BQA NCQF QUALIFICATION TEMPLATE

SECTION A:	QUALIFICATION DETAILS																				
QUALIFICATION DEVELOPER (S)	Botswana International University of Science and Technology																				
TITLE	Doctor of Philosophy in Computer Engineering															NCQF LEVEL	10				
STRANDS (where applicable)	N/A																				
FIELD	Manufacturing, Engineering and Technology			SUB-FIELD	Engineering and Engineering Trades											CREDIT VALUE	360				
New Qualification																Legacy 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:

Development of human capital is essential in achieving the VISION 2036 pillars, mainly Pillar 1: Sustainable Economic Development and Pillar 2: Human and Social Development. These two pillars

emphasize the transformation of Botswana's economy to a knowledge-based economy producing a globally competitive human resource. They represent key strategies for driving economic growth and diversification. This qualification, PhD in Computer Engineering, contributes towards Vision 2036's realization by equipping prospective graduates with the necessary skills and competencies for sustainable economic growth.

The NDP 11 goal states the need to provide an adequate supply of qualified, productive and competitive human resources policy frameworks. It is to this effect that the PhD in Computer Engineering qualification is being developed to achieve the vision by equipping the learners with the knowledge, skills and competencies in line with the creation of a knowledge-based economy in Botswana.

The Human Resource Development Council (HRDC) of Botswana has published the document, which provides a list of occupations that have been identified by employers as being in high demand at a national level. 'Engineering and Technology' is one of the fields that are right now encountering deficiencies in the labour market (short term) and occupations that show moderately solid business development (long term) (HRDC, 2023)[6]. Priority skills in each occupation have been identified, and these include both core skills and soft skills (HRDC, 2023) [6].

Prioritization of occupations in demand is also informed by national priorities as outlined in the VISION 2036, National Development Plan-11 and long-term strategies of the different sectors of the economy. The PhD in Computer Engineering qualification was therefore developed to contribute vis a vis human capital development and to fulfil the demand gap as per HRDC 2023 report. It is against this background that this qualification has been developed to address the urgent need for adequately trained manpower to manage the area of Computer Engineering and its sub-fields such as Big Data Engineering, Artificial Intelligence Engineering, Machine Learning Engineering, Deep Learning Engineering, Robotics Engineering, Neural Networks Engineering, Natural Language Processing Engineering, and Genetic Algorithms Engineering, etc in various sectors of the economy (HRDC 2023, Vision 2036, National Development Plan 11).

According to the Global Innovation Index, Botswana is ranked 89th out of 131 countries and is classified as one of the top five economies in Sub-Saharan Africa[1]. In recognition of the country's poor performance globally, the Government of Botswana has taken proactive steps to develop human capacity and infrastructure to drive sustainable economic diversification that leverages research, science, technology, and innovation[2,3,4]. Vision 2036 advocates for sustainable economic development, together with human and social development, that requires Batswana to attain the necessary skills and competencies so as to advance their country5. National Development Plan

(NDP) 11 Goal states the need to provide an adequate supply of qualified, productive and competitive human resources policy frameworks[6].

It is to this effect that the Doctor of Philosophy (PhD) in Computer Engineering qualification is necessary. This is one of the vital engineering qualifications, particularly in developing countries like Botswana [7,8]. It provides strong theoretical foundation, practical skills, professional conduct and critical thinking in computer engineering [9,10].

Aims

The creativity and scientific knowledge are combined in Computer engineers for new ideas and innovations which can work with technology, networks, and communication system design. Students will have different options in the specialization like network management, traffic engineering and router internals, which can work with engineering trade-offs and design principles used in Computer networks. Computer engineering developed with the latest changes in computer systems and networks. Particularly Smart Grid techniques to transmit and distribute power to the consumers by integrating renewable energy resources into the electrical grid. Electrical and Computer networks are integral to modern power grid operations and are becoming increasingly critical as grid dynamics speed up and as more controls become closed loop in form. Existing operation and control (especially remote control) rely on communication between the power systems from generation, transmission, distribution, and consumer. Intelligent power systems have become increasingly interdependent due to advances in sensor, network, and software technologies that enable more cost-effective means to interconnect grid devices.

