THE TANZANIA COMMISSION FOR UNIVERSITIES

BENCHMARKS FOR BACHELOR DEGREE PROGRAMMES IN ENGINEERING

February 2024

EXECUTIVE SUMMARY

The Tanzania Commission for Universities (TCU) is mandated to regulate university education in the country. In line with this mandate, its duties extend to setting general standards of quality and quantity of contents for academic programmes and mode of their execution by universities at their respective levels and categories. It is also involved in the coordination and harmonization of courses and programmes in universities. Given the rapid expansion of universities in the country accompanied by an increase in demand for higher education in the region, TCU is obliged to ensure that this expansion does not compromise the quality of education being delivered.

It is within this context that TCU initiated a process of developing Programme Benchmarks. The main purposes being to ensure that these institutions offer programmes that are comparable and exude excellence in teaching and learning. This initiative is expected to improve the quality in teaching and learning while getting rid of mismatch in skills, knowledge and competences for graduates from similar engineering programmes offered by different university institutions in the country. Further to that, benchmarks for engineering programmes will facilitate cross border education both at national and international echelons, and enhance assessment of engineering programmes by National Regulatory Agencies such as Tanzania Commission for Universities (TCU) and Engineers Registration Board (ERB). In addition, the initiative will provide a robust framework for the labour market to use in assessing the quality of graduates being produced by universities as well as facilitate mobility pathways for engineering professionals across the region.

In developing the Benchmarks for the Bachelor degree programmes in Engineering, it was necessary to first review the global literature as well as to organize validation meetings so as to obtain inputs from key stakeholders. The literature review involved selected documents on benchmarks of various programmes for universities at national and international levels. The first draft, post consultation, was developed and included comments from stakeholders. Based on the analysis of the results of the review of various documents as well as inputs from key stakeholders, it was possible to establish the current situation pertaining to establishment of the benchmarks for engineering programmes.

Pursuant to the above, it was possible to establish the status of Bachelor's degree programmes in engineering through an environmental scan of various universities in the country. The results of the environmental scan indicated that there are seven (07) institutions that offer engineering programmes in the country. The institutions are, namely; Ardhi University (ARU), Mbeya University of Science and Technology (MUST), Sokoine University of Agriculture (SUA), St. Augustine University of Tanzania (SAUT), St. Joseph University in Tanzania (SJUIT), University of Dar es Salaam (UDSM) and University of Dodoma (UDOM). Further, the scan unveiled disparities in nomenclature of the Bachelor's degree in engineering programmes, entry qualifications, expected learning outcomes and content. Conversely, an international scan on engineering programmes revealed that within individual countries, such parameters of Bachelor's degree programmes are consistent. The discrepancy noted in the national engineering programmes obviously calls for the need of benchmarks.

In this regard, it was important to develop generic benchmarks for the Bachelor's degree programmes in engineering to act as a frame of reference for development of benchmarks for specific Bachelor's degree programmes in engineering. The overarching goal being to articulate engineering graduate attributes such as ability to execute engineering projects through acquired skills, knowledge and competences including being able to communicate effectively. Furthermore, Bachelor of Engineering programmes should be designed to address specific concerns and needs of diverse stakeholders. This can be achieved by focusing on the grouped programme objectives including academic ability, employability and personal development as well as through use of the generic expected learning outcomes, entry qualifications, credits as well as identifying minimum courses/subject areas (core, supportive and elective courses) that form part of the curriculum for a Bachelor's degree programme.

The methodology employed to establish the generic benchmarks for a Bachelor's degree programme in engineering was adopted to develop specific benchmarks for Bachelor's degree programmes in Agricultural Engineering, Chemical and Process Engineering, Civil Engineering, Electrical Engineering and Mechanical Engineering. Each of these engineering programmes had expected learning outcomes developed and translated into minimum courses/subjects that form part of the curriculum for a Bachelor's degree programme. Based on lessons learnt from national and international levels, nomenclatures, entry qualifications, exit learning outcomes and engineering course profiles, the Bachelor of engineering programmes at national level were developed.

It is important to note that the generic benchmarks for the engineering cluster, as a whole, and benchmarks for the specific engineering disciplines provide a foundation for engineering institutions to design and develop curricula in any engineering field such as textile engineering, mining engineering, mineral and process engineering. The benchmarks will further ensure that similar engineering programmes maintain comparability at both national and regional levels fostering cross border education and free labour mobility.

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

AHELO	Assessment of Higher Education Learning Outcomes
ARU	Ardhi University
CAD	Computer Aided Design
CALOHEE	Comparing Achievement of Learning Outcomes in Higher Education
CAM	Computer Aided Manufacturing
EAC	East African Community
EAQFHE	East African Qualification Framework for Higher Education
ECSA	Engineering Council of South Africa
EE:	Electrical Engineering
EIA	Environmental Impact Assessment
ELOs	Expected Learning Outcomes
EQF	European Qualifications Framework
ERB	Engineering Registration Board
ESIA	Environmental & Social Impact Assessment
GPA	Grade Point Average
IoMT	Internet of Medical Things
IUCEA	Inter-University Council for East Africa
LLL	Lifelong learning
MRA	Mutual Recognition Agreement
OECD	Organization for Economic Co-operation and Development
PBL	Problem Based Learning
PCB	Printed Circuit Board
QAA	Quality Assurance Agency
QAAC	Quality Assurance and Accreditation Council
SADC	Southern African Development Community

SAUT	St. Augustine University of Tanzania
SJUIT	St. Joseph University in Tanzania
SUA	Sokoine University of Agriculture
TCU	Tanzania Commission for Universities
TE	Telecommunications Engineering
UDOM	University of Dodoma
UDSM	University of Dar es Salaam
UGC	University Grants Commission
UKZN	University of KwaZulu Natal
UQF	University Qualifications Framework
UTM	University of Technology of Malaysia

CHAPTER 1

INTRODUCTION

1.1 Background

The Tanzanian Commission for Universities (TCU) is a body corporate established by the Universities Act (Chapter 346 of the Laws of Tanzania) to regulate and coordinate all matters pertaining to university education and training in Tanzania. In order to ensure that the quality of education provided by different institutions is comparable, section (10)(1) (a) & (f) of the said Act gives a legal mandate to the Accreditation Committee of the Commission to develop benchmarks for use by universities. Correspondingly, at the regional level, the Inter-University Council for East Africa (IUCEA), which oversees quality assurance for universities within the East African Community (EAC) is also mandated to facilitate the maintenance of internationally comparable higher education standards in East Africa so as to promote the region's competitiveness.

In recent years, Tanzania has experienced rapid expansion of and enrolment levels in universities caused, among others, by previous education expansion programmes in its primary and secondary schools under the Primary Education Development Programme (PEDP) and Secondary Education Development Programme (SEDP) between 2001-2007. This trend is also true in other East African countries such as Kenya and Uganda and has been triggered by the exponential increase in demand for access to higher education in neighbouring countries and abroad. Furthermore, in recent years, student mobility within East African countries and globally has increased tremendously necessitating the need to institute mechanisms for not only quality assurance but also comparability of the quality of education in universities in the country. It is envisaged that such tools will, in turn, facilitate cross-border education both at national and regional levels while ensuring its quality.

In light of the above context, TCU developed the University Qualifications Framework (UQF) while IUCEA established the East African Qualifications Framework for Higher Education (EAQFHE) both aimed at facilitating the harmonization of education and training systems as well as qualifications. These frameworks have benchmarked the programmes learning outcomes, different qualification levels, credit system and recognition of prior learning. Henceforth, the frameworks are meant to facilitate mutual recognition of qualifications across the region as envisioned in the EAC Common Market Protocol. All these interventions will contribute significantly to increased quality assurance in universities at national and regional levels. In this regard, universities are supposed to develop programmes that would facilitate the harmonization of higher education in Tanzania and other countries by aligning their programmes with benchmarks that will provide a baseline for comparability of the Bachelor's degree programmes in the engineering disciplines.

1.2 Objectives and Justification of the Formulated Benchmarks in Engineering Programmes

The main objective of developing benchmarks for the bachelor's degree programmes in engineering is to provide guidance to key stakeholders at both the national and international levels that will facilitate quality assurance during curriculum design and review while harmonizing the quality of teaching and learning so as to produce innovative engineering graduates. It is important to note that the education sector is multifaceted, comprising a myriad of stakeholders such as the government, students, academic staff, industries, universities and parents/guardians each with unique interests, demands and expectations. Thus, having benchmarks in place can address potential grievances and demands from the various groups of stakeholders and hence facilitating smooth running of engineering programmes in the country and making the programmes more appealing to international students from around the globe.

Further, with benchmarks established, both horizontal and vertical progression of students, including cross-border education, will be facilitated in universities at national and international levels. This will ensure consistent assessment of exit learning outcomes, which provide direction for instruction and thereby convey the intent of instruction to others, as well as provide guidelines for testing and examining students. Consequently, student mobility (cross-border education) will be enhanced. National Regulatory Agencies such as TCU and the Engineers Registration Board (ERB), will then be better positioned to assess the quality of the Bachelor's degree programmes in engineering at both national and international levels. Furthermore, these benchmarks in engineering programmes will enable universities in the country to effectively implement, evaluate, and review Bachelor's degree programmes in Engineering, hence aligning more closely with the original visions and missions for which these institutions were founded.

More importantly, the benchmarks will guide the labour market in assessing the quality and calibre of graduates at both the national and international levels. This will further offer insights on optimizing training methods in line with the job market demands and hence improving the employability of graduates. It is worth noting that under the Mutual Recognition Agreement (MRA) for engineering professionals in EAC, engineering professionals from one state in the region should be recognized as professionals in all the member states so as to facilitate engineers' mobility within EAC states (Barugahara and Sebbale, 2016, 41).

1.3 Development Process

Eight (08) steps were adopted towards accomplishing the task as shown hereunder:

i) Identification, collection and review of documents, available data and information relevant to the assignment.

ii) Identifying and earmarking universities in the country which offer engineering courses and their respective programmes. This was followed by conducting a comprehensive internet search for engineering institutions and their programmes in Africa, Asia and Pacific and Europe.

iii) Review of various documents related to benchmarks for various Bachelor's degree programmes in different clusters such as ICT, Engineering, Medicine and Nursing. In tandem with the review of documents, an extensive review of literature on benchmarking of programmes in universities in countries such as Nigeria, Uganda, Pakistan, Malaysia, the United Kingdom and South Africa was carried out.

iv) Analysis to discern discrepancies in higher learning engineering institutions programmes (nomenclature, knowledge areas, and leaning outcomes) within the country and across the African content, Asia and Europe. This formed part of the situational analysis.

v) Establishment of a guiding tool for developing generic benchmarks in engineering fields that will be used by institutions to design and develop curricula in the engineering fields and serve as a guide for the labour market in judging the quality of graduates.

vi) Development of benchmarks for Bachelor's degree programmes in five (05) selected engineering disciplines, namely: agricultural engineering, chemical and process engineering, civil engineering, electrical engineering, and mechanical engineering.

vii) Sharing of the draft benchmarks with key stakeholders, including universities, professional bodies and employers.

viii) Incorporate stakeholders' comments and suggestions on the draft benchmarks.

CHAPTER 2

USE OF THE BENCHMARKS

2.1 Benchmarks and Qualifications Framework

Programme benchmarks are important tools for the harmonization of academic programmes within the same disciplinary area. This harmonization of programmes seeks to ensure comparable quality of graduates from different universities who enrol and pursue similar programmes. As provided in the Standards and Guidelines for University Education in Tanzania, 2019, it is mandatory that all academic programmes in universities in the country be harmonized using programme benchmarks. It is worth noting that for effective harmonization of programmes, each university programme should be based on well-formulated learning outcomes that are benchmarked against level descriptors indicated in the University Qualifications Framework (UQF). In addition, regional qualifications frameworks such as those for the East African Community (EAC) and Southern African Development Community (SADC) can be used while taking into consideration provisions in the programme benchmarks developed by TCU and/or IUCEA.

The East African Qualifications Framework defines Qualifications Framework as "an instrument for the development and classification of qualifications according to a set of criteria for levels of learning and skills and competencies achieved." This document provides benchmarks for Bachelor's degree programmes in Engineering. It is worth noting that the level and duration of bachelor's degrees within the EAC Partner States and from other countries may differ. For example, the European Qualifications Framework (EQF) puts Bachelor's and Master's degrees at levels 6 and 7, respectively, whereas the East African Qualifications Framework for Higher Education (EAQFHE) puts these degrees at levels 8 and 9 (IUCEA, 2019), respectively. However, the descriptors for these levels are, to a large extent, consistent.

In Tanzania, the UQF puts the Bachelor's degree at level 8. The descriptor for this level states that "The Bachelor's degree qualifies individuals to have advanced knowledge, skills, and competencies in a discipline, field of work or study, involving a critical understanding of theories and principles and ability to work independently". The level descriptor stipulates the general learning outcomes, skills, competencies and the volume of learning (minimum number of credits) for all programmes at that level. As such, the description of the Bachelor's level in the UQF is very general.

In order for UQF to be operationalized, the level has to be filled in and elaborated with statements of learning outcomes. In UQFs, the level descriptors are elaborated through generic learning outcomes. Each programme has to interpret the generic learning outcomes into specific course units within specific subjects. For example, in engineering, one of the generic learning outcomes is the ability to identify, formulate and solve problems using both conventional and information technology. This can be achieved through the operationalization of research concepts and techniques either to solve engineering problems or to address emerging challenges in higher education institutions delivering programmes in engineering fields.

2.2 Benchmarking of Engineering Curriculum Design

This section outlines the objectives of engineering programme benchmarks, programme objectives, and learning outcomes. It further describes the benchmarks and quality assurance of engineering programmes, the implementation of engineering programme benchmarks, and the review of engineering benchmarks.

2.2.1 Objectives of Benchmarks in Engineering Programmes

The main objective of benchmarks in engineering programmes is to support university institutions in the country and other countries which are considering attaining high quality education in engineering within the country and across borders. It is a tool which enables universities to evaluate the quality of their programmes as well as programmes of universities from other countries. Thus, benchmarks play a significant role in the harmonization of quality assessment and quality assurance at institutional, national and regional levels. With the harmonization of the programme in place, horizontal and vertical progression of students in the field of engineering within the country and outside the country (cross border) could easily be facilitated as it allows smooth movements of students from one university to another within and outside the country.

It is also worth noting that a benchmark is a minimum yardstick used by regulatory bodies such as ERB and TCU to assess or gauge engineering programmes in terms of knowledge, skills and competence and also to ensure that they align with the demands and expectations of the dynamic labour market. In this regard, benchmarks offer external assessment teams such as TCU a frame of reference in assessing the quality of a programme. In the long run, benchmarks will help to guarantee that the academic qualifications are consistent and comparable allowing free labour movement across the boundaries of the countries.

The first step in designing or redesigning a programme is the formulation of the learning outcomes. The purpose of the learning outcomes is to describe clearly what the student is expected to demonstrate after completing a module, a course or the whole programme. Universities are expected to compare their formulated learning outcomes with the benchmarks and establish what is missing or what should be rephrased. Furthermore, for each learning outcome, it is important to describe how the learning outcome would be measured and assessed. Benchmarks which are derived from formulated learning outcomes are essential because they guarantee the following:

(i) Increased national and international mobility of students and academic staff;

(ii) Identification of barriers accompanied by mitigating measures to effective teaching and learning;

(iii) Comparable quality levels of the graduates within and outside the country;

(iv) Facilitation of collaboration among higher education institutions in the region and beyond;

(v) Improved students' learning, retention and completion;

(vi) Producing quality and innovative graduates;

(vii) Increased students´ chances for employability;

(viii) Providing guidance to instructors/academic staff for teaching and learning;

(ix) Facilitating the labour market to understand the competencies that engineering graduates possess; and

(x) Having comparable chances for the graduates in the labour market.

2.2.2 Programme objectives

Programme objectives are broad statements that describe the type of career and professional accomplishments that the programme is preparing the graduate to achieve. Programme objectives should, therefore, reflect the level at which a particular subject is taught. Likewise, the learning objectives should clearly show the complexity of the subject matter. It is, therefore, important to link learning objectives to level descriptors, i.e., descriptors for level 8 in a four-year degree programme.

Any engineering programme should be designed in such a way that it addresses the concerns of different stakeholders, namely the Government, industry, professional bodies, employers, students, parents/guardians and the society at large. Each of these stakeholders has different expectations. In this regard, stakeholders' expectations should be reflected in the programme objectives. Universities are expected to train their students on how to apply knowledge, skills and attitudes attained through education, research and training in a competent and ethical manner. Thus, learning objectives should:

(a) Provide direction for instructions;

(b) Convey intent of instruction to others, and

(c) Provide guidelines for testing and examining students.

2.2.3 Learning outcomes

Learning outcomes or whole qualification outcomes for a given qualification are competencies that are acquired in the learning process during formal education and training, leading to the award of a qualification. Since these outcomes refer to the whole qualification, they are best assessed at the completion of the study. More importantly, for each learning outcome, it is important to describe how the learning outcome would be measured and assessed. Therefore, qualifications formally recognize the attainment of the outcomes of learning.

In order for an engineering programme to adequately prepare a graduate to work in the real world, certain competencies have to be defined by both the service provider (university) and stakeholders (employers, professional societies, etc.). In some countries, such as South Africa, competencies are normally endorsed by the relevant professional body. Designing a programme with a focus on outcomes provides a framework for decision-making. Outcomes provide a strong roadmap for the curriculum by identifying the ultimate goals to be accomplished. Individual course objectives are tied to curriculum goals and the programme mission. Instructional objectives and assessment strategies integrate the individual classroom experience into the larger learning experience. By articulating a clear roadmap of the educational process, outcomes allow students to have an understanding of the educational programme and their role in that process through self-directed learning.

Most importantly, in order to achieve the desired programme learning outcomes, each course should have its own learning outcomes well written and articulated. The course learning outcomes collectively contribute to the programme learning outcomes. It is advisable to apply Bloom's Taxonomy when writing learning outcomes (see Figure 1).

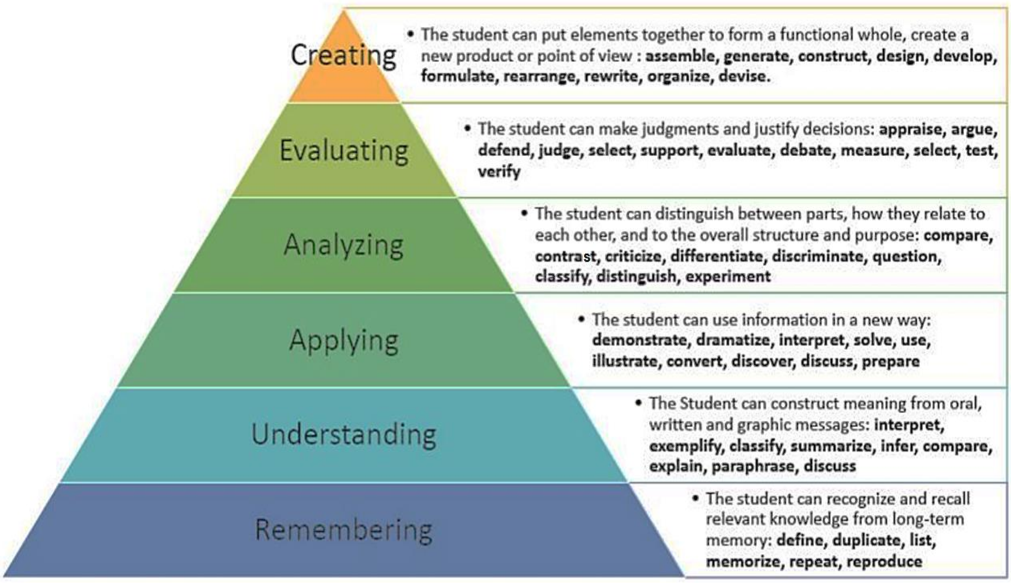

Figure 1: Bloom's Revised Taxonomy (Anderson & Krathwohl, 2001)

2.3 Benchmarks and Quality Assurance of Engineering Programmes

Benchmarks play a significant role in programme quality assurance and can play a significant role in harmonizing engineering programmes, quality assessment, and quality assurance in Tanzania and the EAC region at large. Implementing quality assurance in benchmarks offers terms of reference for external assessment of the quality of a given engineering programme. For universities in engineering, benchmarks offer a good tool for evaluating the quality of their own programmes.

Benchmarks for engineering programmes are essential for ensuring that all engineering graduates in the country are trained and equipped with the same level of learning and have achieved comparable learning outcomes and competencies. Although each university may have its criteria for formulating learning outcomes and assessing the quality of the engineering training programme, the benchmarks play a pivotal role in harmonizing the quality of assessment and quality assurance of the Bachelor of engineering degree in the country.

