SECTION A:	***QUALIFICATION DETAILS***				
QUALIFICATION DEVELOPER (S)	Botswana International University of Science and Technology				
TITLE	Bachelor of Science Honours in Industrial Mathematics			***NCQF LEVEL***	*8*
FIELD	Natural, Mathematical and Life Sciences	***SUB-FIELD***	Mathematical Sciences	***CREDIT VALUE***	660
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. In our current world it is through an extensive use of mathematical tools and model analysis together with the power of computers in investigating complex and unpredictable problems that have contributed to the creation of new technologies in various areas of the economy. 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 highly 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.). Industrial Mathematics can contribute to the modelling, analysis, decision making and management of complex systems, to the automation of various services, and to the re-engineering of various technological equipment.

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. It has been reported through the Industrial Advisory Board (IAB) that industries are forced to engage various external consultants to fill the gap of knowledge required in various specialized sectors. Therefore, there is a need to fill this required gap by producing industrial mathematicians who have the required knowledge and skills to fill this gap.

PURPOSE:

The purpose of this qualification is to produce graduates who have knowledge, skills and competences that will enable them to:

- Critically apply skills of analyses, computational, modelling and programming to solve complex and unpredictable industrial problems.
- Critically apply techniques of solving complex and unpredictable problems with deterministic and non-deterministic systems from relevant industries.
- Conceptualise design research problems and carry out specialized basic and applied research skills to contribute to solving relevant industrial problems.
- Apply entrepreneurial skills to work professionally and create jobs.

ENTRY REQUIREMENTS (including access and inclusion)
Entry into this qualification is through any one of the following requirements. • 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. • Bachelor's degree at NCQF level 7 in a related field with provisions for exemptions, where applicable, in line with CAT or RPL policy.

SECTION B	***QUALIFICATION SPECIFICATION***
GRADUATE PROFILE (LEARNING OUTCOMES)	***ASSESSMENT CRITERIA***
1. Apply highly specialised knowledge in Mathematical analysis and modelling to solve complex industrial problems.	1.1 Design and analyse complex industrial problems by applying knowledge of contemporary principles of mathematics. 1.2 Execute theories, principles and concepts of mathematical computations and algorithmic analysis to critically analyse problems from relevant industries. 1.3 Develop computer programmes for implementing algorithms that solve complex and unpredictable challenging industrial problems. 1.4 Formulate models, analyse, and solve both concrete and abstract type of problems from relevant industries. 1.5 Select appropriate technologies to effectively gather data, analyse and communicate qualified information. 1.6 Critically analyse the diversity of industrial standards in different regions and implement them within their profession as an industrial scientist.
2. Identify appropriate mathematical techniques and software, and critically synthesise models to automate systems in relevant industries.	2.1 Identify appropriate mathematical tools for solving industrial problems. 2.2 Identify Industrial problems from relevant industries, formulate mathematical models for such problems and solve and analyse them. 2.3 Generate codes to implement complex mathematical algorithms that solve unpredictable industrial problems. 2.4 Synthesize various mathematical models to solve complex and unpredictable industrial problems.

	2.5 Formulate models and algorithms to automate various systems in relevant industries.
3. Work effectively in a team / group or organisation/ community in scientific projects or investigations and manage activities responsibly and effectively.	3.1 Execute study skills like learning from text, note-taking, summarising, analysing and synthesise information appropriately. 3.2 Develop effective learning strategies which suit personal needs and contexts. 3.3 Manage time effectively to complete tasks by deadlines. 3.4 Provide evidence of working effectively as a member of a team or group in scientific projects and / or investigations with significant contribution. 3.5 Initiate, organise and manage group works effectively. 3.6 Communicate effectively the outcomes of a scientific group work to relevant audiences.
4. Carry out basic and specialised research and explain the results to relevant audiences.	4.1 Formulate and refine a research problem. 4.2 Assemble a theoretical base appropriate to the topic involving a critical analysis of literature and proper use of citation within arguments. 4.3 Select appropriate research methods and associated research design. 4.4 Apply analytical, critical, and creative thinking skills to solve problems. 4.5 Apply highly specialised computational skills to carry out basic research that can possibly lead to a development of commercial software packages suitable to the specific problem as necessary. 4.6 Carry out basic research, critical evaluation and synthesis of ideas, issues, and concepts to identify