Utilities increasingly adopt data analytics in their operational systems to drive efficiency, reliability, and more informed decisions. These analytics are enabled by the data-rich environments that the increasingly intelligent devices and sensors provide, which need smart systems. This further emphasizes the dependence on communication networks that provide these connections to the utility operational systems. It is in this view that in the discipline of Engineering, it is important to form the Doctor of Philosophy (Ph.D.) in Computer Engineering Qualification.

The qualification allows the students to cover all the basics of circuit analysis, digital signals and systems, wireless data network convergence, radio, broadband and optical networks, antennas and microwave components and Computer techniques and their applications. The qualified PhD computer Engineers will be ready to take up employment, conduct research and innovation in the computer industry on antennas and microwave, wireless data networks, software-defined radio,

optical networks, digital systems and signals and broadband networks to develop the economy and the scientific knowledge pool in Botswana and in the world11.

The computer engineering PhD qualification offers post-master's candidates an opportunity to study various areas. In most instances, these areas tend to overlap with other disciplines within the faculty of engineering and University. PhD in computer engineering qualification provides a comprehensive preparation in design, programming, theory, and applications. This qualification is offered to both academically oriented candidates and candidates with professional ambitions in business, industrial and public sector occupations which require advanced knowledge of computer theory and technology.

A typical PhD student in computer engineering will study theoretical and empirical studies in a topic area of his/her interests and those of the faculty advisor. Courses and research are offered. It is highly desirable to have external collaborations with industry and government laboratories.

The Doctor of Philosophy (PhD) Computer Engineering Qualification aims to produce highly qualified engineers in a variety of subfields of computer engineering, including operating systems, computer architecture, computer graphics, pattern recognition, artificial intelligence, machine learning, embedded systems, computer networks, and software systems, analysis of algorithms, parallel processing, VLSI, computational geometry, design automation, cyber security, information assurance and data science to support the growth of the Botswana economy and to improve the world too. A conducive environment is to be established with the computer companies in Botswana to adapt the specialisation's qualifications to the critical needs encountered in this industry[6, 12, 13, 14]. Students will have a great opportunity to learn through research in their domain and to create their own business, mainly in the Computer sector engineering industry.

PURPOSE: (itemise exit level outcomes)

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

1. Conduct original research of international standard that reveals thematic and conceptual coherence, intellectual autonomy, independence, scholarly integrity, ethical respect for, and application of, the relevant academic and/or professional codes of research and practice.

2. Assess, evaluate, and synthesize scientific information.
3. Critically apply most advanced Science and Engineering Knowledge exhibiting strong practical knowledge, skill, and competence in Computer applications.
4. Communicate professional and technical scientific information in writing, orally and using visual, symbolic and/or other forms of representation to technical and non-technical clients.

MINIMUM ENTRY REQUIREMENTS (including access and inclusion)

Entry into this qualification is through any one of the following requirements:

- NCQF level 9 in computing or related field.
- Credit Accumulation and Transfer (CAT) shall apply in admission following ETP policy which is aligned to national policy.

SECTION B	***QUALIFICATION SPECIFICATION***
GRADUATE PROFILE (LEARNING OUTCOMES)	***ASSESSMENT CRITERIA***
1. Carry out original research of international standard that reveals thematic and conceptual coherence, intellectual autonomy, independence, scholarly integrity, ethical respect for, and application of, the relevant academic and/or professional codes of research and practice.	The learner must be able to: 1.1 Demonstrate a strong foundation in computer engineering as measured by the successful completion and presentation of concept paper, proposal, and progress report. 1.2 Identify major concepts and principles of Computer techniques which are identified, described, and explained. 1.3 Critically Interpret the major concepts and principles of Computer engineering and how

	they are applied to solve practical societal problems as well as problems in industry. 1.4 Critically understand the significance of contested scientific knowledge in a contemporary context is recognised. 1.5 Distinguish how scientific information and ideas become generally accepted is demonstrated. 1.6 Identify the fundamental concepts and principles of Computer engineering to the solution of complex engineering problems.
2. Assess, evaluate, and synthesize scientific information.	2.1 Use the library, internet and other data storage and other facilities to access information. 2.2 Scientific reasoning is used to evaluate the quality of information. 2.3 Information from a variety of sources, which may be contradictory or divergent, is synthesized. 2.4 Appropriate procedures for reframing relevant information used for designed, selected, and applied with due concern for bias and for any ethical or safety considerations. 2.5 Appropriate forms of criticism are conducted by applying standard procedures within the discipline of Computer Engineering, such as theoretical, experimental, and computational techniques.