2.4 Implementation of Engineering Programme's Benchmarks

The implementation of the engineering programme benchmarks is the responsibility of universities while the Regulatory Authority (TCU) has the responsibility of overseeing the implementation of the benchmarks. In the design process of the engineering programmes, universities will develop courses, modules and learning outcomes as described in the benchmarks.

2.5 Review of the Engineering Benchmarks

The benchmarks for engineering programmes are developed considering the current level of technological advancement and are not static. Engineering, in particular, is a rapidly progressive discipline which must stay abreast with cutting-edge global technologies. It is therefore expected that future reviews and updates of the engineering programmes will take place from time to time to ensure the relevance of the programmes. Thus, in order to keep pace with the rapid changes in the engineering sector and take account of these changes and innovations that reflect subject development and new innovations, engineering benchmarks should be regularly reviewed. Consequently, under the guidance of TCU, the review of engineering benchmarks shall be conducted after every five (05) years and shall involve key stakeholders so as to get feedback and assess the performance of the benchmarks under review.

CHAPTER 3

GENERIC BENCHMARKS FOR BACHELOR DEGREE PROGRAMMES IN ENGINEERING

3.1 Overview

This chapter presents key elements of an engineering programme benchmarks. It comprises insights from the environmental scan or situational analysis on existing engineering programmes at national, regional and international levels. Furthermore, the chapter presents the goal of the engineering programme, graduate attributes, programme objectives and expected learning outcomes. Lastly, the chapter outlines the translation of expected learning outcomes into basic and other courses, as well as aligning the expected learning outcomes and engineering courses to be provided in the bachelor's degree programme.

3.2 Summary of Results from Situational Analysis

An environmental scan of all Bachelor's degree programmes in the engineering cluster in the country revealed the existence of various engineering degree programmes taught in more than seven (07) universities with significant variations in terms of nomenclature, entry qualifications, expected learning outcomes and contents of the Bachelor's degree programme. In contrast, an international environmental scan on engineering programmes indicates that within a particular country, the nomenclature, entry qualifications, expected learning outcomes and content for the Bachelor's degree programmes in engineering are typically standardized. Furthermore, expected learning outcomes were noted to be developed by professional bodies, whereas in Tanzania, each university is mandated to set its own. This discrepancy presents a challenge in allowing student mobility and credit transfer within the country and the region as engineering programmes are not readily comparable.

In order to address these disparities, the idea of developing benchmarks in engineering disciplines is imperative. Thus, based on the environmental scan, it was possible to take advantage of experiences or lessons gained from regional and international levels to develop the national nomenclatures, entry qualifications, exit learning outcomes and engineering and course profiles for the bachelor of engineering programmes at the national level.

3.2.1 Bachelor of Engineering Programme nomenclature

During the environmental scan of the bachelor of engineering programmes in the country, it was observed that the first degree in engineering is variously referred to as BSc. Engineering, B.E. or bachelor in the specific engineering field, i.e., B.E. in Civil Engineering and Bachelor of Civil Engineering, respectively. The main issue of concern is whether the naming of the final qualification is related to the type of engineering curriculum. To address the said controversy, it is recommended that all bachelor's degrees in engineering should be referred to as BSc in Engineering.

3.2.2 Entry qualifications

Entry qualifications for the Bachelor of Engineering programmes from various universities were noted to have certain similarities as they all stress having two principal passes in Physics and Mathematics or Chemistry at an Advanced Level or Form Six. Other universities specify "two principal level passes in appropriate subjects" without clearly specifying the subjects. Universities have additional requirements or equivalent requirements for Diploma graduates seeking admission. This situation creates significant challenges for Diploma holders as entry qualifications they possess do vary widely, with some not meeting the expected academic standards hence complicating the admission process.

Pursuant to the above, it is important that entry qualifications for the bachelor of engineering programme are standardized. In this regard, the entry qualifications for the Bachelor of Engineering programmes should have the following:

(a) Two principal passes with at least a "D" grade in Physics and Mathematics or Chemistry at the Advanced Secondary Education level (Form 6), at which the combination of subjects will depend on the field of specialization.

(b) Diploma Certificate or Equivalent as approved by Senate: with at least a "C" grade in Mathematics and an average of "B" or GPA of 3.0 in all subjects as prescribed by most of the universities in the country. In addition, an applicant must have a minimum of "D" grade in two science subjects and a minimum of "D" grade in Mathematics at O-Level.

3.3 The Generic Engineering Programme Benchmarks

3.3.1 Definition of Engineering

Engineering is the application of principles of science, e.g., mathematics and physics, to provide practical solutions to problems ensuring socio-economic and technological progress, safety of life and operations as well as environmental protection in our ever-changing world. It also involves the conception, design, construction, operation, maintenance, commissioning, decommissioning, disposal and recycling of infrastructure, products, processes and systems.

3.3.2 Goal for Bachelor's Degree programme in Engineering

The goal of an engineering programme is to produce a graduate engineer who can apply scientific, mathematical, economic and social knowledge in the conception, design, construction, manufacture and operation, as well as using modern engineering and information technology (IT) tools in complex engineering activities, with an understanding of their limitations. Further to that, it includes maintenance, disposal and recycling of structures, products, processes and systems in an efficient and economic manner as applicable to the specific field of engineering.

3.3.3 Frame of reference for Engineering discipline

The objective of formulating generic benchmarks is to act as a frame of reference for specific engineering programmes. This will, in turn, articulate the engineering graduate attributes, which cut across all engineering fields of the discipline, the learning outcomes, and the components of the curriculum using a specific frame of reference.

3.3.4 Engineering graduate attributes

All engineering programmes must be designed in such a way that graduates from any university possess the desired attributes. In this aspect, the graduate must be able to articulate the attributes listed in Table 1. When designing the curricula, the listed attributes should be reflected in the Expected Learning Outcomes (ELOs) for all engineering programmes.

Table 1: Attributes required by engineering graduates

Attribute	Description
Communicate Effectively	(a) Technical communication through reports, drawings and specifications. (b) Digital literacy in design, drawings production, report writing, and presentation.
Execution of Engineering Projects	(c) Must be able to supervise/oversee the execution of engineering projects (d) Understand production/construction procedures
Flexibility	Ability to develop sustainable solutions in changing circumstances through critical thinking and creativity, independently or collaboratively.
Requisite Basic Knowledge	Possess and utilize fully the fundamental engineering science, mathematics, political and socio-economic sciences and information technology in daily execution of their duties/functions.
Ethics and Professionalism	Possess and display a high level of integrity, ethical conduct and professional competence including proficiency in standards and codes of practice.
Professional Responsibility	Be aware of the impacts of engineering decisions on economic, environmental, health and safety, business and the social and cultural aspects of the society.
Teamwork, Leadership and Entrepreneurship	(a) Be an active team player; (b) Possess sound management attitudes; (c) Exercise responsibility; (d) Respect cultural and gender diversity; (e) Respect others' opinions, be courteous and exercise collective responsibility; (f) Empathetic and exercise fairness and trust; and Apply entrepreneurial skills.
Engineering Competences	Competence in conceptualization, design, construction, manufacture, operation and maintenance of structures, processes and systems as

Attribute	Description
	well as application of information technology in solving engineering problems.
Life-long Learning	Commitment to continuous improvement, curiosity and ability to be innovative, undertake inquiry and "think outside the box".

3.3.5 Course profile for Engineering programmes

Table 2 shows the course profile for engineering programmes and is in line with graduate attributes summarized in Table 1. It can be seen that more weight of the total credits (60 percent) has been assigned to the engineering fundamentals and design & synthesis. This is to provide engineers with the necessary skills and knowledge to design and develop engineering systems, understand production/construction procedures, supervise/oversee the execution of engineering projects and think innovatively and creatively. Mathematics has been given ten (10) percent of the total credits so as to provide engineers with the necessary theoretical foundation and analytical tools to solve problems, design systems and develop new technologies. The basic sciences such as physics and chemistry have been given seven (07) percent because they are essential components of engineering education and they provide the foundation for understanding the natural world and the principles that govern it.

Table 2: Course profile for engineering programmes

Module	Mathematics	Basic Sciences	Computer applications & IT	Engineering Fundamentals	Design & Synthesis	Complementary Studies	Discretional credits
Percent of total credits	10	7	3	35	25	10	10

Complementary studies refer to the non-technical courses that complement and supplement the technical courses in engineering training such as communication skills and technical writing while discretionary credits refer to the courses that universities can include in a given programme so as to attain competitive advantage in the market – these courses can be core or electives. Thus, complementary and discretion studies have been assigned 10 percent of the total credits each. Computer applications and information technology (IT) has been assigned three (03) percent of the total credits as this is an essential component of engineering training. Specific ways in which computer applications and IT are important in engineering training include: design and modelling using Computer Aided Design (CAD) and data analysis. Depending on the nature of the programme, computer application and IT can take advantage of complementary studies space which has been assigned 10 percent of the total credits.

3.3.6 Engineering Programme objectives

The Bachelor of Engineering programmes should be designed in such ways that they address the concerns of requisite/different stakeholders. This can be achieved by focusing on the following grouped programme objectives:

(a) Academic Ability

The programme objectives under this category are to equip learners with:

(i) Ability to develop effective ways to solve engineering problems creatively and innovatively;

(ii) Ability to apply scientific engineering principles and mathematics;

(iii) Ability to design and implement engineering products, processes and systems applications using both conventional and information technology (IT);

(iv) Ability to adapt and adopt emerging engineering applications/technologies, and

(v) Ability to undertake research and to progress to postgraduate/higher levels of studies.

(b) Employability

The programme objectives under this category are to equip learners with:

(i) Up-to-date engineering skills and knowledge for the industry;

(ii) Problem solving skills including the use of information and technology tools for engineering related tasks;

(iii) Analytical skills to understand impacts of engineering on individuals, organisations and society;

(iv) Ability to integrate theory and practice to work effectively and efficiently in organisations; and

(v) Knowledge, skills, know-how/competencies and understanding that enable creativity, innovativeness and entrepreneurship in the field of engineering.

(c) Personal Development

The programme objectives under this category are to:

(i) Prepare learners for life-long learning and research;

(ii) Empower students to progress in their personal career; impart professional ethics to the learner, and equip the learner with skills and attitude to work in multicultural and global environments;

(iii) Equip the learner with knowledge, know-how, understanding and skills to work as a team in the engineering field; and

(iv) Enable the learner to develop skills and competencies to perform effectively in technical and non-technical environments.

3.3.7 Generic expected learning outcomes

Learning outcomes have been formulated taking into account the Bloom's Taxonomy, emphasizing not only on higher order cognitive but also psychomotor and affective skills. Adoption of this approach seeks to ensure that engineering graduates exit from universities equipped with requisite knowledge, skills and competences which amplifies their employability prospects. In this regard, expected learning outcomes have been developed with reference to the UQF level 8 descriptors in form of knowledge, skills and competences as well as engineers' attributes as explained in Section 3.3.4.

Furthermore, in formulating the generic learning outcomes, reference was also made to a number of benchmarks from various regulatory and professional bodies and initiatives such as TCU, IUCEA, the Engineering Council of South Africa (ECSA), Quality Assurance and Accreditation Council (QAAC). Others include the University Grants Commission (UGC), Tuning Europe Project, the Quality Assurance Agency for Higher Education, UK (QAA, UK), Tuning Africa Project, Tuning-Comparing

Achievements of Learning Outcomes in Higher Education in Europe (CALOHEE) project, and Tuning-Assessment of Higher Education Learning Outcomes (AHELO) project.

Benchmarks from the above sources were compared and analysed in terms of required knowledge, skills, and competences and were found to have a lot of similarities in terms of numbers and assessment criteria of exit learning outcomes. It is worth noting that the number of exit learning outcomes given in this benchmarks should be taken to be minimum. Table 3 shows the generic expected learning outcomes for a Bachelor's degree programme in Engineering. It should be noted that the number of learning outcomes under knowledge, skills and competences are three (3), four (4) and five (5), respectively.

Table 3: Expected Learning Outcomes for a Bachelor's Degree Programme in Engineering

Category	Expected Learning Outcome
Knowledge (K)	On successful completion of the degree programme, graduates should have:
	K1. Ability to apply scientific engineering concepts and theories including the use of information technology tools to solve engineering problems;
	K2. Ability to use research concepts, theories, facts and methods in investigations of engineering problems including design of experiments, analysis and interpretation of data; and
	K3. An ability to recognize the importance of, and pursue lifelong learning (LLL) in the broader context of innovation and technological developments.
Competences (C)	S1. Ability to formulate design solutions for complex engineering problems and design systems components or processes that meet specified needs using both conventional and information technology methods;
	S2. Ability to apply management skills to manage projects in a multi-disciplinary environment;
	S3. Ability to communicate effectively with confidence, including able to write and make convincing presentation on complex engineering problem; and

Category	Expected Learning Outcome
	S4. Ability to continuously seek and apply contemporary and emerging technologies.
	C1. Ability to evaluate the sustainability and impact of professional engineering works and solve complex engineering problems in societal and environmental contexts; C2. Ability to apply innovation and entrepreneurship principles to create business opportunities; C3. Ability to investigate complex engineering problems using research-based knowledge and methods to produce conclusive results; C4. Ability to apply appropriate techniques, resources, and modern-techniques such as modelling and simulation to solve complex engineering problems; and C5. Ability to function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

3.3.8 Translating generic expected learning outcomes into basic and other courses

The generic ELOs in Table 3 need to be translated into an engineering programme. Programmes in engineering fields as defined at Bachelor's level (UQF Level 8) and are seen as a coherent set of courses/modules/units leading to a Bachelor's degree in a specific field of engineering. The courses are divided into three (03) groups i.e., core, supportive and elective:

(a) **Core courses:** are the essential courses offering a thorough foundation in the field. They are the backbone of the field, and are typical specific engineering field courses mandatory for every individual enrolled in an engineering programme.

(b) **Supportive courses:** are those that back up the core courses. These are mandatory courses for backing the intended learning outcomes. An example is “Mathematics” and “Computer Fundamentals and ICT.” Without these courses, it will be difficult to achieve the learning outcomes of a given programme.

(c) **Elective courses:** are those that can be taken by a learner to deepen or broaden his/her knowledge in a specialisation of a particular programme for a field of engineering. The courses are not compulsory; however, a learner has to make a choice to meet the minimum credit requirements for graduation. It should be noted that institutions are free or allowed to upgrade electives to core courses and not vice versa.

Table 4 translates the ELOs in Section 3.3.7 into minimum courses/subject areas that form part of the curriculum for a Bachelor's degree programme in an engineering field. These are given under different clusters. For each of the specific engineering fields, a translation of learning outcomes into the basic and any specialisation phases of the programmes are indicated in the requisite sections of Chapter 4 of this document.

Table 4: Minimum courses/subject areas for the shared phase of a Bachelor's Degree programme in Engineering

Core	Supportive	Elective
Basic Engineering (i) Engineering Drawing (ii) Introduction to Engineering Field (iii) Strength of Materials (iv) Engineering Mechanics **Engineering Fundamentals** Courses/subject areas specific to an engineering field e.g. (i) Civil engineering, (ii) Mechanical engineering (iii) Electrical and electronics engineering (iv) ICT and telecommunication engineering (v) Agricultural engineering	**Basic Sciences** (i) Physics for Engineers (ii) Chemistry for Engineers **Mathematics for Engineers** Mathematics for Engineers including: (i) Algebra (ii) Calculus (iii) Differential Equations, Linear Transformation and Matrices (iv) Complex Analysis	These are meant to deepen or broaden a learner's knowledge in a specialization of a particular programme for a field of engineering)

Core	Supportive	Elective
Engineering Analysis, Design and Manufacturing (i) Computer Aided Engineering Analysis (ii) Design and Manufacturing/Implementation (iii) Design Project **Experiential Learning** (i) Workshop Practice (ii) Industrial Training (iii) Problem Based Learning (PBL) Project **Engineering Research** (i) Research Methodology (ii) Research Project **Environmental Management and Sustainability** (i) Environmental Management and Sustainability (including ESIA, EIA, EA, and Health and Safety Practice) (ii) Risk Management	(v) Laplace Transforms, Fourier series (vi) Numerical Methods (vii) Vector Analysis) (viii) Probability and Statistics for Engineers **Programming** (i) Programming for Engineers (including languages) (ii) Computer Fundamentals and ICT **Writing and Communication** (i) Technical Writing for Engineers (ii) Communication Skills for Engineers **Basic Social Sciences and Humanities** (i) Development Studies (ii) Sociology (and Gender) (iii) Basic Economics	
Engineering Management and Economics (i) Engineering Management (including project management) (ii) Engineering Economics (iii) Entrepreneurship (including marketing) **Law and Professional Practice** Law, Ethics, Integrity and Professional Practice		

3.3.9 Generic expected learning outcomes and alignment for a Bachelor's degree programme in Engineering

To check if the planned courses cover the learning outcomes, it is important to develop a curriculum alignment matrix, an example of which is shown in Table 5. For each course, the specific learning outcomes have to be formulated and one must check/assess how far this course contributes to the achievement of the programme learning outcomes.

Table 5: Curriculum alignment matrix

Learning Outcomes	Course 1	Course 2	Course 3	Course 4	Course m
Learning outcome 1	X		X		
Learning outcome 2		X	X	X	
Learning outcome 3	X			X	
Learning outcome…n		X			X

The alignment matrices for the programmes in the specific fields of engineering in Chapter four (4) of this document reflect the alignment of ELOs and courses for the selected bachelor's degree programmes in engineering.

3.3.10 Experiential learning outcomes and project works

Experiential learning is the process of learning by doing. By engaging students in hands-on experiences and reflection, they are better able to connect theories and knowledge learned in the classroom to real-world situations.

(a) Workshop Practice

Workshop practice is to be conducted during the first year of study within the programme during which learners should be subjected to vocational training in which they attain practical skills in a workshop environment. Workshop practice should be included as a first-year subject at universities. Students adventure into designing and making basic products, practicing with materials in a workshop set-up while observing health, safety and environmental concerns. Students should be exposed to different materials commonly used in the various fields of engineering.

(b) Laboratory and Field Practice

Most engineering programmes include practical experimental activity in the laboratory as well as in the field. Many academics and authoritative bodies agree that a significant level of such activity is essential to the formation of professional engineers. Field and laboratory practices should ideally be a component of all applicable practical courses, directly incorporated into each course and must form part of the learner’s assessment through reports, presentations, demonstrations and/or otherwise.

(c) Industry, Community Visits and Guest Lecturers

For the learners to adequately understand the engineering field of study, programme designs should ensure sufficient learner-centred exposure to industrial and community visits to enhance the learner's thought independence, creativity, innovation, teamwork, technical presentation and communication skills, as well as relate their learning to real-life applications and challenges. Provision shall be made by universities for guest lecturers from the industry to deliver lectures which give typical industrial/community problems and their solutions.

(d) Industrial Training

Industrial training in a practical engineering environment, directly assisting professional engineers, would give the student valuable insights into professional practice. Such experience would complement the formal studies at the educational establishment and should ideally consist of several different types of experience. As such, an engineering programme should allow for adequate time for industrial attachment. In this way, learners can enhance their skills, knowledge, work abilities and attitude towards their area of specialization. Practical training forms a foundation towards producing a competent professional engineer.

The industrial training may be conveniently scheduled at the end of each academic year for the first three (03) years of the programme for a reasonable period of time of not less than eight (08) weeks per year. However, it is recommended that in the third year, students should take advantage of identifying their final year projects. Alternative arrangements for industrial training timing can be made by universities without affecting the minimum duration required. Students should be supervised by staff in the industry and visited by university staff to ensure that the objective is achieved. Students will keep a logbook of their activities and write reports documenting the experience they acquired and that should form part of their assessment.

Table 6 depicts the allocation of marks and responsible supervisors for industrial training in universities. It should be noted that the assessment structure within a given university varies department-wise and year of study. Each institution should develop its own assessment structure in line with Table 6, which will be approved by the respective Senate. Furthermore, the allocation of marks could differ depending on the year of study.

Table 6: Allocation of marks and responsible supervisors

SN	Allocation of Marks and Responsible Supervisors			
1.	Industrial Supervisor	Internal/Academic Supervisor	Internal Examiner (Report)	Oral Exam (Optional)
2.	10	20	50	20

(e) Problem Based Learning Project

Problem-based learning (PBL) is a student-cantered approach in which students learn about a subject by working in groups of not more than five (05) to solve an open-ended problem. In PBL, students are given the opportunity to engage with the community and industry to contribute to solving some of the challenges faced and, at the same time, enable students to learn from the engagements. In their group kind of learning, students are jointly supervised by university staff and industry partners, whereby the university staff is the main supervisor. This approach should be used right from the first to the last year and attempts should be made to have solutions in multi-disciplinary teams.

