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

RATIONALE AND PURPOSE OF THE QUALIFICATION

Mechatronics Engineering deals with systems that combine mechanical, electronics, control and software components together to create intelligent systems while Industrial Instrumentation is the science of measurements, instrumentation, and control of process variables within a production or manufacturing plant. Botswana has an established mining sector but efforts are being made to diversify the economy away from minerals, through manufacturing and other related production industries. Systems, processes and machineries used in such manufacturing and production industries are automated, hence `electro-mechanical in nature. These type of systems require well-rounded engineers who understand them from all perspectives: mechanical, electronics, software and control. Hence, the need to train, develop and produce engineers with cross-disciplinary skills. A study of the Botswana's eleventh National Development Plan 11 (NDP 11) and vision 2036 indicates a shortage of engineers who can drive her vision of transformation to a knowledge-based economy by moving from a traditionally product driven market to a

services market [1]**.** Botswana still import expatriate engineers annually to support her local industries [2]. Moreover, efforts by Botswana government to minimize skills shortage in the field of engineering by sending her citizens to foreign universities for training has cost her millions in sponsorship money annually. It is also pertinent to note that the training that Batswana have received in foreign universities has not been tailored to meet the needs of Botswana's local industries. Labor surveys conducted by the World Bank also found that at least 50% of manufacturing firms in Botswana find it extremely difficult to find engineering graduates with appropriate skills [4]. Hence, the government of Botswana through NDP11 mandated universities to produce engineers with appropriate skills. Mechatronics is listed among the top ten scarce skills regionally (SADC) and internationally [5]. Therefore, the BIUST's B.Eng. Mechatronics & Industrial Instrumentation qualification is aligned to the NDP 11, the vision 2036 and the BIUST Strategic Plan 2016-2022. Graduates with this qualification will be able to work in a wide range of engineering fields such as production & manufacturing industries, power generation, mining, steel, oil & gas, automobile and other related fields. They will also be engaged by various consulting firms and, government departments. Some will be engaged by parastatals; research institutions such as BITRI and Botswana Innovation Hub (BIH), as well as universities. Generally, there is a shortage of engineers, technologists, lecturers, and researchers in the field of Mechatronics. Research in this field is also still very fertile as this is a relatively new discipline of engineering and also important for future developments especially as the world gears towards the 4th Industrial Revolution (4IR).

The purpose of this qualification is to produce graduates with knowledge, skills, and competence to:

- Apply scientific and engineering knowledge to solve cross disciplinary and electro-mechanical engineering problems including those in emerging knowledge and technologies.
- Design, synthesize, model, and simulate electro-mechanical systems and products.
- Select and apply appropriate scientific research methods to investigate, design experiments and perform data analysis and apply engineering methods and skills including those based on information technology.
- Manage engineering activities and communicate professionally and technically.
- Assess and demonstrate critical awareness of the impact of engineering activities on the environment and surroundings.
- Work effectively as an individual and in multidisciplinary teams.

ENTRY REQUIREMENTS (including access and inclusion)
Minimum Formal Entry Qualifications*:* Certificate IV, NCQF level 4 or equivalent. Admission through RPL is recognized.

QUALIFICATION SPECIFICATION **SECTION B**	
GRADUATE PROFILE (LEARNING OUTCOMES) **At the end of this qualification, graduates will be able to:**	**ASSESSMENT CRITERIA**
LO1: Solve electro-mechanical engineering problems creatively and innovatively.	AC1: The candidate applies in a number of varied instances, a systematic problem-solving method including: 1. Critically analyse and define the problem, identifies the criteria for an acceptable solution. 2. Identify necessary information and applicable engineering and other knowledge and skills. 3. Generate and formulate possible approaches to solution of problem. 4. Model and analyse possible solution(s). 5. Evaluate possible solutions and selects best solution. 6. Formulate and present the solution in an appropriate form.
LO2: Apply highly specialized scientific knowledge (mathematics, basic sciences) and engineering knowledge (engineering sciences) from first principles	AC2: The candidate: 1. Brings mathematical, numerical analysis and statistical knowledge and methods to bear on

