and effectively communicate the result to appropriate audiences.	7.2 Evaluate and appraise a given business plan.
	7.3 Produce written reports that communicate complex disciplinary and interdisciplinary ideas and information effectively for the intended audience and purpose.

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SECTION C		QUALIFICATION STRUCTURE				
COMPONENT	TITLE	Credits Per Relevant NCQF Level				Total (Per Subject/ Course/ Module/ Units)
		Level [5]	Level [6]	Level [7]	Level [8]	
FUNDAMENTAL COMPONENT *Subjects/ Courses/ Modules/Units*	Fundamental Component Total Credit Hours					84
	Mathematical Foundations	24				24
	Science Foundations I	36				36
	Computing Foundations	12				12
	Science Foundations II		12			12
CORE COMPONENT *Subjects/Courses / Modules/Units*	Core Component Total Credit Hours					330
	Calculus		48			48
	Mathematical Statistics		24			24
	Algebra		24			24
	Computer Programming		30			30
	Discrete Mathematics		12			12
	Linear algebra and its applications		24			24

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	Differential Equations		24		24
	Probability		12		12
	Data Structure and Algorithm		12		12
	Work Integrated Learning		12		12
	Analysis		24		24
	Numerical Analysis		12		12
	Mechanics		24		24
	Mathematical Modelling		12		12
	Optimization and Applications		12		12
	Project in Industrial Mathematics		12		12
	Fourier and Wavelet Analysis			12	12
ELECTIVE/ OPTIONAL COMPONENT *Subjects/Courses / Modules/Units*	**Electives Modules: Choose six Modules (66 credits) from the following list.**				*66*
	Discrete and Network Optimization		12		12
	Linear Programming and Network		12		12
	Multi-Criteria Optimization		12		12
	Advanced Fluid Dynamics		12		12
	Statistical Inference	12			12
	Introduction to Stochastic Processes	12			12
	Stochastic Differential Equations		12		12

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Stochastic Programming			12		12
Computational Discrete Mathematics			12		12
Optimal Control			12		12
Numerical Fluid Dynamics			12		12
Dynamical Systems			12		12
Computational Discrete Mathematics			12		12
Robotics Modelling and Simulation			12		12
Algorithm Analysis and Design			12		12
Computer Network and Security			12		12
Machine Learning			12		12
Introduction to Technical Communication and Academic Literacy		6			6
Writing Process		6			6
Management and Entrepreneurship – Concepts and Principles		6			
Technical and Professional Communication		6			6
Starting and Sustaining a Business			6		6
Developing Strategic Business Plan			6		6

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SUMMARY OF CREDIT DISTRIBUTION FOR EACH COMPONENT PER NCQF LEVEL	
TOTAL CREDITS PER NCQF LEVEL	
NCQF Level	*Credit Value*
5	72
6	192
7	204
8	12
TOTAL CREDITS	**480**

Rules of Combination:

(Please Indicate combinations for the different constituent components of the qualification)

This qualification will have 480 credits.

The credit combination for the qualification is from 84 credits fundamental component, 330 credits core component, and 66 credits elective component.

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ASSESSMENT ARRANGEMENTS

All assessments, formative and summative, leading to the award of credits in this qualification shall be based on module learning outcomes, and the qualification exit-level outcomes.

- Formative Assessment - A formative assessment aligned to the module learning outcomes and exit-level outcomes will be administered continuously throughout the learning period in each module. The recommended weights of the formative assessment should be at least 50% and should not exceed 60% of the final marks for that module.

- Summative Assessment - Learners shall undergo a summative assessment which may include a written examination at the end of learning period in each module. The recommended weights of the summative assessment will vary from 40% to 50% of the final marks for that module. All summative practical assessments must, as far as possible, be conducted in real-work settings.

MODERATION ARRANGEMENTS

- Internal Moderation - All assessment instruments and processes shall be subjected to internal moderation by BQA registered and accredited Assessors and Moderators before to ensure fairness, validity, reliability and consistency of assessments.

- External Moderation – Exit level assessment instruments and processes shall be moderated by an External Moderator to ensure fairness, validity, reliability and consistency of assessments. Qualified external moderators shall be appointed from an accredited Education and Training Providers (ETPs).

RECOGNITION OF PRIOR LEARNING

Recognition of Prior Learning (RPL) will be considered in the award of the qualification in accordance with applicable policy of the ETP which is aligned to the National policies on RPL.