(f) Final Year Project

A final year project should ideally be performed during the last year of the programme. Learners should be given an opportunity to demonstrate their ability to conceptualise, design, innovate, and justify the innovation and business case and prototype engineering solutions. This involves having a creative and innovative ability to design and develop an economically viable product, processes or systems which meet defined needs. Final year projects usually impart knowledge and skills that assist students to:

(i) Investigate, identify and define a problem and identify its constraints and broad environmental issues.

(ii) Understand customer and user needs, including industrial design considerations.

(iii) Propose a solution for the identified problem.

(iv) Identify and apply a comprehensive methodology (Data collection, design analysis, model construction and testing) to solve a given problem.

(i) Discuss results and compile a report.

In order to allow more time for the final year projects, it is important that the final year project is allocated in the second semester of the final year, which shall comprise mainly the final year project and only a few lectures.

3.3.11 Teaching and learning assessment

(a) Methods of Delivery and Design of Programmes

The methods of delivery and the design of programmes should be regularly informed by current developments in the field and related fields; accounting for appropriate research and policy alterations, industry best practices and employer requirements. For the learners to adequately understand subject matters in the engineering field of study, the programme designs should ensure sufficient learner-centred exposure to field and laboratory-based practical work, and significant individual and group activities. Programmes should also be designed to include research, project works, design exercises, industrial placements and industrial visits. The above conditions are aimed to ensure that graduates can work independently as well as be able to work in teams apart from being innovative and creative.

Delivery of the different components of a programme, including courses of study, should ideally include support from industry experts visiting and giving lectures and exhibiting products at universities to expose students to industry practices, experiences, products and technology in addition to learners' industrial visits and public seminars and lectures by industry experts. The industry experts should include but not be limited to manufacturers, private business service engineers, public service engineers and managers. The programme designs should be undertaken to cater for such industry participation in programme delivery.

(b) Assessment of Engineering Programmes

Students in engineering programmes are usually assessed to find out whether they have acquired adequate skills, knowledge and competencies when they graduate. The assessment is based on the learning outcomes as stipulated in the engineering programmes. In this case, the design of the programmes, teaching and learning practices should be formulated in such a way that there is an alignment of learning activities and assessment tasks with programme learning outcomes.

Experiences have shown that the assessment of engineering programmes is guided by two modes: continuous assessment (CA) and university examinations (UE). The continuous assessments include assessment of delivered courses (coursework) as a whole in terms of tests, laboratory activities and projects in a given semester. Also, laboratory experiments and projects are key to the continuous assessment for every semester. Laboratory experiments and projects, and/or workshop assignments can be assessed in groups of not more than five students to ensure thorough participation of each student. The university examinations should be designed to cover all materials encompassing all learning outcomes which were targeted for that particular semester.

(c) Overall Assessment

The overall marks for any given course shall be 100 percent. The distribution of marks between CA and UE shall depend on the number of hours spent on CA. When the programme is practical oriented, more marks shall be given to CA than UE. However, the normal distribution of marks used in the engineering programmes between CA and UE is 40% and 60%, respectively, but may vary depending on the practical nature of the programme. It is worth noting that a 40/60 distribution between CA and UE is proposed to ensure students are assessed on several aspects of learning, to incentivize students' engagement in day-to-day learning, and to reduce the impact of a single examination on student grades. However, the ratio may vary depending on the practical nature of the course. Practical assessment can be carried out in the following areas: field and workshop practice, industrial training and laboratory and mini projects:

(i) **Field and workshop practice:** This should be based on assessment which will be based on supervision (i.e. academic and field supervision, as applicable), inspection and a technical report compiled by the learner. The academic and field supervision assessment components shall contribute a larger proportion to the grading as compared to the technical report.

(ii) **Industrial training:** This should be based on both the industry supervisor and academic supervisor's assessment based on the learner's performance during attachment to the organisation and the academic supervisor's assessment of a technical report written by the learner after the training.

(iii) **Laboratory, Design projects, PBL and Research projects**: These should be assessed through technical reports written by the learners as well as oral presentations of the same reports by the learners reflecting knowledge of the subject matter and the project undertaken.

3.3.12 Duration of Bachelor degree programmes in Engineering

Due to the intensity of knowledge area coverage, it is recommended that the duration of the engineering programmes should be four (04) years and a minimum of 480 credits.

CHAPTER 4

BENCHMARKS FOR SELECTED BACHELOR DEGREE PROGRAMMES IN ENGINEERING

4.1 Benchmarks for Bachelor Degree Programme in Agricultural Engineering

4.1.1 Definition of Agricultural Engineering

Agricultural engineering is the branch of engineering that deals with the design of farm machinery, location and planning of farm structures, farm drainage, soil management and erosion control, water supply and irrigation, use of information, electrical technologies and processing and production of farm products. It includes relevant aspects of civil, mechanical, electrical, and environmental engineering as well as construction technology, hydraulics, soil mechanics, and agricultural production and processing technologies.

4.1.2 Programme description

Agricultural engineering is a multi-disciplinary science involving the application of engineering technology and biological science to agricultural, food and biological systems for the benefit of human society. Also referred to as "bio-engineering" and "resource systems engineering": Agricultural engineering includes specialisation in power systems and machinery design; structure design; environment, food and bioprocess engineering. It also involves studies on soil and water conservation as well as innovative ways of processing agricultural products. Agricultural engineers use their expertise in research and development, production, operations, sales and management.

4.1.3 Programme objectives

The Bachelor's degree programme in agricultural engineering should be designed in such a way that it addresses the concerns of requisite/different stakeholders. This can be achieved by focusing on the following grouped programme objectives:

(a) Academic Ability

The programme objectives under this category are to equip learners with:

(i) Knowledge, skills, know-how and understanding for developing effective ways to solve engineering problems creatively and innovatively;

(ii) Knowledge and know-how in scientific principles, mathematics and engineering applications;

(iii) Ability to design and implement engineering products, processes and systems applications using both conventional and information technology;

(iv) Ability to adapt and adopt emerging engineering applications/technologies; and

(v) Ability to undertake research at higher levels of studies at postgraduate studies.

(b) Employability

The programme objectives under this category are to equip learners with:

(i) Up-to-date engineering skills and knowledge for the agriculture engineering industry;

(ii) Problem-solving skills for engineering related tasks;

(iii) Analytical skills to understand the impacts of engineering on individuals, organisations and society;

(iv) Ability to integrate theory and practice to work effectively and efficiently in organisations; and

(v) Knowledge, skills, know-how and understanding that enable creativity, innovativeness and entrepreneurship in the field of engineering.

(c) Personal Development

The programme objectives under this category are to:

(i) Prepare learners for life-long learning and research;

(ii) Empower students to progress in their personal career; impart professional ethics to the learner and equip the learner with skills and attitude to work in multicultural and global environments;

(iii) Equip the learner with knowledge, know-how, understanding and skills to work as a team in the engineering field; and

(iv) Enable the learner to develop skills to perform effectively in technical and non-technical environments.

4.1.4 Expected learning outcomes for the Agricultural Engineering programme

The Expected Learning Outcomes (ELOs) provide a mechanism for describing not just knowledge and relevant practical skills but also personal and transferable skills. They describe what a student is expected to know or can do after graduation. ELOs are categorised into knowledge, skills (cognitive, practical and interpersonal), and competencies. In order to harmonize the Bachelor degree programme in the agricultural engineering, the presented learning outcomes have been formulated to be used as benchmarks linked to the graduate attributes in the agricultural engineering programme. A learner completing a Bachelor in the agriculture engineering programme should be able to demonstrate the knowledge, skills and competencies as provided in Table 7.

Table 7: Expected learning outcomes for Bachelor degree programmes in Agricultural Engineering

Category	Expected Learning Outcomes
	On successful completion of the degree programme, graduates should have the:
Knowledge (K)	K1. Ability to apply knowledge of mathematics, science, agricultural engineering concepts and theories, including the use of information technology tools to solve complex engineering problems; K2. Ability to use research concepts, theories, facts and methods in investigations of Agricultural engineering problems, including design of experiments, analysis and interpretation of data; and

Category	Expected Learning Outcomes
	K3. Ability to recognize the importance of and pursue lifelong learning (LLL) in the broader context of innovation and technological developments in Agricultural engineering.
Competences (C)	S1. Ability to formulate design solutions for complex Agricultural engineering problems, design systems and components or processes that meet specified needs using both conventional and information technology methods; S2. Ability to apply management skills to manage projects in a multidisciplinary environment; S3. Ability to communicate effectively with confidence, including being able to write and make convincing presentation on complex Agricultural engineering problems, and S4. Ability to continuously seek and apply contemporary and emerging technologies
	C1. Ability to evaluate the sustainability and impact of professional engineering works including solving complex agricultural engineering problems in societal and environmental contexts; C2. Ability to apply innovation and entrepreneurship principles to create business opportunities; C3. Ability to investigate complex Agricultural engineering problems using research-based knowledge and information technology tools to produce conclusive results; C4. Ability to apply appropriate techniques, resources, and modern-techniques such as modelling and simulation to solve complex Agricultural engineering problems; and C5. Ability to function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.

4.1.5 Translating learning outcomes into Agricultural Engineering programmes

The translation of the ELOs into Agricultural Engineering programmes involves alignment between learning outcomes and course contents. This is followed by mapping the learning outcomes and grouping them into core, supportive and elective courses. The three types of groups of subject areas can be distinguished as follows:

(a) **Core Courses (or Subject areas):** These are the essential courses offering a thorough foundation of the discipline, and they are mandatory for every student. The core courses are the backbone of the discipline, and they are typical courses.

(b) **Supporting courses (or subject areas):** These are mandatory courses for backing up the intended learning outcomes. Without these courses, it will be difficult to achieve the learning outcomes of a given programme.

(c) **Elective courses (or subject areas):** These are courses that can be taken by a student to deepen or broaden the knowledge, but they are not compulsory. However, a student has to make a choice to meet the minimum credit requirements for graduation. However, the selected elective courses must come from a list of courses approved by the University Senate.

It should be noted that within the programme, the courses shall be largely assessed through coursework and examinations, although some courses may be of audited nature (i.e., courses in which a learner attends but is not examined). During programme curriculum design, it must be ensured that there is sufficient coverage of requisite, pre-requisites and co-requisite courses. A Bachelor's degree programme in a specified field of engineering can be divided into two phases, i.e., basic phase and specialisation phase.

(a) The basic phase is common for the entire specific engineering field and consists of core and supportive courses.

(b) The specialisation phase allows learners to choose applicable specialisations in line with their interests in the engineering field of study.

The benchmarks development process involved analysis of regional and international practices followed by the establishment of minimum/key courses to be covered in the agricultural engineering programme. Table

8 translates some of the ELOs into minimum courses/subject areas that form part of the curriculum for a Bachelor degree programme in agricultural engineering. The minimum courses/subject areas were then evenly distributed across the main thematic areas of agricultural engineering. Table 8 therefore shows the minimum courses/subject areas for a Bachelor degree programme in agricultural engineering; categorised into core, supportive and elective courses.

Table 8: Minimum courses/subject areas for Bachelor degree programmes in Agricultural Engineering

Core	Supportive	Elective
Basic Engineering (i) Introduction to Agricultural Engineering (ii) Engineering Drawing (iii) Fundamentals of Electrical and Mechanical Engineering (iv) Fluid Mechanics (v) Engineering Hydraulics (vi) Strength of Materials (vii) Engineering Mechanics (viii) Thermodynamics for Engineers (ix) Mechanics of Machines (x) Materials Science and Engineering **Engineering Fundamentals** (i) Measurement and Instrumentation (ii) Engineering Properties of Biological Materials (iii) Engineering Surveying (iv) Soil Mechanics (v) Electrical Power Systems and Machines (vi) Renewable Energy Resources and Technologies (vii) Waste Management (viii) Ergonomics, Safety and Maintenance (ix) Farm Planning and Construction of Farm Structures	**Basic Sciences** (i) Introduction to Animal Production (ii) Introduction to Crop Production (iii) Soil Sciences (iv) Extension Methods (v) Agricultural Biometry **Mathematics for Engineers** (i) Algebra, (ii) Calculus, (iii) Differential Equations, (iv) Linear Transformation and Matrices, (v) Complex Analysis, Laplace Transforms, (vi) Fourier series, and (vii) Numerical Methods, Vector Analysis) **Programming** (i) Programming for Engineers (including languages)	(i) Water Supply (ii) Soil and water conservation (iii) Rainwater Harvesting Systems (iv) Drainage and Land Reclamation (v) Specific Crop Processing (vi) Controlled Environment Production Systems (vii) Process and Plant Design (viii) Earth Moving Equipment (ix) Sensors and Controls for Precision Agriculture (x) Design of Water Reservoirs and Small Dams (xi) Perishable Produce Storage and Processing (xii) Design and Installation of Renewable Energy Systems (xiii) Packaging Engineering

Core	Supportive	Elective
(x) Principles of Hydrology (xi) Water Resources Engineering and Management (xii) Land use Planning and Management (xiii) GIS and Remote Sensing (xiv) Soil and Water Conservation (xv) Design and Analysis of Farm Structures (xvi) Design of Irrigation and Drainage Systems (xvii) Agricultural Machinery Design (xviii) Fluid Power and Hydraulic Systems (xix) Agricultural Machinery and Equipment (xx) Farm Implements, Operation and Maintenance (xxi) Irrigation and Drainage Management (xxii) Agricultural Produce Storage, Packaging and Transport (xxiii) Agricultural Machinery Management (xxiv) Thermal Processing of Biological Materials (xxv) Mechanical Processing of Biological Materials	(ii) Computer Fundamentals and ICT **Probability and Statistics** Probability and Statistics for Engineers **Writing and Communication** Communication Skills for Engineers **Basic Social Sciences and Humanities** (i) Development Studies (ii) Sociology (and Gender) (iii) Basic Economics **Law and Professional Practice** Law, Ethics, Integrity and Professional Practice	

Core	Supportive	Elective
Engineering Analysis, Design and Manufacturing (i) Computer Modelling and Simulation (ii) Computer Aided Design and Manufacturing (CAD/ CAM) (iii) Engineering Design (iv) Design Project **Experiential Learning** (i) Workshop Practice (ii) Industrial Training (iii) Problem Based Learning (PBL) Project **Engineering Management and Economics** (i) Agricultural Engineering Management (including project planning and management) (ii) Engineering Operations Management (Operations Research) (iii) Agribusiness and Entrepreneurship (including marketing) **Engineering Research** (i) Research Methodology (ii) Research Project **Environmental Management and Sustainability** Environmental Management and Sustainability (including ESIA, EIA, EA, and Health and Safety Practice)		

4.1.6 Credit frameworks for Agricultural Engineering programme

UQF defines a credit as a numerical value that represents the estimated time needed for a learner to achieve required specific learning outcomes. A credit within the UQF equates to the learning outcomes achievable in 10 hours of learning time. It is a measurement unit for 'notional' or 'average learning' time which includes all the activities which the average learner is expected to undertake in order to achieve the learning outcomes. Such activities for UQF level 8 conventional mode of learning include but are not limited to lectures, seminars/tutorials, assignments, independent studies, and practical training as stipulated in the example given in Table 9.

Table 9: Credit framework for conventional mode of learning

UQF Level	% on Lectures	% on Seminars and Tutorials	% on Assignments	% on Independent Studies and Research	% on Practical Training
8	40	20	10	20	10

The UQF defines 480 as minimum cumulative credits required for a learner to graduate with Bachelor of Science in Agricultural Engineering. It should be noted that for a subject area, Agricultural Engineering programme designers are flexible to assign more weight to an activity that heavily contributes to the student's learning. For instance, for a student to learn programming, more weight should be assigned to the practical activity. Universities offering B.Sc. Agricultural Engineering programme should assign more weight on practical and industrial field activities as compared to theoretical learning.

4.1.7 Normal learning matrix for Agricultural Engineering programme

Normal Learning Matrix and Course Matrix shall be provided for determination of the percentage (%) of time assigned for learning at UQF level 8. In this regard, universities should design an agricultural engineering programme such that a student covers a minimum of 480 credits in four years for core and supporting subject areas. In addition, the number of electives to be taken shall also be indicated. Table 10 presents a sample matrix for year 1, semester 1 of the bachelor's degree programme in Agricultural engineering.

Table 10: Sample of a normal learning and course matrix for Agricultural Engineering programme

Year 1, Semester 1

Course code	Course Name	Course Status (Core/Elective)	Lecture Hrs	Tutorial/ Seminar hrs	Assignment hrs	Independent study hrs	Practical hrs	Total hours	Credits
AGE 110	Workshop Training, I	Core							
AGE 111	Engineering Drawing	Core							
AGE 112	Engineering Statics	Core							
IWRE 111	Introduction to (GIS) and Remote Sensing	Elective							
CIT 100	Computer Application	Elective							
ENV 103	Introduction to Meteorology	Elective							
	Total Credits								

4.1.8 Agricultural Engineering course description

All courses or modules to be taught and learnt within the Agricultural engineering degree programme should follow the outline shown in Table 11.

Table 11: Course description

SN	Description
1	**Course Title:** Refer to UQF qualification titles and nomenclatures.
2.	**Course Code**: A unique number that identifies the course
3.	**Prerequisite:** A pre-requisite should be a course that provides the required foundation knowledge in order to progress into this particular course
4.	**Course Aim:** Course aims are statements that describe the overarching intentions of a course. They should try to answer, "What is the purpose of the course?", "What is the course trying to achieve?"

SN	Description
5.	**Course Requirements:** List tools, resources, and materials needed by the student for success in the course e.g. access to labs, web-based resources, etc.
6.	**Course Expected Learning Outcome(s):** Course Learning outcome should try to describe what students will be able to do/learn by the end of the course in terms of knowledge, skills and competency.
7.	**Course Status:** Should indicate whether the course is core or elective.
8.	**Credit rating**: Reference should be made to the UQF credit framework.
9.	**Total Hours Spent:**
10.	**Course Content:**
11.	**Mode of Delivery**: The mode of delivery is an important consideration when designing learning activities that will support students to develop the skills, knowledge and understandings required in achieving the intended learning outcomes, as measured by the assessment in a unit. Ideally, an instructor should select the most appropriate mode of delivery for each activity based on what will best support student development of the skills, knowledge and understandings students are expected to achieve.
12.	**Assessment Methods:** An assessment criterion on how to achieve the outcomes in (CA/UE)
13.	**Recommended Texts & Other Readings:** Indicate up-to-date list of the required course textbooks, journals and the reference books. Include details such as full name of textbook, author, edition, ISBN, description (if desired), and where it can be purchased. If a required text is available online, indicate where it can be accessed.

4.1.9 Learning outcomes and curriculum alignment matrix for Agricultural Engineering programme

Development of the curriculum alignment matrix is necessary for checking if the subject areas cover the learning outcomes. For each subject area, one must formulate the specific learning outcomes for that course and has also to assess how much a given course contributes to the programme learning outcomes. Table 12 gives an example of a curriculum alignment matrix for the expected learning outcomes of the B.Sc. in Agricultural Engineering programme. For each subject area, the contribution to the expected learning outcomes is given. The letters K, S, and C stand for Knowledge, Skills, and Competence, respectively.

Table 12: Curriculum alignment matrix for Agricultural Engineering

SN	Subject Area	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
1.0	**Core Subject Areas**												
1.	Basic Engineering Science	√		√									
2.	Engineering Fundamental	√		√				√					
3.	Engineering Analysis, Design and Manufacturing	√	√	√	√			√	√		√	√	√
4.	Experiential Learning	√	√	√			√	√	√		√	√	
5.	Engineering Management and Economics		√	√		√	√			√	√		√
6.	Engineering Research	√	√	√	√		√		√	√	√	√	√
2.0	**Supportive Subject Areas**												
7.	Mathematics for Engineers	√									√		
8.	Computer Programming	√		√	√		√	√				√	√
9.	Statistics	√	√	√		√	√		√		√	√	
10.	Communication Skills						√						√
11.	Basic Social Sciences and Humanities		√	√			√		√				√
12.	Law and Professional Practice					√	√		√				√

SN	Subject Area	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
3.0	**Elective Courses**												
14.	Rainwater Harvesting Systems	√	√	√	√	√		√		√		√	
15	Process and Plant Design	√	√	√	√		√	√	√	√	√	√	√
16.	Fluid Power and Hydraulic Systems	√	√	√	√			√	√	√	√	√	

4.1.10 Agricultural Engineering Benchmarks for specialization

In addition to the selection listed in specialization courses, institutions are free to make additional subjects. Also, students may choose to deepen their knowledge in one or more of the following specializations:

(a) Farm Power and Machinery Engineering

(b) Land and Water Engineering

(c) Processing or Post Harvest Systems Engineering

(d) Farm Structures and Environmental Control Engineering

(e) Forestry and Wood Product Engineering

(f) Food Engineering

Other areas that are emerging for the specializations include Amenity (Ecological) Engineering, Mechatronics and Robotics, Information and Communication Technology, and Renewable Energy and Environmental Engineering.