to solve electro-mechanical engineering problems including problems in emerging knowledge and technologies.	engineering problems by using an appropriate mix of: a) Critical analysis and advanced modelling of engineering components, systems or processes. b) Communicating concepts, ideas and theories with the aid of mathematics. c) High level reasoning about and conceptualizing engineering components, systems or processes using mathematical concepts. d) Dealing with uncertainty and risk through the use of probability and statistics. 2. Advanced use of physical laws and knowledge of the physical world as a foundation for the engineering sciences and the solution of engineering problems by an appropriate mix of: a) Critical analysis and advanced modelling of engineering components, systems or processes using principles and knowledge of the basic sciences. b) High level reasoning about and conceptualizing engineering problems, components, systems or processes using principles of the basic sciences. 3. Uses advanced techniques, principles and laws of engineering science at a fundamental level and in at least one specialist area to:

	a) Identify and solve open-ended engineering problems. b) Identify and pursue engineering applications. c) Work across engineering disciplinary boundaries through cross disciplinary literacy and shared fundamental knowledge.
LO3: Design advanced electro-mechanical components, systems, engineering works, products and processes that addresses customer needs and comply with applicable standards.	AC3: The candidate executes a design process encompassing the following: 1. Identify and formulate the design problem to satisfy user needs, applicable standards, codes of practice and legislation. 2. Plan and manage the design process: focusses on important issues, recognizes and deals with constraints. 3. Acquire and evaluate the requisite knowledge, information and resources: applies correct principles, evaluates and uses design tools. 4. Perform design tasks including analysis, quantitative modelling, and optimization. 5. Critically evaluate alternatives and preferred solution: exercises judgment, tests implementability and performs techno-economic analyses. 6. Critically assesses impacts and benefits of the design: social, legal, health, safety, and environmental. 7. Communicate the design logic and information
LO4: Critically analyze data and produce a technical report.	AC4: The candidate executes an acceptable process including but not restricted to:

	1. Plan and conduct investigations and experiments. 2. Conduct a literature search and critically evaluates material. 3. Perform the necessary critical analyses. 4. Select and use highly specialized equipment or software. 5. Critically analyze, interpret, and derive information from data. 6. Draw conclusions based on evidence. 7. Communicate the purpose, process and outcomes in a technical report.
LO5: Apply appropriate engineering methods, skills and tools, including those based on information technology.	AC5: The candidate: 1. Use advanced method, skill or tool effectively by: a) Selecting and assessing the applicability and limitations of the method, skill or tool. b) Properly applying the method, skill or tool. c) Critically testing and assessing the end-results produced by the method, skill or tool. 2. Create advanced computer applications as required by the discipline.
LO6: Communicate professionally and technically (both orally and in writing) with engineering audiences and the community at large.	AC6: The candidate executes effective written communication as evidenced by: 1. Use appropriate structure, style and language for purpose and audience. 2. Use effective graphical support; 3. Applies methods of providing information for use by others involved in engineering activity. 3. Meet the requirements of the target audience.

	The candidate executes effective oral communication as evidenced by: a) Use appropriate structure, style, and language. b) Use appropriate visual materials. c) Deliver fluently and meet the requirements of the intended audience.
LO7: Demonstrate critical awareness of the impact of engineering activities on the social, industrial and physical environment.	AC7: 1. The impact of technology on society. 2. Occupational and public health and safety. 3. Impacts on the physical environment. 4. The personal, social, cultural values and requirements of those affected by engineering activity.
LO8: Demonstrate competence to work effectively as an individual, in teams and in multidisciplinary environments.	AC8: 1. Identify and focus on objectives, work strategically, and execute tasks effectively. 2. Deliver completed work on time. 3. Make individual contribution to team activity and perform and form critical functions. 4. Enhance work of fellow team members and benefit from support of team members. 5. Communicate effectively with team members and deliver completed work on time. 6. Acquire a working knowledge of co-workers' discipline. 7. Use a systems approach. 8. Communicate across disciplinary boundaries.
LO9: Demonstrate competence to engage in independent learning through well-developed learning skills.	AC9: 1. Reflect on own learning and determines learning requirements and strategies. 2. Source and critically evaluate information.