	2.6 Judge data collected and recorded accurately, truthfully and in appropriate formats. 2.7 Data and scientific evidence are appraised and from such analysis valid arguments and conclusions are presented. 2.8 Compare, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using engineering sciences to design new ways of using Computer techniques to develop and improve the new products.
3. Demonstrate application of Science and Engineering Knowledge exhibiting strong practical knowledge, skill, and competence in Computer applications.	3.1 Calculate the theoretical tools and the law controlling electric circuits to analyse critical quantities in Computer signals and systems. 3.2 Logical thinking is illustrated; naive and flawed scientific reasoning is produced. 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 Hypothetical-deductive reasoning can be performed. 3.5 Cause-effect relations can be shown in the face of some level of uncertainty or gap in available information. 3.6 Thinking and reasoning process are illustrated. 3.7 The self-conscious capacity to interpret when understanding has been achieved or a problem has been adequately solved is demonstrated.

	3.8 Provide technical solutions, design and testing system, managing, and constructively working with a team of engineers.
4. Communicate professional and technical scientific information in writing, orally and using visual, symbolic and/or other forms of representation to technical and non-technical clients.	4.1 Scientific and Engineering language are expressed correctly to produce clear and coherent written documents, which follow appropriate engineering conventions. 4.2 Scientific and engineering information is explained verbally in front of others. 4.3 Appropriate referencing conventions are distinguished, plagiarism is avoided, and intellectual property is respected. 4.4 Non-verbal forms of representation are inferred correctly and appropriately. 4.5 Produce effective reports and design documentation, make effective presentations, and give and receive clear instructions.
5. Conduct engineering design exercises involving investigative research, interviewing techniques and indirect methods of proof used to solve problems.	5.1 Effectively compose original scientific research in computer engineering as measured by the successful oral defense of a prospectus, PhD thesis, conference presentations, conference publications, or peer-reviewed journal articles. 5.2 Concrete and abstract problems, in familiar and unfamiliar contexts, are formulated, analysed, and solved. 5.3 Theory is developed and formulated to real-world contexts, and particular to problems in industry.

	5.4 Knowledge from various disciples or modes of enquiry integrated, in solving scientific and industrial problems. 5.5 Capacity to produce valid measured results comparing them to the model and simulation results. 5.6 Compose high quality scientific and technical reports based on the experimental data systematically checking all reports with anti-plagiarism tools. 5.7 Integrate research-based knowledge and research methods including prediction and modelling to complex engineering activities with an understanding of the limitations. 5.8 The Doctoral graduate is capable of demonstrating self-direction, authority, strategic leadership, accountability, and an advanced level of management of systems relevant to the field of research.
6. Analyse engineering methods, skills, tools, effective Information and Communication Technology (ICT) skills.	6.1 Ability to classify correctly complex Computer systems and networks models. 6.2 Capacity to distinguish consistent steps to realize any system starting from theory and simulation to the final system. 6.3 Tasks related computer literacy skills are appraised. 6.4 The validity of ICT solutions for problems posed by Computer Engineering as a discipline are critically analysed.

	6.5 Use of ICT that is appropriate to Computer Engineering as a discipline is selected for: mathematical model construction; simulation applications; image and pattern recognition; automation and control; managing and controlling the system. 6.6 create, select, and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
7. Demonstrate skills on the impact of engineering activity on and around oneself.	7.1 Comply with precautions to protect oneself, colleagues and the work environment against Computer engineering risks and the output of any invention. 7.2 Scientific knowledge that is relevant to current societal issues is identified. 7.3 Demonstrate critical understanding of the impact of professional engineering solutions in the society and demonstrates the knowledge of and need for sustainable development.
8. Work effectively as a member of a team or group in scientific project or investigations and have capacity of implementation and management with full responsibility and accountability, strategic leadership, high level of initiative, authority, and autonomy etc.	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.