4.1.11 Minimum entry qualification for Agricultural Engineering programme

(a) Two principal passes with at least a "D" grade in Physics and Mathematics or Chemistry at advanced level or Form six at which the combination of subjects will depend on the field of specialization.

(b) Diploma Certificate or equivalent qualification approved by the Senate with at least a "C" grade in Mathematics and an average of

"B" or GPA of 3.0 in all subjects as prescribed by most of the universities in the country. In addition, an applicant must have a minimum of "D" grade in two science subjects and a minimum of "D" grade in Mathematics at O-Level.

4.1.12 Duration of the Agricultural Engineering programme

The duration for Bachelor of Science in Agricultural Engineering programme shall be four (04) years with eight (08) semesters and a minimum of 480 credits.

4.1.13 Graduation requirement for Agricultural Engineering programme

At the end of each academic year, a student is required to complete a minimum of 120 credits. A student is required to accumulate a minimum of 480 credits (4800 notional hours) of learning for him/her to graduate.

4.1.14 Evaluation and course assessment for Agricultural Engineering programme

Evaluation

The Bachelor of Agricultural Engineering programme will normally take four (04) years to complete. It is important to review the programme within one to three years after completion of one delivery programme cycle. The review will be based on a graduate survey involving key stakeholders such as alumni, employers, academic staff, regulatory bodies and students. The survey will be based on standard developed tools/guidelines to capture the marketability of the programme and employability of the graduates, including new developments in science and technology.

Assessment

Programme assessment will be based on the achievement of learning outcomes and will depend on the nature of the courses. Students' performance in the majority of theoretical courses will be measured based on continuous assessment and final examinations. The ratio between continuous assessment and final examination will depend on the weight between the two components. Continuous assessment will comprise mainly of tests, mid-semester tests, projects/assignments reports, practical training in the industry, laboratory reports and presentations and will contribute 40 percent, and university examinations will contribute 60 percent. Examination and Continuous assessment will cover all expected learning outcomes.

4.1.15 Resource requirement for the Agricultural Engineering programme

(a) Teaching and Learning Resources

Universities in Tanzania are required to provide adequate physical resources to support teaching and learning activities with adherence to quality aspects corresponding to the benchmarks set by the Commission while observing standards applicable to the resources in universities and outside the EAC region. Every university is supposed to deploy quality physical facilities adequate for the effective discharge of the teaching and learning functions with respect to but not limited to lecture rooms, lecture theatres, seminar rooms, common rooms, etc. The standards and guidelines set by the Commission will serve as the minimum requirements in terms of the teaching and learning resources for the agricultural engineering programme.

(b) Laboratories and Workshops

Universities in Tanzania that run programmes that require the use of laboratories/ workshops/teaching clinics shall ensure the adequacy of these facilities for the provision of teaching and learning activities that adhere to quality aspects corresponding to benchmarks set by the Commission. This should be in line with standards applicable to the resources used in universities and outside the EAC region.

(c) Computation Facilities

Computation is now regarded as an equal and indispensable partner, along with theory and experiment, in the advance of scientific knowledge and engineering practice. Numerical simulation enables the study of complex systems and natural phenomena that would be too expensive or dangerous, or even impossible, to study by direct experimentation. The quest for ever higher levels of detail and realism in such simulations requires enormous computational capacity, and has provided the impetus for dramatic breakthroughs in computer algorithms and architectures. Due to these advances, computational scientists and engineers can now solve large-scale problems that were once thought intractable. Universities should indicate the available computation facilities for the programme.

(d) Teaching and Technical Staff

Effective teaching and learning need to have comprehensive, adequate and competent human resources. Further, there should also be human resource (HR) targets set in line with higher learning departments' requirements accompanied by comprehensive succession plans to address staff attrition (retirements, demise, exodus, etc.). There must be enough staff to provide course offerings that allow students to complete a degree in a timely manner. The interests and qualifications of staff members must be enough not only to teach the courses but also to plan and modify the courses and curriculum to meet the market demand. Faculty members must remain current in the discipline. Professional development and scholarly activities are a joint obligation of the institution and the individual faculty members. The programme is enhanced significantly when faculty/staff acquire practical experience in the profession through activities such as training, consulting, sabbatical leave and industry exchange programmes. Staff must also be equipped to develop teaching materials for their students.

4.1.16 Industrial training

The industrial training may be conveniently scheduled at the end of each academic year for the first three (03) years of the programme for a reasonable period of time of not less than eight (08) weeks per year. However, it is recommended that third-year students should take advantage of identifying their final year projects during their practical training. Table 13 depicts the allocation of marks and responsible supervisors for industrial training in universities. It should be noted that the assessment structure within a given university varies department wise and year of study. It is proposed that each institution to develop its own assessment structure that should be approved by the respective Senate.

Table 13: Allocation of marks and responsible supervisors

SN	Allocation of Marks and Responsible Supervisors			
1.	Industrial Supervisor	Internal/Academic Supervisor	Internal Examiner (Report)	Oral Exam (Option)
2.	10	20	50	20

4.1.17 Final year project

A final year project should ideally be performed during the last years of the programme. Learners have an opportunity to demonstrate that they can conceptualise, design, innovate, and justify the innovation and business cases and prototype engineering solutions. Final year projects usually impart knowledge and skills that assist students to:

(i) Investigate, identify and define a problem, including its constraints and broad environmental issues.
(ii) Understand customer and user needs, including industrial design considerations.
(iii) Propose a solution for the identified problem.
(iv) Identify and apply a comprehensive methodology (Data collection, design analysis, model construction and testing) to solve a given problem.
(v) Discuss results and compile a report.

In order to allow more time for the final year projects, it is important that the final year project is allocated in the second semester of the final year, which shall comprise mainly the final year project and only a few lectures.

4.2 Benchmarks for Bachelor Degree Programme in Chemical and Process Engineering

4.2.1 Definition of Chemical and Process Engineering

Chemical and Process Engineering (CPE) is the profession in which knowledge of mathematics, chemistry, physics, biology and other natural sciences gained by study, experience and practice is applied with judgment to develop economical ways of processing raw materials into valuable and marketable products in order to solve industrial and societal problems. This includes designing equipment, systems, and processes for refining raw materials and for mixing, compounding, and processing chemicals. The necessary skills encompass all aspects of modelling, simulation, design, testing, scale-up, operation, control and optimization. Thus, the term Chemical and Process Engineering refers more towards the knowledge and experience in terms of the applied sciences.

4.2.2 Description of Chemical and Process Engineering programme

CPE programme is aimed at producing graduates with knowledge, skills and competences required for the production and manufacturing of products through chemical processes. The programme, therefore, is meant to provide a detailed understanding of the various "unit operations", such as unit operations involving mass and heat transfer (distillation, absorption, leaching, evaporation, liquid extraction, drying, evaporation, crystallization, etc.), and unit operations involving particle-fluid interactions (size reduction, mixing and agitation, fluidization, etc.), fluid mechanics, thermodynamics, reaction kinetics, heat and mass transfer, plant design and economics, process dynamics and control, gas and petroleum processing, biological processes, etc., that make these conversions possible.

The breadth of scientific and technical knowledge inherent in this profession has caused world scientists to describe the CP Engineer as the "Universal Engineer". While the core competences lie on unit operations and transport phenomena (heat, mass and momentum), there are a series of programme elements, which complement the programme, such as industry specific knowledge (pharmaceutical, plastic, fuel, food, etc.), mathematics (used in modelling and statistics), computer skills for process control and simulation, energy and environmental sustainability and biological skills (biotechnology and bioprocesses). Furthermore, CPE programme includes business concepts where management, economics and supply chain skills are imparted to graduates. Also, the programme provides higher order skills (communication and team work), safety of equipment, systems and personnel as well as other professions such as legal and banking skills to graduates.

4.2.3 Chemical and Process Engineering programme objectives

The Bachelor's degree programme in Chemical and Process Engineering should be designed in such a way that it addresses the concerns of requisite/different stakeholders. This can be achieved by focusing on the following grouped Chemical and Process Engineering programme objectives:

(a) Academic Ability

The Chemical and Process Engineering programme objectives under this category are to equip learners with ability to develop effective ways to solve chemical and process engineering problems creatively and innovatively, including:

(i) Ability to apply mathematics and scientific principles as well as information technology tools in chemical and process engineering;

(ii) Ability to design and implement chemical and process engineering products, processes and systems applications using both conventional and information technology methods;

(iii) Ability to adapt and adopt emerging chemical and process engineering applications/technologies; and

(iv) Ability to undertake research and to progress to postgraduate/higher levels of studies in chemical and process engineering field.

(b) Employability

The programme objectives under this category are to equip learners with:

(i) Up-to-date engineering skills and knowledge for the chemical and process industry;

(ii) Problem solving knowledge, skills and competencies for engineering related tasks;

(iii) Analytical skills to understand impacts of engineering on individuals, organisations and society;

(iv) Ability to integrate theory and practice to work effectively and efficiently in organisations; and

(v) Knowledge, skills, know-how and understanding that enable creativity, innovativeness and entrepreneurship in the field of engineering.

(c) Personal Development

The programme objectives under this category are to:

(i) Prepare learners for life-long learning and research;

(ii) Empower students to progress in their personal career; impart professional ethics to the learner, and equip the learner with skills and attitude to work in multi-cultural and global environments;

(iii) Equip the learners with knowledge, know-how, understanding and skills to work as a team in the engineering field; and

(iv) Enable the learners to develop skills to perform effectively in technical and non-technical environments.

4.2.4 Expected learning outcomes from the programme

Expected Learning Outcomes (ELOs) provide a mechanism for describing not just knowledge and relevant practical skills but also personal and transferable skills. They describe what a student is expected to know/learn or can do after graduation. ELOs are categorised into knowledge, skills (cognitive, practical and interpersonal), and competencies. To harmonize the Bachelor programme in Chemical and Process Engineering, the presented learning outcomes have been formulated to be used as benchmarks linked to the graduate attributes in the Chemical and Process engineering programme. A learner completing a Bachelor in Chemical and Process Engineering programme should be able to demonstrate the knowledge, skills and competencies as provided in Table 14.

Table 14 summarizes the expected learning outcomes for the Chemical and Process Engineering programme. The ELOs are subdivided into those falling in Knowledge (K), Skills (S) and Competencies (C) categories, with three (03), four (04) and five (05) ELOs, respectively, making a total of twelve (12) outcomes for the programme.

Table 14: Expected Learning Outcomes for Bachelor's degree in Chemical and Process Engineering programme

Category	**Expected Learning Outcomes**
Knowledge (K)	On successful completion of the degree programme, graduates should have the:
	K1. Ability to apply knowledge of mathematics, science, Chemical & Process engineering concepts and theories, including information and technology, to solve complex engineering problems; K2. Ability to use research concepts, theories, facts and methods in investigations of Chemical & Process engineering problems, including design of experiments, analysis and interpretation of data; and K3. Ability to recognize the importance of and pursue lifelong learning (LLL) in the broader context of innovation and technological developments in Chemical & Process engineering.
Competencies(C)	S1. Ability to formulate design solutions for complex Chemical & Process engineering problems, design systems and components or processes that meet specified needs using both conventional and information methods; S2. Ability to apply management skills to manage projects in a multi-disciplinary environment; S3. Ability to communicate effectively with confidence, including being able to write and make convincing presentation on complex Chemical & Process engineering problems; and S4. Ability to continuously seek and apply contemporary and emerging technologies
	C1. Ability to evaluate the sustainability and impact of professional engineering work, including solving complex Chemical & Process engineering problems in societal and environmental contexts; C2. Ability to apply innovation and entrepreneurship principles to create business opportunities;

Category	Expected Learning Outcomes
	C3. Ability to investigate complex Chemical & Process engineering problems using research-based knowledge and methods to produce conclusive results; C4. Ability to apply appropriate techniques, resources and modern–techniques such as modelling and simulation to solve complex Chemical & Process engineering problems, and C5. Ability to function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

4.2.5 Translating the expected learning outcomes into the CPE Programme

The translation of the ELOs into the Chemical and Process Engineering programme involved alignment between learning outcomes and course contents. This was followed by mapping the learning outcomes into courses and grouping them into core, supportive and elective courses. The three types of groups of subject areas can be distinguished as follows:

(a) **Core Courses (or Subject areas):** These are the essential courses offering a thorough foundation of the discipline, and they are mandatory for every student. The core courses are the backbone of the discipline, and they are typical courses.

(b) **Supporting courses (or subject areas):** These are mandatory courses for backing up the intended learning outcomes. Without these courses, it will be difficult to achieve the learning outcomes of a given programme.

(c) **Elective courses (or subject areas):** These are courses that can be taken by a student, to deepen or broaden the knowledge, but they are not compulsory. However, a student has to make a choice to meet the minimum credit requirements for graduation. However, the selected elective courses must come from a list of courses approved by the University Senate.

It should be noted that within the programme, the courses shall be largely assessed through coursework and examinations, although some courses may be of audited nature (i.e., courses in which a learner attends but is not examined). During programme curriculum design, universities must ensure that there is sufficient coverage of requisite, pre-requisites and co-requisite courses. A Bachelor's degree programme in a specified field of engineering can be divided into two (02) phases, i.e., the basic phase and the specialisation phase, as follows:

(a) The basic phase is common for the entire specific engineering field and consists of core and supportive courses.

(b) The specialisation phase allows learners to choose applicable specialisations in line with their interests in the engineering field of study.

The benchmarks development process involved analysis of regional and international practices followed by establishment of the minimum/key courses to be covered in each of the selected fields' programmes. Table 15 translates some of the ELOs into minimum courses/subject areas that form part of the curriculum for a Bachelor's degree programme in Chemical and Process engineering. The minimum courses/subject areas were then evenly distributed across the main thematic areas of Chemical and Process engineering. Table 15 therefore shows the minimum courses/subject areas for a Bachelor's degree programme in Chemical and Process Engineering categorised into core, supportive and elective courses.

Table 15: Benchmarks for core and supporting subject areas for CPE programme

Core Subject Areas	Supporting Subject Areas	Elective Subject Areas
(i) Biochemical Engineering (ii) Chemical Engineering Fluid Mechanics (iii) Chemical Engineering Laboratory	**Mathematics** (i) Matrices and Basic Calculus for Non-Majors (ii) One Variable Calculus & Differential	(i) Design of Experiments (ii) Engineering Properties of Foods and Packaging Materials

Core Subject Areas	**Supporting Subject Areas**	**Elective Subject Areas**
(iv) Chemical Reaction Engineering (v) Comp Applications in CPE • Computer Programming • Modelling and Simulation (vi) Engineering Thermodynamics (vii) Environmental Engineering (viii) Final Year Project I &II (ix) Introduction to CPE • Fundamental of Chem. & Process Eng. • Materials and Energy Balances (x) Gas and Petroleum Processing (xi) Heat and Mass Transfer (xii) Plant Design • Plant Design and Economics	Equations for Non-Majors (iii) Several Variable Calculus for Non-Majors (iv) Statistics for Non-Majors **Chemistry** (i) Organic Chemistry (ii) Systematic Inorganic Chemistry (iii) Physical Chemistry (iv) Chemical Engineering Laboratory I **Engineering Management** (i) Engineering Operations Management (ii) Engineering Economics (iii) Industrial Safety and Maintenance (iv) Entrepreneurship for Engineers **Mechanical Engineering** (i) Engineering Drawing (ii) Computer Aided Drafting (iii) Strength of Materials I	(iii) Ferment. Tech and Applications (iv) Introduction to Industrial Ecology (v) Plant Design and Optimization (vi) Plant Design and Optimization (vii) Plastic Technology (viii) Process Plant Technology (ix) Pulp and Paper Tech (x) Risk Assessment and Management.

Core Subject Areas	Supporting Subject Areas	Elective Subject Areas
• Process Eng. Design • Process Plant Equipment • Chemical Reactor Design (xiii) Process Dynamics and Control (xiv) Quality control in Chemical and Food Industries (xv) Unit Operations • Unit Operations involving Fluid-Particle Interactions (I) • Unit operations Involving Heat and Mass Transfer (II)	(iv) Design Methodology (v) Strength of Materials II	

4.2.6 Credit framework for the programme

The UQF defines a credit as a numerical value on a Qualifications Framework standard that represents the estimated time needed for a learner to achieve required specific learning outcomes. A credit within the UQF equates to learning outcomes achievable in 10 hours of learning time. It is a measurement unit for 'notional' or 'average learning' time which includes all the activities which the learner is expected to undertake in order to achieve the learning outcomes. Such activities for UQF level 8 conventional mode of learning include but not limited to:

lectures, seminars/tutorials, assignments, independent studies, and practical training as stipulated in Table 16 as an example.

Table 16: Credit framework for CPE programme

UQF Level	% on Lectures	% on Seminars and Tutorials	% on Assignments	% on Independent Studies and Research	% on Practical Training
8	40	20	10	20	10

UQF defines 480 as minimum cumulative credits required for a learner to graduate with Bachelor of CPE. It should be noted that, for a subject area, CPE programme designers are flexible to assign more weight to an activity that heavily contributes to the student's learning. For instance, for a student to learn programming, more weight should be assigned to the practical activity. Universities offering B.Sc. Chemical and Process Engineering programmes should assign more weight on practical and industrial field activities as compared to theoretical learning.

4.2.7 Normal learning matrix for the Bachelor's degree programme in CPE

Normal Learning Matrix and Course Matrix shall be provided for determination of the percentage (%) of time to be assigned for learning at UQF level 8. In this regard, universities should design a Chemical and Process engineering programme such that a student covers a minimum of 480 credits in four years for core and supporting subject areas. In addition, the number of electives to be taken shall also be indicated. Table 17 presents a sample matrix for year 4, semester 1 of the Bachelor's degree programme in Chemical and Process engineering.

Table 17: Sample of Normal Learning and Course Matrix for Bachelor's degree programme in Chemical and Process Engineering

Year 4, Semester 1

Course code	Course Name	Course Status (core/optional	Lecture Hrs	Tutorial or Seminar hrs	Assignment hrs	Independent study hrs	Practical hrs	Total hours	Credits
CP 428	Mass and Energy Balances Drainage	Core	-	-	-				
CP 432	Unit Operations II	Core	-	-	-				
CP 406	Process Dynamics and Control Design	Core							
CP 475	Design of Experiments	Elective							
CP 372	Fermentation Technology	Elective							
	Total credits								

4.2.8 Course description

Course descriptions provide students with basic information to evaluate and enrol in courses. Universities should provide course descriptions for students in all degree programmes to orient them in the course rationale, frames a brief overview of the key content, including knowledge and skills to be learned, and states the major learning strategies and activities that students will experience. Course descriptions should include course title, course code, prerequisite, number of credits, course aim, course requirements, course contents, expected learning outcomes, course status (Core/elective), mode of delivery, assessment method, and recommended readings. A course description should:

(a) Be student-centred rather than teacher-centred or course-centred.

(b) Use brief, outcomes-based, descriptive phrases that begin with an imperative or active verb (e.g., design, demonstrate, plan, analyse).

(c) Be clear, concise, and easy to understand.

(d) Indicate significant learning outcomes of the course.

(e) Align the outcomes with the course contents.

Table 18 shows the guidance on how to prepare a course description for Chemical and Process engineering courses. All courses or modules to be taught and learnt within the programme should follow the outline shown in Table 18.

Table 18: Guidance to course description

SN	Description
1.	**Course Title:** Refer to UQF qualification titles and nomenclatures.
2.	**Course Code:** A unique number that identify the course
3.	**Prerequisite:** A prerequisite should be a course that provides the required foundation knowledge in order to progress into this particular course
4.	**Course Aim:** Course aims are statements that describe the overarching intentions of a course. They should try to answer, "What is the purpose of the course?", "What is the course trying to achieve?"
5.	**Course Requirements:** List tools, resources, and materials needed by the student for success in the course, e.g., Access to Labs, web-based resources etc.
6.	**Course Expected Learning Outcome(s):** Course learning outcome should try to describe what students will be able to do/learn by the end of the course in terms of knowledge, skills and competency.
7.	**Course Status:** Should indicate whether the course is core or elective.
8.	**Credit rating**: Reference should be made to UQF credit framework.
9.	Total Hours Spent:
10.	Course Content:
11.	**Mode of Delivery:** The mode of delivery is an important consideration when designing learning activities that will support students to develop the skills, knowledge and understandings required achieving the intended learning outcomes, as measured by the assessment in your unit. Ideally, an instructor should select the most appropriate mode of delivery for each activity based on what will best support student development of the skills, knowledge and understandings students are expected to achieve.
12.	**Assessment Methods:** An assessment criterion on how to achieve the outcomes in (CA/UE). This section should specify the components contribution to the final marks, that is, assignments, tests, UE and laboratory work where necessary.

SN	Description
13.	**Recommended Texts & Other Readings:** Indicate up-to-date list of the required course textbooks, journals and the reference books. Include detail such as full name of textbook, author, edition, ISBN, description (if desired), and where it can be purchased. If a required text is available online, indicate where it can be accessed.