	and solve complex and unpredictable challenges from different industries. 4.7 Draw appropriate inferences and conclusions. 4.8 Produce a substantial report giving an honest account of research undertaken. 4.9 Present the result of the research work in a workshop, seminar, or conference setting.
5. Apply highly specialized knowledge in contemporary theories, principles and concepts of mathematical optimization to identify best possible decisions in relevant industries.	5.1 Apply specialised principles, concepts and theories of optimization to formulate and solve complex and unpredictable industrial problems. 5.2 Implement appropriate computational techniques to estimate relevant parameter values of a model using field data. 5.3 Formulate optimal control problems in various forms and master the techniques to solve them. 5.4 Execute the principles behind the most standard algorithms to numerically solve problems linked with transportation, traffic control, logistics, network flows, telecommunications, airport terminal layout, location planning, etc.
6. Apply contemporary theories, principles and concepts of control theory for solving complex industrial problems.	6.1 Analyse and solve dynamical systems with control parameters that emerge from practical problems in the industry. 6.2 Appreciate issues of robustness, optimality, architecture and uncertainty in control problems. 6.3 Identify controllability and attainability of dynamical systems that model complex systems from industry
7. Apply highly specialised mathematical tools for data science to solve problems in relevant industries.	7.1 Apply contemporary theories, principles and concepts of data science to solve practical problems from industry.

	7.2 Effectively organize and cluster datasets for analytic projects. 7.3 Critically evaluate and synthesis ideas of ethical, privacy and security challenges in data analytics. 7.4 Identify and develop databases and data warehouses and apply data mining technologies to establish relationships in data to predict trends to support decision making. 7.5 Apply specialised mathematical techniques to formulate algorithms for artificial intelligence procedures that can transform data into the required usable form.
8. Communicate scientific understanding orally and in writing using various forms of representation relevant to the target audience.	8.1 Produce written reports that communicate complex disciplinary and interdisciplinary ideas and information effectively for the intended audience and purpose. 8.2 Produce oral presentations that communicate complex disciplinary and interdisciplinary ideas and information effectively for the intended audience and purpose. 8.3 Communicate scientific results to the target audience using visual, symbolic, graphic etc. forms.
9. Identify entrepreneurial concepts, evaluate and appraise their business plans and effectively communicate the result to appropriate audiences.	9.1 Formulate ideas and/or methods that can be transformed into new products or services. 9.2 Evaluate and appraise a given business plan. 9.3 Apply entrepreneurial skills to identify and create business opportunities, and ideas that can be transformed into new products or services that may be commercialised successfully.

	9.4 Identify and analyse key practical issues and problems in the industry and recommend suitable and well justified solutions.

SECTION C	***QUALIFICATION STRUCTURE***				
COMPONENT	***TITLE***	***Credits Per Relevant NCQF Level***			***Total*** ***(Per** Subject/ Course/ Module/ Units)*
		Level [ ]	***Level [ ]***	***Level [ ]***	
FUNDAMENTAL COMPONENT *Subjects/ Courses/ Modules/Units*	Mathematical Foundations	5			24
	Science Foundations I	5			36
	Computing Foundations	5			12
	Academic Literacy and Social Sciences I	5			12
	Science Foundations II	6			12
	Academic Literacy and Social Sciences II	6			06
CORE COMPONENT *Subjects/Courses/ Modules/Units*	Calculus	6			48
	Mathematical Statistics	6			24
	Algebra	6			24
	Computer Programming	6			30