	3. Access, comprehend and apply advanced knowledge acquired outside formal instruction; 4. Critically challenges assumptions and embraces new thinking
LO10: Act professionally, ethically and commits to the norms of Mechatronics & Industrial Instrumentation Engineering.	AC10: 1. Being aware of requirements to maintain 2. continued competence and to keep abreast of up-to-date tools and techniques. 3. Display understanding of the system of professional development. 4. Accept responsibility for own actions. 5. Display high level judgment in decision making during problem solving and design. 6. Limit decision making to area of current competence. 7. Reason about and make judgment on ethical aspects in case study context. 8. Discern boundaries of competence in problem solving and design.
LO11: Manage engineering activities in a multi-disciplinary environment.	AC11: 1.Demonstrate fundamental knowledge of project management activities for all project management functions during each life cycle phase. 2. Use advanced techniques from economics, business management; project management applied to one's own work. 3. Use advanced techniques from economics, business management; project management applied as a member and leader in a team, to manage projects and in multidisciplinary environments.

LO12: Apply appropriate scientific research methods to solve engineering problems, and critique current research practices and techniques.	AC12: 1. Advanced methodologies are selected, accurate and relevant data is collected, recent literature is evaluated and the results are discussed and presented. 2. Theoretical predictions are compared with published data to evaluate the significance of the results in context. 3. The implications of the findings on the problem under consideration are reflected upon. 4. Results of an experiment or other type of research investigation are analyzed and valid conclusions are drawn and the level of uncertainty in these results and expected outcomes are evaluated. 5. Recommendations related to the research problem are proposed. 6. Critical analytical ability is used to manipulate precise and intricate ideas to construct logical arguments. 7. Scientific experiments or other types of research investigation are performed which produce meaningful results. 8. Critical analysis of the data is undertaken and results are discussed in terms of published scientific literature and presented in the form of a written dissertation.

FUNDAMENTAL COMPONENT	Title	NCQF Level	Credits

Subjects / Units / Modules /Courses	**FOUNDATION COMPONENT**		**108**
	General Chemistry I	5	12
	Pre-Calculus	5	12
	Introductory Physics I	5	12
	General Chemistry II	5	12
	Introductory Calculus	5	12
	Introductory Physics II	5	12
	Introduction to Statistics	5	12
	Introduction to Technical Communication & Academic Literacy	5	6
	Introduction to Computing	5	12
	Technical Report Writing	5	6
	FUNDAMENTAL COMPONENT		**96**
	Introduction to Engineering	5	6
	Workshop Practice	5	12
	Engineering Graphics	5	12
	Fundamentals of Electrical Engineering I	5	12
	Procedural Programming	5	12
	Engineering Mathematics I	5	12
	Engineering Mechanics I (Statics)	5	12
	Engineering Mathematics II	5	12
	Design Methods	5	6
CORE COMPONENT Subjects / Units / Modules /Courses	**CORE COMPONENT**		**336**
	Object Oriented Programming	6	12
	Fundamentals of Electrical Engineering II	6	12
	Materials Science	6	12
	Strength of Materials	6	12
	Engineering Mechanics II (Dynamics)	6	12
	Technical and Professional Communication	6	6
	Electric Circuit Theory	6	12
	Digital Electronics	6	12