4.2.9 Expected learning outcomes and curriculum alignment matrix for the Bachelor Degree programme in CPE

The development of the curriculum alignment matrix is necessary for checking if the subject areas cover the learning outcomes. For each subject area, one must formulate the specific learning outcomes for that course and also assess how much a given course contributes to the programme learning outcomes. Table 19 gives an example of a curriculum alignment matrix for the ELOs of the B.Sc. in Chemical and Process Engineering programme. For each subject area, the contribution to the ELOs is given. The letters K, S, and C stand for Knowledge, Skills, and Competence, respectively.

Table 19: Curriculum alignment matrix for Bachelor's degree programme in Chemical and Process Engineering

SN	CPE Subject areas	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
	Core subject areas												
1	Biochemical Engineering	√	√	√	√			√			√	√	
2	Chemical Engineering Fluid Mechanics	√			√			√			√	√	
3	Chemical Reaction Engineering	√	√	√	√			√		√	√	√	
4	Computer Applications in Chemical Engineering	√		√	√		√	√				√	√
5	Elements of Environmental Engineering.	√	√	√	√			√			√	√	

SN	CPE Subject areas	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
6	Engineering Thermodynamics	√	√	√	√			√		√	√	√	
7	Fundamental of Chem. & Process Engineering	√		√				√			√	√	
8	Gas and Petroleum Processing	√	√	√	√	√		√	√		√	√	
9	Heat and Mass Transfer	√	√	√	√			√	√		√	√	
10	Materials and Energy Balances	√		√				√			√	√	
11	Plant Design and Economics /Process Engineering Design	√				√	√	√	√	√	√	√	√
12	Process Dynamics and Control	√	√	√	√			√	√		√	√	
13	Quality Control in Chemical and Food Industries												
14	Unit Operations	√	√	√	√			√	√		√	√	
	Supportive subject areas												
15	Mathematics for Engineers	√									√		
16	Computer Programming	√		√	√		√	√				√	√
17	Statistics	√	√	√		√	√		√		√	√	
18	Communication Skills						√						√
19	Basic Social Sciences and Humanities		√	√			√		√				√
20	Law and Professional Practice					√	√		√				√

SN	CPE Subject areas	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
	Elective Study areas												
21	Design of Experiments	√	√	√	√		√				√	√	√
22	Fermentation Technology and Applications	√	√	√	√			√		√		√	√
23	Plant Design and Optimization	√	√	√	√	√	√	√	√	√	√	√	√

4.2.10 Benchmarks for specialization in CPE programme

In addition to the selection listed in specialization courses, universities are free to make additional subjects. Also, students may select additional subjects to deepen their knowledge in one or more of the following specializations:

(a) Plastic Technology

(b) Food Processing

(c) Petroleum and Gas Engineering

(d) Fermentation Technology

(e) Environmental Engineering

(f) Risks Assessment and Management

(g) Engineering Management

(h) Leather and Textile Engineering

4.2.11 Minimum entry qualification for the CPE programme

(a) Two principal passes with at least a “D” grade in Physics and Mathematics or Chemistry at advanced level or Form six at which the combination of subjects will depend on the field of specialization.

(b) Diploma Certificate or equivalent qualification approved by Senate with at least a “C” grade in Mathematics and an average of “B” or GPA of 3.0 in all subjects as prescribed by most of the universities in the country. In addition, an applicant must have a minimum of a

"D" grade in two science subjects and a minimum of a "D" grade in Mathematics at O-Level.

4.2.12 Duration of the CPE programme

The duration for CPE programme shall be four (04) years (8 semesters) with a period for Practical Training (PT) in the industry at the end of each of the first three (03) years of the study.

4.2.13 Graduation requirements for the CPE programme

At the end of each academic year, a student is required to complete a minimum of 120 credits. A student is required to accumulate a minimum of 480 credits for the four (04) years of the programme which account to 4,800 notional hours of learning.

4.2.14 Evaluation and course assessment for the Bachelor's degree programme in Chemical and Process Engineering

Evaluation

The Bachelor of Chemical and Process engineering programme will normally take four (04) years to complete. It is important to review the programme within one to three years after completion of one delivery programme cycle. The review will be based on graduate survey involving alumni, employers and stakeholders, faculty and students. The survey will be based on standard developed tools/guidelines to capture the marketability of the programme and employability of the graduates, including new developments in science and technology.

Assessment

Programme assessment will be based on the achievement of learning outcomes and depends on the nature of the courses. Students' performance in the majority of theoretical courses will be measured based on continuous assessment and final examinations. The ratio between continuous assessment and final examination will depend on the weight between the two components. Continuous assessment will comprise mainly of tests, mid-semester tests, projects/assignments reports, practical training in the industry, laboratory reports and presentations and will contribute 40 percent, and university examinations will contribute 60 percent. Examination and Continuous assessment will cover all expected learning outcomes.

4.2.15 Resource requirements for the CPE programme

(a) Laboratory Resources

Universities should possess world-class, modern, engineering teaching and learning facilities designed to provide for the distinctive way Chemical and Process engineering students engage actively with their learning process through design-make-test activities. The specialist engineering research laboratories and research facilities should be modernised so as to provide the setting for student practical work and many student and staff projects.

(b) Computation Facilities

Computation is now regarded as an equal and indispensable partner, along with theory and experiment, in the advance of scientific knowledge and engineering practice. Numerical simulation enables the study of complex systems and natural phenomena that would be too expensive or dangerous, or even impossible to study by direct experimentation. The quest for ever higher levels of detail and realism in such simulations requires enormous computational capacity and has provided the impetus for dramatic breakthroughs in computer algorithms and architectures. Due to these advances, computational scientists and engineers can now solve large-scale problems that were once thought intractable. Universities should indicate the available computation facilities for the programme.

(c) Teaching and Technical Staff

Academic staff members are vital to the strength of a Chemical and Process Engineering programme. Its faculty needs both academic training and practical experience. There must be enough staff to provide course offerings that allow the students to complete a degree in a timely manner. The interests and qualifications of the academic staff members must be enough not only to teach the courses but also to plan and modify the courses and curriculum to meet the market demand. Academic staff members must remain current in the discipline. Professional development and scholarly activities are a joint obligation of the institution and the individual academic staff members. The programme is enhanced significantly when faculty acquire practical experience in the profession through activities such as training, consulting, sabbatical leave, and industry exchange programmes. The academic staff members must also be equipped to develop teaching materials for their students. The faculty must have available technology at least equivalent to and compatible with that available to students so that they may prepare educational materials for use by students.

The number of full-time staff needed by the programme is influenced by such factors as the number of students in the programme, the number of required courses, the number of service and elective courses offered, and the teaching load of the faculty. A programme should have a minimum number of full-time staff members with a primary commitment to the Chemical and Process Engineering programme in order to meet the teaching and advising needs of the programme and to provide depth and breadth of faculty expertise.

4.2.16 Industrial Training

The industrial training may be conveniently scheduled at the end of each academic year for the first three (03) years of the programme for a reasonable period of time of not less than eight (08) weeks per year. However, it is recommended that third-year students should take advantage of identifying their final year projects. Table 20 depicts the allocation of marks and responsible supervisors for industrial training in universities. It should be noted the assessment structure within a given university varies department wise and year of study. It is proposed that each institution to develop its own assessment structure that should be approved by the respective Senate.

Table 20: Allocation of marks and responsible supervisors

SN	Allocation of Marks and Responsible Supervisors			
1.	Industrial Supervisor	Internal/Academic Supervisor	Internal Examiner (Report)	Oral Exam (Option)
2.	10	20	50	20

4.2.17 Final year project

A final year project should ideally be performed during the last years of the programme. Learners have an opportunity to demonstrate that they can conceptualise, design, innovate, and justify the innovation and business case and prototype engineering solutions. Final year projects usually impart knowledge and skills that assist students to:

(i) Investigate, identify and define a problem including its constraints and broad environmental issues.

(ii) Understand customer and user needs including industrial design considerations.

(iii) Propose a solution for the identified problem.

(iv) Identify and apply a comprehensive methodology (Data collection, design analysis, model construction and testing) to solve a given problem.

(v) Discuss results and compile a report.

In order to allow more time for the final year projects, it is important that the final year project is allocated in the second semester of the final year, which shall comprise mainly the final year project and only a few lectures.

4.3 Benchmarks for Bachelor Degree Programme in Civil Engineering

4.3.1 Definition of Civil Engineering

Civil Engineering is a profession directed towards skilled application of a distinctive body of knowledge and understanding based on mathematics, science and technology, integrated with business and management, which is acquired through education and professional formation in a particular engineering discipline. The civil engineer must be able to exercise original thought, have good professional judgement and be able to take responsibility for the direction of important tasks. It is necessary, therefore, that undergraduate programmes for Civil Engineering students foster and inculcate the appropriate knowledge and skills as well as understanding abilities and qualities of mind.

4.3.2 Programme description

Civil engineering programmes offered by universities in Tanzania must follow the acceptable minimum standards as spelt out by the Commission. It is expected that civil engineering programmes will lay the right foundation for a career in civil engineering and prepare students to adequately deal with the conception, design, construction, supervision, operation and maintenance of infrastructure projects and systems in the public and private sectors; including roads, bridges, canals, dams, buildings, railways, tunnels, airports, pipelines and systems for water supply and waste treatment using both conventional and information technology tools. The field of Civil engineering is traditionally broken into sub-disciplines, for example, geotechnical, coastal, construction, earthquake, structural, environmental, transportation, municipal and water resources engineering.

4.3.3 Programme objectives

The Bachelor of Civil Engineering programmes should be designed in such a way that they address the concerns of requisite/different stakeholders. This can be achieved by focusing on the following three grouped programme objectives:

(a) Academic Ability

The Civil engineering programme objectives under this category are to equip learners with:

(i) Ability to apply mathematics, scientific principles and information technology in civil engineering applications;

(ii) Ability to apply knowledge, skills and competencies in developing effective ways to solve civil engineering problems creatively and innovatively;

(iii) Ability to design and implement civil engineering products, processes and systems applications;

(iv) Ability to adapt and adopt emerging civil engineering applications/technologies; and

(v) Ability to undertake research and to progress to postgraduate/higher levels of studies.

(b) Employability

The programme objectives under this category are to equip learners with:

(i) Up-to-date engineering skills and knowledge for the Civil engineering industry;

(ii) Ability to use skills, knowledge and competencies in solving civil engineering-related tasks;

(iii) Analytical skills to understand the impacts of civil engineering on individuals, organisations and society;

(iv) Ability to integrate theory and practice to work effectively and efficiently in organisations; and

(v) Knowledge, skills, and competencies that enable creativity, innovativeness and entrepreneurship in the discipline of civil engineering.

(c) Personal Development

The programme objectives under this category are to:

(i) Prepare learners for life-long learning and research;

(ii) Empower students to progress in their personal career; impart professional ethics to the learner, and equip the learner with skills and attitude to work in multi-cultural and global environments;

(iii) Equip the learner with knowledge, skills and competencies (including attitude) to work as a team in the civil engineering discipline; and

(iv) Enable the learner to develop skills to perform effectively in technical and non-technical environments.

4.3.4 Expected learning outcomes for the Bachelor's degree programme in Civil Engineering

Expected Learning Outcomes (ELOs) provide a mechanism for describing not just knowledge and relevant practical skills but also personal and transferable skills. They describe what we expect a student will know/learn or can do by the time of graduation. ELOs are categorised into knowledge, skills (cognitive, practical and interpersonal), and competencies. To harmonize the Bachelor programme in Civil engineering, the presented learning outcomes have been formulated to be used as benchmarks linked to the graduate attributes. A learner completing a Bachelor in Civil Engineering programme should be able to demonstrate the knowledge, skills and competencies as provided in Table 4.3.1.

Table 21: Expected learning outcomes for Bachelor Degree programme in Civil Engineering

Category	**Expected Learning Outcome**
Knowledge (K)	On successful completion of the degree programme, graduates should have:
	K1. Ability to apply knowledge of mathematics, science, Civil engineering concepts and theories including the use of information technology to solve complex engineering problems; K2. Ability to use research concepts, theories, facts and methods in investigations of Civil engineering problems including design of experiments, analysis and interpretation of data; and K3. An ability to recognize the importance of, and pursue lifelong learning (LLL) in the broader context of innovation and technological developments in Civil engineering.
Competences (C)	S5. Ability to formulate design solutions for complex civil engineering problems and design systems and components or processes using both conventional and information methods that meet specified needs; S1. Ability to apply management skills to manage projects in a multi-disciplinary environment; S2. Ability to communicate effectively with confidence, including being able to write and make convincing presentation on complex Civil engineering problems; and S3. Ability to continuously seek and apply contemporary and emerging technologies.
	C1. Ability to evaluate the sustainability and impact of professional engineering work and solve complex civil

Category	Expected Learning Outcome
	engineering problems in societal and environmental contexts; C2. Ability to apply innovation and entrepreneurship principles to create business opportunities; C3. Ability to investigate complex civil engineering problems using research-based knowledge and methods to produce conclusive results; C4. Ability to apply appropriate techniques, resources, and modern—techniques such as modelling and simulation to solve complex civil engineering problems; and C5. Ability to function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

4.3.5 Translating the expected learning outcomes into programme

The translation of the expected learning outcomes into the Civil Engineering programme involved alignment between learning outcomes and course contents. This was followed by mapping the learning outcomes into courses and grouping them into core, supportive and elective courses. The three (03) types of groups of subject areas can be distinguished as follows:

(a) **Core Courses (or Subject areas):** These are the essential courses offering a thorough foundation of the discipline and they are mandatory for every student. The core courses are the backbone of the discipline and they are typical courses.

(b) **Supporting courses (or subject areas):** These are mandatory courses for backing up the intended learning outcomes. Without these courses it will be difficult to achieve the learning outcomes of a given programme.

(c) **Elective courses (or subject areas):** These are courses that can be taken by a student, to deepen or broaden the knowledge, but they are not compulsory. However, a student has to make a choice to meet the minimum credit requirements for graduation. However, the selected elective courses must come from a list of courses approved by the University Senate

It should be noted that within the programme, the courses shall be largely assessed through coursework and examinations, although some courses may be of audited nature (i.e., courses in which a learner attends but is not examined). During programme curriculum design, universities must ensure that there is sufficient coverage of requisite, pre-requisites and co-requisite courses. A Bachelor's degree programme in a specified field of engineering can be divided into two (02) phases, i.e., the basic phase and the specialisation phase as follows:

(a) The basic phase is common for all the specific engineering field and consists of core and supportive courses.

(b) The specialisation phase allows learners to choose applicable specialisations in line with their interests in the engineering field of study.

The benchmarks development process involved analysis of regional and international practices followed by establishment of minimum/key courses to be covered in each of the selected fields' programmes. Table 22 translates some of the ELOs into minimum courses/subject areas that form part of the curriculum for a Bachelor's degree programme in Civil Engineering. The minimum courses/subject areas were evenly distributed across the main thematic areas of Civil Engineering. Table 22 therefore shows the minimum courses/subject areas for a Bachelor's degree programme in Civil engineering; categorised into core, supportive and elective courses.

Table 22: Minimum subject areas for a Bachelor degree programme in Civil Engineering

Core Subject Areas	Supportive Subject Areas	Electives
Basic Engineering (i) Engineering Drawing (ii) Computer Aided Design (CAD) (iii) Introduction to Civil Engineering (iv) Fundamentals of Electrical Engineering (v) Statics	**Mathematics for Engineers** Mathematics for Engineers including (i) Algebra, (ii) Calculus, (iii) Differential Equations, (iv) Linear Transformation	(i) Airport Planning and Design of Airports (ii) Railway and Habours Engineering (iii) Design of Bridges (iv) Transportation Economics (v) Irrigation and

Core Subject Areas	Supportive Subject Areas	Electives
(vi) Dynamics of Solids (vii) Strength of Materials (viii) Fundamentals of Building Design **Structural Engineering** (i) Structural Analysis (ii) Reinforced Concrete Design (iii) Design of Masonry and Timber Structures (iv) Design of Steel Structures **Transportation Engineering** (i) Transportation systems and Planning (ii) Highway Materials (iii) Pavement Design (iv) Traffic Engineering and Management (v) Highway Route and Geometric Design **Geotechnical Engineering** (i) Soil Mechanics (ii) Foundation Design (iii) Geology For Engineers **Water Resources Engineering** (i) Fluid Mechanics for Civil Engineers (ii) Open Channel Hydraulics (iii) Hydraulic Practicals (iv) Water Supply and Treatment (v) Design of Hydraulic structures & Machinery (vi) Wastewater Treatment (vii) Engineering hydrology	and Matrices, (v) Complex Analysis, Laplace Transforms, (vi) Fourier series, (vii) Numerical Methods, Vector Analysis) **Programming** (i) Programming for Engineers (ii) (including languages) (iii) Computer Fundamentals and ICT **Statistics** Probability and Statistics for Engineers **Writing and Communication** (i) Technical Writing for Engineers (ii) Communication Skills for Engineers **Basic Social Sciences and Humanities** (i) Development Studies (ii) Sociology (and Gender)	Drainage Engineering (vi) Management of Solid and Hazardous Waste (vii) Environmental Impact Assessment (viii) Pre-stressed Concrete Design (ix) Seismic Design

Core Subject Areas	Supportive Subject Areas	Electives
Construction Management (i) Engineering Economics and Planning Techniques (ii) Construction Techniques and Site Organisation (iii) Contract Management (iv) Geomatics Engineering (v) Engineering Surveying (vi) GIS Application in Civil Engineering **Experiential Learning** (i) Workshop Practice (ii) Industrial Training (iii) Problem Based Learning (PBL) Project **Engineering Research** (i) Research Methodology (ii) Research Project	**Law and Professional Practice** Law, Ethics, Integrity and Professional Practice	

4.3.6 Credit framework for the Bachelor degree programme in Civil Engineering

The UQF defines a credit as a numerical value on a Qualifications Framework standard that represents the estimated time needed for a learner to achieve required specific learning outcomes. A credit within the UQF equates to learning outcomes achievable in 10 hours of learning time. It is a measurement unit for 'notional' or 'average learning' time which includes all the activities which the learner is expected to undertake in order to achieve the learning outcomes. Such activities for UQF level 8 conventional mode of learning include but are not limited to lectures, seminars/tutorials, assignments, independent studies, and practical training as stipulated in Table 23 as an example.

Table 23: Credit framework for the conventional mode of learning

UQF Level	% on Lectures	% on Seminars and Tutorials	% on Assignments	% on Independent Studies and Research	% on Practical Training
8	40	20	10	20	10

UQF defines 480 as the minimum cumulative credits required for a learner to graduate with a Bachelor's in Civil engineering. It should be noted that the curriculum designers are flexible to assign more weight to an activity such as practical training and experimental works that heavily contributes to the student's learning.

4.3.7 Normal learning matrix of the Bachelor degree programme in Civil Engineering

Normal Learning Matrix and Course Matrix shall be provided for the determination of the percentage (%) of time to be assigned for learning at UQF level 8. In this regard, universities should design a civil engineering programme such that a student covers a minimum of 480 credits in four years for core and supporting subject areas. In addition, the number of electives to be taken shall also be indicated. Table 24 presents a sample matrix for year 4, semester 1 of the Bachelor's degree programme in civil engineering.

Table 24: Sample of normal learning and course matrix for Bachelor's degree programme in Civil Engineering

Year 4, Semester 1

Course code	Course Name	Course Status	Lecture	Tutorial or Seminar hrs	Assignment hrs	Independent study hrs	Practical hrs	Total hours	Credits
		(core/ optional	Hrs						
CE 421	Reinforced Concrete Design	Core	-	-	-				

Course code	Course Name	Course Status (core/ optional	Lecture Hrs	Tutorial or Seminar hrs	Assignment hrs	Independent study hrs	Practical hrs	Total hours	Credits
CE 422	Pavement Design and Drainage	Core	-	-	-				
CE 425	Airport Engineering	Elective							
	Total credits								

4.3.8 Course description

All courses or modules to be taught and learnt within the programme should follow the following outline for their course description, as shown in Table 25.

Table 25: Guidance to course description

SN	Description
1.	**Course Title:** Refer to UQF qualification titles and nomenclatures.
2.	**Course Code:** A unique number that identify the course
3.	**Pre-requisite:** A prerequisite should be a course that provides the required foundation knowledge in order to progress into this particular course
4.	**Course Aim:** Course Aims are statements that describe the overarching intentions of a course. They should try to answer, “What is the purpose of the course?”, “What is the course trying to achieve?”
5.	**Course Requirements:** List tools, resources, and materials needed by the student for success in the course e.g. Access to Labs, web-based resources etc.
6.	**Course Expected Learning Outcome(s):** Course Learning outcome should try to describe what students will be able to do/learn by the end of the course in terms of knowledge, skills and competency.
7.	**Course Status:** Should indicate whether the course is core or elective.
8.	**Credit rating**: Indicate total credit for the course depending on the total number spent for lectures, tutorials, assignments, practicals and independent study.