	Discrete Mathematics	6			12
	Linear algebra and its applications	6			24
	Management and Entrepreneurship		7		18
	Differential Equations		7		24
	Probability		7		12
	Data Structure and Algorithm		7		12
	Work Integrated Learning		7		18
	Analysis		7		24
	Numerical Analysis I		7		12
	Mechanics		7		24
	Mathematical Modelling		7		12
	Optimization and Applications		7		12
	Project in Industrial Mathematics		7		24
	Fourier and Wavelet Analysis			8	12
	Dynamical System			8	12
	Numerical Analysis II			8	12
	Optimal Control			8	12
	Neural Network			8	12
	Honours Project in Industrial Mathematics			8	36

ELECTIVE/ OPTIONAL COMPONENT *Subjects/Courses/ Modules/Units*	*Choose at least 24 credits from a pool of modules in Mathematics and Statistics, 24 credits from other Science fields. The remaining 60 credits can be selected from any area of the learner's choice*				
	Programming and Operating System	6			36
	Statistical Methods and Computing		7		24
	Dynamical Systems		7		24
	Analysis		7		24
	Computer System and Algorithm		7		24
	Science and Engineering		7		24
	Language and Culture Studies		7		18
	Management and Entrepreneurship		7		18
	Multi-criteria Optimization			8	12
	Stochastic Differential Equations			8	12
	Numerical Fluid Dynamics			8	12
	Computational Discrete Mathematics			8	12
	Computer Network and Security			8	12
	Mathematical models on Signal Processing			8	12

	Software Engineering			8	12
	Machine Learning			8	12

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SUMMARY OF CREDIT DISTRIBUTION FOR EACH COMPONENT PER NCQF LEVEL	
TOTAL CREDITS PER NCQF LEVEL	
NCQF Level	***Credit Value***
5	84
6	192
7	240
8	144
TOTAL CREDITS	***660***

Rules of Combination:

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

This qualification will have 660 credits.

The credit combination for the qualification is from 102 fundamental components, 450 core components and 108 elective components.

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 - 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 the learning period in each module. The recommended weights of the summative assessment will vary from 50% to 40% of the final marks for that module. All summative practical assessments must, as far as possible, be conducted in real-work settings.

MODERATION ARRANGEMENTS

Pre-assessment moderation will be carried out before administering assessments that contribute towards the award of credits in this qualification and post-assessment moderation will be carried out after the assessment tasks have been marked.

- Internal Moderation – Assessment instruments shall be subjected to internal moderation by BQA registered and accredited Assessors and Moderators before being administered to ensure fairness, validity, reliability and consistency of assessments.
- External Moderation –Exit level assessment instruments 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 RPL policy of the ETP which are aligned to BQA / National policies on the same.

CREDIT ACCUMULATION AND TRANSFER

Credit transfer will be awarded in accordance with applicable ETP CAT policies and guidelines which are aligned to BQA / National policies on the same.

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 degrees and Postgraduate Diplomas in related areas. Qualifications of similar level at NCQF Level 8 include:

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

Vertical Articulation

The qualification provides vertical articulation to higher level qualifications at NCQF Level 9 and 10. The graduate of this qualification can thus progress to enrol to related postgraduate qualification(s) such as Masters of Science (MSc) and Doctor of Philosophy (PhD) in:

- Master of Science in Industrial Mathematics,
- Master of Science in Applied Mathematics,
- Master of Science in Applied Mathematics and Computer Science,
- Master of Science in Applied Science,
- Master of Science in Mathematical Sciences,
- Master of Science in Financial Mathematics.
- Doctor of Philosophy in Industrial Mathematics,
- Doctor of Philosophy in Applied Mathematics,

- Doctor of Philosophy in Applied Mathematics and Computer Science,
- Doctor of Philosophy in Applied Science,
- Doctor of Philosophy in Mathematical Sciences,
- Doctor of Philosophy in Financial Mathematics.

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. Bachelor of Science Honours in Industrial Mathematics graduates are sought after by 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 operations 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; specialising 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,
- Operations research analysts, sales and marketing executives in service industries,
- Operations / logistics 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 Honours in Industrial Mathematics after attaining the stipulated 660 credits

Certification

A certificate shall be awarded.