	8.4 Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.
9. Apply engineering knowledge and ways of thinking to societal and industrial issues, considering ethical and cultural considerations.	9.1 Illustrate 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 applied. 9.3 Ethically and culturally sensitive decisions on the effects of engineering-based activities on society are demonstrated. 9.4 The socio-economic impact of engineering interventions in society and industry is shown. 9.5 Engineering knowledge is related for the direct benefit of society and also to drive industry. 9.6 Demonstrate critical understanding of ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
10. Manage the learning activities responsibly and independently.	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 organisation and time management. 10.4 Recognizes the need for and has the preparation and ability to engage independent

	and lifelong learning in the broadest context of technological change.
11. Apply social, legal, ethical, and professional issues in engineering decision making.	11.1 Maintain continued competence and to keep abreast of up-to-date tools and techniques are illustrated. 11.2 Understanding of the system of professional development is demonstrated. 11.3 Acceptance of responsibility for own actions by individual is shown. 11.4 Judgment in decision making during problem solving and design issues is manipulated. 11.5 Limitation of decision making to area of current competence is calculated. 11.6 Apply reasoning informed by the contextual knowledge to access societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional engineering practice.

SECTION C	***QUALIFICATION STRUCTURE***				
COMPONENT	***TITLE***	***Credits Per Relevant NCQF Level***			***Total Credits***
		Level [ ]	***Level [ ]***	***Level [10]***	
FUNDAMENTAL COMPONENT *Subjects/ Courses/ Modules/Units*	Research Methodology			0	*0*
	Research Concept paper			0	*0*
	Research Proposal			0	*0*
CORE COMPONENT *Subjects/Courses/ Modules/Units*	Doctoral Thesis in Computer Engineering			360	360

STRANDS/ SPECIALIZATION	*Subjects/ Courses/ Modules/Units*	***Credits Per Relevant NCQF Level***			***Total Credits***
		Level [ ]	***Level [ ]***	***Level [ ]***	
1.					
	N/A				
2.	***N/A***				

Electives					

SUMMARY OF CREDIT DISTRIBUTION FOR EACH COMPONENT PER NCQF LEVEL	
TOTAL CREDITS PER NCQF LEVEL	
NCQF Level	***Credit Value***
Level 10	360
TOTAL CREDITS	***360***

Rules of Combination:

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

To graduate with the 3-years Doctor of Philosophy (Ph.D.) degree Qualification in **Computer Engineering**, students must have successfully completed a minimum of 360 Credit Units. The Doctor of Philosophy (Ph.D.) qualification in Computer Engineering offers an integrated approach of these skills by project-based learning and subject-specific courses. Applied electronics-based projects are part of the research. The total study duration of the Qualification is 3 years of full time research.

ASSESSMENT ARRANGEMENTS

All assessments leading to the award of credits in this qualification shall be based on the qualification exit-level outcomes.

- Formative Assessment (0 credits) - Formative assessment aligned to the exit-level outcomes will be administered continuously throughout the learning period.

  Learners are continuously assessed through:
  - Concept paper
  - Proposal
  - Progress reports
  - Presentations

Summative Assessment (360 credits) - Learners shall undergo a summative assessment which includes a written thesis and oral examination at the end of the learning period. This assessment must be aligned to the exit level outcomes.

MODERATION ARRANGEMENTS

Appointment of Internal Examiners

Since all the assessments for this qualification are through a written dissertation and a Viva Voce oral presentation, assessment instruments are moderated only before administering assessments that contribute towards the award of credits in this qualification, namely assessment of a thesis/dissertation (by appointed examiners as per PG regulations) and an oral Viva Voce presentation (by panel as per PG regulations). Therefore, exit level assessment instruments shall be moderated by an External Moderator to ensure that assessments are aligned with exit level outcomes. 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 applicable for award of credits towards the qualification, according to institutional policy which is aligned with BQA/ national policy.

CREDIT ACCUMULATION AND TRANSFER

RPL and CAT will be applicable for award of credits towards the qualification, according to institutional policy which is aligned with BQA/ national policy.

PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)

Learning Pathway: Those who have achieved the qualification can progress as mentioned below.

Vertical:

- Post-doctoral activities/studies in Computer Engineering.