CREDIT ACCUMULATION AND TRANSFER

Credit Accumulation and Transfer (CAT) will be considered for the award of Bachelor of Science in Industrial Mathematics in accordance with applicable ETP policy and guidelines which are aligned to National policy on CAT.

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PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)

LEARNING PATHWAYS

This qualification is intended to provide learners with both horizontal and vertical articulation pathways, nationally, regionally and internationally.

Horizontal Articulation

The qualification articulates horizontally with various local, regional and international Bachelor of Science degree qualifications at NCQF Level 7 or equivalent which include:

- Bachelor of Science in Applied Sciences,
- Bachelor of Science in Applied Mathematics and Computer Science,
- Bachelor of Science in Applied and Computational Mathematics,
- Bachelor of Science in Mathematical Sciences.
- Bachelor of Science in Financial Mathematics.

Vertical Articulation

The qualification provides vertical articulation to higher level qualifications at NCQF level 8 and 9. The graduate of this qualification can thus progress to enrol to related postgraduate qualification(s) such as Bachelor of Science (Honours) or Master of Science in:

- Industrial Mathematics,
- Applied Mathematics,
- Applied Mathematics and Computer Science,
- Applied Science,
- Mathematical Sciences.

EMPLOYMENT PATHWAYS

Employment prospects are good as mathematics graduates have high level problem-solving skill. Mathematics can be a steppingstone to a wide and diverse career. Industrial mathematics graduates are sought after by

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many central and local government departments, research organisations, industries and consultancies due to their scientific training, critical thinking skills and problem-solving abilities.

The graduates will have the requisite competencies and attributes to work in the following sectors:

- Industrial sector and operation research sector
- Transport and networking sector
- Information technology and Computing
- Manufacturing sectors
- Agriculture sector and Beef industries
- Public health sector
- Research and innovation

The graduates will be qualified to hold high-level positions/roles such as:

- Quality assurance manager,
- Researchers in creative industries in innovation, data collection, analysis and documentation, monitoring and evaluation, analytical and critical analysis,
- Science and technology researchers; specialisation in climate change, big data, software engineering,
- Computational Fluid Dynamics (CFD) analyst and planning officer in industries,
- Database designer, Data Analyst / Scientist,
- Information Technologists,
- Project analyst / manager,
- Computer network professional,
- Application programmers,
- System analyst and developer
- Programmer / Software developers,
- Air traffic controller / traffic controller,
- Mathematical and related associate professionals,
- Computer numerical control operators,
- Production control manager,
- Consulting manager,

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- Operations research analysts, sales and marketing executives in service industries,
- Operations / logistic managers,
- Administrative officers in public and private sectors,
- Games designer,
- City traffic planner / manager,
- Scheduler,
- Supply chain Manager,
- Academicians and researchers in academic and research institutions,
- Entrepreneurs.

QUALIFICATION AWARD AND CERTIFICATION

Minimum standards of achievement for the award of the qualification

Candidate(s) will be awarded the degree of Bachelor of Science in Industrial Mathematics after attaining the stipulated minimum credits of 480; inclusive of 84 credits from fundamental modules, 330 credits from core modules and 66 credits from elective modules as specified in the rules of combination and credit distribution.

Certification

Candidates meeting prescribed requirements will be awarded the qualification in accordance with standards prescribed for the award of the qualification and applicable policies. A certificate of the award of the degree of Bachelor of Science in Industrial Mathematics will be given upon successful completion of the qualification**.**

REGIONAL AND INTERNATIONAL COMPARABILITY

The qualification was compared with various institutions,regionally and internationally running the Industrial Mathematics qualifications. The qualification compares very well in terms of learning outcomes, scope of content, level and duration with:

- Bachelor of Science in Industrial Mathematics, Curtin University, Australia,
- Bachelor of Science in Industrial Mathematics, University of Technology, Malaysia.
- Bachelor of Science in Industrial Mathematics, University of South Australia, Australia,

The qualification was also compared with the following institutions offering Industrial Mathematics. Even though the benchmarked qualifications had some aspects that were similar to this qualification, they were in general found not compare favourably with the learning outcomes, scope and depth covered in some of the benchmarked qualifications:

- Bachelor of Science Degree in Industrial Mathematics, Jomo Kenyatta University of Agriculture and Technology, Kenya
- Bachelor of Science in Industrial Mathematics, Dublin University of Technology, Ireland,
- Bachelor of Science in Industrial Mathematics, University of Ontario, Canada,

The Bachelor of Science in Industrial and Applied Mathematics Major offered at Curtin University (CU) is a three-year qualification (NCQF level 7) that puts more emphasis on numerical optimization and computational mathematics. The qualification covers 60 percent of the proposed qualification. CU qualification gives students an opportunity to complete an industrial project at year three. The proposed qualification is designed to put more emphasis on mechanics and control, computational methods including algorithm and data science with blend of mathematics with industrial needs.