SN	Description
9.	**Total Hours Spent**: Total number of hours required for the course
10.	**Course Content**: should indicate details of what is to be taught in the course.
11.	**Mode of Delivery:** The mode of delivery is an important consideration when designing learning activities that will support students to develop the skills, knowledge and understandings required achieving the intended learning outcomes, as measured by the assessment in your unit. Ideally, the instructor shall select the most appropriate mode of delivery for each activity based on what will best support student development of the skills, knowledge and understandings students are expected to achieve.
12.	**Assessment Methods:** An assessment criterion on how to achieve the outcomes in (CA/UE**)**
13.	**Recommended Texts & Other Readings:** Indicate up-to-date list of the required course textbooks, journals and the reference books. Include detail such as full name of textbook, author, edition, ISBN, description (if desired), and where it can be purchased. If a required text is available online, indicate where it can be accessed.

4.3.9 Expected learning outcomes and curriculum alignment matrix for Bachelor degree programme in Civil Engineering

Development of the curriculum alignment matrix is necessary for checking if the subject areas cover the learning outcomes. For each subject area, one must formulate the specific learning outcomes for that course and needs to check how much a given course contributes to the programme learning outcomes. Table 26 gives an example of a curriculum alignment matrix for the expected learning outcomes of B.Sc. in Civil engineering. For each subject area, the contribution to the expected learning outcomes is given. The letters K, S, and C stand for Knowledge, Skills, and Competence, respectively.

Table 26: Curriculum alignment matrix for Bachelor degree programme in Civil Engineering

SN	Civil Engineering Subject areas	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
	Core Subject Areas												

SN	Civil Engineering Subject areas	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
1.	Basic Engineering	√		√									
2.	Structural Engineering	√	√	√	√			√	√		√	√	√
3.	Transportation Engineering	√	√	√	√			√	√		√	√	√
4	Geotechnical Engineering	√	√	√	√			√	√		√	√	√
5.	Water Resources Engineering	√	√	√	√	√		√	√		√	√	√
6.	Construction Management	√	√		√	√			√	√		√	√
7.	Geomatics Engineering	√	√	√	√			√	√		√	√	√
8.	Experiential Learning	√	√	√			√	√	√		√	√	
9.	Engineering Research	√	√	√	√		√		√	√	√	√	√
	Supportive Subject Areas												
10.	Mathematics for Engineers	√									√		
11.	Programming	√		√	√		√	√				√	√
12.	Statistics	√	√	√		√	√		√		√	√	
13	Communication Skills						√						√
14.	Basic Social Sciences and Humanities		√	√			√		√				√
15.	Law and Professional Practice					√	√		√				√
	Electives												
16.	Irrigation and Drainage Engineering	√	√	√	√			√	√		√	√	√
17.	Airport, Railway	√	√	√	√			√	√		√	√	√

SN	Civil Engineering Subject areas	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
	and Habours Engineering												
18.	Transportation Economics	√	√		√	√			√	√		√	√
19.	Management of Solid and Hazardous Waste	√	√		√	√			√	√		√	√
20.	Environmental Impact Assessment			√		√	√		√				√
21	Design of Bridges	√	√	√	√			√	√		√	√	√
22	Pre-stressed Concrete Design	√	√	√	√			√	√		√	√	√

4.3.10 Benchmark for specialization

In addition to the selection listed in specialization courses, universities are free to make additional subjects. Also, students may choose to deepen their knowledge in one or more of the following specializations:

(a) Intelligent transportation systems (ITS)

(b) Building information modelling

(c) Drowns for monitoring

(d) Augmented reality in reality

4.3.11 Minimum entry qualification for the Bachelor's degree programme in Civil Engineering

Minimum entrance requirements for the Bachelor's degree in Civil Engineering shall be as follows:

(a) Two principal passes with at least a "D" grade in Physics and Mathematics or Chemistry at advanced level or Form six, at which the combination of subjects will depend on the field of specialization.

(b) Equivalent Diploma Certificate approved by the Senate: At least a "C" grade in Mathematics and an average of "B" or GPA of 3.0 in all subjects as prescribed by most of the universities in the country. In addition, an applicant must have a minimum of a "D" grade in two science subjects and a minimum of a "D" grade in Mathematics at O-Level.

4.3.12 Duration of the Bachelor's Degree Programme in Civil Engineering

The duration of the Bachelor's degree programme in Civil Engineering will normally be four (04) years (8 semesters), with a period for practical training at the end of each of the first three (03) years.

4.3.13 Graduation requirements for the Bachelor's degree programme in Civil Engineering

At the end of each academic year, a student is required to complete a minimum of 120 credits. A student is required to accumulate a minimum of 480 credits for the four (04) years of the programme which account to 4,800 notional hours of learning.

4.3.14 Evaluation and course assessment for the Bachelor degree programme in Civil Engineering

Evaluation

The Bachelor of Civil Engineering programme will normally take four (04) years to complete. It is important to review the programme one to three years after completion of one delivery programme cycle. The review will be based on a graduate survey involving alumni, employers and stakeholders, faculty and students. The survey will be based on standard developed tools/guidelines to capture the marketability of the programme and employability of the graduates, including new developments in science and technology.

Assessment

Programme assessment will be based on the achievement of learning outcomes. Assessments are based on the nature of courses. Students' performance in the majority of theoretical courses will be measured based on continuous assessment and final examinations. The ratio between continuous assessment and final examination will depend on the weight between the two components. Continuous assessment will comprise mainly of tests, mid-semester tests, projects/assignments reports, practical training in industry, laboratory reports and presentations and will contribute 40 percent and university examinations will contribute 60 percent. Examination and Continuous assessment must cover all expected learning outcomes.

4.3.15 Resource requirements for the Bachelor's degree programme in Civil Engineering

(a) Teaching and learning infrastructure and facilities

Generally, universities should possess major teaching and learning infrastructure and facilities. These include major teaching theatres, the main library, student hostels, student cafeterias, etc. This makes it possible to share the university facilities, including lecture theatres, seminar rooms, library, conference facilities, teaching equipment and offices. However, facilities here should include only those directly related to the programme and not institutional-wide facilities.

A standard and modern classroom needs to have an easy-to-use integrated teaching console with common audio-visual equipment, LCD projector, standard networked computers, laptop connection and control facilities installed. Most of the control of the teaching equipment can be performed through the control panel on the teaching console. Teaching staff can conduct multimedia presentations through these consoles without the hassles of setting up equipment on the spot.

(b) Laboratory Resources

The university should possess world-class, modern, engineering teaching and learning facilities designed to provide for the distinctive way civil engineering students engage actively with their learning process through design-make-test activities. The specialist engineering research laboratories and research facilities should be modernised so as to provide the setting for student practical work and many student and staff projects.

(c) Computation Facilities

Computation is now regarded as an equal and indispensable partner, along with theory and experiment, in the advance of scientific knowledge and engineering practice. Numerical simulation enables the study of complex systems and natural phenomena that would be too expensive or dangerous, or even impossible, to study by direct experimentation. The quest for ever higher levels of detail and realism in such simulations requires enormous computational capacity and has provided the impetus for dramatic breakthroughs in computer algorithms and architectures. Due to these advances, computational scientists and engineers can now solve large-scale problems that were once thought intractable. Universities should indicate the available computation facilities for the programme.

(d) Teaching and Technical Staff

Effective teaching and learning need to have comprehensive, adequate and competent human resources. Further, there should also be human resource targets set in line with higher learning departments' requirements, accompanied by comprehensive succession plans to address staff attrition (retirements, demise, exodus, etc.).

There must be enough staff to provide course offerings that allow the students to complete a degree in a timely manner. The interests and qualifications of the staff members must be enough not only to teach the courses but also to plan and modify the courses and curriculum to meet the market demand. Faculty members must remain current in the discipline. Professional development and scholarly activities are a joint obligation of the institution and the individual faculty members. The programme can be enhanced significantly when faculty acquire practical experience in the profession through activities such as training, consulting, sabbatical leave, and industry exchange programmes. Staff must also be equipped to develop teaching materials for their students. They must have available technology at least equivalent to and compatible with that available to students so that they may prepare educational materials for use by students.

4.3.16 Industrial training

The industrial training may be conveniently scheduled at the end of each academic year for the first three (03) years of the programme for a reasonable period of time of not less than eight (08) weeks per year. However, it is recommended that third-year students should take advantage of identifying their final year projects. Table 27 depicts the allocation of marks and responsible supervisors for industrial training in universities. It should be noted the assessment structure within a given university varies department wise and year of study. It is proposed that each institution to develop its own assessment structure that should be approved by the respective Senate.

Table 27: Allocation of marks and responsible supervisors

SN	Allocation of Marks and Responsible Supervisors			
1.	Industrial Supervisor	Internal/Academic Supervisor	Internal Examiner (Report)	Oral Exam (Option)
2.	10	20	50	20

4.3.17 Final year project

A final year project should ideally be performed during the last years of the programme. Learners have an opportunity to demonstrate that they can conceptualise, design, innovate, and justify the innovation and business case and prototype engineering solutions. Final year projects usually impart knowledge and skills that assist students to:

(i) Investigate, identify and define a problem, including its constraints and broad environmental issues.

(ii) Understand customer and user needs, including industrial design considerations.

(iii) Propose a solution for the identified problem.

(iv) Identify and apply a comprehensive methodology (Data collection, design analysis, model construction and testing) to solve a problem.

(ii) Discuss results and compile a report.

In order to allow more time for the final year projects, it is important that the final year project is allocated in the second semester of the final year, which shall comprise mainly the final year project and only a few lectures.

4.4 Benchmarks for Bachelor Degree Programme in Electrical Engineering

4.4.1 Definition of Electrical Engineering

Electrical Engineering is concerned with the study, design, development, and application of electrical and electronic systems and their components, ensuring that they operate effectively, efficiently, and safely. This encompasses a wide range of technologies, including power generation and distribution; communications systems; electronic devices and systems.

4.4.2 Programme description

The goal of an electrical engineering programme is to produce an engineering graduate who can apply scientific, mathematical, economic and social knowledge in the conception, design, construction, manufacture, operation, maintenance, disposal and recycling of electrical products, processes and systems in an efficient and economic manner. The Electrical Engineering programme includes a number of core courses such as electrical power systems, electrical machines and drives, power electronics, power plants, and digital control. The programme needs to be supported by a strong foundation of mathematics and basic sciences which provide tools necessary to analyse the concepts and principles of the electrical engineering courses. Also, the programme needs to be supported by laboratories, field trips, projects and industrial practical training.

4.4.3 Programme objectives

The objective of the electrical engineering degree programme is to prepare graduates for professional and supervisory positions in the field of electrical engineering. Electrical engineering programmes must, therefore, include opportunities to develop skills and knowledge that support high-tech electrical engineering environments, both at national and international levels. In the designing of the electrical engineering programme, it is important that graduates from the programme meet the following specific objectives:

(a) Academic Ability

Every Electrical Engineering programme should aim to equip learners with academic knowledge/skills/ability to:

(i) Ability to model, design, construct, operate, evaluate and maintain electrical engineering systems, including using information technology to solve engineering problems;

(ii) Ability to analyse a problem and then identify and define the engineering requirements appropriate to the problem solution; and

(iii) Evaluate the extent to which the engineered solution meets the criteria defined for its current use and scale up to future development.

(b) Employability

The programme objectives under this category are to equip learners with knowledge and skills that match the industrial needs as follows:

(i) Ability to integrate theory and practice to work effectively and efficiently in organizations;

(ii) Ability to acquire knowledge and skills that enable creativity, innovativeness and entrepreneurship in the field of electrical engineering;

(iii) Ability to assess risk-related and analyse the impact of local and global trends of Electrical Engineered solutions on individuals, organizations and society; and

(iv) Ability to demonstrate critical thinking, creativity and innovativeness in developing electrical engineered solutions to real world problems in societies and industries.

(c) Personal Development

The programme objectives under this category are to:

(i) Empower learners to progress in their personal career, impart professional ethics to the learner, equip the learner with skills and attitude to work in multi-cultural and global environments;

(ii) Enable the learner to develop skills and competencies to perform effectively in technical and non-technical environments, as a team member and at the individual level; and

(iii) Communicate effectively with experts and non-experts.

4.4.4 Expected learning outcomes

Expected Learning Outcomes (ELOs) provide a mechanism for describing not just knowledge and relevant practical skills but also personal and transferable skills. They describe what we expect a student will know/learn or can do by the time of graduation. To harmonize the Bachelor programme in Electrical engineering, ELOs have been formulated to be used as benchmarks. ELOs are categorised into knowledge, skills (cognitive, practical and interpersonal), and competencies. The ELOs, as stipulated in Table 28, are the threshold: all graduates of the Bachelor's programme in Electrical Engineering must achieve them. Universities may consider adding learning outcomes as and when necessary, in line with their mission and vision or other identified need(s).

Table 28: Expected learning outcomes for Bachelor degree in Electrical Engineering

Category	Expected Learning Outcome
Knowledge (K)	On successful completion of the degree programme, graduates should have:
	K1. Ability to apply knowledge of mathematics, science, Electrical engineering concepts and theories including the use information technology tools to solve complex engineering problems.
	K2. Ability to use research concepts, theories, facts and methods in investigations of Electrical engineering problems including design of experiments, analysis and interpretation of data.
	K3. Ability to recognize the importance of, and pursue lifelong learning (LLL) in the broader context of innovation and technological developments in Electrical engineering.
Competences (C)	S1. Ability to formulate design solutions for complex electrical engineering problems and design systems, components or processes using both conventional and information technology methods to meet specified needs.
	S2. Ability to apply management skills to manage projects in a multi-disciplinary environment.
	S3. Ability to communicate effectively with confidence, including able to write and make convincing presentation on complex Electrical engineering problems.

Category	Expected Learning Outcome
	S4. Ability to continuously seek and apply contemporary and emerging technologies.
	C1. Ability to evaluate the sustainability and impact of professional engineering work and solve complex Electrical engineering problems in societal and environmental contexts. C2. Ability to apply innovation and entrepreneurship principles to create business opportunities. C3. Ability to investigate complex Electrical engineering problems using research-based knowledge and methods to produce conclusive results. C4. Ability to apply appropriate techniques, resources, and modern–techniques such as modelling and simulation to solve complex Electrical engineering activities. C5. Ability to function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

4.4.5 Translating learning outcomes into Electrical Engineering Programme

The translation of the ELOs into the Electrical engineering programme involved alignment between learning outcomes and course contents. This was followed by mapping the learning outcomes into courses and grouping them into core, supportive and elective courses. The three (03) types of groups of subject areas can be distinguished as follows:

(a) **Core Courses (or Subject areas):** These are the essential courses offering a thorough foundation of the discipline, and they are mandatory for every student. The core courses are the backbone of the discipline, and they are typical courses.

(b) **Supporting courses (or subject areas):** These are mandatory courses for backing up the intended learning outcomes. Without these courses, it will be difficult to achieve the learning outcomes of a given programme.

(c) **Elective courses (or subject areas):** These are courses that can be taken by a student, to deepen or broaden the knowledge, but they are not compulsory. However, a student has to make a choice to meet the minimum credit requirements for graduation.

However, those selected courses must come from a list of courses approved by the University Senate

It should be noted that within the programme, the courses shall be largely assessed through coursework and examinations, although some courses may be of audited nature (i.e. courses in which a learner attends but is not examined). During programme curriculum design, it must be ensured that there is sufficient coverage of requisite, pre-requisites and co-requisite courses. A Bachelor's degree programme in a specified field of engineering can be divided into two phases, i.e., the basic phase and the specialisation phase, as follows:

(a) The basic phase is common for the entire specific engineering field and consists of core and supportive courses.

(b) The specialisation phase allows learners to choose applicable specialisations in line with their interests in the engineering field of study.

The benchmarks development process involved analysis of regional and international practices followed by the establishment of minimum/key courses to be covered in each of the selected fields' programmes. Table 29 translates some of the ELOs into minimum courses/subject areas that form part of the curriculum for a Bachelor's degree programme in Electrical engineering. The minimum courses/subject areas were evenly distributed across the main thematic areas of Electrical Engineering. Table 29, therefore, shows the minimum courses/subject areas for a Bachelor's degree programme in Electrical Engineering, categorised into core, supportive and elective courses.

(a) The core subject areas refer to the knowledge and skills that every student in all EE degree Programmes should attain;

(b) The titles of the courses may differ from one University to another;

(c) The emphasis should be on the contents rather than the title. The autonomy and the uniqueness of universities will be taken into consideration in formulating the core courses for the basic phase. Universities will have the choice to add their own courses beyond the core and supporting courses; and

(d) The knowledge areas are not courses, and the core components do not constitute a complete curriculum. Each EE programme may choose to cover the core knowledge units in a variety of ways.

The goal of designing this EE programme benchmarks is to keep the required component of the body of skills and knowledge as small as possible. This is to allow programmes in EE to be as flexible as possible since programme goals or objectives vary widely from programme to programme. Each subject area, as shown in Table 29, may be made up of one or more courses.

Table 29: Benchmarks core subject areas, supporting subject areas and electives

Core Knowledge Area	
Electronics Foundation (i) Analogue Electronics (ii) Digital Electronics (iii) Analogue Electronics Practical (iv) Digital Electronics Practical	**Electrical Foundation** (i) Fundamentals of Electrical Engineering (ii) Electrical Network Analysis and Design (iii) Electrical Materials (iv) Electrical Power Systems (v) Electrical Machines and drives (vi) Power Electronics (vii) Power Plants
Electronics Measurements (i) Electrical and Electronics Measurements and Instrumentation (ii) Intelligent Instrumentation (iii) Very Large-Scale Integrated Circuits	**Communication Foundation** (i) Introduction to Telecommunication (ii) Microwave electronics (iii) Engineering Electromagnetics
Embedded Systems (i) Solid State Electronics (ii) Optoelectronics (iii) Microcontrollers (iv) Microprocessors (v) Introduction to Robotics (vi) Electromechanical systems (vii) Hardware Interfacing Techniques	**Preparation for Professional Practice** (i) Entrepreneurship for Engineers (ii) Innovation Management (iii) Research skills (iv) Practical Training

Core Knowledge Area	
Computer Engineering Foundation Computer Hardware and System Maintenance	**Control Systems** (i) Control Theory Control Systems Engineering
Computer Communication and Networks (i) Introduction to Computer Networks (ii) Computer Network Design and Administration	**Hardware Design and Implementation** (i) Engineering Drawing (ii) Computer Aided Drafting and Design (iii) Industrial Electrical and Electronics Design
Project Engineering (i) Final Year Project (ii) Workshop Training (iii) General Engineering Procedures and Ethics (iv) Engineering Project Management	**Programming** (i) Object Oriented Programming e.g. Java, Python, C++ (ii) Procedural Programming e.g. C, etc
Supporting Subject Area	
Mathematics (i) Calculus (ii) Statistics and Probability (iii) Linear Algebra (iv) Discrete Mathematics	**Signal Processing** (i) Fundamentals of Signals and Systems (ii) Signal Image Processing (iii) Digital Image Processing **General Studies** (i) Communication Skills for Engineers (ii) Perspectives in Development
Electives	
(i) Renewable Energy Technology (ii) Artificial intelligence applications to power systems	Energy Management

4.4.6 Credit framework for the programme

A credit is a numerical value on a Qualifications Framework standard that represents the estimated time needed for a learner to achieve required specific learning outcomes. A credit within the UQF equates to learning outcomes achievable in 10 hours of learning time. It is a measurement unit for 'notional' or 'average learning' time which includes all the activities which the learner is expected to undertake in order to achieve the learning outcomes. Such activities for UQF level 8 conventional mode of learning include but are not limited to lectures, seminars/tutorials, assignments, independent studies, and practical training, as stipulated in Table 30 as an example.

Table 30: Credit Framework for the Electrical Engineering programme

UQF Level	% Lectures	% Seminars and Tutorials		% Assignment	% Independent Studies	% Practicals
8	40	20		10	10	20

UQF defines 480 as the minimum cumulative credits required for a learner to graduate with a Bachelor of EE. It should be noted that curriculum designers are flexible in assigning more weight to an activity that heavily contributes to the student's learning.

4.4.7 Normal learning matrix for Bachelor degree programme in Electrical Engineering

Normal learning matrix and course matrix shall be provided for the determination of the percentage (%) of time to be assigned for learning at UQF level 8. In this regard, universities should design electrical engineering programmes such that a student covers a minimum of 480 credits in four (04) years for core and supporting subject areas. In addition, the number of electives to be taken shall also be indicated. Table 31 presents a sample matrix for year 4, semester 1 of the Bachelor's degree programme in electrical engineering.