Horizontal:

A Doctor of Philosophy in Computer Engineering candidate could continue to pursue a Doctor of Philosophy qualification in any other university in the Electrical and Communications specialized disciplines such as;

- Doctor of Philosophy in Electronics Engineering
- Doctor of Philosophy in Electrical Engineering
- Doctor of Philosophy in Telecommunications Engineering

Employment Pathway:

The qualification will produce graduates suitable for positions such as

Research Engineer

Computer System Manager

Project Manager

Research Supervisors

QUALIFICATION AWARD AND CERTIFICATION

The learner will be awarded a **"Doctor of Philosophy in Computer Engineering"** after attaining 360 credits as specified in the rules of combination and credit distribution. Certificate will be awarded to the candidates who have met the qualification requirements.

SUMMARY OF REGIONAL AND INTERNATIONAL COMPARABILITY

Summary of Similarities

Only universities offer a Ph.D. in Computer Engineering qualification. The University of KwaZulu-Natal qualification titled PhD Computer Engineering is offered for three years in full time and five years part time and the Essex University qualification titled PhD Computer Systems Engineering is offered for three to four years as full-time program. All the two (2) institutions cover research domain in Computer Engineering, and they all have the outcome of a final research project. There is a strong similarity in terms of exit level outcomes, these include application of scientific and engineering knowledge**,** problem solving, use of ICT, practical skills etc. All the qualifications from the two (2) institutions articulate to a PhD degree.

Summary of differences

The University of KwaZulu-Natal, South Africa qualification offers the Ph.D. in Computer Engineering course for 360 credits with NQF level of 10 and for a duration of 3 years for part time and 5 years for full time. The Essex University in UK offers the Ph.D. in Computer Engineering for 240 credits with FHEQ level of 8 and for a duration of three to four years full time. The domains covered in University of KwaZulu-Natal is Computer Engineering covered over the three-year period. This is reflected through the open elective modules that are subject to supervisor's approval such that unique and relevant modules for the student's final dissertation are introduced based on project needs. The assessment strategies for University of KwaZulu-Natal are mainly dissertation examinations in a case where student has taken elective modules to support the needs of their research. Emphasis is more on the dissertation. The qualification rules for University of KwaZulu-Natal are that the students should pass all the modules prescribed for the qualification if at all they undertake the modules and successfully complete dissertation. Essex University, UK covers computer engineering. The assessment strategies follow through successful completion of submission of thesis dissertation and public viva voce. The project is continuously assessed in each semester period and concludes with submission of a final thesis, as well as an oral assessment based upon the proposed engineering design/solution. The Final degree classification will be based upon aggregated achievement from the project stages of 240 credits.

Comparability and articulation of the proposed qualification with the ones examined
PhD Electronics Engineering, BIUST, NQF level 10 The proposed qualification seeks to provide an educational approach where emphasis is placed on having both taught and research-based learning for PhD candidates to produce graduates who are generalists, rather than specialists. Provision of taught modules as in the compared institutions has contributed in improving the outcome of learners as taught fundamentals guide the students on the basics necessary for their domain. The Computer Engineering qualification aims to produce highly qualified engineers in the domain of applied electronics, VLSI, signal processing, image processing engineering to support the growth of Botswana economy and to contribute towards an industrialized and knowledge-based economy. Strong relationship is to be established with the energy production companies in Botswana to adapt the specialization qualification to the critical needs encountered in this industry. Collaborations with the industries provide an opportunity for students to apply themselves in the real-world market and relate their theories and solutions with live time data. With a pool of all rounded PhD holders, the industries have a variety of choice of exceptionally qualified personnel to engage and consult for board management and directorship. Candidates are required to achieve a minimum of 360 credits to graduate. Graduates for this qualification may pursue Post Doctorate Degree in Computer Engineering. Graduates may work as control engineer, electronics engineer, VLSI engineer, medical electronics engineer, researcher, consulting engineer. Thus, the proposed degree qualification compares better with degrees offered in the UK and South Africa.

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CODE (ID)			
REGISTRATION STATUS	**BQA DECISION NO.**	**REGISTRATION START DATE**	**REGISTRATION END DATE**

LAST DATE FOR ENROLMENT		**LAST DATE FOR ACHIEVEMENT**	
REVISION DATE:		**NAME OF PROFESSIONAL BODIES/REGULATORY**	