REGIONAL AND INTERNATIONAL COMPARABILITY

The qualification was compared with various institutions, locally, 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 with Honours, University of Technology, Malaysia,
- Bachelor of Science Honours in Industrial Mathematics, Dublin University of Technology, Ireland,
- Bachelor of Science Honours in Industrial Mathematics, University of Ontario, Canada.

Moreover, this qualification was also compared with the following institutions offering Industrial Mathematics in a general bachelor's degree level. The proposed qualification compares well in terms of the learning outcomes, scope and depth covered in some of the benchmarked qualifications, while it excels in terms of research and advanced level topics in some areas. These qualifications are:

- Bachelor of Science Degree in Industrial Mathematics, Jomo Kenyatta University of Agriculture and Technology, Kenya,
- Bachelor of Science in Industrial and Applied Mathematics, Curtin University, Australia,
- Bachelor of Mathematics (Industrial and Applied Mathematics), University of South Australia, Australia.

University of Technology, Malaysia offers a four-year BSc programme with Honours (equivalent to NCQF level 8) in industrial mathematics. They have introduced the industrial mathematics qualification from the first year which gives a nice start up to the students. The qualification has an equal distribution among topics in statistics, mathematical methods, programming, statistics, and optimization theory. Both semesters of the final year promise with undergraduate project. The curriculum of the proposed qualification contains 75 % of this programme and the discrepancy between the two is believed to be due to the additional diversity in the electives of the proposed qualification. However, the proposed qualification provides an Honours qualification of five years and the final year of the Honours qualification is attached with an Honours project. The proposed qualification provides learners with an opportunity to gain hands-on work experience through the industrial attachment, and research skills by completing the final year project.

The Bachelor of Science Honours in Industrial Mathematics offered at Dublin Institute of Technology (DIT) is a four-year Honours qualification (which is equivalent to NCQF level 8). The proposed qualification 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 are attached with industries for 72 weeks. The proposed qualification is a five (5) year Honours qualification, and it includes an industrial attachment at year 3 and industrial project in year four (4) and year five (5). In addition, the proposed 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 Ontario offers a four-year Bachelor of Science qualification with two majors in Applied and Industrial Mathematics. They have a project at year four which is done in two semesters. The proposed qualification also facilitates industrial attachment at year 3. The proposed qualification gives more focus on the computational methods that are applied in industries, and computer programming which includes data science and optimization theory.

The Bachelor of Science in Industrial Mathematics offered at Jomo Kenyatta University of Agriculture and Technology (JKUAT) is a four-year qualification that puts more emphasis on mechanics and control, optimization and industrial statistics with financial mathematics. The elements contain almost 60 percent of our prescribed programme. However, the proposed qualification emphasises more on mechanics and control, optimization control and data science. In the proposed qualification, learners will be equipped with 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 in Industrial and Applied Mathematics Major offered at Curtin University (CU) is a three-year qualification that puts more emphasis on optimization mainly on numerical optimization and computational mathematics. The elements contain almost 60 percent of our 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.

University of South Australia offers a 3-year Bachelor of Mathematics (Industrial and Applied Mathematics) with majors in applied mathematics and industrial mathematics. The qualification mainly focuses on 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 a blend of mathematics with industrial needs. Our 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 programme's learning outcome. In addition, it emphasises on students being attached with industry through industrial attachment and further they continue the learning process through their fourth year and fifth year project with guidance by departmental faculty.

In conclusion, the proposed Bachelor of Science Honours in Industrial Mathematics qualification generally compares well with all the qualifications benchmarked since the learning outcomes cover similar scope and depth and are aligned to the 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 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 offered within the region and beyond to appreciate international trends. We have compared the name of the awarding body, title of qualification with NCQF 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 University of Technology, Dublin University of Technology, University of Ontario along with Jomo Kenyatta University of Agriculture and Technology, Curtin University and University of South Australia.

REVIEW PERIOD

The qualification will be reviewed after 5 years, after running its full cycle.

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