Table 31: Sample of normal learning and course matrix for Bachelor's degree programme in Electrical Engineering

Year 4, Semester 1

Course code	Course Name	Course Status	Lecture	Tutorial/ Seminar hrs	Assignment hrs	Independent study hrs	Practical hrs	Total hours	Credits
		(core/optional	Hrs						
EE 4101	Power Electronics	Core	-	-	-				
EE 4102	Modelling and Simulation	Elective	-	-	-				
EE 4106	Project Work Phase I	Core							
	Total credits								

While an EE programme learning matrix may differ from one university to another in terms of number of courses offered and the weight of learning activities, more credit weight must be directed towards knowledge units and courses that distinguish EE graduates from graduates of other fields such as industrial and mechanical engineering.

4.4.8 Course description for Bachelor of Electrical Engineering

All courses or modules to be taught and learnt within the programme should follow the outline for its course description, as shown in Table 32. Universities may use numbering for listing purposes.

Table 32: Course description

SN	Description
1.	**Course Title:** Refer to UQF qualification titles and nomenclatures.
2.	**Course Code:** A unique number that identify the course.
3.	**Prerequisite:** A prerequisite should be a course that provides the required foundation knowledge in order to progress into this particular course.
4.	**Course Aim:** Course Aims are statements that describe the overarching intentions of a course. They should try to answer, "What is the purpose of the course?", "What is the course trying to achieve?"
5.	**Course Requirements:** List tools, resources, and materials needed by the student for success in the course e.g. Access to Labs, web-based resources etc.
6.	**Course Expected Learning Outcome(s):** Course Learning outcome should try to describe what students will be able to do/learn by the end of the course in terms of knowledge, skills and competency.
7.	**Course Status:** Should indicate whether the course is core or elective.
8.	**Credit rating**: Reference should be made to UQF credit framework.
9.	Total Hours Spent:
10.	Course Content:
11.	**Mode of Delivery:** The mode of delivery is an important consideration when designing learning activities that will support students to develop the skills, knowledge and understandings required achieving the intended learning outcomes, as measured by the assessment in your unit. Ideally, the instructor shall select the most appropriate mode of delivery for each activity based on what will best support student development of the skills, knowledge and understandings students are expected to achieve.
12.	**Assessment Methods:** An assessment criterion on how to achieve the outcomes in (CA/UE).
13.	**Recommended Texts & Other Readings:** Indicate up-to-date list of the required course textbooks, journals and the reference books. Include detail such as full name of textbook, author, edition, ISBN, description (if desired), and where it can be purchased. If a required text is available online, indicate where it can be accessed.

4.4.9 Expected learning outcomes and curriculum alignment matrix for the Bachelor degree programme in Electrical Engineering

Development of the curriculum alignment matrix is necessary for checking if the subject areas cover the learning outcomes. For each subject area, one must formulate the specific learning outcomes for that course and needs to assess how much a given course contributes to the programme learning outcomes. Table 4.4.6 gives an example of a curriculum alignment matrix for the expected learning outcomes of the BSc in Electrical Engineering. For each subject area, the contribution to the expected learning outcomes is given. As reflected in ELOs' Table 4.4.6**.** K, S, and C stand for Knowledge, Skills, and Competence, respectively.

Table 33: Curriculum alignment matrix for Bachelor's degree programme in Electrical Engineering

SN	Electrical Engineering Subject area	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
	Core Subject Areas												
1.	Electrical Foundation	√		√				√		√			
2.	Electronics Foundation	√		√				√		√			
3.	Electronics Measurements	√	√	√	√			√	√	√	√	√	√
4.	Communication Foundation	√		√				√		√			
5.	Embedded Systems	√	√	√	√			√	√	√	√	√	√
6.	Preparation for Professional Practice	√	√	√		√	√	√	√	√	√	√	√
7.	Computer Engineering Foundation	√		√				√		√			
8.	Control Systems	√	√	√	√			√	√	√	√	√	√
9.	Computer	√		√	√			√	√	√	√	√	√

SN	**Electrical Engineering Subject area**	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
	Communication and Networks												
10.	Hardware Design and Implementation	√	√	√	√		√	√	√	√	√	√	√
11.	Project Engineering		√	√	√	√	√	√	√	√	√	√	√
12.	Programming	√		√	√		√	√		√		√	
	Supportive Subject Ares												
13.	Mathematics	√									√		
14.	Signal Processing	√	√	√	√		√	√		√	√	√	√
15.	General Studies		√	√			√		√				√
	Electives												
17.	Renewable Energy Technology	√	√	√	√			√	√	√	√	√	√
18.	Industrial Energy Management		√	√	√	√	√	√	√		√	√	√
19.	Power Plants	√	√	√	√	√		√	√	√	√	√	√

4.4.10 Benchmark for specialization

In addition to the selection listed in specialization courses, universities are free to make additional subjects. Also, students may choose to deepen their knowledge in one or more of the following specializations:

(a) Wearable Devices

(b) Smart Grid

(c) Graphine Supercapacitors

(d) IoMT (Internet of Medical Things)

(e) Innovations in Batteries

(f) Nanotechnology

(g) Micro-electronics engineering

4.4.11 Entry qualifications for Bachelor in Electrical Engineering

The minimum entrance requirement for the B.Sc. Electrical Engineering programme shall be as follows:

(a) Two principal passes with at least a "D" grade in Physics and Mathematics or Chemistry at advanced level or Form six at which the combination of subjects will depend on the field of specialization.

(b) Diploma Certificate or equivalent qualification approved by the Senate with at least a "C" grade in Mathematics and an average of "B" or GPA of 3.0 in all subjects as prescribed by most of the universities in the country. In addition, an applicant must have a minimum of a "D" grade in two science subjects and a minimum of a "D" grade in Mathematics at O-Level.

4.4.12 Programme duration for Bachelor in Electrical Engineering

An EE programme typically reflects Electrical Engineering, Telecommunication and Computer Science knowledge areas in varying weight coverage depending on the vision of the EE department. Due to the intensity of knowledge area coverage, it is recommended four (04) years of EE programme duration.

4.4.13 Graduation requirements for Bachelor in Electrical Engineering

An EE learner is required to accumulate a minimum of 480 credits, which account to 4,800 notional hours of learning to graduate. Universities should ensure learners undertake Industrial Practical Training within each academic year except the final year in which they intend to graduate.

4.4.14 Evaluation and assessment for Bachelor in Electrical Engineering

Evaluation

The Bachelor of Electrical Engineering programme will normally take four (04) years to complete. It is important to review the programme within one to three years after completion of one delivery programme cycle. The review will be based on graduate survey involving alumni, employers and stakeholders, faculty and students. The survey will be based on standard developed tools/guidelines to capture the marketability of the programme and employability of the graduates, including new developments in science and technology.

Assessment

Programme assessment will be based on the achievement of learning outcomes. Assessments are based on the nature of courses. Students' performance in the majority of theoretical courses will be measured based on continuous assessment and final examinations. The ratio between continuous assessment and final examination will depend on the weight between the two components. Continuous assessment will comprise mainly of tests, mid-semester tests, projects/assignments reports, practical training in industry, laboratory reports and presentations and will contribute 40 percent and university examinations will contribute 60 percent. Examination and continuous assessment will cover all expected learning outcomes.

4.4.15 Resources requirements for Bachelor’s degree programme in Electrical Engineering

(a) Laboratory Experience

Laboratory experiences are an essential part of the EE curriculum and they serve multiple functions. It is important that EE students have many opportunities to observe, explore, and manipulate characteristics and behaviours of actual devices, systems, and processes. This includes designing, implementing, testing, and documenting electronic devices and software.

EE Laboratory Equipment: Many courses in EE should contain laboratory experiences. Typically, a laboratory experience lasts one to two hours and it occurs in a location configured with specialized equipment. The depth and breadth of these experiences will vary among institutions. The variation often depends on the time allocated within the curriculum, physical space, and resources. The benchmarks recommendation on the list of equipment for an EE Laboratory includes Spectrum analyzers, Oscilloscopes, Signal generators, Power Meters, Power supplies, Training boards (for digital electronics), High Voltage simulator, motors, transformers and Direct Current (DC) and Alternating Current (AC) machines.

(b) Software Considerations

Software tools and packages related to EE will vary based on the philosophy and needs of each programme. Examples of some simulation software and software that could appear on all machines within specific laboratory settings include:

Design Modelling & Simulation: Circuit-level (e.g., SPICE), Gate-level (schematic entry), Digital systems (e.g., VHDL, Verilog), Analog/mixed-signal circuits (e.g., VHDL-AMS, Verilog-AMS) System-level design (e.g., System Verilog, System C)

Software Development: Integrated Circuits/ASIC Design, Systems Engineering Tools, Digital Hardware Prototyping. Others include: Microcontroller system Design; Mathematics Packages; Lab Automation and Instrumentation; Computer Aided Design and Modelling (CAD tools), Printed Circuit Board (PCB) Design. It is not envisioned that any programme will incorporate every one of these software applications. Each programme should determine its own needs and consider including the most current version of appropriate applications.

(c) ICT Infrastructure Requirements

ICT infrastructure consists of hardware, software, and technical support. Adequate computing facilities are essential for effective delivery of the EE programme though the form in which this infrastructure is allocated has changed significantly. These formerly involved a blend of computer facilities of varying capabilities and complexity. Most incoming undergraduates enter college with computer resources, so access plays a much more significant role. Therefore, network access should be available for faculty and students to use with their own computers. Classrooms should have access to the internet and extranet networks, either with port per seat or wireless networking capabilities.

In addition to software and hardware, it is paramount that these tools have adequate technical support. Modern ICT infrastructure is highly complex, requiring technically trained support staff to maintain the equipment. This is beyond the scope of academic staff duties, a waste of precious faculty resources, and often outside the academic staff's expertise. Support staff who maintain hardware, software and communications resources rarely have overlapping skills: an interest in teaching due to the focus on product design and provider relationships. These technical experts are a vital necessity in a campus environment.

(d) Library

Library support is an important part of an academic programme. It is especially important for disciplines with rapid development of knowledge such as EE. Libraries should provide both traditional and digital access wherever possible to journals, proceedings, monographs, and reference books. The holdings should include access to digital journals and proceedings of the electrical engineering professional societies.

(e) Human Resource Requirements

Academic staff members are vital to the strength of the EE programme. Its staff needs both academic training and practical experience. There must be enough staff to provide course offerings that allow the students to complete a degree in a timely manner. The interests and qualifications of the academic staff members must be enough not only to teach the courses but also to plan and modify the courses and curriculum to meet the market demand. Academic staff members must remain current in the discipline. Professional development and scholarly activities are a joint obligation of the institution and the individual faculty members. The programme is enhanced significantly when academic staff acquire practical experience in the profession through activities such as training, consulting, sabbatical leave, and industry exchange programmes. The faculty must also be equipped to develop teaching materials for their students. Academic staff must have available technology at least equivalent to and compatible with that available to students so that they may prepare educational materials for use by students.

The number of full-time staff needed by the programme is influenced by such factors as the number of students in the programme, the number of required courses, the number of service and elective courses offered, and the teaching load of the faculty. A programme should have a minimum number of full-time staff members with a primary commitment to the EE programme in order to meet the teaching and advising needs of the programme and to provide depth and breadth of faculty expertise.

4.4.16 Industrial training

The industrial training may be conveniently scheduled at the end of each academic year for the first three (03) years of the programme for a reasonable period of time of not less than eight (08) weeks per year. However, it is recommended that third-year students should take advantage of identifying their final year projects. Table 34 depicts the allocation of marks and responsible supervisors for industrial training in universities. It should be noted the assessment structure within a given university varies department wise and year of study. It is proposed that each university to develop its own assessment structure that should be approved by the respective Senate.

Table 34: Allocation of marks and responsible supervisors

SN	Allocation of Marks and Responsible Supervisors			
1.	Industrial Supervisor	Internal/Academic Supervisor	Internal Examiner (Report)	Oral Exam (Option)
2.	10	20	50	20

4.4.17 Final year project

A final year project should ideally be performed during the last years of the programme. Learners have an opportunity to demonstrate that they can conceptualise, design, innovate, and justify the innovation and business case and prototype engineering solutions. Final year projects usually impart knowledge and skills that assist students to:

(i) Investigate, identify and define a problem, including its constraints and broad environmental issues.

(ii) Understand customer and user needs, including industrial design considerations.

(iii) Propose a solution for the identified problem.

(iv) Identify and apply a comprehensive methodology (Data collection, design analysis, model construction and testing) to solve a given problem.

(v) Discuss results and compile a report.

In order to allow more time for the final year projects, it is important that the final year project is allocated in the second semester of the final year which shall comprise mainly the final year project and only a few lectures.

4.5 Benchmarks for Bachelor Degree Programme in Mechanical Engineering

4.5.1 Definition of Mechanical Engineering

The mechanical engineering field is built on the principles of mathematics, physics and materials science for analysis, production, and usage of heat, electrical and mechanical power for the design, manufacture, and maintenance of various mechanical systems and processes. It is also a discipline that facilitates the functionality of all other engineering disciplines, either directly or indirectly. Hence, a mechanical engineer is expected to make use of these core principles along with other tools such as simulation and modelling, computer-aided engineering, and lifecycle engineering to develop, modify, and analyse various mechanical systems such as manufacturing systems, heating and cooling systems, transport and handling systems, watercraft and medical devices.

4.5.2 Mechanical Engineering programme description

The mechanical engineering degree programme should be designed to enable learning of materials technology (science and engineering), machine design, manufacturing, solid and fluid mechanics, thermodynamics, heat transfer, digital control (Automation) and instrumentation. It also involves understanding mechanical systems, including traditional manufacturing processes (metal cutting processes, welding, forging and casting) and modern manufacturing processes and systems such as Computer Aided manufacturing (CAM), Computer Aided Design (CAD), flexible manufacturing and Robotics. In general, the mechanical engineering programme should be designed to enable learning of materials, machine design and manufacturing.

4.5.3 Mechanical Engineering programme objectives

The Mechanical Engineering Bachelor degree programme should be designed in such a way that it addresses the concerns of requisite/different stakeholders, including Government, academia, industry, parents, and students. This could be achieved by focusing on the following groups of programme objectives:

(a) Academic Ability

The programme objectives under this category are to equip learners with:

(i) Ability to apply science, engineering and mathematical principles, including the use of information technology in solving complex mechanical engineering problems;

(ii) Ability to develop effective ways to properly identify, analyse and solve mechanical engineering problems creatively and innovatively;

(iii) Ability to design and implement application of engineering products, processes and systems;

(iv) Ability to adapt and adopt emerging/evolving technologies;

(v) Ability to undertake research and to progress to postgraduate/higher levels of studies and;

(vi) Ability to communicate effectively in oral and written form.

(b) Employability

The programme objectives under this category are to equip learners with:

(i) Up-to-date mechanical engineering skills and knowledge of the industry;

(ii) Ability to identify and solve mechanical engineering-related problems using both conventional and information technology tools;

(iii) Analytical and innovative skills and knowledge to analyse the impacts of mechanical engineering on individuals, organisations and society;

(iv) Ability to integrate theory and practice to work effectively and efficiently in organisations;

(v) Knowledge, skills and competencies that enable creativity, innovativeness and entrepreneurship in the field of engineering, and

(vi) Ability to meet the requirements of the labour market and have a competitive advantage.

(c) Personal Development

The programme objectives under this category are to:

(i) Prepare learners for life-long learning and research;

(ii) Empower students to progress in their personal career; impart professional ethics to the learner, and equip the learner with skills and attitude to work in multi-cultural and global environments;

(iii) Equip the learner with knowledge, skills and competencies to work as a team in the mechanical engineering field; and

(iv) Enable the learner to develop skills and knowledge to perform effectively in technical and non-technical environments.

4.5.4 Expected learning outcomes from the programme

Expected learning outcomes or exit learning outcomes are explanations of what a student needs to attain in terms of knowledge and relevant practical skills, personal and transferable skills upon graduation. In order to harmonize and ensure the Bachelor programme degree in the mechanical engineering field is comparable to other programmes given at national and regional levels, learning outcomes have been established and adopted based on a number of studies carried out at national and international levels and shall be used as benchmarks for the mechanical engineering programme. It is worth noting that the formulated learning outcomes are the threshold or minimum requirements, and all graduates of the Bachelor's programme in Mechanical Engineering must be able to achieve them. Apart from the stipulated learning outcomes shown in Table 35, graduates must also be able to achieve the learning outcome for their electives or options. Universities may consider adding more learning outcomes where necessary to complement core and supportive courses so as to impact extra skills and knowledge fit for the world of work.

Table 35: Expected learning outcomes for Bachelor's degree in Mechanical Engineering

Category	Expected Learning Outcomes
Knowledge (K)	On successful completion of the degree programme, graduates should have:
	K1. Ability to apply knowledge of mathematics, science, Mechanical engineering concepts and theories, including information technology tools, to solve complex engineering problems; K2. Ability to use research concepts, theories, facts and methods in investigations of Mechanical engineering problems, including design of experiments, analysis and interpretation of data; and K3. Ability to recognize the importance of and pursue lifelong learning (LLL) in the broader context of innovation and technological developments in Mechanical engineering.
Competences (C)	S1. Ability to formulate design solutions for complex mechanical engineering problems and design systems, components or processes using both conventional and information technology tools that meet specified needs; S2. Ability to apply management skills to manage projects in a multi-disciplinary environment; S3. Ability to communicate effectively with confidence, including able to write and make convincing presentation on complex Mechanical engineering problems; and S4. Ability to continuously seek and apply contemporary and emerging technologies.
	C1. Ability to evaluate the sustainability and impact of professional engineering work and solve complex Mechanical engineering problems in societal and environmental contexts;

Category	Expected Learning Outcomes
	C2. Ability to apply innovation and entrepreneurship principles to create business opportunities; C3. Ability to investigate complex Mechanical engineering problems using research-based knowledge and methods to produce conclusive results; C4. Ability to apply appropriate techniques, resources, and modern—techniques such as modelling and simulation to solve complex Mechanical engineering problems; and C5. Ability to function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

4.5.5 Translating the expected learning outcomes into programme

The translation of the ELOs into the Mechanical Engineering programme involved alignment between learning outcomes and course contents. This was followed by mapping the learning outcomes into courses and grouping them into core, supportive and elective courses. The three (03) types of groups of subject areas can be distinguished as follows:

(a) **Core Courses (or subject areas):** These are the essential courses offering a thorough foundation of the discipline and they are mandatory for every student. The core courses are the backbone of the discipline and they are typical courses.

(b) **Supporting courses (or subject areas):** These are mandatory courses for backing up the intended learning outcomes. Without these courses it will be difficult to achieve the learning outcomes of a given programme.

(c) **Elective courses (or subject areas):** These are courses that can be taken by a student, to deepen or broaden the knowledge, but they are not compulsory. However, a student has to make a choice to meet the minimum credit requirements for graduation. However, the selected courses must come from a list of courses approved by the University Senate

It should be noted that within the programme, the courses shall be largely assessed through coursework and examinations, although some courses may be of audited nature (i.e., courses in which a learner attends but is not examined). During programme curriculum design, it must be ensured that there is sufficient coverage of requisite, pre-requisites and co-requisite courses. A Bachelor's degree programme in a specified field of engineering can be divided into two (02) phases, i.e., the basic phase and the specialisation phase as follows:

(a) The basic phase is common for the entire specific engineering field and consists of core and supportive courses.

(b) The specialisation phase allows learners to choose applicable specialisations in line with their interests in the engineering field of study.

The benchmarks development process involved analysis of regional and international practices followed by establishment of minimum/key courses to be covered in each of the selected fields' programmes. Table 36 translates some of the ELOs into minimum courses/subject areas that form part of the curriculum for a Bachelor's degree programme in Mechanical Engineering. The minimum courses/subject areas were evenly distributed across the main thematic areas of the Mechanical Engineering field. Table 36, therefore, shows the minimum courses/subject areas for a Bachelor's degree programme in Mechanical Engineering, categorised into core, supportive and elective courses.