	Engineering Mathematics III	6	12
	Fluid Mechanics I	6	12
	Theory of Machines & Mechanisms	6	12
	Measurements & Instrumentation	6	12
	Electronic Circuit Analysis & Design	6	12
	Signals & Systems	6	12
	Engineering Mathematics IV	6	12
	Engineering Project Management	6	12
	Fluid Power Control	6	12
	Systems Dynamics Modelling & Simulation	6	12
	Electromagnetic Field Theory	6	12
	Software Applications	6	12
	Linear Control Systems	7	12
	Digital Signal Processing	7	12
	Economics, Business & Entrepreneurship	7	12
	Industrial Process Automation	7	12
	Principles of Microcontrollers & Microprocessors	7	12
	Electrical Machines	7	12
	Industrial Training	7	36
	Mechanical, Energy and Industrial Engineering Design Project I (Research Project Part I)	8	12
	Artificial Intelligence & Machine Learning for Engineers	8	12
	Professional Practices & Ethics	8	12
	Mechanical, Energy and Industrial Engineering Design Project II (Research Project Part II)	8	24
	Engineering Business & Society	8	12
	Technology & Innovation Management	8	12
	Data Analytics	8	12
	Mechatronics Systems Design	8	12
	Embedded Systems Design	8	12

	Robot Motion Planning & Design	8	12
	Reliability & Maintenance Engineering	8	12
	Design for Manufacturing	8	12
ELECTIVE COMPONENT Subjects / Units / Modules /Courses	**ELECTIVE COMPONENT**		**24**
	Digital Control Systems	8	12
	Operations Research	8	12
	Computer Integrated Manufacturing	8	12
	Control Systems Design	8	12
	***elective component is based on selection of 12 credits in semester one (1) and 12 credits in semester two (2)**		
RULES OF COMBINATIONS, CREDIT DISTRIBUTION (where applicable):			
This qualification is worth a total of 636 credits, and it comprises of 96 credits (fundamentals), 336 credits (core) and 24 credits (elective components).			

ASSESSMENT AND MODERATION ARRANGEMENTS

Assessment and Moderation will be carried out by suitably qualified persons as per assessment and moderation policies of BIUST which is aligned with BQA guidelines.

RECOGNITION OF PRIOR LEARNING (if applicable)

Candidates may submit evidence of prior learning and current competence and/or undergo appropriate forms of RPL assessment for the award of credits towards the qualification in accordance with applicable RPL policies and relevant national-level policy and legislative framework. Implementation of RPL shall also be consistent with requirements, if any, prescribed for the field or sub-field of study by relevant national, regional or international professional bodies.

PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)

LEARNING PATHWAYS

Horizontal articulation

- Bachelor of Engineering (Honours) in Mechanical & Energy
- Bachelor of Engineering (Honours) in Computer & Telecommunications

- Bachelor of Engineering (Honours) Electrical & Electronics

Vertical articulation

- Master of Engineering in Mechatronics & Industrial Instrumentation (NCQF Level 9)
- Master of Engineering in Mechanical & Energy (NCQF Level 9)
- Master of Engineering in Computer & Telecommunications (NCQF Level 9)
- Master of Engineering in Electrical & Electronics (NCQF Level 9)

EMPLOYMENT PATHWAYS

- Robotics Engineers
- Software Engineers
- Automation Engineers
- Control Systems Engineers
- Instrumentation Engineers
- Maintenance Engineers
- Reliability Engineers
- Asset Management Engineers
- Mechanical Design Engineers
- Data scientist/big data analyst
- Electronics design engineer
- Electrical design Engineer
- Research Engineer

QUALIFICATION AWARD AND CERTIFICATION

Minimum standards of achievement for the award of the qualification

A candidate is required to achieve the stipulated total credits (636) inclusive of the fundamental (96), core (336) and elective components (24), to be awarded the qualification.

Certification

A certificate will be awarded to candidates who successfully complete the qualification.