The Bachelor of Science in Industrial Mathematics offered at Jomo Kenyatta University of Agriculture and Technology (JKUAT) is a four year qualification (NCQF level 8) that puts more emphasis on mechanics and control, optimization and industrial statistics with financial mathematics. The qualification covers almost 60 percent of the proposed qualification. However, the proposed programme emphasises more on mechanics and control, optimization control and data science. In the proposed qualification, learners will be facilitated by key competences and the opportunity to gain hands-on experience in the industry and to acquire research skills through final year research dissertation.

The Bachelor of Science Industrial Mathematics offered at Dublin Institute of Technology (DIT) is a four year Honours programme (NCQF level 8). The present programme is a blend of mechanics and control, optimization control and computational methods including algorithm and data science. This qualification covers 75 percent of the proposed qualification. DIT qualification gives students an opportunity to complete an industrial project at year four. The students can attach with industries for 72 weeks. The proposed qualification like the DIT qualification, acknowledges the importance work-integrating learning and final year research project, and thus includes an industrial attachment at year 3 and final year industrial project. In addition, the proposed

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qualification, explores the knowledge of students in the direction of computer programming and mathematical tools including knowledge on C, C++, JAVA programming language and MATLAB tools.

University of South Australia offers a 3-year Bachelor of Science in Mathematics (NCQF level 7) with majors in applied mathematics and industrial mathematics. This qualification mainly focused on the Optimization and Statistics as their majors. The proposed qualification is designed to put more emphasis on mechanics and control, computational methods including algorithm and data science with blend of mathematics with industrial needs. The proposed qualification also put a lot of emphasis on entrepreneurship and computer programming and/or software to equip learners with skills and attributes that can be used in self-employment and a range of applications in line with the exit-level learning outcome. In addition, it emphasises students to attach with industry through industrial attachment and further they continue the learning process through their final year project.

University of Ontario offers a four year Bachelor of Science qualification (NCQF level 7) with two majors in Applied and Industrial Mathematics. They have a project at year four which is done in two semesters. The proposed qualification offers an industrial attachment at year 3. The proposed qualification gives more focus on the computational methods applied in industries, computer programming which includes data science and optimization theory.

University of Technology, Malaysia offers a four year Bachelor of Science qualification (NCQF level 7) on the industrial mathematics. The qualification introduces the industrial mathematics course from the first year which gives a nice start up to the students. This qualification has an equal distribution among topics in statistics, mathematical methods, programming, statistics and optimization theory. Both semesters of the final year covenants with undergraduate project. The proposed qualification is in line with 75 percent of this qualification offering more diversity of learners. Furthermore, the proposed qualification provides learners with opportunity to gain hands-on work experience through the industrial attachment, and research skills by completing the final year project.

In conclusion, the proposed Bachelor of Science Industrial Mathematics qualification generally compares well with all the qualifications benchmarked since the learning outcomes cover similar scope and depth and are aligned to exit-level descriptors typical of this level and type of qualification. The qualification covers in detail all the core technical aspects of Industrial Mathematics that includes: dynamics and control theory, optimization

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and networking, computer and computational programming and data science. In addition, the qualification equips learners with skills on how to conceptualise, design, and implement research to contribute to the existing body of knowledge in the relevant industries.

A comparison table made as benchmarking has been done against a sample of similar types and levels qualifications and/or programmes offered within the continent and beyond to appreciate international trends. The developer of this qualification has compare the name of the awarding body, title of qualification with NQF level and credit, main exit outcomes domain covered and credit weighting, assessment strategies, qualifications rules and minimum standard for the award of the qualifications, education and employment pathways with Curtin University, University of South Australia and Jomo Kenyatta University of Science and Technology.

REVIEW PERIOD

The qualification will be reviewed every 5 years.

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