Table 36: Minimum courses/subject areas for a Bachelor's degree programme in Mechanical Engineering

Core Subject Areas		
Mechanical Engineering Courses (Fundamentals)	**Materials Technology Courses**	**Mathematics and Computing Courses**
(i) Engineering Drawing (ii) Strength of Materials (iii) Statics and Dynamics	(i) Materials Technology I (Testing of materials, Structure and transformation of materials and materials technology practicals) and	(i) Introduction to Computers and Programming for Engineers (ii) Matrices and Basic Calculus for Non-Majors (iii) Statistics for Non-Majors

Core Subject Areas		
(iv) Machine Elements and Design and Design Projects (v) Dynamics of mechanical structures /Vibration Engineering (vi) Material Handling Systems (vii) Computer Aided Design **Manufacturing Technology** (i) Manufacturing Technology I (Metal cutting/machining processes and Metal forming) and II (Casting and welding) (ii) Computer Aided Manufacturing (iii) Industrial Automation/Digital control (iv) Plastic processing technologies.	(ii) Materials technology II (Metals and non-metals, Deterioration of materials in service and strength of materials) **Energy Engineering Courses** (i) Thermodynamics (ii) Mechanics of Fluids (iii) Mechanical Control Systems (iv) Turbomachinery (v) Combustion and Heat Transfer **Industrial Engineering and Management Courses** (i) Engineering Operations Management (ii) Research Methods for Engineers (iii) Engineering Economics (iv) Industrial Safety and Maintenance (v) Entrepreneurship for Engineers	**Electrical and Electronics Fundamental Courses** (i) Fundamentals of Electrical Engineering and II (ii) Measurements and Instrumentation for Non-majors (iii) Fundamentals of Electronics **Technical Skills Courses** (i) Workshop Training (machining, casting, welding, forging, electrical, electronics and welding, chemical and process) (ii) Design exercises (iii) Final Project

Core Subject Areas
Supporting Courses
(i) Humanity and Social Science Courses (ii) Communication Skills for Engineers (iii) Development Perspective
Elective Courses
(i) Renewable Energy Technology (ii) Power Plants (iii) Refrigeration and Air-conditioning (iv) Automotive Engineering (v) Innovation Management

4.5.6 Credit framework for the programme

The UQF defines a credit as a numerical value on a Qualifications Framework standard that represents the estimated time needed for a learner to achieve required specific learning outcomes. A credit within the UQF equates to learning outcomes achievable in 10 hours of learning time. It is a measurement unit for 'notional' or 'average learning' time which includes all the activities which the learner is expected to undertake in order to achieve the learning outcomes. Such activities for UQF level 8 conventional mode of learning include but are not limited to; lectures, seminars/tutorials, assignments, independent studies, and practical training as stipulated in Table 37 as an example.

Table 37: Credit framework for the conventional mode of learning

UQF Level	% On Lectures	% On Seminal and Tutorial	% On Assignment	% On Independent Studies and Research	% On Practical Training
8	40	20	10	20	10

UQF defines 480 as the minimum cumulative credits required for a learner to graduate with a Bachelor of Mechanical Engineering. It should be noted that, for a subject area, Mechanical Engineering programme designers are flexible to assign more weight to an activity that heavily contributes to the student's learning. For instance, for the design exercise subject, more weight should be assigned to the practical activity. On the other hand, for courses that consist mainly of lecturers, tutorials and laboratory work, 1 Contact Hour will be equalled to equal to 2 Notional Hours. This is because for every hour of lecture (every hour of contact between lecturer and student), a student will require another one (01) hour of private study (learning time*)*.

4.5.7 Normal learning matrix of the programme

The normal learning matrix and course matrix shall be provided for the determination of the percentage (%) of time to be assigned for learning at UQF level 8. In this regard, universities should design a Mechanical Engineering programme such that a student covers a minimum of 480 credits in four (04) years for core and supporting subject areas. In addition, the number of electives to be taken shall also be indicated. Table 38 presents a sample matrix for year 3, semester 1 of the Bachelor's degree programme in Mechanical Engineering.

Table 38: Sample of normal learning and course matrix of the Bachelor's degree programme in Mechanical Engineering

Year 3, Semester 1

Course code	Course Name	Course Status	Lecture	Tutorial or Seminar hrs	Assignment hrs	Independent study hrs	Practical hrs	Total hours	Credits
		(core/optional	Hrs						
ME 332	Manufacturing Technology	Core	-	-	-				
ME 302	Design Exercises	Core	-	-	-				
ME 308	Vibrations	Core							
ME 303	Computer Aided Design	Core							
ME 329	Automotive Engineering	Elective							
	Total credits								

4.5.8 Mechanical Engineering course description

All courses or modules to be taught and learnt within the programme should follow the following outline for their course description, as shown in Table 39.

Table 39: Course description

SN	Description
1.	**Course Title:** Refer to UQF qualification titles and nomenclatures.
2.	**Course Code:** A unique number that identify the course
3.	**Prerequisite:** A prerequisite should be a course that provides the required foundation knowledge in order to progress into this particular course
4.	**Course Aim:** Course Aims are statements that describe the overarching intentions of a course. They should try to answer, "What is the purpose of the course?", "What is the course trying to achieve?"
5.	**Course Requirements:** List tools, resources, and materials needed by the student for success in the course e.g. Access to Labs, web-based resources etc.
6.	**Course Expected Learning Outcome(s):** Course Learning outcome should try to describe what students will be able to do/learn by the end of the course in terms of knowledge, skills and competency.
7.	**Course Status:** Should indicate whether the course is core or elective.
8.	Credit rating: Reference should be made to UQF credit framework.
9.	Total Hours Spent:
10.	Course Content:
11.	**Mode of Delivery:** The mode of delivery is an important consideration when designing learning activities that will support students to develop the skills, knowledge and understandings required achieving the intended learning outcomes, as measured by the assessment in your unit. Ideally, the instructor shall select the most appropriate mode of delivery for each activity based on what will best support student development of the skills, knowledge and understandings students are expected to achieve.
12.	**Assessment Methods:** An assessment criterion on how to achieve the outcomes in (CA/UE**)**
13.	**Recommended Texts & Other Readings:** Indicate up-to-date list of the required course textbooks, journals and the reference books. Include detail such as full name of textbook, author, edition, ISBN, description (if desired), and where it can be purchased. If a required text is available online, indicate where it can be accessed.

4.5.9 Expected learning outcomes and curriculum alignment matrix of the programme

Development of the curriculum alignment matrix is necessary for checking if the subject areas cover the learning outcomes. For each subject area, one must formulate the specific learning outcomes for that course and have to assess how much a given course contributes to the programme learning outcomes. Table 40 gives an example of a curriculum alignment matrix for the expected learning outcomes of the B.Sc. in Mechanical Engineering. For each subject area, the contribution to the expected learning outcomes is given. The letters K, S, and C stand for Knowledge, Skills, and Competence, respectively.

Table 40: Curriculum alignment matrix for the Bachelor's degree programme in Mechanical Engineering

SN	Mechanical Engineering Course	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
Core subject areas													
1.	Mechanical Engineering and Mechanics	√		√	√			√			√	√	
2.	Mechanical Design and Mechanics	√	√	√	√		√	√	√		√	√	√
3.	Manufacturing Engineering	√	√	√		√	√	√	√	√	√	√	√
4.	Materials Technology	√	√	√	√			√	√	√	√	√	
5.	Energy Engineering	√	√	√	√	√	√	√	√	√	√	√	√
6.	Industrial Engineering and Management	√	√	√		√	√	√		√		√	√
7.	Mathematics and Computing	√									√		
8.	Electrical and Electronics	√	√	√				√		√			

SN	Mechanical Engineering Course	K1	K2	K3	S1	S2	S3	S4	C1	C2	C3	C4	C5
	Fundamental												
9.	Technical Skills	√	√	√	√			√	√	√		√	√
Supporting Subject areas													
10	Humanity and Social Science		√	√			√		√				√
11.	Communication Skills for Engineers						√						√
12	Development Perspective		√	√			√		√				√
Electives Subject areas													
13	Renewable Energy Technology	√	√	√	√			√	√	√	√	√	√
14	Power Plants	√	√	√	√	√		√	√	√	√	√	√
15	Refrigeration and Air-conditioning	√	√	√	√			√	√	√	√	√	
16	Automotive Engineering	√	√	√	√			√	√	√	√	√	
17	Innovation Management		√	√		√	√	√		√			√

4.5.10 Benchmarks for specialization

In addition to the selection listed in the specialization courses, universities are free to make additional subjects. Also, students may select certain subjects to deepen their knowledge in one or more of the following specializations:

(a) Flexible manufacturing

(b) Powder metallurgy

(c) Nano technology

(d) Internet of Things

(e) Artificial Intelligence

(f) Rapid Prototyping

4.5.11 Minimum entry qualification for the programme

Minimum entrance requirement for the BSc. Mechanical Engineering Programme shall be as follows:

(a) Two principal passes with at least a "D" grade in Physics and Mathematics or Chemistry at the advanced level or Form six, at which the combination of subjects will depend on the field of specialization.

(b) Diploma Certificate or equivalent qualification approved by the Senate with at least a "C" grade in Mathematics and an average of "B" or a GPA of 3.0 in all subjects as prescribed by most universities in the country. In addition, an applicant must have a minimum of a "D" grade in two science subjects and a minimum of a "D" grade in Mathematics at O-Level.

4.5.12 Duration of the programme

The duration of the Bachelor of Mechanical Engineering should be four (04) years, with a number of semesters generally eight (08) (02 semesters per year), including eight (08) weeks of practical training for the first three (03) years.

4.5.13 Graduation requirements for the programme

At the end of each academic year, a student is required to complete a minimum of 120 credits. A student is required to accumulate a minimum of 480 credits (4,800 notional hours) of learning for him/her to graduate, including practical training.

4.5.14 Evaluation and course assessment for the programme

Evaluation

The Bachelor of Mechanical Engineering programme will normally take four (04) years to complete. It is important to review the programmes within one to three years after completion of one delivery programme cycle. The review will be based on a graduate survey involving alumni, employers and stakeholders, faculty, and students. The survey will be based on standard developed tools/guidelines to capture the marketability of the programme and the employability of the graduates, including new developments in science and technology.

Assessment

Programme assessment will be based on the achievement of learning outcomes. Assessments are based on the nature of courses. Students' performance in the majority of theoretical courses will be measured based on continuous assessment and final examinations. The ratio between continuous assessment and final examination will depend on the weight between the two components. Continuous assessment will comprise mainly of tests, mid-semester tests, projects/assignments reports, practical training in industry, laboratory reports and presentations and will contribute 40 percent and university examinations will contribute 60 percent. Examination and continuous assessment will cover all expected learning outcomes.

4.5.15 Resource requirements for the programme

Effective teaching and learning require adequate resources both in quantity and quality in terms of infrastructure/space, teaching and technical staff, and laboratory and workshop equipment. Other requirements include Information Technology (IT) infrastructure and facilities. These are explained below:

(a) **Classrooms:** In terms of classroom space, the mechanical engineering programmes should have adequate space to accommodate all students during their training. Also, staff should have enough offices with the minimum number of staff sharing offices.

(b) **Physical facilities**: These need to be adequate and suitable to support the Mechanical engineering programmes from UQF 6 to 8 levels. This is because, for proper teaching and learning in mechanical engineering, subjects require adequate and state-of-the-art equipment and machinery that covers mechanical engineering subjects so as to supplement the theoretical knowledge taught in classes. Typical machinery recommended include metal cutting machines, metal forming machines, pneumatic and hydraulic kits, welding machines, energy equipment and machinery as well as material testing equipment and machinery. Also, workshops should have new and modern manufacturing machines such as CNC machines, robotics and digital controls machinery.

(c) **Teaching and technical staff:** Effective teaching and learning need to have comprehensive, adequate and competent human resources. Further, there should also be human resource targets set in line with higher learning departments' requirements, accompanied by comprehensive succession plans to address staff attrition (retirements, demise, exodus, etc.). For the Mechanical Engineering subjects, it is recommended to have the ratio between students and lecturer of 8:1 to 15 to 1. As for the technical staff, it is recommended that 10 students should be served by one technician.

(d) **Laboratory and workshop resources:** Laboratory resources should be adequate so as to avoid many students from sharing the few laboratory facilities available. In addition, physical facilities should be new and of the state of the art.

(e) **ICT network:** The Mechanical engineering programme needs to be supported with state-of-the-art computer laboratories as well as efficient and effective ICT infrastructure for strategic teaching and learning. Students should have opportunities to access electronic journals or reference materials.

4.5.16 Industrial training

The industrial training may be conveniently scheduled at the end of each academic year for the first three (03) years of the programme for a reasonable period of time of not less than eight (08) weeks per year. However, it is recommended that third-year students should take advantage of identifying their final year projects. Table 41 depicts the allocation of marks and responsible supervisors for industrial training in universities. It should be noted that the assessment structure within a given university varies department wise and year of study. It is proposed that each university to develop its own assessment structure that should be approved by the respective senate.

Table 41: Allocation of marks and responsible supervisors

SN	Allocation of Marks and Responsible Supervisors			
1.	Industrial Supervisor	Internal/Academic Supervisor	Internal Examiner (Report)	Oral Exam (Option)
2.	10	20	50	20

4.5.17 Final year project

A final year project should ideally be performed during the last years of the programme. Learners have an opportunity to demonstrate that they can conceptualise, design, innovate, and justify the innovation and business case and prototype engineering solutions. Final year projects usually impart knowledge and skills that assist students to:

(i) Investigate, identify and define a problem, including its constraints and broad environmental issues.

(ii) Understand customer and user needs, including industrial design considerations.

(iii) Propose a solution for the identified problem.

(iv) Identify and apply a comprehensive methodology (Data collection, design analysis, model construction and testing) for solving a given problem.

(v) Discuss results and compile a report.

In order to allow more time for the final year projects, it is important that the final year project is allocated in the second semester of the final year which shall comprise mainly the final year project and only a few lectures.

BIBLIOGRAPHY

Alfredo Squarzoni and Alfredo Soeiro, eds., 2018. TUNING, Guidelines and Reference Points for the Design and Delivery of Degree Programmes in Civil Engineering. Edition 2018.

American Society of Engineering Education (ASEE). 2014. The Attributes of a Global Engineer Project. USA, ASEE.

Anderson, L.W. (Ed.), Krathwohl, D.R. (Ed.), Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., & Wittrock, M.C., 2001. A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of Educational Objectives (Complete edition). New York: Longman.

Charles Awono Onana, Olusola Bandele Oyewole, Damtew Teferra, Pablo Beneitone, Julia González and Robert Wagenaar (Editors), 2014. Tuning and Harmonisation of Higher Education: The African Experience. University of Deusto, Bilbao, 2014.

Committee of Vice-Chancellors & Directors and University Grants Commission, Sri Lanka, 2006. Subject Benchmark Statement in Civil Engineering, August 2006.

CTL Guide to Learning Outcomes at the University of Alberta, 2017.

D. Briassoulis, P. Panagakis, E. Nikopoulos & F. Ayuga, 2008. The Emerging Evolution from Agricultural Engineering to Biosystems Engineering Studies in Europe. Conference Paper, January 2008.

ESMU et al., 2008. A Practical Guide: Benchmarking in European Higher Education. ISBN/EAN 978-90-9023635-3. August 2008

ESMU et al., 2010. A University Benchmarking Handbook: Benchmarking in European Higher education. November 2010 – ISBN/EAN 978-90-8164070-1.

European Association for Quality Assurance in Higher Education, 2012. Internal Quality Assurance Benchmarking. AISBL 2012, Brussels ENQA AISBL, Avenue de Tervuren 38 bte 4, 1040 Brussels, Belgium. ISBN 978-952-5539-68-4 (web publication), ISSN 1458-106X.

European Association for Quality Assurance in Higher Education, 2012. Quality Assurance and Qualifications Frameworks: exchanging good practice. AISBL 2012, Brussels ENQA AISBL, Avenue de Tervuren 38 bte 4, 1040 Brussels, Belgium. ISBN 978-952-5539-

69-1 (paperbound), ISBN 978-952-5539-70-7 (pdf), ISSN 1458-106X.

http://unaab.edu.ng/funaab-ocw/opencourseware/Introduction%20to%20Agricultural%20Engineering.pdf

IUCEA, 2019. Benchmarks for Civil, Mechanical, Electrical, Electronics and Telecommunication, Agricultural Engineering Programmes (Draft June 2019).

IUCEA, The East African Qualifications Framework, May 2015.

J. Bankel, K.F. Berggren, M. Engstrom, I. Wiklund, E.F. Crawley, D. Soderholm, K.E. Gaidi, S. Ostlund, 2005. Benchmarking of Engineering Curricula with the CDIO Syllabus. Int. J. Engng Ed. Vol. 21, No.1, pp. 121-133.

Jenneke Lokhoff, Bas Wegewijs, Katja Durkin, Robert Wagenaar, Julia González, Ann Katherine Isaacs, Luigi F. Donàdalle Rose, Mary Gobbi (Editors), 2010. A Tuning Guide to Formulating Degree Programme Profiles including Programme Competences and Programme Learning Outcomes. Bilbao, Groningen and The Hague, 2010.

OECD, 2011. A TUNING-AHELO Conceptual Framework of Expected/Desired Learning Outcomes in Engineering. OECD EDU Working Paper No. 60. 21st February 2011.

Oliver, R. G., 2003. Exploring benchmarks and standards for assuring quality online teaching and learning in higher education. Proceedings of Open and Distance Learning Association of Australia Biennial Forum. (pp. 79 - 90). Canberra, ACT. Open and Distance Learning Association of Australia, Incorporated. Available here This Conference Proceeding is posted at Research Online. https://ro.ecu.edu.au/ecuworks/3279.

National Academy of Engineering. 2016. Forum on Proposed Revision to ABET Engineering Accreditation Commission General Criteria on Student Outcomes and Curriculum (Criteria 3 and 5): A Workshop Summary. Washington: National Academies press. Doi: 10.17226/23556.

National University of Singapore. Subject Benchmark in ASEAN Universities. Power Point Presentation by Tan Kay Chuan, Ong Chee Bin, Zhou Qi. Office of Quality Management. National University of Singapore.

https://asem-education.org/wp-content/uploads/2021/03/ws3_tankaychuan.pdf

Nigeria-National Universities Commission, 2007. Benchmark Minimum Academic Standards for Undergraduate Programmes in Nigerian Universities, Engineering & Technology, April, 2007.

Pakistan Engineering Council & Higher Education Commission Islamabad, 2020. Curriculum of Agricultural Engineering Bachelor of Engineering Programme.

Qassim University Deanship of Development and Quality, 2019. Benchmarking of Academic Programmes Manual/Handbook.

Quality Assurance and Accreditation Council and University Grants Commission, Sri Lanka, 2011. Subject Benchmark Statement in Mechanical Engineering, January 2011.

Quality Assurance and Accreditation Council and University Grants Commission, Sri Lanka, 2011. Subject Benchmark Statement in Electrical Engineering, January 2011.

Quality Assurance and Accreditation Council and University Grants Commission, Sri Lanka, 2011. Subject Benchmark Statement in Chemical and Process Engineering, January 2011.

Rao, N.J., 2020. Outcome-Based Education: An Outline. Article in Higher Education for the Future · January 2020. DOI: 10.1177/2347631119886418.

Robert Wagenaar, ed., 2018. Tuning-CALOHEE Assessment Reference Frameworks for Civil Engineering, Teacher Education, History, Nursing, Physics.

SnježanaRezić, Andre Govaert, DejanBokonjić, Karl Heinz Gerholz, Marina Matošević, DuškaRadmanović, 2014. Benchmarking Handbook for the Universities of BIH.

TCU, 2021. A Booklet on Institutional and Programme Clusters (November 2021).

TCU, 2021. Curriculum Development Framework for all Levels of University Education in Tanzania.

TCU, 2019. Handbook for Standards and Guidelines for University Education in Tanzania, 3rd Edition (December 2019).

TCU, 2012. University Qualifications Framework (UQF) (August 2012).

The Engineering Council, UK, 2020. The Accreditation of Higher Education Programmes (AHEP), 4th Edition, August 2020.

The Quality Assurance Agency for Higher Education (QAA), 2019. Subject Benchmark Statement Engineering, October 2019.

The Tanzanian Commission for universities, National Qualification framework, final draft, March 2010.

The European Qualification Framework for Life Long Learning, European Commission, 2008.

The Quality Assurance Agency for Higher Education. 2015. Subject Benchmark Statement: Engineering. Gloucester, UK.

Tuning, A Guide to Formulating Degree Programme Profiles, Bilbao/The Hague, 2010.

Universiti Teknologi Malaysia (UTM), 2018. Undergraduate Handbook 2 (Curriculum and Syllabus) 2018 / 2019. Bachelor of Engineering (Civil).

Universiti Teknologi Malaysia (UTM), 2018. Undergraduate Handbook 2 (Curriculum and Syllabus) 2018 / 2019. Bachelor of Engineering (Mechanical).

University of KwaZulu-Natal (UKZN), College of Agriculture, Engineering and Science. Handbook For 2021.

University Qualifications Framework (UQF) 6 - 10) (November 2021).

University Studies of Agricultural Engineering in Europe; a Thematic Network (USAEE TN), 2003. Core Curricula of Agricultural / Biosystems Engineering for the First Cycle Pivot Point Degrees of the Integrated M.Sc. or Long Cycle Academic Orientation.

WANG Hong, 2008. Benchmarks and quality assurance for online course development in higher education. Mar. 2008, Volume 5, No.3 (Serial No.40). US-China Education Review, ISSN1548-6613, USA.