REGIONAL AND INTERNATIONAL COMPARABILITY

BEng Hons Mechatronic & Robotic, The University of Sheffield, UK, QAA FHEQ Level 6

This qualification seeks to give students a firm understanding of the principles of mechatronics and robotics, learn how to design, analyze and test transforming robots, autonomous vehicles and other complex electro-mechanical systems. Students are also shown how to control robotic systems using modern microprocessor technology. They also explore advanced concepts including manufacturing systems, noise and vibration control, spacecraft systems and robot technology. Candidates are required to achieve a minimum of 360 credits. Graduates for this qualification may pursue MSc in Advance Control & Systems Engineering. Graduates may work as professional engineers in a variety of industries such as manufacturing, power generation and sustainable energy.

BEng Mechatronic, University of Stellenbosch, South Africa, NQF level 8

This qualification seeks to develop mechatronic engineers who are equipped to develop specialized embedded controllers and the relevant electronics. Candidates are required to achieve a minimum of 607 credits. Graduates for this qualification may pursue a Masters of Engineering (MEng) by research or structured. Graduates may work in the following industries; aerospace, automotive, chemical processing, computers, communications, education, electronics, healthcare, manufacturing and automation, marine engineering, research and development.

BS, Mechatronics Engineering Technology, Purdue University, US

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

Similarities

All the three (3) institutions mentioned above cover all main the domains of Mechatronics engineering: Mechanical, Computing, Control and Electrical & Electronics. There is also 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 three (3) institutions articulate to a postgraduate Master's degree.

- Both The University of Sheffield and University of Stellenbosch offer a Bachelor of Engineering with honours (BEng Hons)

- University of Stellenbosch and Purdue University offer a four (4) year qualification
- All the three (3) institutions cover the domains of Mechatronics engineering: Mechanical, Computing, Control and Electrical & Electronics
- 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 three (3) institutions articulate to a Master's degree

Differences

- Both the University of Sheffield and University of Stellenbosch offer BEng Hons while Purdue University offer a Bachelor of Science.
- The University of Sheffield has a credit value of 360 at NQF level 6, duration of qualification is 3 years.
- University of Stellenbosch has a credit value of 607 at NQF level 8, duration of qualification is 4 years.
- Purdue University has a credit value of 120 at an unspecified NQF level, duration of qualification is 4 years.
- The University of Sheffield has a systems approach to engineering in covering domains leading to specialization in specific application areas of robotics and bio-mechatronics, renewable energy and electrical energy management.
- Purdue University's application focus is in primarily industrial environments.
- University of Stellenbosch offers a general mechatronics qualification.

Bachelor of Engineering (Hons) Mechatronics & Industrial Instrumentation, NQF level 8

The developed qualification seeks to provide an educational approach where emphasis is placed on integrated studies and on the production of graduates who are generalists, rather than specialists. It aims to meet the increasing demand for engineers with cross-disciplinary skills, particularly in Botswana industries which use electro-mechanical systems such as mining, production & manufacturing, power generation etc. Candidates are required to achieve a minimum of 654 credits. Graduates for this qualification may pursue MEng degrees in Mechatronics & Industrial instrumentation, Mechanical & Energy, Computer & Telecommunications and, Electrical & Electronics at NCQF Level 9. Graduates may work as robotics engineers, software engineers, automation engineers, control systems engineers, instrumentation engineers, maintenance engineers, reliability engineers, asset management engineers, Mechanical Design

Engineers, data scientist / big data analyst, electronics design engineer, electrical design engineer, consulting engineers, researchers etc.

REVIEW PERIOD

This qualification shall be reviewed every five years.

OTHER INFORMATION

Criteria for Selection of Assessors and Moderators

Qualification(s) required

- A minimum of Master's degree in a relevant field plus evidence of competence in assessment and moderation

Professional work experience required

- At least two years of academic experience plus work experience in a relevant field.

Professional registration and accreditation

Assessors and moderators must have valid registration and accreditation with Botswana Qualifications Authority (BQA).